

## Article

# Digitization and Financial Performance of Banking Sectors Facing COVID-19 Challenges in Central and Eastern European Countries

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**Abstract:** The COVID-19 pandemic deeply impacted not only human wealth but also all segments of the economy as well as the field of technology. Thus, the purpose of this paper was to analyze the effects that the pandemic crisis and digitization have had on the financial performance of banks in Central and Eastern European Union countries (CEEC) during the 2010–2021 period. In order to capture an overview of the financial performance of the banking systems in the 10 CEECs, we used three variables—ROA, ROE and NPL—as reference indicators. In order to highlight the impact of the COVID-19 pandemic on the performance of banking systems, we used the number of reported cases as a variable, and to highlight the impact of digitization, we used as indicators the number of automated teller machines (ATMs) per 100,000 adults, number of certificates of secure internet servers, number of credit cards, number of debit cards, percentage of individuals using internet banking, and the number of commercial bank branches per 100,000 adults. Thus, the impact of digitization and the pandemic crisis generated by the COVID-19 virus on the performance of the banking systems in the 10 CEECs is outlined through three regression models using the robust regression model. The obtained results show that, as the infection rates with COVID-19 increased, the performance of banks measured by ROE and ROA decreased. Regarding the impact of digitization on performance, we note that an increase in the use of internet banking and the security of bank servers generated positive effects on the performance of banks. The results of the study are useful for banking product development departments, who should consider the important role of digitization in increasing the performance of banking services and thus design new digital products or ways to expand existing ones on a larger scale.

**Keywords:** digitization; financial performance; COVID-19 pandemic; banking sector

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## 1. Introduction

Beyond the effects that the COVID-19 pandemic has generated on human health, the virus has also generated an important effect on local economies and on the global economy, at the level of all segments of the economy, with important effects in the field of technology [1]. Analysts of the situation generated by the pandemic have metaphorically called it the phenomenon of the black swan, a surprising, unpredictable event of great importance that generates serious consequences and massive changes in political and economic environment [2,3].

The COVID-19 pandemic crisis, through infection control measures such as social distancing and lockdowns of parts of society taken to slow the spread of COVID-19, has affected the functioning and performance of businesses and increased the need for contactless financial products and services [4]. This pandemic has highlighted the fundamental role that digital infrastructure can play in the rapid delivery of services by banks and other financial institutions. The scale of the changes is seen in the fact that in developing countries, 71% of people now have a bank account, up from 42% a decade ago, while globally,

76% of adults worldwide have a bank account today, compared to 51% a decade ago [5]. The biggest increase in digital payments was recorded during the mobility restrictions and when the authorities suggested a limitation on the use of cash as it was unsanitary.

With all the adverse effects on most segments of the economy, there were also activities that registered growth trends, especially electronic commerce, which generated a need for digitization to conduct online business [6,7]. The conditions imposed in the pandemic have led the population to make more transactions through digital platforms, which has accelerated the adoption of banking and financial digitization, including the technological progress in banks, both to improve their performance and provide better services to current customers.

Banking institutions also played an important role in supporting the real sector, being compelled by central banks and governments to absorb the shocks caused by the pandemic crisis to the economy with effects on their profitability and performance [8,9]. The authorities in European countries have made a series of decisions to mitigate the effects of the pandemic crisis on households and companies. Thus, we can outline the decision of the National Bank of Romania to require banks to accept delays in the payment of loans by individual and corporate borrowers that registered losses of income due to the COVID-19 pandemic [10]. There is also the example of Germany, where the practice of providing liquidity has been used, with German banks continuing to support entrepreneurs and companies to help them weather a difficult period [11].

Taking into account the prudent regulatory actions that governments have taken in 27 countries regarding bank capital requirements, it emerged that banks can play a constructive role in supporting economic activities during the COVID-19 pandemic. Thus, banks should maintain high capital ratios over the medium-term horizon to absorb future losses, as the effect of COVID-19 on the economy may take time to fully materialize [12].

From a study carried out in Romania [13], it was found that more companies resorted to delaying payments to banks than individuals, which also highlights the importance that banks had in the proper functioning of the economic and financial mechanisms. The ability of banks to ensure sustained economic recovery depends on their resilience and financial health, as non-payment of loans can lead to the depletion of banks' capital [14]. However, currently, as a result of the regulations determined by the financial crisis of 2008, banks are much better capitalized [15].

Although there are many papers in the literature that analyze the effects of the COVID-19 crisis on bank performance and others that analyze the importance of digitization in banking systems as a result of the pandemic crisis, the purpose of this paper was to analyze the effects that the pandemic crisis and digitization have had on the financial performance of banks in Central and Eastern European Union countries (CEEC). Thus, this paper strives to cover a gap identified in the literature in the field by performing an analysis not only from the perspective of a single country, as is the case with most papers, but also by analyzing the effects of the pandemic crisis and digitization on the performance of banks.

This paper will allow us to highlight the lessons learned from this pandemic that can positively and definitively change the way banking services are performed, settled and transacted. The banking industry has changed some of its old ways, and all these implemented changes in the way it operates will definitely influence the way the banking system looks in the future.

The paper is structured as follows: Section 2 describes the most relevant studies in the field in order to support our findings; Section 3 emphasizes the used methodology; Section 4 reveals the findings and presents the discussions accordingly, and the last section outlines the conclusions, practical implications and limitations of the study.

## 2. Literature Review

In the literature in recent years, there are many papers that analyze the impact that the COVID-19 crisis has had on banking institutions, on the profitability of banks, or also

in terms of the accentuated digitization and its effects, but there are none that address the effects of COVID-19 on digitization and bank performance, and especially the relationship between digitization and performance in the context of the pandemic.

*The effects of digitization on banking activity and performance were highlighted even before the pandemic crisis* in some studies that identified the main factors that lead banks to go digital, such as the supply of cheaper services, the reduction of branches and cost savings, but also the need to adapt to customers' lifestyles [16,17]. Thus, we can observe that with the manifestation of the pandemic crisis, banks' orientation towards digital activity has been determined by other factors.

During the pandemic, people turned to banks to continue to carry out routine transactions such as paying bills, buying food and other products [18]. This period led to major and rapid changes that compelled banks to go digital, including the front-end, so that customers could benefit from a modern and credible digital interface.

Furthermore, the development of internet banking applications has made it possible to develop new payment methods, the advantage being that they are efficient ways of carrying out transactions in a simplified way. Tarazi [19] believes that this accelerated digitization will continue because conventional or traditional banks are more vulnerable to a sudden drop in lending activity, while large, digitized banks are able to better withstand it. Forcadell et al. [20] believe that by combining investments in technology with other intangible resources, such as CSR, banks can gain a competitive advantage that will lead to better performance.

Banks are the ones that must move towards digital transformation and aim to offer accessible, transparent, easy-to-use services at transparent and reduced costs compared to traditional services [13]. Customers will be motivated to use digital services only if they are offered an accessible interface, with increased security if the bank acts as a partner for them [21,22].

It was observed that the COVID-19 crisis accentuated the usefulness of financial digitization and raised new issues related to access to digitized financial instruments for all categories of citizens, highlighting the need for transaction security and financial education of the population, as the main factors facilitating financial digitization [23].

Moreover, studies based on questionnaires have proven that the pandemic crisis has accelerated the use of mobile banking services both in developed countries and especially in less-developed countries [24–29].

Nevertheless, *the pandemic context forced banks to reinvent themselves and to create new and diverse services*. Thus, in the World Retail Banking Report [30], it was highlighted that the negative effects of the COVID-19 pandemic on banks were much more important and of longer duration than on corporations, or on other non-financial institutions. The pandemic crisis has generated many changes in banking systems, especially in the way banks work, but also in terms of new operations and procedures. According to a KPMG study [31], only three-quarters of bank branches remained open during the pandemic period, and in their case, the activity was with reduced hours of business for the public and based on appointments. The post-lockdown economy is likely to witness an acceleration in demand for simple, intuitive and personalized services delivered through integration into digital platforms, both bank-owned and operated by non-bank players [32].

However, *another effect of the introduction of the new digitized services is related to their cybersecurity*. Thus, according to the OECD, although on the one hand, the COVID-19 pandemic facilitated the acceleration of changes in the banking sector, on the other hand, it could lead to increased uncertainty and decreased profits, to which are also added the cyber risks that appear with digitization [33]. Thus, banking consumers faced significant security issues during the pandemic, which helped fuel customer preferences for Fintech platforms, due to quantum information technologies used in combination with traditional encryption techniques to ensure security [34].

Furthermore, *a relevant factor affecting the performance of banks is related to the non-repayment of bank loans*. The effects generated by the pandemic crisis on banks were com-

pared to those generated by the 2008 financial crisis and were found to be similar in terms of their impact on stock price performance. The more profitable and well-capitalized banks bore these effects the best [35]. Additionally, according to the European Central Bank and the International Monetary Fund, as a result of the COVID-19 crisis, banks will record increases in loan losses, determined by late payments of mortgage installments and defaults on company loans [36–39].

In the same view, as emphasized by some scholars [40,41], COVID-19 affected the number of bank branches, the volume of loans granted and changes to the traditional business models of banks. Thus, [40] they took into account bank loans, macroeconomic indicators and the number of COVID-19 cases and deaths and observed that the higher the number of cases and deaths, the lower the lending capacity of banks. From an analysis of the reaction of European banks to the COVID-19 pandemic, it was found that they reduced their loans in the first quarter of 2020, but that banks with greater exposure to COVID-19 reduced their loans significantly less, that is, they had a relative increase in lending compared to other European banks [42].

Other threads in the literature [43,44] concluded that the emergence and spread of COVID-19 reduced the extent of consumer financing and increased the vulnerability of financial institutions by increasing operational risk and reducing profitability. Li et al. [43] observed through an empirical analysis that banks experienced a reduction in loans and profitability as an effect of the pandemic and outlined the need to diversify their activity towards sources of income other than interest. Apergis also reached similar conclusions regarding the significant threats posed by the COVID-19 crisis on banking risk and profitability, but through the lens of non-performing loans [45].

Other scholars outlined the importance of country economic development and bank size in analyzing the impact of the pandemic on banks' performance. Thus, an analysis of the impact of COVID-19 on the profitability and stability of banks emphasized that the increase in loans and deposits did not support profitability during the pandemic in the case of banks from countries in the east, center and north of the EU, but that digitization helped the big banks to compensate for the problems generated by traditional sources of income [46]. Furthermore, a significant impact from the pandemic on bank returns on assets and equity was identified, differentially affecting banks in developing and developed countries. Bank profitability no longer depends specifically on credit quality and bank efficiency, but more on bank size and liquidity [47]. A study on the Ugandan banking system [48] found a negative effect from the COVID-19 pandemic on bank profitability but only in the long term. Another study analyzing the effects of digitization on bank performance in Vietnam found a positive impact on the performance of Vietnamese commercial banks and that the positive effects of digitization depended on the size of the banks [49].

As for the impact of digitization on the performance of banks in the pandemic context, many authors highlighted different approaches. Thus, digitization increases the performance of banks because it allows working with more customers and reduces the required human resources and the time required for the execution of transactions [50].

A study conducted at the level of the banking system in Serbia led to the conclusion that banks that also focused on digitization and sustainability were profitable even during the COVID-19 crisis [51].

Additionally, at the level of the banking system in the Russian Federation, it was documented that prospects for the development of the banking sector were related to the improvement in methods of carrying out banking activities based on advances in information technology [52].

Brynjolfsson [53] identified the J-curve of productivity according to which companies tend to delay adopting new technologies, and when they do, productivity often falls in the short term and then rises. A study conducted on the performance of US banks during the COVID-19 crisis documented a reduction in performance, but also the fact that banks

that invested in IT more in the pre-pandemic period were less affected by the pandemic crisis [54].

Furthermore, another study examined the effects of accelerated digitization fostered by COVID-19 on bank employees who had to deal with changes in banking processes and practices in the Swedish banking system, such as crisis management, digital changes and remote work with digital customers [55]. It was found that employees had a positive perception of the digitization process in banks, but both positive and negative effects of this process were identified.

Additionally, Baicu et al. [28] analyzed the effects of the pandemic from the perspective of Romanian bank customers and observed that due to the pandemic, customers' confidence in the safety of internet/mobile banking services increased and they became aware of the ease of use of new technologies.

### 3. Data and Methodology

The main purpose of this study was to analyze the effects that the pandemic crisis and digitization process have had on the financial performance of banks in the banking sectors of Central and Eastern European countries. A time period of only 12 years (2010–2021) was chosen depending on the availability of data related to the variables considered representative. In order to fulfill the proposed objective, we selected a set of variables that characterized the researched phenomena, as presented in Table 1.

**Table 1.** Variables and data sources.

Acronym	Definition	Unit of Measure	Time Period	Data Source
ROA	Return on assets	Percentage	2010–2021	International Monetary Fund
ROE	Return on equity	Percentage	2010–2021	International Monetary Fund
NPL	Non-performing loans to total gross loans	Percentage	2010–2021	International Monetary Fund
ATM	Automated teller machines (ATMs)	Per 100,000 adults	2010–2021	World Bank, World Development Indicators
SEC	Secure internet servers	No. of certificates	2010–2021	World Bank, World Development Indicators
CC	Credit cards	No. of credit cards	2010–2021	International Monetary Fund
DC	Debit cards	No. of debit cards	2010–2021	International Monetary Fund
IB	Internet use: internet banking	Percentage of individuals	2010–2021	Eurostat
CBB	Commercial bank branches	per 100,000 adults	2010–2021	International Monetary Fund
COV_tc	Total coronavirus cases	No. of cases	2010–2021	Worldometer Database

In order to highlight the impact of the COVID-19 pandemic on the performance of banking systems, we used the number of reported cases as a variable, as in other studies [8,56,57], unlike others that used a dummy variable [47,58].

The impact of digitization and the pandemic crisis generated by the COVID-19 virus on the performance of the banking systems in the 10 CEECs is highlighted through three regression models based on the following equation:

$$Y_{it} = \beta_0 + \beta_1 X_{1t} + \dots + \beta_i X_{it} + \varepsilon_{it} \quad (1)$$

where:

$Y$  = the dependent variable, which can be ROA, ROE or NPL, used to characterize the performance of the banking system,

$X$  = the independent variables, which can be ATM, SEC, CC, DC, IB, or CBB, used to characterize the digitization process in the banking system, and COV\_tc, used to characterize the pandemic crisis,

$\beta_{0,1..i}$  = the associated coefficients of the variables,

$t$  = the time period,

$\varepsilon$  = the standard error of the regression

To select the optimal type of regression for the available dataset, it is necessary to analyze the size of the residuals:

$$e_i = y_i - \left( \hat{\beta}_0 + \hat{\beta}_1 x_{1t} + \dots + \hat{\beta}_i x_{it} \right) \quad (2)$$



A point that has a large residual value is called an outlier. The presence of these outliers in a regression analysis can lead to erroneous results. Traditionally, the analysis of outliers and structural breaks in regression analysis was conducted by testing the statistical significance of a parsimonious, predetermined set of related indicator variables. More recently, advances in computing power and the development of general-to-specific (GETS) modeling permit testing of indicators at each observation in the estimation sample.

The indicator saturation approach is an extension of least squares regression for testing for outliers and structural breaks in a regression specification. The indicator saturation approach works by including indicator variables for outliers or structural breaks at every observation in the regression, and then employing the GETS algorithms to select which of the included variables should be retained in a final regression model.

Taking into account that our datasets contain outliers, the least squares regression is not suitable for our analysis, and it is recommended to use robust regression to overcome the influence of extreme observation [59]. The mathematical forms of the model equations are the following:

Model 1:

$$ROA_{it} = \beta_0 + \beta_1 \ln ATM_{it} + \beta_2 \ln SEC_{it} + \beta_3 \ln CC_{it} + \beta_4 \ln DC_{it} + \beta_5 \ln IB_{it} + \beta_6 \ln CBB_{it} + \beta_7 COV_{tc_{it}} + \varepsilon_{it} \quad (3)$$

Model 2:

$$ROE_{it} = \beta_0 + \beta_1 \ln ATM_{it} + \beta_2 \ln SEC_{it} + \beta_3 \ln CC_{it} + \beta_4 \ln DC_{it} + \beta_5 \ln IB_{it} + \beta_6 \ln CBB_{it} + \beta_7 COV_{tc_{it}} + \varepsilon_{it} \quad (4)$$

Model 3:

$$\ln NPL_{it} = \beta_0 + \beta_1 \ln ATM_{it} + \beta_2 \ln SEC_{it} + \beta_3 \ln CC_{it} + \beta_4 \ln DC_{it} + \beta_5 \ln IB_{it} + \beta_6 \ln CBB_{it} + \beta_7 COV_{tc_{it}} + \varepsilon_{it} \quad (5)$$

The robust regression model allows for three estimation methods for computing the covariance matrix of the coefficient estimates [60]. In our research, we use the Huber M-estimator (“M” for “maximum likelihood estimator-like”) that computes the coefficient values that minimize the summed values of a function  $\rho$  of the residuals:

$$\hat{\beta}_M = \underset{\beta}{\operatorname{argmin}} \sum_{i=1}^N \rho_c \left( \frac{r_i(\beta)}{\sigma \omega_i} \right) \quad (6)$$

where  $\sigma$  is a measure of the scale of the residuals,  $c$  is an arbitrary positive tuning constant associated with the function, and  $\omega_i$  are individual weights that are generally set to 1.

## 4. Results and Discussions

### 4.1. Evolution of Financial Performance of the Banking Systems in CEECs

In order to capture an overview of the financial performance of the banking systems in the 10 CEECs, we used three variables—ROA, ROE and NPL—as reference indicators. The evolution of these indicators in the period 2010–2021 is presented in Figures 1 and 2.

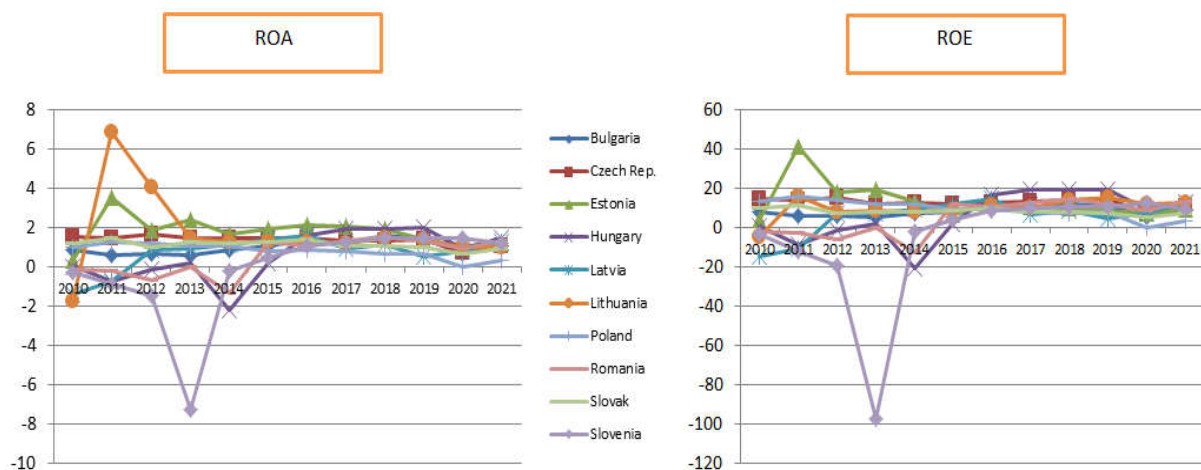


Figure 1. Return on assets (ROA) and return on equity (ROE) in CEECs, %.

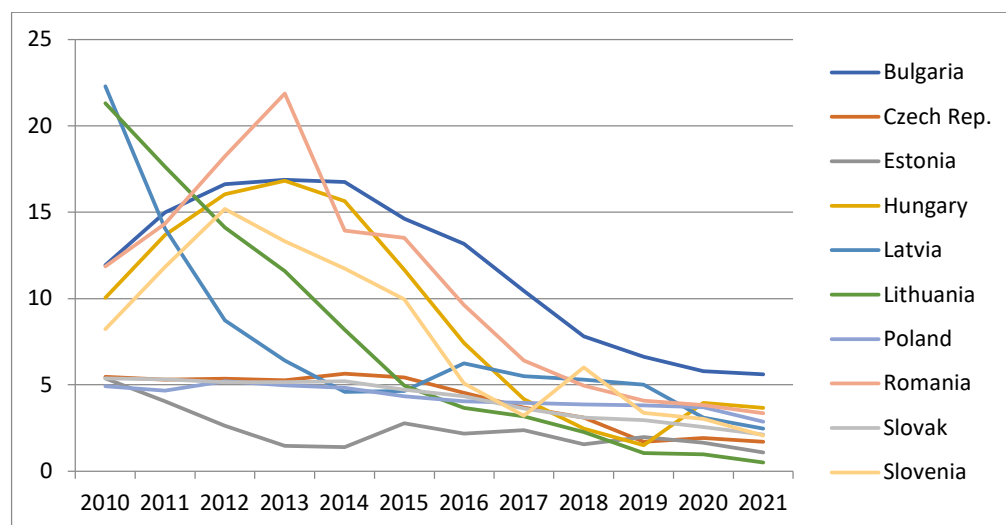


Figure 2. Non-performing loans to total gross loans, %.

In most of the countries included in the analysis, ROA recorded positive values that fell within the range of 1–2%, with a few exceptions that are important to mention because they will represent future outliers in the econometric analysis. First of all, Lithuania shocked by jumping from the value of  $-1.72\%$  recorded in 2010 to no less than  $6.89\%$  in 2011, being the country with the highest ROA among those analyzed in the period 2010–2021. According to Novickytė and Drożdż, the profitability of Lithuanian banks is increasing due to significantly decreased interest expenses and increased efficiency [61]. Another exceptional situation was found in Slovenia, a country where the ROA suffered a significant and sudden drop from  $-1.48\%$  in 2012 to  $-7.29\%$  in 2013. This decrease is explained by the fact that the quality of loan portfolios had continuously deteriorated, but also by the need for large banks with state capital to receive additional capital [62]. Still other exceptions, but of a smaller scale, were Estonia with a positive value of ROA in 2011 of  $3.54\%$  and Hungary with a negative value of ROA of  $-2.24\%$ .

Return on equity measures a company's (in our case, banking system's) net income divided by shareholders' equity. The values of this indicator fell within the range of 0–20% for the entire time period analyzed, with a few exceptions. It is thus worth noting the positive value of ROE registered by Estonia in 2011, of over 41%. Significant negative and continuously decreasing values of ROE were recorded in Slovenia, reaching the negative historical maximum of 97% in 2013. Negative values of ROE were also recorded in countries such as Hungary (around 20% in 2014) and Latvia (about 15% in 2010) as a result of the effects of the world economic crisis of 2008.

Regarding the value of non-performing loans, we found, as an overall assessment, that they had registered a downward trend, in 2021 reaching a percentage below 5% of the total loans issued (less in Bulgaria), but even in the case of this indicator, we found some exceptions, among which it is important to mention Romania, which in 2013 registered a growth point and exceeded 20% in its level of non-performing loans to total loans, together with Latvia and Lithuania, which were in the same situation in 2010.

#### 4.2. Digitization in CEEC Banking Systems

From the point of view of digitization, we considered it appropriate to approach it through the lens of bank server security and the intensity of internet banking use, but also the technological tools frequently exposed to bank fraud, such as ATMs and credit or debit cards.

Although we are in an era of digitization and the need to access banking services online has been increasing in light of the restrictions imposed by the COVID-19 pandemic, a significant percentage of the population is reluctant to use digital solutions to access

banking services. This is due on the one hand to the skills of the users, and on the other hand, to the often questionable security of digital services.

In Figure 3, we outline the evolution of server security from the point of view of the number of registered certificates. We note that although until 2015 the number of certificates was insignificant, since 2016 it has registered substantial increases, with the leading country in this regard being Poland, followed by the Czech Republic, Romania, Bulgaria and Hungary. However, there were also outstanding countries from this point of view, one of them being Latvia, where the number of registered certificates practically stagnated during the entire time period under analysis.

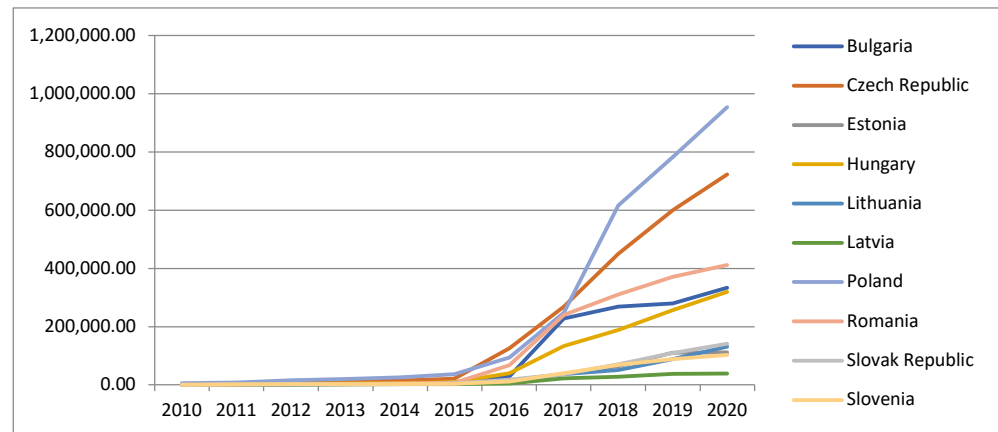


Figure 3. Secure internet servers—number of certificates.

However, the security of bank servers does not necessarily influence the intensity of internet banking use. We observe in Figure 4 that, although in absolutely all CEECs the percentage of use of internet banking increased significantly from 2010 to 2021, the highest percentage of internet banking users were registered in Estonia, followed by Latvia, the Czech Republic and Lithuania. In contrast, in countries such as Romania and Bulgaria, less than 20% of internet users used the internet to access banking services, and that was due to the low level of digital skills of their populations.

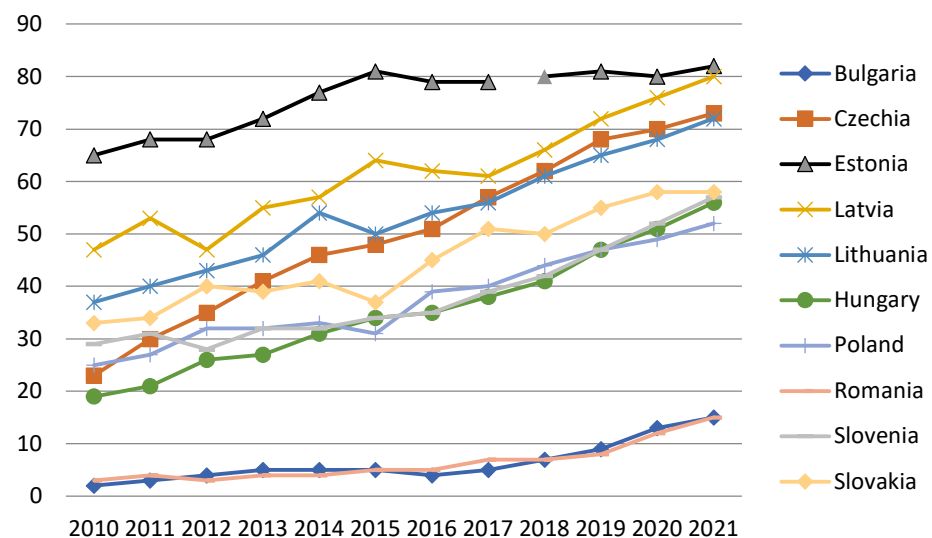


Figure 4. Internet use: internet banking (IB).

If we analyze the developments related to debit and credit cards in selected European countries, we can cite a disjointed market. We also observed that these differences between countries were accentuated during the pandemic, which led us to wonder what their effects were on the performance of the banking systems.



The two graphs above (Figure 5) clearly show the dominance of debit cards in the CEECs, a fact that can be partially explained by the position among banks in the analyzed countries that any current account should be accompanied by a card. Another explanation would be that, from a risk perspective, issuing a debit card is less risky for financial institutions compared to issuing a credit card, but also that these cards are preferred for online purchases and contactless payments.

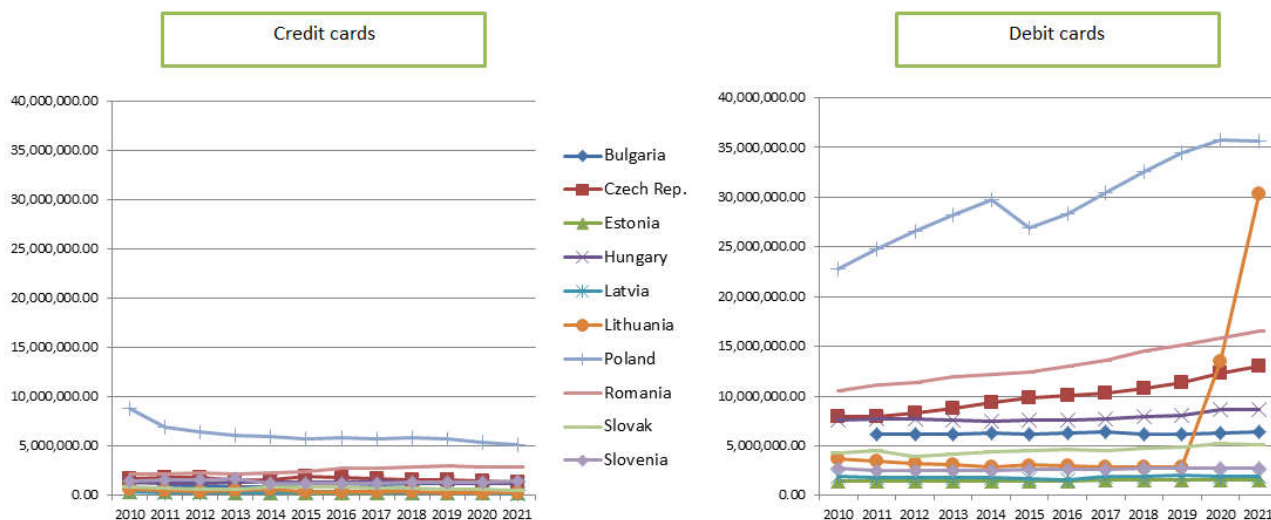


Figure 5. Evolution of credit cards (CC) and debit cards (DC).

The indicators related to ATMs and commercial bank branches were used in the analysis because they show the orientation of banks and society towards increasing the volume of digital operations, at the expense of physical bank branches.

Although ATMs were initially a successful strategy to achieve greater productivity, as they provide greater efficiency than cashiers, the growing preference for digital transactions has led banks to reduce ATMs in some of the countries analyzed (Figure 6). Thus, in Lithuania, Latvia, Slovenia, and Estonia throughout the analyzed period, the total number of ATMs continued to decrease, with transactions being transferred to mobile banking services. Bulgaria continued to be the country with the highest number of ATMs per 100,000 inhabitants, of over 90; the Czech Republic and Slovakia recorded a permanent increase in the number of ATMs, while Hungary, Romania, and Poland recorded increases until 2014 and 2015, followed by a period of decrease in the number of ATMs.

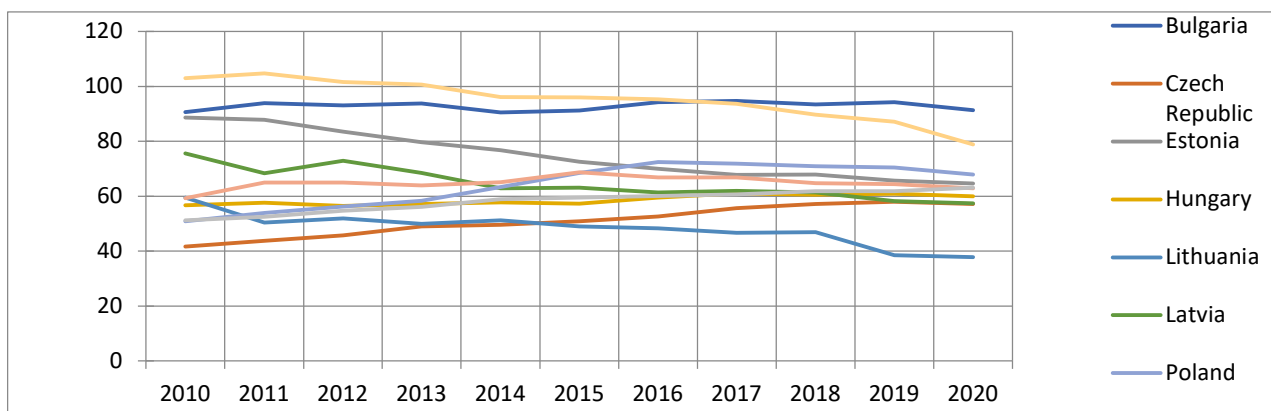
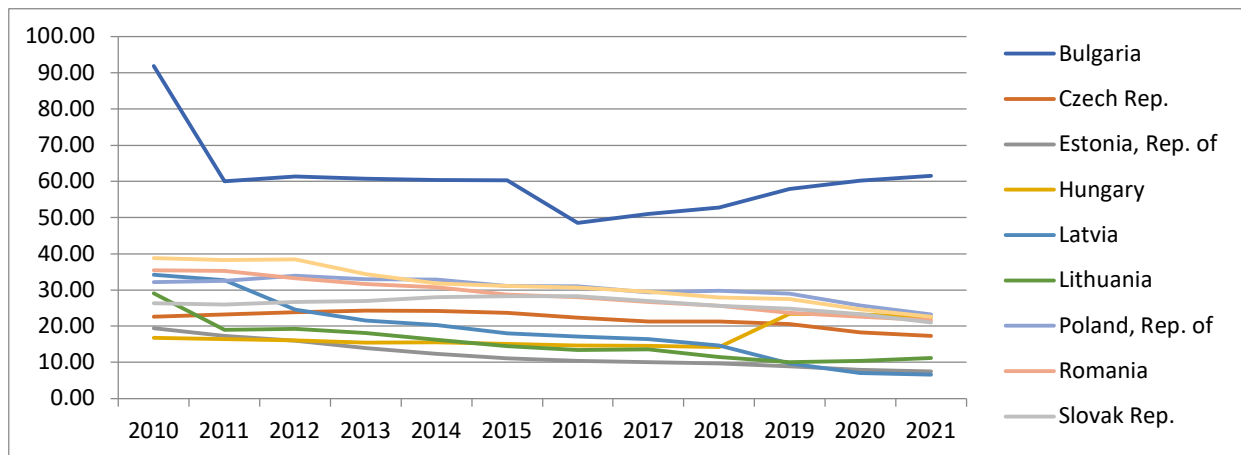


Figure 6. Evolution of automated teller machines (ATMs).

In general, for the entire period, we observed a downward trend (Figure 7) in almost all countries, with the exception of Bulgaria and Hungary, which after a period of decline until 2016 and 2018, respectively, registered an increase in the number of banking units per

100,000 adults. The explanation for the reduction in the number of units in most countries is that with the reduction in profitability, all banks have tried to make their operations more efficient by reducing the number of employees and the number of bank branches and by recently focusing on digital banking services.



**Figure 7.** Evolution of commercial bank branches per 100,000 adults.

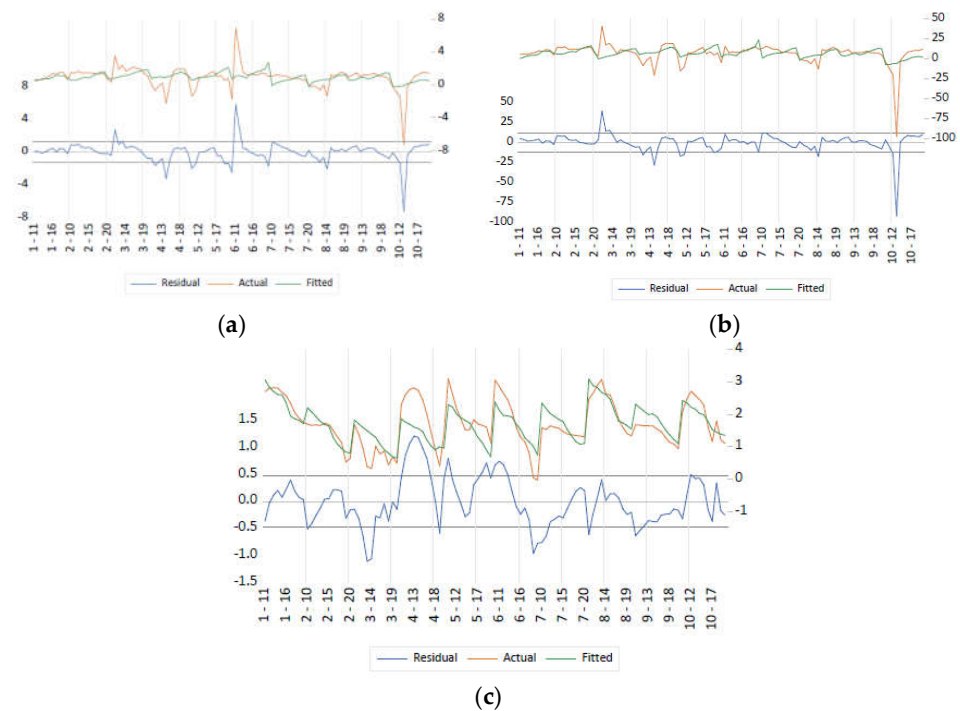
#### 4.3. Estimation of Influence and Causality of COVID-19 Pandemic Crisis and Digitization on the Banking System Performance

Before analyzing the robust regression equations, it was necessary to analyze the autocorrelation between the variables. From Table 2, we can see that there was no autocorrelation within the selected models because none of the coefficients associated with the variables was equal to 1. However, we did notice a strong positive correlation between ROA and ROE, as well as between  $\ln CC$  and  $\ln DC$ , that did not affect the analysis of the regression models.

**Table 2.** Correlation matrix.

	ROA	ROE	$\ln NPL$	$\ln ATM$	$\ln SEC$	$\ln CC$	$\ln DC$	$\ln IB$	$\ln CBB$	COVID19_TC
ROA	1.0000									
ROE	0.8682 0.0000	1.0000								
$\ln NPL$	−0.3733 0.0001	−0.4433 0.0000	1.0000							
$\ln ATM$	−0.1394 0.1482	−0.2147 0.0250	0.2150 0.0248	1.0000						
$\ln SEC$	0.1599 0.0968	0.2563 0.0071	−0.5370 0.0000	−0.0701 0.4688	1.0000					
$\ln CC$	−0.1999 0.0372	−0.0708 0.4644	0.1948 0.0424	0.0980 0.3105	0.3027 0.0014	1.0000				
$\ln DC$	−0.0736 0.4466	0.0739 0.4449	0.0918 0.3424	−0.1267 0.1893	0.4048 0.0000	0.8833 0.0000	1.0000			
$\ln IB$	0.1158 0.2303	0.0982 0.3096	−0.5859 0.0000	−0.3028 0.0014	0.1557 0.1060	−0.3264 0.0005	−0.3525 0.0002	1.0000		
$\ln CBB$	−0.2482 0.0093	−0.2005 0.0366	0.5541 0.0000	0.4883 0.0000	−0.1109 0.2512	0.5226 0.0000	0.3855 0.0000	−0.6705 0.0000	1.0000	
COVID19_TC	−0.0628 0.5166	−0.0300 0.7565	−0.1747 0.0692	−0.0123 0.8989	0.3545 0.0002	0.1752 0.0684	0.2564 0.0071	0.0690 0.4756	−0.0073 0.9396	1.0000

As we specified in the methodology, before deciding on the optimal type of regression for our analysis, we proceeded to identify outliers using the GETS algorithms. Analyzing Figure 8, we noticed that two outliers were identified in the case of Model 1 and Model 2, and more outliers in the case of the third model. So, we needed a parameter estimation method that was robust, where the value of the estimation would not be affected much by small changes in the data.



**Figure 8.** GETS algorithm results for: (a) Model 1; (b) Model 2; (c) Model 3.

The optimal method for our analysis turned out to be the robust least squares regression with M estimation, which addresses dependent variable outliers where the value of the dependent variable differs markedly from the regression model norm (large residuals). In Table 3, we present the results obtained by applying the robust least squares M estimator for the three proposed models.

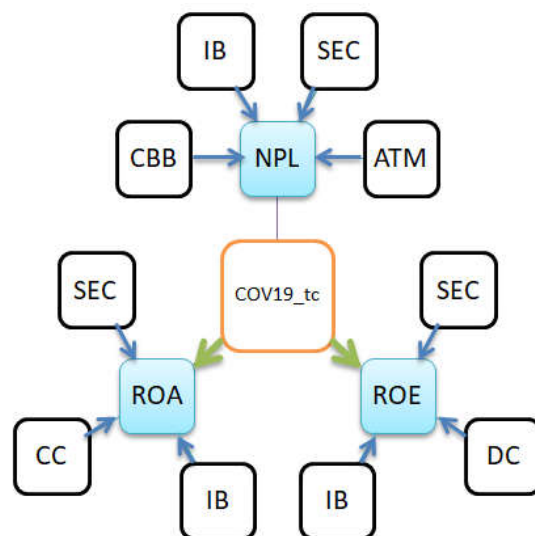
**Table 3.** Robust least squares M estimation results.

Variable	ROA				ROE				lnNPL			
	Coef.	Std. Error	z-Stat.	Prob.	Coef.	Std. Error	z-Stat.	Prob.	Coef.	Std. Error	z-Stat.	Prob.
lnATM	0.27	0.21	1.32	0.19	−2.53	1.77	−1.43	0.15	0.27	0.16	1.66	0.10
lnSEC	0.09	0.03	2.87	0.00	0.87	0.28	3.08	0.00	−0.17	0.03	−6.66	0.00
lnCC	−0.05	0.16	−0.29	0.07	−0.42	1.36	−0.31	0.76	0.04	0.13	0.33	0.74
lnDC	−0.02	0.13	−0.18	0.86	1.04	1.13	0.92	0.06	0.09	0.10	0.87	0.38
lnIB	0.13	0.08	1.63	0.09	0.84	0.69	1.21	0.03	−0.22	0.06	−3.47	0.00
lnCBB	−0.12	0.21	−0.56	0.57	−0.47	1.80	−0.26	0.79	0.32	0.17	1.93	0.05
COV19_tc	−0.43	0.00	−2.91	0.00	−0.60	0.00	−3.23	0.00	0.00	0.00	−0.01	0.99

According to the results presented in Table 3, we noticed that banking performance in the last decade was mainly influenced by the security of the servers and the use of internet banking. Bank security, expressed by the increase in the number of registered certificates of bank servers, positively influenced ROA and ROE and also led to a reduction in non-performing loans. On the other hand, the use of internet banking yielded a positive impact through increases in both ROA and ROE, as well as an increase in non-performing loans, albeit to a lesser extent compared to the first two dependent variables.

Regarding the pandemic crisis we are still in, we observed a statistically significant negative impact from the COV19\_tc variable on ROA and ROE, and at the same time the lack of any influence on non-performing loans. Other statistically significant results included the negative influence of credit cards (lnCC) on ROA in the first proposed model, the positive influence of debit cards (lnDC) on ROE in the second model, and the positive influence of lnATM and lnCBB on the increase in non-performing loans in the case of the third model.

To identify the direction of causality between the variables included in the three models, we used the causality test proposed by Dumitrescu and Hurlin (2012) [63], allowing all coefficients to be different across cross-sections, as presented in Figure 9.



**Figure 9.** Pairwise Dumitrescu–Hurlin panel causality test.

## 5. Conclusions

As the COVID-19 pandemic had deeply impacted not only human wealth but also all segments of the economy as well as the field of technology, in this paper, we aimed to analyze the effects that the pandemic crisis and digitization have had on the performance of banking systems in Central and Eastern European countries. To achieve this goal, we applied a robust regression model using as dependent variables ROA, ROE and NPL, and a series of independent variables to capture digitization in the banking systems and one to highlight the influence of the pandemic crisis.

As technology advances, individuals and businesses are becoming increasingly interested in digital banking practices, which led us to analyze the impact of digitization on the performance of Central and Eastern European banking systems. How has the outbreak of COVID-19 affected the dimension of performance and the level of digitization? The obtained results show that, as the infection rates with COVID-19 increased, the performance of banks measured by ROE and ROA decreased, which is in line with the results obtained in other studies at the European level [46,47] or at the level of selected countries [58,64,65]. Regarding the impact of digitization on performance, we note that an increase in the use of internet banking and the security of bank servers generated positive effects on the performance of banks, as was also confirmed in other papers [54,66,67].

Contradictory results were generated by the variables related to cards. Thus, we underlined that an increase in credit cards negatively influenced the performance of banks, which contradicts other studies, while the increase in debit cards led to an increase in performance, the result being in line with other studies [68,69].

The results did not lead to conclusions regarding the effects of COVID-19 on the level of non-performing loans, but influences from digitization on the increase in the level of non-performing loans and the expansion of the bank network were identified.

Regarding the theoretical implications of the conducted study, the literature has mainly focused on the impact of COVID-19 on banking sector performance and the impact of digitization as separate studies. In fact, it turned out that during the pandemic, these factors were closely related to each other; therefore, in this paper, COVID-19 and digitization, rather than the existence of an amplification effect between them, were analyzed to confirm their dual impact on the performance of banking systems. Thus, there are important theoretical implications given the complex picture of the impact of the pandemic and digitization on banking systems.

From a practical point of view, the study allows highlighting the importance that banks must give to digital activities in order to be prepared in the event of future unexpected events and to improve their performance and increase competitiveness. The results of the study are useful for banking product development departments, which should consider the important role of digitization in increasing the performance of banking services and accordingly design new digital products or explore ways of expanding existing ones on a larger scale.

This study was limited by a lack of data over a longer period of time, but also by differences in the structure of the banking systems between the different countries included in the study, which made the results in this paper heterogeneous at the national level. Therefore, a future development of the study could aim at testing the conclusions of this paper by collecting relevant data from other countries.

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