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PROFITABILITY AND BANK DE-BRANCHING IN THE DIGITAL AGE: EVIDENCE FROM RUSSIAN REGIONS

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PROFITABILITY AND BANK DE-BRANCHING IN THE DIGITAL AGE: EVIDENCE FROM RUSSIAN REGIONS[3,4]

Bank de-branching is one of the key trends in banking sectors all over the world. This paper explores the conditions in which de-branching brings more profits to the bank. This issue is attracting considerable interest due to recent technological developments and increasing competition, including from fintech companies. Using the data from 84 Russian regions over the period of 2010–2020, we test whether the adoption of internet technologies and financial digital literacy (FDL) are positively related to bank de-branching and whether they add to bank de-branching efficiency in terms of bank profitability. We show that a higher degree of adoption of technological innovation and higher levels of FDL are positively related to bank de-branching. Furthermore, we observe that banks closing their branches in regions exhibiting higher levels of internet development and FDL gain more profits from de-branching. The results are robust to various model specifications.

JEL: G21, G01, P2

Keywords: De-branching, Banks, Bank Profitability, Financial digital literacy, Innovations, Russia, Regions

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1 Introduction

Bank de-branching is one of the key trends appearing in the banking sector all over the world. Keil and Ongena (2020) argue that "four out of five branches have been or will be closed" in OECD countries, while in the US around 10,000 bank branches "have been closed" (Keil & Ongena, 2020, p. 1). Bank branches are closing at a rapid pace in Russia, as well.

Figure 1 shows the decreasing number of brick-and-mortar bank institutions in recent years: as of April 2022, according to Bank of Russia statistics, there were only 365 credit organizations.[5] Compared to 2010, the number of banks in Russia decreased by 63.4%. The statistics on the number of bank branches are more dramatic: as of April 2022, the number of bank branches in Russia was 467, 84% fewer compared to the number of bank branches in 2010. The difference in the reduction rates of banks and bank branches indicates that bank de-branching could be explained not only by the large number of bankruptcies or license withdrawal, but also by other factors.

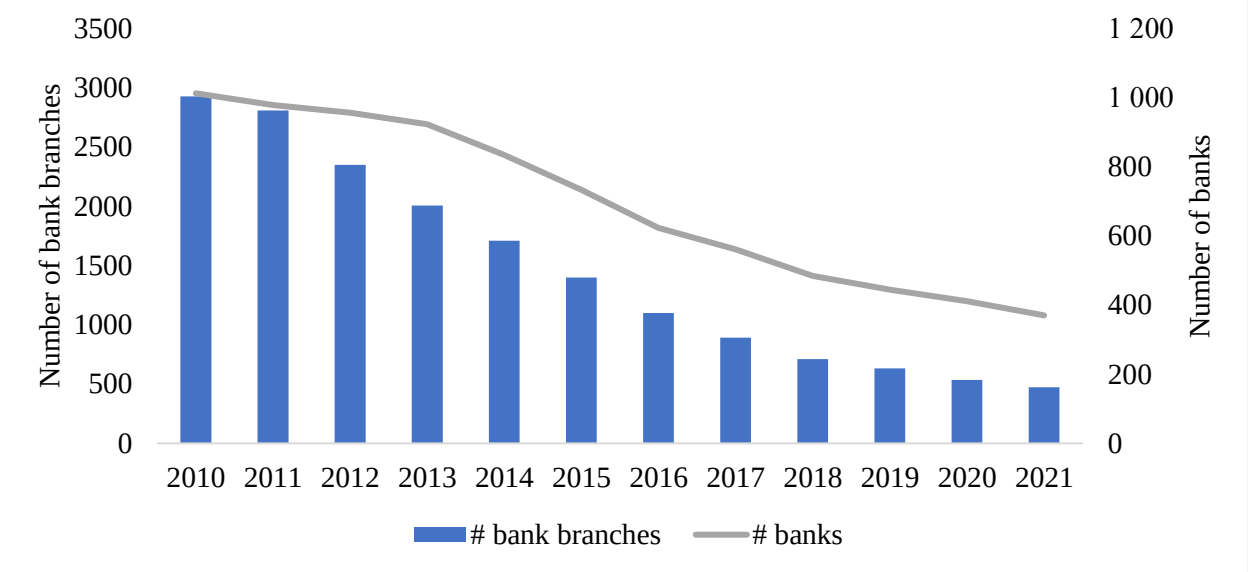

Figure 1. Number of banks and bank branches in Russia in 2010-2021

Source: Quantitative characteristics of the Banking Sector of the Russian Federation / The official website of the Bank of Russia. URL: http://www.cbr.ru/statistics/bank_sector/lic/

The reason for the dramatic decrease in the number of banks is mostly due to the strict regulation of the banking system by the Bank of Russia. Since mass license revocation in the banking sector started in 2013 there has been an increase in bank de-branching. According to the

[5] Quantitative characteristics of Banking Sector of the Russian Federation / The official website of the Central Bank of Russia. URL: http://www.cbr.ru/statistics/bank_sector/lic/ (date of access 2022-05-03)

Bank of Russia,[6] the two-fold decline in the number of banks due to license withdrawal almost did not affect the number of bank branches, as these banks did not have a wide network of branches. In addition, the report discusses the optimization of the branch network of existing banks because of new remote banking technologies and the increasing competition from non-banking companies such as fintech companies. The report also highlights the heterogeneity of Russian regions since not all regions have sufficient Internet access, etc. For this reason, the Bank of Russia demands that systemically important banks have branches in such regions.

Is de-branching associated with gains in profitability? The relationship between bank de-branching and bank profitability is attracting considerable interest. The literature highlights different reasons why banks are closing their branches. The key determinant of bank de-branching, especially in recent years besides license withdrawals, which result into forced closures of branches - is technological progress, which makes banks unprofitable if they have a lot of branches. People stop visiting bank offices, as they replace the traditional usage of banking services in branches with the online banking. In 2020, the Covid-19 pandemic accelerated the development of online technologies, including a more rapid transition to online banking.

Financial products are becoming more complicated, which requires good financial literacy, and a growing number of people are opening brokerage accounts and investing in stocks, bonds, and other financial instruments. This gives the rise to another trend in the banking industry, namely increasing demand for greater financial digital literacy (FDL). For this reason, the Bank of Russia is implementing different programs to improve FDL.

In this paper we investigate how bank de-branching in Russia is associated with the profitability of banks. We suppose that this relationship should differ depending on the adoption of technological innovations and FDL.

We contribute to the understanding of the factors that drive bank de-branching using a sample of Russian regions. In particular, we are interested in whether the adoption of technological innovation and FDL should be considered as factors in bank de-branching. It might be the case that banks are unwilling to close their branches if online banking is not in demand in regions which exhibit a lower level of innovation adoption and a lower level of FDL. This work also offers one of the first investigations into the role of FDL and the adoption of innovation in terms of bank profitability. This study determines whether the adoption of technological

[6] The Central Bank of Russia (2018). Results of the decade 2008-2017 in the Russian banking sector: trends and factors. *Series of reports on economic research. 31* (In Russian). https://www.cbr.ru/Content/Document/File/43933/wps31.pdf

innovation and FDL add to bank de-branching efficiency in terms of bank profitability. The literature mostly checks the impact of ICT on bank de-branching in the developed countries, therefore, another point of our interest is to consider the same effects in a developing country, Russia. Therefore, this work makes a contribution to understanding the determinants of bank de-branching and the relationship between bank de-branching and bank profitability.

Using data from 84 Russian regions from 2010 to 2020, we show that technological innovation and FDL are positively associated with bank de-branching, i.e., we observe a larger decrease in the number of bank branches in regions with sufficiently high levels of technological innovations and FDL. We also analyze the effect of technological innovation and FDL on the relationship between bank de-branching and bank profitability and find that banks increase their profits on average if they close branches in regions with sufficiently high levels of technological innovation and FDL.

This paper is organized as follows. Section 2 includes an analysis of studies on bank de-branching and bank profitability, as well as recent articles on technological transformations in the banking sector, and the role of FDL. Section 3 describes the dataset and the empirical model used to test the hypotheses stated in the literature review. In Section 4, we provide different specifications of the econometric models and interpretations. Section 5 presents a robustness check using other sets of observations, independent variables, and other techniques to check the stability of the results. Section 6 concludes by answering the research question, confirming the hypotheses, and providing the limitations of the study.

2 Literature Review

2.1 Drivers of bank de-branching and bank profitability

In recent years, researchers have become increasingly interested in studying the factors that affect bank de-branching around the world, as it is a key priority in optimizing the cost structure in the digital age (Ageeva and Mishura, 2017; Timin and Pushko, 2018; Keil and Ongena, 2020; Carletti et al., 2020; Novopashina, 2020). There are different reasons why banks close their branches: from digitization and switching to online, while seeking ways to increase their profits and gain additional competitive advantages to bankruptcy and withdrawal from the market.

Keil and Ongena (2020) highlight the core reasons for the current bank de-branching:

- Technology, especially the internet and online banking. Since customers are becoming more technologically advanced, they stop visiting local bank branches. Therefore, banks are less profitable if they have many local branches with lower demand.
- Bank fragility. Since banks are exposed to macroeconomic cyclicality, negative macroeconomic shocks impact banks causing them to decrease the number of branches.
- Bank consolidation. Merges and acquisitions allow banks to optimize their branch networks.
- Cost reductions. A large number of branches results in higher administrative costs and a complex management system.

The authors use a country-year panel of 36 OECD countries for the period 2004–2018 and show that technology and de-branching are highly connected at the country level and less so at the level of US counties and individual banks. Negative economic shocks are significant factors in de-branching. Mergers and acquisitions significantly affect bank closure where there is overlapping bank networks. The authors highlight the role of bank de-branching in terms of higher profitability, especially due to the appearance of online banking; the brick-and-mortar banking model is becoming less profitable due to lower demand and branch closures tend to be associated with higher profitability.

Carletti et al. (2020) studied the impact of technology on the optimization of bank structures. They note the importance of the Covid-19 pandemic, which accelerated the digitization of the banking sector, the transformation from a brick-and-mortar banking model to an internet banking ecosystem, and the importance of investing in technological infrastructure.

Novopashina's (2020) findings support those of Keil and Ongena (2020) in terms of the development of ICT. This article explains the relationship between bank closure due to

technological progress and the volume of loans issued. Using balanced panel data for 80 Russian regions for the period 2010–2016, the author shows the negative influence of bank closures on the volume of loans issued. Bank closure itself is statistically significant, but the closure of branches was insignificant. This result indicates that companies cannot completely replace traditional banking services with online banking, raising the question of the other factors that affect the transition to digital services. The insignificance of branch closure as a regressor in the econometric model might indicate that it might be significant depending on the characteristics of the Russian regions. Novopashina (2020), with respect to Russian regions, includes government support of too-big-to-fail banks preventing their bankruptcy and the growth of state banks resulting in regional banks being competitive than state banks. Ageeva and Mishura (2017) acknowledge the role of ICT in de-branching, but also consider such factors as economies of scale, market power, and government support for systemically important banks.

Regarding bank profitability in Russia, Belousova et al. (2016) investigate the macroeconomic factors that affect bank profitability. They use a sample of Russian banks from Q1 2008 to Q3 2014. The latter is a period of economic sanctions against Russia, so the authors also explore the role of deteriorating economic conditions and decreasing real GDP, etc. They divide the macro-factors into three groups: macroeconomic conditions, banking structure, and the availability of banking services. Macroeconomic conditions include population density, population income per capita, GDP per capita, demand density, inflation, and the real exchange rate. Banking structure is represented by the loan-to-deposit ratio and the number of banks per capita. Theavailability of banking services includes the density of bank branches, deposits to the number of branches, and GDP per bank branch. Bank profitability is measured by ROA and ROE. Due to the multicollinearity problem, the authors test several specifications using different subsets of regressors. All the factors are significant in most specifications tested. The authors verify their results with a robustness check using subsamples with different time periods, excluding the largest banks, and estimation with a multiplication of population density with a cyclical indicator.

Le and Ngo (2020) discuss factors influencing bank profitability at the country level, considering 23 countries from 2002 to 2016. They find that IT-based methods including online product and service delivery, bank cards issued, ATM and POS-terminals are significantly associated with bank profitability. This study highlights that the development of internet technologies can boost bank performance due to cost optimization. The macroeconomic

conditions and the global financial crisis are also found to influence bank performance. The authors consider the development of the financial market as a trigger for better bank performance.

Adelopo et al. (2018) investigate the determinants of bank performance examining three time periods: before, during, and after the financial crisis of 2007–2009, using panel data from Bankscope and World Bank databases in the Economic Community of West African States from 1999 to 2013. They explore a wide set of determinants including bank-specific, macroeconomic, and industry-level variables. Their results show that in general the financial crisis did not affect the relationship between bank-specific determinants, including size, liquidity, cost management, and bank profitability measured through ROA and NIM.

Tan (2016) investigates the influence of risk and competition on bank performance in China after several banking reforms aimed at increasing the competitiveness and improving financial stability of the Chinese banking system. Tan explores the period from 2003 to 2011 and uses bank-level data for state-owned, joint-stock, and city commercial banks. Although he does not find any significant relationship between risk and competition on bank profitability, the research is of core interest for us since the author summarizes the determinants of bank profitability and tests them in his specifications. In particular, Tan finds that bank size negatively relates to ROA because such banks are harder to manage, hence, they have high administrative costs. Furthermore, liquidity (calculated as total loans divided by total assets) also negatively affects ROA since higher loan exposure implies lower liquidity and hence leads to lower bank profits. Tan finds significant effects of banking sector development, inflation, and GRP on bank performance.

To summarize, technological progress is the key factor driving bank branch closures around the world. It provides cheaper and faster ways to interact with clients, hence, not requiring a wide network of bank branches and leading to an increase in bank profitability. Furthermore, recent papers show that the development of the banking sector is positively associated with bank profitability. However, banks have strong new competitors in this field—fintech companies—which can reduce bank profits.

Romānova and Kudinska (2016) confirm the importance of financial technologies and their integration into banking systems. However, there are fintech companies that are strong competitors for traditional credit institutions, leading to lower revenue and margins for the latter. Such companies might provide special banking services, for example, easier and cheaper payment systems. For these reasons, it is difficult for a bank to compete with these smaller

companies providing a limited set of banking services with higher quality and cheaper prices. Hence, banks are forced to increase investments in fintech and perhaps change their business model, e.g., to shift toward a mobile app ecosystem business model or to provide banking services exceptionally online so as not to lose their competitive advantages. Having investigated the experience of US and leading European banks, the authors conclude that traditional banks need to cooperate with fintech companies to protect their market share since the latter tend to operate in the form of start-ups that often lack funding.

Cole et al. (2019) discuss whether traditional banking and fintech are substitutes for or complements to each other from the point of crowdfunding. Using a database of crowdfunding projects in US covering approximately 1.1 million projects, the authors observe consistent support in favor of the complementarity of banking finance and fintech crowdfunding. Therefore, the observations of this paper further corroborate Romanova & Kudinska's (2016) result that fintech is a great opportunity for banks to promote new financial technologies if they actively cooperate with them.

The Covid-19 crisis accelerated the development of online technology, including a more rapid transition to online banking. Dadoukis (2021) investigates the role of ICT on bank outputs depending on the Covid-19 crisis. The results confirm the hypothesis that better ICT adoption is associated with the creation of shareholder value despite the pandemic compared to a sample of banks with low ICT adoption. This result is of great importance, since it signifies a link between bank profitability and the pandemic, meaning that banks with greater IT adoption had a smaller decrease in bank performance controlling for the Covid-19 crisis.

2.2 The heterogeneity of Russian regions

2.2.1 Banking sector development in Russian regions

There is the large body of Russian research that raises the problems of regional banks and the issues related to the increasing concentration of the banking system. In this part, we discuss what drives regional banks and the possible reasons why regional banks are about to disappear or to be merged with larger market players.

If we compare the performance indicators of regional banks with the banking sector as a whole,[7] we see that the average ROA of the banking sector is 1.9%, while the average ROA of regional banks is 1.4% (in the first three quarters of 2020). Average ROE is 17.3%, while the

[7] Association of Banks of Russia. Banking system in figures and graphs. URL: https://asros.ru/upload/iblock/52f/3-kvartal-2020.pdf (date of access 2022-05-04).

ROE of regional banks is about 11.75%. The ROE of regional banks with a universal license is 14%; however, regional banks with a basic license have ROA and ROE at zero level since they are substantially restricted in their banking operations. Another reason why regional banks lag far behind the average performance indicators of the banking system is that they place a significant part of their assets in low-yield deposits and interest-free correspondent accounts in the Bank of Russia.

Ageeva and Mishura (2017) consider the role of regional banks and confirm they have advantages which allow them to occupy certain market niches. These include proximity to customers, awareness of local conditions, and flexibility in decision making. There are also several disadvantages, such as a lack of diversification and liquidity and the need to undertake riskier projects, resulting in regional banks being replaced by branches of large banks. We note that this does not change the number of banks and bank branches operating in the regions since either the bank branches replace the regional banks or regional banks themselves become branches of large banks.

The paper discusses the factors that affect the territorial placement of banks in regions. Using the data from the Bank of Russia and the Federal State Statistics Service throughout the period of 2000–2013, the authors estimate the model with fixed effects and reveal that regional banks tend to operate more in the Russian republics with relatively independent public administration and with pronounced national and ethnic characteristics. The authors conclude that the number of regional banks decreases as regional and local authorities play a smaller role in the national political system.

Zverkova and Zverkov (2019) offer a comprehensive overview of why regional, small, and medium-sized banks cannot exist in the digital age. They state that there are only two options for such banks: being taken over by larger banks or leaving the market. There are several reasons for this conclusion. First, regional banks lack the funding to participate in the technology race. Small and medium-sized banks tend to specialize in some specific areas of banking services or merge with larger companies, including fintech companies. Regional banks should concentrate their efforts on creating banking products for the clients of a certain region. Larger banks including systemically important ones are considered to bear more costs related to regional market niches compared to regional banks, giving them a chance to operate in a region in the short-term.

Despite the large body of research that recognizes the importance of bank de-branching in the digital age in terms of cost optimization and bank profitability, no serious explanation has

been given as to whether the adoption of technological innovations in a region and the FDL in a region could be enhancing factors for a bank closing its branches or not. Nor has it been established whether FDL and the adoption of technological innovations could have a complementary effect on the relationship between de-branching and bank profitability. In the next section, we see why FDL should be considered as an institutional factor that improves the benefits of closing bank branches.

2.2.2 The development of internet infrastructure in Russian regions

The heterogeneity of Russian regions in terms of internet infrastructure is the major topic discussed in Zverev and Kamalzade (2018). The authors underscore the obstacles to the introduction of modern financial technologies in Russian regions. These obstacles include the low degree of informatization of certain regions, problems with the confidentiality of bank financial information, and electronic signatures.

Nosonov (2016) made a significant contribution to the field of heterogeneity of Russian regions in terms of internet infrastructure and information society. The author uses provisions of the UN methodology (International Telecommunication Union – ITU) to construct an ICT development index for Russian regions. Using the data from the Federal State Statistics Service, the author uses the ITU methodology but constructs his own sub-indices such as general indicators of ICT development, usage of ICT in organizations, and usage of ICT in households.[8] He calculates the index as the geometric mean of all indicators. However, the author does not take into account the level of education or digital literacy as the ITU does, since the author suggests that there are no significant differences in terms of the level of education in Russian regions. The study confirms the heterogeneity of Russian regions using the constructed index, which is used to divide the Russian regions into four groups. The first group includes regions with high ICT costs and access to the internet. These are the most developed Russian regions such as Moscow and St. Petersburg. At the other extreme is the fourth group, which includes the North Caucasus, Eastern Siberia, the Republic of Crimea, and Sevastopol due to their low level of socioeconomic development and the poor quality of the internet infrastructure.

Using our data and PCA methodology, we construct our own index for ICT development in Russian regions (Section 3 describes the data used). Figure 2 shows the ranking of regions depending on the level of ICT development for 2020.

[8] According to ITU methodology of the ICT development index, there are 3 subindices: access to ICT, usage of ICT, and ICT skills.

It seems reasonable that the heterogeneity of Russian regions with respect to the development of internet infrastructure should be considered when making decisions whether to close bank branches in these regions or not. This is in line with Novopashina (2020), who concludes that online banking does not replace the traditional banking system in Russia in terms of loans issued.

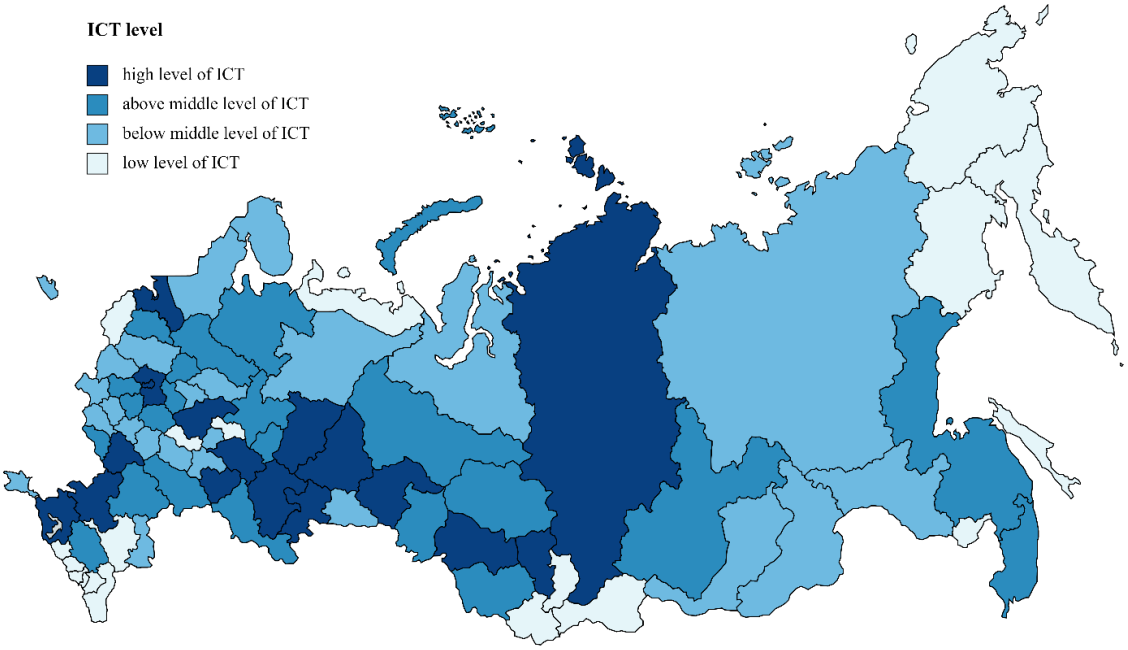

Figure 2. Russian Regions by ICT (as of 2020)

2.5.3 Financial digital literacy in Russian regions

Another source of heterogeneity in Russian regions is FDL. This is important for banks to consider when making decisions about de-branching, since if they close bank branches in regions with a low level of FDL across the population, it could lead to a decrease in bank profitability, as people will not be able to quickly adapt to the use of online banking.

Financial literacy is highly related to "well-informed financial decisions" (Lusardi & Mitchell, 2011, p. 2). Remund (2010) defines financial literacy as a measure of the degree to which people understand key financial concepts and have the confidence to manage their personal financial resources in the short-term and long-term. In other words, financial literacy represents not only the knowledge of financial instruments, their pricing, and opportunities to gain profit, but also skills including digital literacy and the psychological characteristics that allow for managing these resources in practice.

Davydenko et al. (2020) state that there is a great need for financial education since there is a growing number of banking services, digital payment services and so on. They claim that financial competency should be considered not only as the psychological characteristics of a person, but also as an institutional factor that minimizes behavioral risks in the digital age. The latter has become extremely important in the transition to the digital economy since an increasing number of people is getting involved in the digital world.

Regarding the role of financial education, Fernandes et al. (2014) underscores that policymakers have stated the important role of financial education as an antidote to the complicated financial decisions over recent years. However, the role of financial education in explaining the level of financial literacy is overestimated by governments and businesses according to research. The authors do a meta-analysis investigating 168 papers on the relationships between financial education and financial literacy. They find that financial education explains at most 0.1% of the variance of financial behavior, with even weaker effects when considering households with low income. Even with many hours of education, financial behavior did not change significantly in the 20 months and more following this education. The authors also discuss the strong association between financial education and financial literacy. However, this decreases dramatically when including controls for psychological traits and instruments with respect to the level of financial literacy to mitigate the problem of an omitted variable bias. All of this signifies that we cannot measure the level of financial literacy using financial education, since there are indeed other characteristics (including psychological traits) that affect financial literacy through the choice of financial education.

Kodongo (2018) indicates that financial literacy plays a significant role in financial access and therefore financial inclusion. The author uses data from the 2015 Kenyan household survey and bank data from Bankscope and shows that financial literacy is associated with a higher level of financial access. The latter is directly linked with the usage of financial services; hence it might be the case that higher values of financial literacy lead to higher bank profits through this channel.

Rooji et al. (2014) study the relationship between financial literacy level and participation in the stock market. To measure financial literacy, they construct an expanded list of questions concerning about knowledge of basic concepts of finance and economics such as inflation, time value of money, risk diversification, the difference between stocks and bonds etc. They summarize all the answers to the survey into two indices of financial literacy from two sets of questions: basic and advanced using factor analysis for each set. They then look at the

association between these two indices and stock market participation and find that the majority of people in the survey have basic financial knowledge (compound interest, inflation) and very few have advanced financial knowledge (stocks, bonds, interest rates, etc.). They conclude that financial literacy influences the participation in the stock market, and hence on the financial behavior of people: a low level of financial literacy is associated with a low level of participation in the stock market. This might signify that people with a low level of financial literacy might be reluctant to use specific banking services such as brokerage accounts, which leads to a decrease in bank profits from non-interest activities.

The role of financial literacy is important for the extension of digital banking channels. Regarding Russia, Shirinkina (2019) states that Russian banks have a great opportunity to quickly transfer their clients to remote banking services. The results indicate that Russia trails most developed countries by 4–6 years in terms of penetration of remote banking services. More importantly, the sales of banking services through digital channels are weakly diversified because of the low financial literacy of Russians and, consequently, distrust of non-cash payments. There is great potential for promoting digital services since internet services appear more quickly in Russian regions than digital banking services. The core result of this research confirms the previous research that financial literacy should be considered as an institutional factor aiding the penetration of digital banking.

Magomedov and Agamagomedova (2018) discuss the relationship between the financial literacy and the number of banks in the Russian regions. The rationale for this relationship is as follows: as people become more financially literate, they tend to stop being customers of low-quality banks and start to prefer more reliable banks, perhaps equipped with brokerage services. The authors use survey results on the level of financial literacy conducted in 42 regions in 2015 (1,600 respondents). The authors then match the data with socioeconomic indicators of the region (salary, population, GDP, etc.), and banking indicators (the number of banks, bank branches, bank size). The results indicate that higher values of financial literacy correspond to fewer bank branches. However, the study leaves the question of endogeneity unanswered since the decrease in the number of banks might be connected with a policy of stricter regulation of banking activities by the Bank of Russia, and, as a consequence, relatively small banks cannot withstand the pressure of the regulator and their licenses are revoked. The increase in financial literacy level might be due to government policy. These two effects are simultaneous and codirectional, hence, might lead to endogeneity.

Digital literacy is an institutional factor affecting banking decisions. It is also essential for banks making decisions about bank de-branching because regions with low levels of digital literacy might exhibit less readiness of people and businesses to transform their traditional behavioral patterns of visiting bank branches to using online banking. We highlight the role of digital literacy separately from the ICT development and financial literacy since it represents the abilities of people and businesses to employ digital devices and technology to effectively use banking services. It significantly differs from the ICT infrastructure in Russian regions (ICT development) and ability to make financial decisions (financial literacy).

In many papers, financial and digital literacies are not considered separately; even the term "financial digital literacy" is applied. For instance Lu (2021) investigates how digital financial inclusion mitigates the high portfolio risk of Chinese households. The results suggest that this largely increases risk diversification, leading to lower portfolio risk. The significant result for our paper is that digital financial literacy is highly significant in the subsample of regions with low-income households, meaning that digital financial inclusion could replace the traditional brick-and-mortar banking model, leading to a better trade-off between risk and return, and hence higher financial well-being.

Similar to the ICT index, we use the data for the Education Index (as one of the components of the Human Development Index) and provide a map of Russian regions (Figure 3) for the Education Index which illustrates the heterogeneity of Russian regions in terms of education (Section 3 describes in detail the data used).

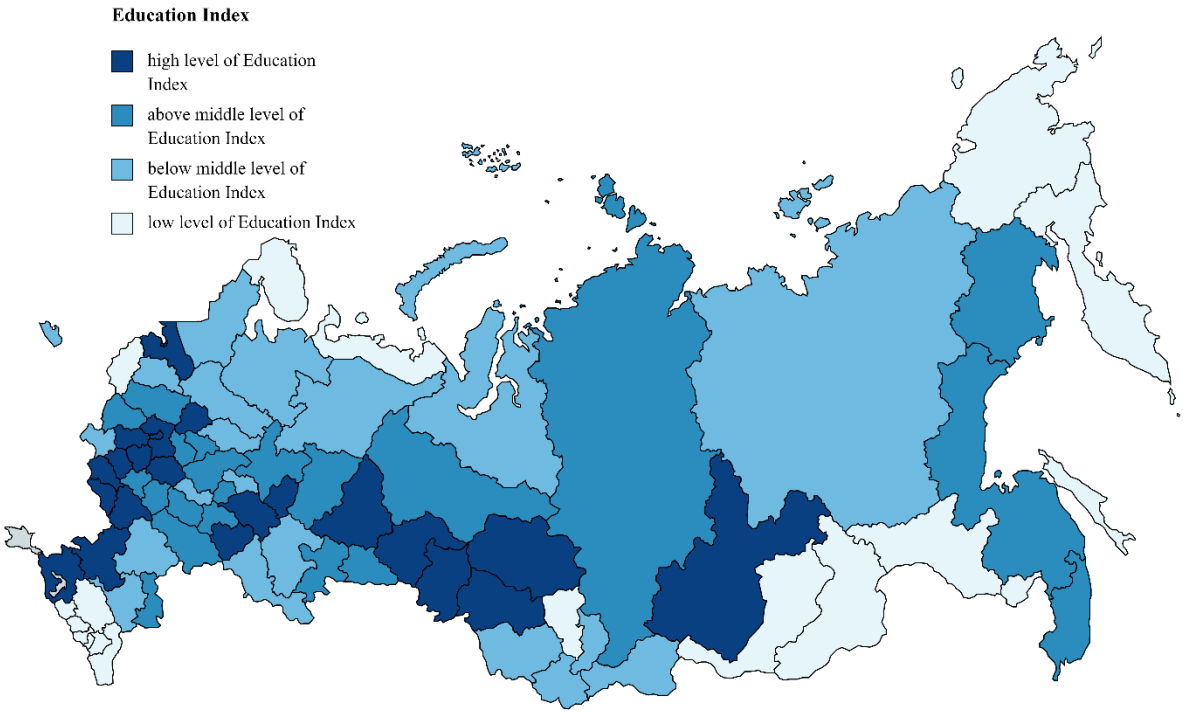

Figure 3. Russian regions by Education Index (as of 2019)

The literature does not pay much attention to the determinants of bank de-branching and its influence on bank profitability. Firstly, it remains unclear whether FDL could be a factor that should be examined by bank management when closing bank branches. Secondly, one needs to check further whether the effects of internet development might be significant explaining bank de-branching given the heterogeneity of regions within the country. Thirdly, to our knowledge, no one has studied whether the adoption of internet development and FDL might be characteristics enhancing the relationship between bank de-branching and bank profitability. These issues bring us to the following hypotheses.

H1 A higher adoption of technological innovation and a higher FDL are associated with a decrease in the number of bank branches (bank de-branching).

H2 A higher adoption of technological innovation and a higher FDL are positively associated with the effect of bank de-branching on bank profitability.

3 Data and Methodology

3.1 Methodology and data description

To see whether FDL and digital innovation in Russian regions are related to a decrease in the number of bank branches (H1), we estimate regression model (1). This model uses lagged values of the independent variables to mitigate the problem of reverse causality and account for the fact that bank decisions on de-branching are complex and not made quickly.

$$\boldsymbol{Branches_{i,t} = \delta_0 + \delta_1 \cdot ICT_{i,t-1} + \delta_2 \cdot FDL_{i,t-1} + \delta_3 \cdot ICT_{i,t-1} \cdot FDL_{i,t-1} + \\ + \delta_4 \cdot Banks_{i,t-1} + \delta_5 \cdot Regions_{i,t-1} + \epsilon_{i,t}} \quad (1)$$

The dependent variable $Branches_{i,t}$ represents the number of bank branches over years in region *i*. We use the statistics of the Bank of Russia "Analytical system of economy activities (Regions)"[9] for the period from 2010 to 2020 to use the first lagged values for independent variables and, therefore, to obtain the data for 2011–2020. By bank de-branching we understand a decrease in the number of branches, i.e. if we get the negative coefficients $\delta_1, \delta_2, etc.$**,** then we interpret this as a decrease of the number of branches implying a positive relationship with bank de-branching. In short, bank de-branching is indicated by negative signs of coefficients.

ICT is used as a proxy for the adoption of innovations which measures the development of internet infrastructure in Russian regions ($ICT_{i,t}$). We calculate it using the UN methodology (International Telecommunication Union – ITU) and the methodology described by Nosonov (2016), the only exception being that the author calculates the ICT index using geometric means. However, we use the PCA method since it allows for a reduction of dimensionality while losing the least amount of information. Therefore, ICT is obtained by aggregating the following indicators using the PCA method: the percentage of organizations that use broadband internet access, the percentage of organizations that have a website, the number of personal computers in organizations, the number of active subscribers, and the amount of information transmitted over the internet.[10] We use the first principal component that accounts for 83.95% of the total variation as the *ICT* variable. Thus, *ICT* is a complex variable comprising all five indicators that positively contribute to the principal component with different weights. The higher the values of *ICT*, the higher the level of ICT infrastructure in regions.

[9] Analytical system of economy activities // The official website of the Central Bank of Russia. URL: http://www.cbr.ru/eng/archive/region/olap/ (date of access 2021-04-03).

[10] Statistics // The official website of Ministry of Digital Development, Communications and Mass Media of the Russian Federation. URL: https://digital.gov.ru/en/activity/statistic/ (date of access 2021-04-03).

We refer to FDL as a predictor representing abilities of people and businesses to make financial decisions using the online banking services without having to visit bank branches. $FDL_{i,t}$ is FDL in region *i* at time *t*. We use the Human Development Index (HDI)[11] and the Education Index as proxies for FDL. HDI is the composition of three indicators: long and healthy life (life expectancy), knowledge (years of schooling, education index), and standard of living (gross national income index per capita). It is calculated as the geometric mean of three indicators, initially normalized. The main rationale to use HDI as a proxy is that there is evidence (Zavatskaya, 2018) on a strongly positive correlation between FDL and HDI. We suppose that higher values of HDI are associated with higher values of financial literacy. However, we understand that this proxy is very broad; the significant association might be related not only to FDL itself, but also to average income per capita. For this reason, we further clear HDI from the impact of income. We use Education Index as a component of HDI, however, this index is available only for limited number of years, so we use this index for robustness check purposes.

The coefficients of interest δ_1, δ_2, δ_3 are important as they signify whether ICT and FDL are associated with bank de-branching. Table 1 represents the expected coefficient signs of regression equation (1) and brief explanations.

Table 1. Expected coefficient signs in regression equation (1)

Independent variable	Estimate	Expected sign	Hypothesis
$ICT_{i,t-1}$	δ_1	–	$\boldsymbol{\delta_1}$ reflects the effect of ICT on bank de-branching. We expect $\boldsymbol{\delta_1}$ to be negative since banks are more willing to close their bank branches in regions that exhibit a higher level of digital innovations.
$FDL_{i,t-1}$	δ_2	–	$\boldsymbol{\delta_2}$ reflects the effect of FDL on bank de-branching. We expect $\boldsymbol{\delta_2}$ to be negative because banks are more willing to close their bank branches in highly financially educated regions.
$ICT_{i,t-1} \cdot FDL_{i,t-1}$	δ_3	–	$\boldsymbol{\delta_3}$ reflects the influence of two-way interaction between ICT and FDL on bank de-branching. We expect $\boldsymbol{\delta_3}$ to be negative because: 1. the higher values of ICT might affect bank de-branching to a higher degree given the population with sufficient FDL.

[11] Human Development Index (HDI) // United Nations Development Programme, Human Development Reports. URL: http://hdr.undp.org/en/content/human-development-index-hdi (date of access 2021-04-03).

	2. the higher values of FDL might affect bank de-branching to a higher degree given the higher values of ICT in these regions.

Next, to examine the effect of adoption of technological innovation and FDL on the relationship between bank de-branching and bank profitability (hypothesis 2), we use the following regression model (2). Following Katusiime (2021), we test for autocorrelation in bank profitability due to a moderate persistence of bank profitability.

$$\begin{aligned} \boldsymbol{ROA_{i,t}} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1} \cdot \boldsymbol{ROA_{i,t-1}} + \boldsymbol{\beta_2} \cdot \boldsymbol{Branches_{i,t}} + \boldsymbol{\beta_3} \cdot \boldsymbol{ICT_{i,t}} + \boldsymbol{\beta_4} \cdot \boldsymbol{FDL_{i,t}} + \\ + \boldsymbol{\beta_5} \cdot \boldsymbol{Branches_{i,t}} \cdot \boldsymbol{ICT_{i,t}} + \boldsymbol{\beta_6} \cdot \boldsymbol{Branches_{i,t}} \cdot \boldsymbol{FDL_{i,t}} + \boldsymbol{\beta_7} \cdot \boldsymbol{Banks_{i,t}} + \\ + \boldsymbol{\beta_8} \cdot \boldsymbol{Regions_{i,t}} + \boldsymbol{\alpha_i} + \boldsymbol{\gamma_t} + \boldsymbol{\varepsilon_{i,t}} \end{aligned} \quad (2)$$

The dependent variable $ROA_{i,t}$ (return on assets) represents the measure of profitability of banks in region *i* in year *t*. ROA is the simplest measure of bank profitability conventionally used in the literature on banking (for instance, Mamatzakis and Bermpei (2016), Kohlscheen et al. (2018), and Le and Ngo (2020)). ROA represents the ability of a bank to generate profits from performing asset management functions (Kohlscheen et al., 2018). We use the data for net income and assets from Mobile and calculate ROA as a ratio of net income to assets.

The sign and significance of β_5, β_6 are crucial to test whether there are significant complementary effects of FDL and the development of the internet infrastructure together with bank de-branching on bank profitability (hypothesis 2). Here α_i are individual fixed effects (on the regional level), γ_t are time fixed effects. Table 2 represents the expected coefficient signs of regression equation (2) and brief explanations.

Table 2. Expected coefficient signs in regression equation (2)

Independent variable	Estimate	Expected sign	Hypothesis
$ROA_{i,t-1}$	β_1	+	$\boldsymbol{\beta_1}$ reflects the effect of persistence of bank profits. In other words, $\boldsymbol{\beta_1}$ measures the extent in what banks make the same profits. If $\boldsymbol{\beta_1}$ is closer to 1, this means that bank profits are highly persistent. It might signify that the industry does not adjust quickly or exhibit low level of competition. If $\boldsymbol{\beta_1}$ approaches to 0, then bank profits are not persistent. We expect to see a positive sign since better performance yesterday leads to higher performance today due to persistence in skills, abilities, etc.
$Branches_{i,t}$	β_2	– / +	$\boldsymbol{\beta_2}$ reflects the effect of bank de-branching on profitability. More probably, the sign would be negative since banks closing their bank branches rather do it to optimize the cost structure. However, according to Keil and Ongena (2020) one of the reasons of bank de-branching is bank fragility that leads to lower profits due to macroeconomic shocks.
$ICT_{i,t}$	β_3	+	$\boldsymbol{\beta_3}$ reflects the effect of ICT on profitability. We expect $\boldsymbol{\beta_3}$ to be positive since higher ICT values relate to significant cost optimization of bank branches and, hence, lower costs of banks.
$FDL_{i,t}$	β_4	+	$\boldsymbol{\beta_4}$ reflects the effect of FDL on profitability. We expect $\boldsymbol{\beta_4}$ to be positive because people tend to invest more often if they are confident about their finances, so banks become more profitable from the higher demand for banking services.
$Branches_{i,t}ICT_{i,t}$	β_5	–	$\boldsymbol{\beta_5}$ reflects the influence of two-way interaction between ICT and Branches on profitability. We expect $\boldsymbol{\beta_5}$ to be negative since we believe that banks tend to decrease their bank branches to a greater extent in regions with higher levels of adoption of innovations.
$Branches_{i,t}FDL_{i,t}$	β_6	–	$\boldsymbol{\beta_6}$ reflects the influence of two-way interaction between FDL and growth in the number of bank branches on bank profitability. We expect $\boldsymbol{\beta_6}$ to be negative since we believe that banks decrease their bank branches to a greater extent in regions with higher levels of FDL among population.

To control for regional characteristics, we include regional control variables, $Regions_{i,t}$, including gross regional product per capita (GRP per capita), income per capita, inflation, and population density. We control for regional characteristics since the socioeconomic development of regions might affect both ICT and FDL in Russian regions and, consequently, bank de-branching decisions and cause an endogeneity problem. Furthermore, there is an extensive branch of literature discussing the effects of such variables on bank profitability (Dietsch et al., 2000; Chaffai et al., 2001; Caner & Kontorovich, 2004; Dietrich & Wanzenried, 2014; Belousova, 2016). Now we introduce each regional control variable with its effect on bank profitability.

The GRP per capita characterizes the regional economy, i.e., the quantity of goods and services produced in a region per year. We use GRP per capita as a proxy to account for unobservables such as the presence of business ethics, the effectiveness of economic institutions, the appropriate behavior of market participants, etc. (Belousova, 2016). GRP per capita positively affects bank profitability since higher values of GRP per capita represent lower bank costs, resulting in higher profits. There is, however, a negative effect of the GRP per capita on bank profitability since higher socioeconomic development in a region can decrease the profitability margin of a bank due to higher deposit rates and lower credit rates. Therefore, the total effect of the GRP per capita on bank profitability is ambiguous (Chaffai et al., 2001). We collect data on GRP per capita from Fedstat.[12]

Income per capita is a measure of purchasing power which can lead to higher bank profits. Higher income per capita is associated with greater activity in the banking industry of a region through a greater number of bank transactions which increases bank profits (Dietsch et al., 2000). The data on income per capita are taken from Fedstat.[13]

Inflation ambiguously affects the bank profitability. If operational expenses (including wages) grow at a slower pace than inflation, then inflation positively affects bank profitability, since banks adjust their deposit rates in case of changes in inflation expectations. Many articles find the positive influence of inflation on bank profitability (Dietrich & Wanzenried, 2014),

[12] Gross regional product per capita // The official website of Unified Interdepartmental Statistical Information System (UniSIS): https://www.fedstat.ru/indicator/42928

[13] Income per capita // The official website of Unified Interdepartmental Statistical Information System (UniSIS): https://www.fedstat.ru/indicator/30992

although some find the negative effects (Caner & Kontorovich, 2004). We take the CPI from Fedstat[14] and calculate the level of inflation subtracting 100% from the CPI.

Population density is a proxy for the number of bank clients. The higher the population density, the lower the bank costs because fixed costs decrease with population growth. It explains why population density is positively related to bank profitability (Dietsch et al., 2000). We calculate the population density by dividing the total number of permanent population on average per year by the total area of a region. We take data on permanent population on average per year[15] and the total area of a region[16] from Fedstat.

We also use $Banks_{i,t}$, which the set of control variables of the banking system in a region including deposits to GRP, assets to GRP, assets to bank structural divisions, the level of financial intermediation, density of structural divisions of banks, deposits to total liabilities, and credits to assets. Although we do not use data based on the banking level, we still must include banking variables to control for the heterogeneity of banks in Russian regions.

To account for banking variables, we use the Banks and Finance (Mobile)[17] dataset, which consists of more than 80 indicators of Russian banks. Mobile aggregates data on banking characteristics at the bank level, so it pulls data from balance sheets and income statements using a Bank of Russia dataset. From this dataset, we take the following variables: deposits, credits, assets, and total liabilities. Data on the number of bank branches and the number of bank structural divisions are taken from the statistics of the Bank of Russia.[18] Using this data, we calculate the aforementioned banking ratios. Since our dataset is collected at the regional level, we aggregate the banking variables taken from Mobile (banking level) to the regional level by summing up all the banking variables of banks representing region *i* in year *t*. Now we introduce each of the bank control variable with its effect on bank profitability.

Deposits to GRP and assets to GRP are used to control for bank size in Russian regions. Larger banks can more easily meet their capital requirements and hence make more loans, increasing their profits. The positive relationship between bank size and bank profitability is

[14] Basic consumer price index for goods and services // The official website of Unified Interdepartmental Statistical Information System (UniSIS): https://www.fedstat.ru/indicator/33568

[15] The number of permanent population on average per year // The official website of Unified Interdepartmental Statistical Information System (UniSIS): https://www.fedstat.ru/indicator/31556

[16] Regions of Russia. Main characteristics of the subjects of the Russian Federation // The official website of the Federal State Statistics Service: https://gks.ru/bgd/regl/b21_14s/Main.htm

[17] In Russian «ИАС Банки и Финансы информационного агентства Мобиле».

[18] Quantitative characteristics of the banking sector of the Russian Federation // The official website of the Central bank of Russia: https://cbr.ru/statistics/bank_sector/lic/

highlighted in Demirgüç-Kunt & Maksimovic (1998), Bikker & Hu (2002), Goddard et al. (2004), and Gul et al. (2011).

We use the density of the structural divisions of banks to control for the availability of banking services. The closeness of structural divisions of banks and bank branches helps banks with a brick-and-mortal model to gain profits due to a larger number of transactions. However, the number of bank divisions greater than the optimal number can lead to oversaturation and hence higher operational costs which lower the bank profits (Dietsch et al., 2000).

The degree of financial intermediation is calculated as the ratio of credits to deposits. This represents the ability of banks to be a financial intermediary, i.e. to effectively accumulate deposits and make loans (Belousova, 2016). Higher values of financial intermediation lead to higher bank profitability.

The major drawback of the data collected is that we use the profitability of banks, assets, and total liabilities depending on the place of their registration, but not their actual location. This might distort the estimates of regression equation (2). To mitigate this problem, we exclude Moscow, St. Petersburg, Moscow region, and Leningrad region from the dataset to eliminate the effects of branches of too-big-too-fail banks. Therefore, we consider only regional banks in the paper. For a robustness check, we further show the results of the estimation for the full sample.

3.2 Sample characteristics of data collected

We use regional-level data on 84 Russian regions for 2010–2020[19] on an annual basis. We have chosen these years for a more complete sample of observations according to all variables. Now, let us describe the variables selected for analysis. Table 3 shows the descriptive statistics for all the variables included in the regression equations (missing values are not included).

Table 3. Variable list and descriptive statistics[20]

Variable	min	mean	sd	median	max
ID of region	1.00	44.65	24.91	46.00	86.00
No of fed. district	1.00	4.31	2.42	5.00	8.00
Year	2010.00	2015.02	3.16	2015.00	2020.00
# of branches	0.00	16.22	20.12	9.00	115.00
Return on assets	-0.88	0.01	0.05	0.01	0.38
ICT	-1.72	-0.00	1.59	-0.48	8.09

[19] We do not include Sevastopol due to lack of data. We include Republic of Crimea only for 2014–2020.

[20] We use some variables in logarithms to make their distribution similar to normal distribution, hence, we put them in the table.

Variable	min	mean	sd	median	max
HDI	0.74	0.84	0.03	0.84	0.92
Education Index	0.81	0.92	0.03	0.93	0.98
log(Income per capita)	8.96	10.07	0.38	10.06	11.41
log(GRP per capita)	10.78	12.73	0.73	12.64	15.83
GRP growth rate	-0.31	0.10	0.08	0.09	0.57
Inflation	0.00	0.06	0.04	0.06	0.42
Population density	0.07	27.36	26.71	20.78	163.72
Deposit-to-GRP	0.00	0.52	0.46	0.40	2.55
log(Asset-to-GRP)	-1.30	4.12	1.66	4.01	8.44
log(Asset-to-bank divisions)	6.03	11.06	1.47	10.93	16.48
Financial intermediation	0.01	0.87	0.53	0.77	4.38
Density of bank divisions	0.00	0.00	0.00	0.00	0.00
log(Deposit-to-liability)	-8.59	-4.60	1.64	-4.72	4.81
log(Loan-to-asset)	-3.11	1.03	1.03	1.08	6.93
# infected by Covid to population	0.00	0.02	0.01	0.02	0.06
Observations	898				

The panel is unbalanced, since some regions do not have banks registered there, hence, the panel has missing values for these regions. For this reason, despite the existence of bank branches in regions, these regions demonstrate a zero level of assets (no registered banks).

Figure 4 shows the profitability of banks in Russia from 2010 to 2020. The significant decline in 2014–2015 can be explained by the sanction policy of the US and the EU and the realization of geopolitical risks, leading to capital outflow and barriers to borrowing that significantly reduced bank profits. The decline in 2020 was caused by a substantial recession in the Russian economy due to consequences of Covid-19 pandemic. We also consider the effect of the pandemic crisis on the bank de-branching and bank profitability.

Table 4 shows[21] the pairwise correlations between the main variables included. The two variables HDI and the logarithm of GRP per capita are highly correlated, which seems intuitive since HDI takes into account the gross national income index per capita. As stated earlier, we need only the educational component of HDI, i.e. without the effect of GRP per capita. For this reason, we regress HDI on the logarithm of GRP per capita and save estimated residuals. We call this variable as $HDI\_without\_income_{i,t}$ and further use it as a proxy for FDL.

[21] Due to limited space, we provide only dependent variables and the main independent variables.

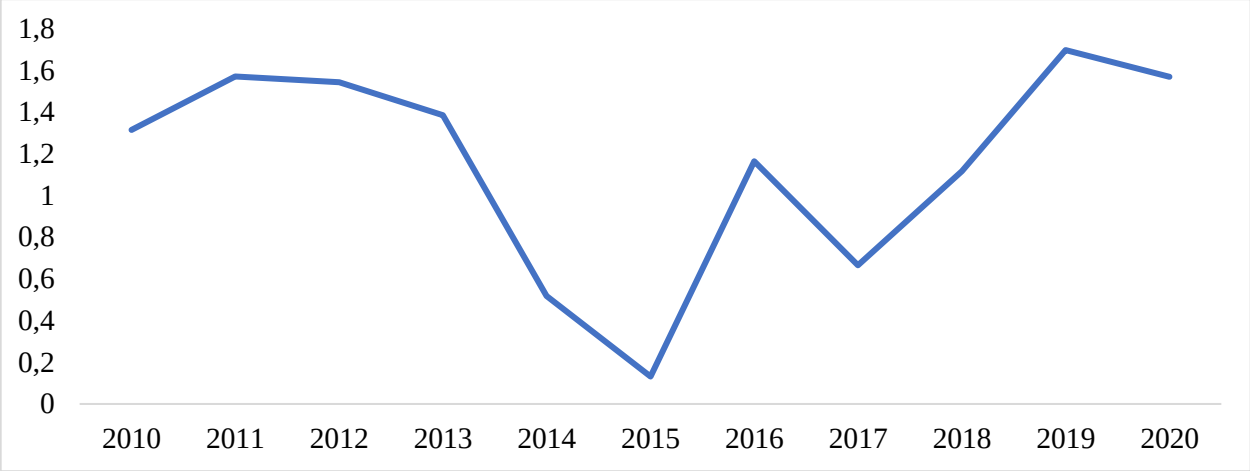

Figure 4. ROA in Russia, in %

Source: made by the author on the basis of the data from the Mobile dataset.

Table 5 represents the results of the estimation with p-value and R-squared. GRP per capita explains 47.46% of total variation in HDI. HDI without income is orthogonal to GRP per capita by the OLS procedure, i.e. the correlation between them is zero, thereby eliminating the highly correlated variables, so we can use them simultaneously in specifications.

In addition, both HDI and HDI without income are significantly positively correlated with ICT (first principal component) which seems to be economically meaningful because both represent the level of economic development of a region. For this reason, HDI and ICT are also significantly correlated with the log of GRP. We also use the logarithm of income per capita to account for the economic development of a region. Due to the strong positive correlation between the logarithm of GRP per capita and the logarithm of income per capita, we use only one variable in the specifications to avoid multicollinearity issues.

The number of bank branches is positively related to HDI which is in line with the literature and economic intuition. The same can be said about the relationship between ICT and bank branches. Bank size (measured as assets to GRP) is positively related to bank de-branching which might signify cost optimization motives. Bank profitability (ROA) is positively correlated with HDI without income and ICT. Overall, none of the variables presented in Table 4 are highly correlated, eliminating any concerns about multicollinearity.

Table 4. Pairwise correlations

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Number of branches	1.000											
2. ROA	0.007	1.000										
3. ICT	0.557***	0.063*	1.000									
4. HDI	0.286***	0.026	0.520***	1.000								
5. HDI without income	0.386***	0.072*	0.410***	0.718***	1.000							
6. log(GRP per capita)	-0.017	0.040	0.336***	0.696***	0.000	1.000						
7. GRP growth rate	0.128***	0.007	-0.127***	-0.031	0.034	-0.155***	1.000					
8. Inflation	0.110***	-0.004	-0.062*	-0.072**	0.084**	-0.219***	0.176***	1.000				
9. log(Asset-to-GRP)	0.631***	-0.012	0.610***	0.378***	0.414***	0.147***	-0.047	0.076**	1.000			
10.log(Deposit-to-liab.)	-0.373***	-0.039	-0.284***	-0.193***	-0.255***	0.002	-0.023	-0.134***	-0.845***	1.000		
11. log(Loan-to-asset)	0.144***	-0.017	0.401***	0.518***	0.128***	0.703***	-0.119***	-0.152***	0.292***	-0.061*	1.000	
12. log(Asset-to-GRP)	0.631***	0.012	0.610***	0.378***	0.414***	0.147***	-0.047	0.076**	1.000***	-0.845***	0.292***	1.000

Note: ***, **, * indicate significance at the 1%, 5%, and 10% level, accordingly.

Table 5. Results of regressing HDI on log(GRP per capita)

Variables	HDI
log(GRP per capita)	0.0297***
	(0.0013)
Constant	0.4681***
	(0.0164)
Observations	810
R-squared	0.4746

Note: Robust standard errors are reported in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% level, accordingly.

4 Results

4.1 Effects of ICT and HDI on bank de-branching and bank profitability

In this section we show the results of estimation for regression equations (1) and (2).

Table 6 shows the results of the estimations for regression equation (1) on the determinants of bank de-branching. We have chosen the panel model in favor of a fixed effects model according to the results of Hausman test, Breusch-Pagan test, and Wald test. We use robust standard errors since they give unbiased estimates under the heteroskedasticity we observe in our data according to Breusch-Pagan and Cook-Weisberg tests for heteroskedasticity.

We subsequently use the variables of interest including the internet development (*ICT*) and the level of FDL (*HDI without income*) in Russian regions. The first specification includes only the internet development, the second specification only the level of FDL, the third specification includes both, and the fourth specification also adds the interaction term between them to control for complementary effects.

The first two specifications with the separate inclusion of the parameters of interest result in a highly significant negative effect of ICT and HDI on the number of bank branches. In other words, ICT and HDI positively contribute to bank de-branching. The coefficients of interest in specification (3) are also significantly negative and their absolute values become stronger when controlling for both effects. When including the interaction term in specification (4), their absolute values become even stronger while interaction term is weakly significant (at 10% level). The coefficient on the interaction term is negative implying the positive complementary effect of HDI on the relationship between ICT and bank de-branching, and the positive complementary effect of ICT on the relationship between FDL and bank de-branching.[22]

These results allow us to confirm H1 that higher levels of adoption of internet technologies and higher values of FDL in Russian regions are associated with a decrease in the number of bank branches.

[22] In regions exhibiting higher values of ICT, the absolute effect of HDI on the number of bank branches becomes stronger resulting in positive complementary effect of ICT on the relationship between HDI and bank debranching. For instance, the highest value of ICT in our sample is 3.115. Then in this region (Sverdlovskaya) the absolute effect of HDI on the number of bank branches is equal to -85.3201 + 3.115 * (-53.3954) = -251.65, i. e. the effect becomes stronger. At the same time, the lowest value of ICT in our sample is -0.996 (Ingush Republic). Then the total effect is -85.3201 + (-0.996) * (-53.3954) = -32.138, i. e. the effect becomes smaller.

Table 6. Regression equation (1): bank de-branching[23]

VARIABLES	(1) # branches	(2) # branches	(3) # branches	(4) # branches
ICT	-28.6651***		-29.4270***	-30.7860***
	(4.2804)		(4.4000)	(4.7223)
HDI without income		-63.2270***	-80.9766***	-85.3201***
		(13.5349)	(15.6645)	(15.3725)
ICT * HDI without income				-53.3954*
				(30.4634)
log(GRP per capita)	14.9649	-1.4370	20.5493	21.9643*
	(12.7353)	(16.7821)	(12.4864)	(11.1731)
GRP growth rate	3.4920	9.4043**	3.3326	4.4544
	(3.1677)	(3.8804)	(3.0288)	(3.3586)
Population density	-2.8621**	-3.5177**	-2.7506**	-2.7773**
	(1.2730)	(1.5810)	(1.2301)	(1.1922)
Inflation	-26.1484***	-17.3239**	-25.7914***	-27.0006***
	(6.2898)	(7.4619)	(6.2839)	(6.0107)
Financial intermediation	-0.7594	-2.2699	-0.9339	-0.5133
	(2.0499)	(2.3957)	(1.9864)	(1.6415)
Density of bank divisions	-52.4189	-15.8778	-64.1802	-63.4989
	(53.1144)	(67.9677)	(51.3333)	(50.8836)
log(Deposit-to-liability)	0.2772	2.6178	-0.5682	-0.6939
	(0.7284)	(1.5766)	(0.7407)	(0.7163)
log(Asset-to-bank divisions)	-22.2480	-18.0279	-26.5336*	-26.9071**
	(13.7123)	(16.5749)	(13.4604)	(12.8759)
Deposit-to-GRP	-7.4077	-48.8147***	-6.3225	
	(9.7271)	(11.4793)	(9.0597)	
log(Asset-to-GRP)	22.6700*	21.8987	25.8989*	26.1045**
	(13.5561)	(16.5733)	(13.2843)	(12.8916)
log(Loan-to-asset)	2.2139	0.9762	1.4754	1.3589
	(2.1821)	(2.6735)	(2.1134)	(2.1257)
Constant	69.1024	284.6517**	28.7848	10.2721
	(78.9387)	(107.9515)	(75.4690)	(64.2112)
Time FE	✓	✓	✓	✓
Observations	592	594	592	592
R-squared	0.7159	0.6070	0.7300	0.7328
Number of id	70	70	70	70

Note: Robust standard errors in parentheses $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. We use lagged values of all independent variables. Time fixed effects are included in all specifications. We choose the panel model in favor of fixed effects in according to Hausman test (p-value is around 0, the null hypothesis about the non-systematic difference in coefficients is rejected).

In summary, the results support the empirical findings that the level of internet infrastructure positively affects bank de-branching. This is in line with the findings of Keil and Ongena (2020) who show that technological progress is related to bank de-branching across

[23] We use reduced sample for estimations excluding Moscow, St. Petersburg, the Moscow oblast, and the Leningrad oblast to eliminate the effects of regions with extremely high concentration of assets and federal banks that have their bank branches all over the country.

countries. Therefore, our findings contribute to the literature on bank de-branching in such a way that these effects can also be observed at the regional level within one country. Furthermore, we can state that higher values of FDL are associated with bank de-branching with and without controlling for ICT, which corroborates the findings of Magomedov and Agamagomedova (2018). ICT and FDL also provide two-way complementary effects amplifying the effect of each other on bank de-branching. Higher values of ICT are associated with the greater association of FDL with bank de-branching; higher values of FDL enhance the effect of ICT on a decrease in the number of bank branches. In other words, banks on average close more bank branches in regions with high levels of both ICT and FDL.

We now discuss the results with respect to the effects of ICT and FDL on the relationship between bank de-branching and bank profitability. To estimate the regression equation (2), we use a generalized method of moments estimator (GMM) (Arellano and Bover, 1995). It accounts for unobserved heterogeneity, considers the persistence of the dependent variable over time, and accounts for it being serially correlated (Arellano, 2002), thus giving consistent estimations. It also mitigates the endogeneity problem because it considers the lagged dependent variable and some lagged regressors (considered to be endogenous) as instruments. We include year dummy variables to account for time fixed effects and dummies on federal districts to account for heterogeneity among federal districts. We use standard tests including Arellano-Bond test for AR(1) and AR(2) and Hansen tests (overidentification). Table 7 shows the results of the estimation of regression equation (2) on the determinants of bank profitability regarding bank de-branching using the Arellano-Bond GMM estimation.

The standard tests for Arellano-Bond GMM estimator include AR(1) and AR(2) tests and Hansen test for overidentification. We apply standard techniques to work with Arellano-Bond GMM estimator (Roodman, 2009), i.e., we include time dummies, put every regressor into the instrument matrix including their lags, and we use two-step estimation with small-sample corrections to covariance matrix, then we use t-tests instead of z-tests and F-test instead of χ^2-test for overall fit. We do not use orthogonal deviations since our dataset does not have time gaps.

Table 7 represents four specifications with the subsequent inclusion of variables of interest. The first specification includes only the internet development (*ICT*) and the interaction term of ICT and bank branches (*bank branches * ICT*), the second specification only the level of financial literacy (*HDI without income*) and the interaction term of HDI and bank branches (*bank branches * HDI without income*), the third specification includes all of them, and the fourth

specification also adds the interaction term between bank branches, ICT and HDI (*bank branches * ICT * HDI without income)* to control for complementary effects.

We observe the persistence in bank profitability since in all specifications we have significant lagged values of ROA. AR(1) is less than 10% significance level, while AR(2) is much higher. The coefficient on the first lag is between 0.1515 and 0.2043 indicating that the banking industry in Russian regions is not monopolized and depends greatly on the performance of the internal bank divisions, macroconditions, etc. Bank profits are not largely persistent, i.e. bank profits change quickly to response to external shocks.

Table 7. Regression equation(2): bank profitability

VARIABLES	(1) ROA	(2) ROA	(3) ROA	(4) ROA
ROA_{t-1}	0.1515***	0.1677***	0.1667***	0.2043***
	(0.0072)	(0.0064)	(0.0098)	(0.0153)
bank branches	-0.0002**	-0.0002**	-0.0003***	-0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
bank branches * ICT	-0.0001		-0.0002	-0.0005***
	(0.0002)		(0.0002)	(0.0001)
ICT	0.0198***		0.0129*	0.0074*
	(0.0029)		(0.0069)	(0.0038)
bank branches * HDI without income		-0.0204***	-0.0170***	-0.0202***
		(0.0025)	(0.0041)	(0.0033)
HDI without income		0.2059***	0.1029*	0.1460***
		(0.0296)	(0.0566)	(0.0389)
bank branches * ICT * HDI without income				-0.0022
				(0.0018)
Population density	-0.0008***	0.0001	0.0005**	-0.0002
	(0.0003)	(0.0002)	(0.0002)	(0.0002)
log(GRP per capita)	0.0130*	0.0284***	0.0379***	0.0249***
	(0.0076)	(0.0051)	(0.0104)	(0.0054)
GRP growth rate	0.0119	0.0261***	0.0216***	0.0226***
	(0.0078)	(0.0049)	(0.0061)	(0.0077)
Inflation	-0.1930***	-0.1955***	-0.1923***	-0.1781***
	(0.0290)	(0.0232)	(0.0269)	(0.0281)
Financial intermediation	0.0078	0.0172***	0.0191***	0.0135***
	(0.0049)	(0.0036)	(0.0039)	(0.0039)
Density of bank divisions	0.2819***	-0.0122	-0.1055**	0.0663
	(0.0488)	(0.0393)	(0.0519)	(0.0423)
deposit_liability	0.0002	-0.0132***	-0.0136***	-0.0095***
	(0.0001)	(0.0006)	(0.0015)	(0.0015)
loan_asset	-0.0015**	-0.0032***	-0.0041***	-0.0024**
	(0.0007)	(0.0007)	(0.0007)	(0.0009)
log(Asset-to-bank divisions)	-0.0009	-0.0208***	-0.0245***	-0.0167***
	(0.0054)	(0.0041)	(0.0051)	(0.0047)
log(Asset-to-GRP)	-0.0010	0.0211***	0.0258***	0.0190***
	(0.0047)	(0.0037)	(0.0056)	(0.0040)
Constant	-0.1392*	-0.2169***	-0.3200***	-0.2230***

	(0.0824)	(0.0577)	(0.1176)	(0.0682)
Time & Fed. districts FE	✓	✓	✓	✓
Observations	651	593	591	591
Number of id	70	70	70	70
Hansen	52.86***	55.17***	47.87***	49.95***
ar1p	0.014	0.019	0.019	0.017
ar2p	0.458	0.534	0.523	0.567

Note: Standard errors in parentheses $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Bank de-branching is positively associated with bank profitability[24] which confirms that banks tend to close their bank branches for technological reasons, to optimize their cost structure and branch network, and these branch closures increase their profits. This corroborates the findings in literature review by Kohlscheen et al. (2018) and Le and Ngo (2020). The effect of bank fragility (when banks might close their bank branches due to their inability to resist negative macroeconomic shocks) is much smaller, so we do not see a negative association. The results highlight that bank decisions about closing their bank branches are on efficient and increase their profits.

Specification 1 introduces the effect of internet development in Russian regions on bank profitability. We see that ICT positively relates to bank profitability. This relationship can be explained through several channels. First, higher ICT values are connected with bank de-branching, as we observed in the results of the first regression equation, and hence are associated with higher bank profitability. We further eliminate this problem by taking the estimated values from the first regression and then use it as a regressor in the second regression. Another reason might be that higher adoption of ICT in regions might directly relate to cost optimization since banks are using the internet infrastructure in a region, hence they benefit more from the cost optimization of technological progress. This finding corroborates the results found by Keil and Ongena (2020).

Regarding the coefficient on the interaction term between ICT and bank branches in specification 1, we observe that it is insignificantly negative, i.e., banks are more profitable when closing their bank branches in regions exhibiting higher levels of internet development. Due to the insignificance, we cannot say whether ICT complementarily affects the relationship between bank de-branching and bank profitability.

[24] We have negative coefficients on the number of bank branches, meaning that a decrease in the number of bank branches (bank debranching) positively relates to bank profitability (ROA).

However, when we control for FDL, we see significant results. Specification 2 uses HDI without income and the interaction term between HDI without income and bank branches similar to the ICT in the first specification. We observe that higher levels of HDI without income are associated with higher bank profits. We expected it to be positive since people tend to invest more when they are confident about their finances, and banks can gain profits from the higher demand for banking services.

The negative coefficient on the interaction term in specification 2 means the positive complementarity of HDI on the relationship between bank de-branching and bank profitability. As we expected, banks tend to close their bank branches to a larger extent in regions exhibiting higher levels of FDL. This partly confirms H2 that HDI can boost bank profitability conditional on bank de-branching.

We see that all these effects remain the same in specification 3 when we use these variables together although the coefficients on ICT and HDI without income become less significant (at 10% level). However, when we include the interaction term between bank branches, ICT and HDI without income in specification 4, we observe a highly significant result for the interaction between ICT and bank branches. Although this is significant only in one specification, we observe weak evidence that banks closing their bank branches in regions with sufficiently high levels of internet development make more profits. This specification allows us to confirm H2 that ICT and HDI each have complementary effects on the relationship between bank de-branching and bank profitability. Although we do not observe the two-way interaction between ICT and HDI on the link between bank de-branching and bank profitability, they separately affect their relationship.

4.2 Addressing possible endogeneity between bank de-branching and bank profitability

One may wonder why the decision to close branches does not depend on bank profitability. We suppose that bank de-branching should be considered as one of predictors of bank profitability and not vice versa, since bank profitability is the core performance measure of bank management. All decisions about whether to close bank branches are aimed at increasing bank profitability. Regression equation (1) uses lags of all regressors, implying the complexity of bank de-branching decisions. Although we do not face directly the simultaneity problem since we do not have ROA on the right-hand side of regression equation (1), as a robustness check and to eliminate the influence of the regressor autocorrelation effect, we use the estimated bank branches from regression equation (1) and use these as predictors in regression equation (2).

Below are the new specifications of regression equations.

$$\widehat{Branches}_{i,t} = \widehat{\delta_0} + \widehat{\delta_1} \cdot ICT_{i,t-1} + \widehat{\delta_2} \cdot FDL_{i,t-1} + \widehat{\delta_3} \cdot ICT_{i,t-1} \cdot FDL_{i,t-1} + \\ + \widehat{\delta_4} \cdot Banks_{i,t-1} + \widehat{\delta_5} \cdot Regions_{i,t-1} \quad (3)$$

$$ROA_{i,t} = \beta_0 + \beta_1 \cdot ROA_{i,t-1} + \beta_2 \cdot \widehat{Branches}_{i,t} + \beta_3 \cdot ICT_{i,t} + \beta_4 \cdot FDL_{i,t} + \\ + \beta_5 \cdot \widehat{Branches}_{i,t} \cdot ICT_{i,t} + \beta_6 \cdot \widehat{Branches}_{i,t} \cdot FDL_{i,t} + \beta_7 \cdot Banks_{i,t} + \quad (4) \\ + \beta_8 \cdot Regions_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Table 8 shows the results of the estimation of regression equation 4 using the values of the bank branches estimated from regression equation 1.

Table 8. Regression equation(2): bank profitability (estimated bank branches)

VARIABLES	(1) ROA	(2) ROA
ROA_{t-1}	0.2086***	0.2134***
	(0.0188)	(0.0180)
bank branches	0.0016***	0.0009***
	(0.0002)	(0.0002)
bank branches * ICT	-0.0001**	-0.0001**
	(0.0000)	(0.0000)
bank branches * HDI without income	-0.0074***	-0.0068***
	(0.0008)	(0.0009)
bank branches * ICT * HDI without income		-0.0024***
		(0.0008)
ICT	0.0593***	0.0367***
	(0.0089)	(0.0075)
HDI without income	0.0610	0.1256**
	(0.0440)	(0.0530)
Population density	0.0041***	0.0022***
	(0.0006)	(0.0006)
log(GRP per capita)	-0.0335***	-0.0187*
	(0.0082)	(0.0095)
GRP growth rate	-0.0107	-0.0149***
	(0.0065)	(0.0056)
Inflation	-0.0920*	-0.0843*
	(0.0488)	(0.0453)
Financial intermediation	-0.0031	-0.0010
	(0.0033)	(0.0042)
Density of bank divisions	0.3001***	0.2522***
	(0.0556)	(0.0607)
deposit_liability	0.0007	-0.0019
	(0.0133)	(0.0135)
loan_asset	0.0022***	0.0012
	(0.0007)	(0.0008)

log(Asset-to-bank divisions)	0.0428***	0.0297***
	(0.0079)	(0.0075)
log(Asset-to-GRP)	-0.0428***	-0.0310***
	(0.0076)	(0.0075)
Constant	-0.0672	-0.0837
	(0.1006)	(0.0888)
Time & Fed. districts	✓	✓
Observations	451	451
Number of id	69	69
Hansen	41.09***	36.56***
ar1p	0.021	0.022
ar2p	0.771	0.814
Number of instruments	153	154

Note: Standard errors in parentheses $^{+}\ p < 0.1$, $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

The persistence of bank profits becomes much larger—ranging from 0.2086 to 0.2134. The absolute values of bank de-branching (the negative growth rate of bank branches) in all specifications becomes substantially larger implying the stronger net effect of bank de-branching on bank profitability. However, these coefficients become positive implying the negative effect of bank de-branching on bank profitability. The coefficient on the complementarity term of ICT and bank de-branching is almost the same in specification 1 as it was before. In addition, the effect of ICT itself also becomes larger by absolute values. The coefficient on HDI in specification 1 becomes insignificant while the complementarity coefficient on HDI and bank de-branching is still significantly negative. In specification 2, we see the significant coefficient on the interaction between bank branches, ICT, and HDI. We also observe that the coefficients on the interaction term between bank branches and HDI are larger by absolute values than the coefficient on bank de-branching. This suggests the following interpretation: banks which are in regions exhibiting higher values of ICT and HDI benefit from closing their bank branches as opposed to regions with low levels of internet development and FDL. The closure of bank branches in these regions might result in a decrease of bank profits since people and organizations could be unable to quickly move to the online banking environment.

In summary, the effects remain almost the same. This confirms the stability of the results obtained from the first regression equation estimated through a fixed effects model.

5 Robustness Checks

To ensure the robustness of the results, we run the same specifications of models for the full sample including Moscow, St. Petersburg, Moscow Region, and Leningrad Region since these regions have the registered federal banks with bank branches all over the country (for instance,

Sberbank, VTB). These regions are highly concentrated in terms of bank assets and net profits. Furthermore, due to the major limitation in the collected data (data on bank profits, assets, and total liabilities are based on the place of bank registration, not the place of actual location), we mitigate this limitation by considering only regional banks in the main specifications. But for a robustness check, we also consider the full sample to check whether the results are stable and whether they are influenced by extreme observations.

Tables A1 and A2 (see Annex) represent the results of the estimation of regression equations (1) and (2) for full sample. Table A1 shows that the signs of the coefficients on the lagged values of ICT and HDI remain the same,[25] but the coefficients increase by absolute values. The coefficients of interest are still highly significant, even the interaction term between ICT and HDI without income becomes highly significant. Table A2 shows the results of the estimation for regression equation (2). ICT and HDI without income become weakly significant, even in specification 4 their significance disappears when controlling for all the interaction terms which are still highly significant. We can conclude that the inclusion of regions with a higher volume of bank assets, net profits, and registered federal banks distorts the estimates for HDI and ICT coefficients, making them larger by absolute values. This illustrates the rationale for why we might require excluding regions with a saturated banking system. To sum up, the results for ICT and HDI are robust to the inclusion of these regions; all previously obtained effects are preserved but some become larger some become insignificant. Such results might indicate the large heterogeneity of the regions since most banks are registered in Moscow and St. Petersburg. Therefore, including Moscow, St. Petersburg, Moscow Region, and Leningrad Region might induce misleading results, although the significance of interaction terms on ICT and HDI remains the same.

Another way to check the robustness of our results is to use other sets of independent variables of interest. In terms of FDL, we previously estimate a regression using HDI without effect of income per capita. In fact, HDI is a very broad index that covers not only FDL, but also the standard of living, health, and life expectancy. To exclude the impact of income and other issues, we take the Education Index, i.e., one of the components of HDI representing the literacy of population in Russian regions measured through a combination of expected and mean years of schooling. The rationale to use this only for a robustness check is that this variable is available for a restricted number of years, only for 2010, 2011, 2013, 2014, and 2019, leading to a

[25] Except for specification 2 in which the coefficient on ICT becomes smaller by absolute value.

substantial reduction in the sample size.[26] The results of the estimation are presented in Table A3 (see Annex). Specification 1 remains the same because it does not contain FDL. Education Index is not significant itself, which can be explained by the small number of observations. However, ICT remains significantly negative and has almost the same absolute value when controlling for the Education Index in specification 3. In specification 4, the complementarity term of ICT and Education index is insignificant, although negative as previously. Education Index is negatively associated with the number of bank branches although insignificantly. The absolute values remain approximately the same. The instability of the results in terms of Education Index might be explained by the substantial decrease in observations that leads to higher standard errors. However, the results for ICT are stable and robust.

Roodman (2009) points out that two-step system of GMM may face a weak instrument problem. Therefore, as a robustness check, we use the estimator by Kripfganz (2016)—the quasi-maximum likelihood fixed effects (QML FE) estimator. This helps to avoid biased estimates especially when time horizon is short. QML FE performs better on finite samples than the two-step GMM system (Moral-Benito, 2013). The results are presented in Table A4 (see Annex). The range for the indicator of the persistence in bank profitability becomes larger from 0.1413 to 0.2565 while still very close to the estimation of the main specification using Arellano-Bond GMM. Such values of the persistence of ROA are also found in (Kohlscheen et al., 2018). However, now we have a positive association of bank branches with bank profitability, meaning that bank de-branching is inefficient given the zero level of ICT and FDL in a region. However, we carefully look at the interaction terms, we can see that they are substantially larger by absolute values implying that banks closing branches in regions with sufficiently high levels of internet development and FDL can make additional profits. Banks in regions with low levels of internet development and FDL could face a decrease in their profits due to the closure of branches. The interaction term between bank branches, ICT, and HDI without income is weakly significant and negative, implying that ICT and HDI amplify each other in their association with bank branches and bank profitability. This effect becomes evident only in the estimation of QML FE.

In summary, the results obtained seem to be robust in most of the specifications tested. We employ different techniques including sample expansion with extreme observations, another proxy for FDL with a smaller number of observations, use of estimated bank branches from

[26] For this reason, we could not use the Education Index in our main specifications not to get misleading estimations.

regression equation (1) as a regressor in regression equation (2), and the use of another estimation procedure—QML FE.

6 Conclusions

Bank de-branching is one of the core transformations occurring in the banking sector all over the world, allowing banks to gain additional competitive advantages. Bank de-branching makes it possible to optimize the cost structure and increase profits due to lower demand for bank branches among the population and organizations. There is a set of key factors driving bank de-branching, including technological progress, bank fragility, bank consolidation, branch network optimization, bank bankruptcies, and license withdrawal.

In this paper, we consider how the adoption of technological innovation and FDL are associated with bank de-branching and bank profitability. We use regional-level data on 84 Russian regions throughout the period from 2010 to 2020 on an annual basis to test two hypotheses whether the adoption of technological innovation and FDL are associated with bank de-branching and whether the adoption of technological innovation and FDL have a complementary effect on the relationship between bank de-branching and bank profitability.

We confirm that a higher adoption of technological innovation and FDL in Russian regions are positively associated with bank de-branching. We also confirm that a higher adoption of technological innovation and a higher FDL are positively associated with the effect of bank de-branching on bank profitability.

We check the robustness of our results using a variety of techniques. First, we include Moscow, St. Petersburg, Moscow Region, and Leningrad Region. The rationale is to show that the results do not depend on regions saturated with banking institutions and are not influenced by extreme observations. We use Education Index as a proxy for financial literacy. To mitigate the endogeneity problem, we take the estimated values from the first regression equation and use them as a predictor of bank profitability for the estimation of the second regression equation. In Covid estimations, we use the time dummy variable for year 2020 and cross-regional variation using number of Covid infections in regions. In general, we find our results robust.

The findings of this research are consistent with the literature in terms of a positive relationship between ICT and bank de-branching, on the one hand, and ICT and bank profitability, on the other hand. We contribute to the study of Keil and Ongena (2020) in that internet development might be significantly associated with bank de-branching in the case of

regional heterogeneity within one country. Our results contribute to the literature in that FDL should be considered as an institutional factor together with the development of internet technology. We state that FDL should be taken into account when deciding whether to close bank branches in certain regions.

The findings have several implications for bank management in deciding how to optimize the cost structure and how bank de-branching might be beneficial for that. This work has shown that FDL as an institutional factor might be associated with bank de-branching, hence it should be taken into consideration by policymakers, perhaps by the Bank of Russia as an additional motivation to improve FDL in Russian regions.

The main limitations of this article are in how we measure FDL and bank profitability. We use the Human Development Index (HDI) as a proxy for FDL even though it comprises three indices including life expectancy, education, and gross national income per capita. Therefore, we have a rather comprehensive proxy for FDL that might be correlated with the error term in the regression equation and cause endogeneity. To mitigate this problem, we estimate regression of HDI on GRP per capita and save estimated residuals, i.e. we eliminate the variation related to gross national income per capita. Estimated residuals are used as a proxy for FDL, though it is not a complete solution to the problem.

In addition, we use data on bank profitability, assets, and total liabilities based on the place of registration of banks, not the actual location. This might result in misleading estimates when testing the second hypothesis. We mitigate this problem by eliminating Moscow, St. Petersburg, Moscow Region, and Leningrad Region since these regions tend to have federal banks that have bank branches all over the country.

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Annex

Table A1. Regression equation (1): bank de-branching (full sample)

VARIABLES	(1) # bank branches	(2) # bank branches	(3) # bank branches	(4) # bank branches
ICT	-14.2268**		-14.5204**	-12.3675**
	(6.5398)		(6.6713)	(5.8452)
HDI without income		-64.0193***	-73.5027***	-74.2427***
		(15.4037)	(16.6816)	(16.9927)
ICT * HDI without income				-31.9324***
				(9.9973)
log(GRP per capita)	-3.8389	-6.4879	1.2298	-0.6257
	(21.2885)	(24.5083)	(21.1610)	(21.3979)
GRP growth rate	12.6997***	18.8322***	12.5741***	12.0941***
	(4.6260)	(5.0391)	(4.6059)	(4.5398)
Population density	-0.1084	-0.2630***	-0.1058	-0.1166
	(0.1108)	(0.0258)	(0.1122)	(0.1144)
Inflation	-23.7750***	-14.9295**	-23.5097***	-18.1905***
	(6.2100)	(6.6663)	(6.2027)	(6.7535)
Financial intermediation	0.8082	0.5448	0.6329	0.1794
	(2.8025)	(3.1765)	(2.7270)	(2.7689)
Density of bank divisions	-9.7168	36.0806	-21.1739	-17.8891
	(94.0505)	(108.0311)	(92.2862)	(93.3393)
log(Deposit-to-liability)	0.0602	0.5072	-0.6629	-0.3108
	(1.2170)	(1.5754)	(1.2273)	(1.2866)
log(Asset-to-bank divisions)	-11.5762	-11.1695	-15.6434	-15.1396
	(22.7434)	(25.7398)	(22.4906)	(22.6654)
Deposit-to-GRP	4.9408*	-0.9700	5.1328*	
	(2.8225)	(1.4362)	(2.9222)	
log(Asset-to-GRP)	11.4247	11.6994	14.5933	14.5306
	(23.1742)	(26.2584)	(22.8331)	(23.0320)
log(Loan-to-asset)	1.2865	-0.2580	0.5611	0.8425
Constant	158.8935	207.2629*	126.7021	151.2385
	(111.7336)	(120.1450)	(112.6395)	(112.1817)
Time FE	✓	✓	✓	✓
Observations	610	612	610	610
R-squared	0.6951	0.6477	0.7034	0.6979
Number of id	72	72	72	72

Note: Robust standard errors in parentheses $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. We use lagged values of all independent variables. Time fixed effects are included in all specifications. We choose the panel model in favor of fixed effects in according to Hausman test (p-value is around 0, the null hypothesis about the non-systematic difference in coefficients is rejected).

Table A2. Regression equation(2): bank profitability (full sample)

VARIABLES	(1) ROA	(2) ROA	(3) ROA	(4) ROA
ROA_{t-1}	0.1504***	0.1876***	0.1729***	0.1928***
	(0.0071)	(0.0080)	(0.0084)	(0.0113)
bank branches	-0.0004***	-0.0000	-0.0003**	-0.0003***
	(0.0000)	(0.0001)	(0.0001)	(0.0001)
bank branches * ICT	0.0000		-0.0002***	-0.0002***
	(0.0000)		(0.0000)	(0.0001)
ICT	0.0022**		0.0075*	-0.0020
	(0.0011)		(0.0038)	(0.0015)
bank branches * HDI without income		-0.0109***	-0.0171***	-0.0084***
		(0.0029)	(0.0031)	(0.0015)
HDI without income		0.1725***	0.1953***	0.0312
		(0.0269)	(0.0312)	(0.0437)
bank branches * ICT * HDI without income				-0.0018***
				(0.0005)
Population density	-0.0000	0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
log(GRP per capita)	0.0052	0.0119**	0.0231***	0.0179***
	(0.0038)	(0.0049)	(0.0037)	(0.0037)
GRP growth rate	0.0032	0.0274***	0.0265***	0.0217***
	(0.0034)	(0.0053)	(0.0069)	(0.0078)
Inflation	-0.1692***	-0.0739***	-0.1219***	-0.1884***
	(0.0219)	(0.0234)	(0.0287)	(0.0315)
Financial intermediation	0.0048**	0.0005	0.0100***	0.0131***
	(0.0022)	(0.0024)	(0.0027)	(0.0034)
Density of bank divisions	0.0768**	0.0922***	0.0330	0.0068
	(0.0317)	(0.0318)	(0.0390)	(0.0365)
deposit_liability	0.0000	-0.0114***	-0.0123***	-0.0105***
	(0.0001)	(0.0009)	(0.0008)	(0.0011)
loan_asset	-0.0006**	0.0001	-0.0014**	-0.0022***
	(0.0003)	(0.0006)	(0.0005)	(0.0005)
log(Asset-to-bank divisions)	-0.0130***	-0.0101***	-0.0187***	-0.0134***
	(0.0037)	(0.0034)	(0.0052)	(0.0050)
log(Asset-to-GRP)	0.0123***	0.0103***	0.0194***	0.0147***
	(0.0031)	(0.0030)	(0.0052)	(0.0046)
Constant	0.0325	-0.0974	-0.1637***	-0.1225**
	(0.0423)	(0.0675)	(0.0439)	(0.0557)
Time & Fed. districts FE	✓	✓	✓	✓
Observations	671	611	609	609
Number of id	72	72	72	72
Hansen	48.49***	55.63***	57.32***	43.34***
ar1p	0.014	0.018	0.018	0.017
ar2p	0.527	0.516	0.506	0.567
Number of instruments	129	117	119	168

Note: Standard errors in parentheses $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A3. Regression equation (1): bank de-branching (with Education index)

VARIABLES	(1) # bank branches	(2) # bank branches	(3) # bank branches	(4) # bank branches
ICT	-28.665***		-32.722***	-7.301
	(4.280)		(4.743)	(75.798)
Education Index		-63.050	-81.033	-75.719
		(66.638)	(56.173)	(71.006)
ICT * Education Index				-25.523
				(77.337)
log(GRP per capita)	14.965	7.571	26.867***	36.102**
	(12.735)	(18.830)	(9.163)	(13.885)
GRP growth rate	3.492	3.201	0.909	0.535
	(3.168)	(9.711)	(7.842)	(7.539)
Inflation	-26.148***	121.230		127.390
	(6.290)	(88.754)		(84.247)
Population density	-2.862**	-2.220*	-1.901**	-2.048**
	(1.273)	(1.324)	(0.814)	(0.836)
Financial intermediation	-0.759	-1.960	-1.389	-1.475
	(2.050)	(2.969)	(1.984)	(2.095)
Density of bank divisions	-52.419	22.077	-56.132*	-64.901*
	(53.114)	(53.342)	(28.205)	(35.395)
log(Deposit-to-liability)	0.277	3.162*	-1.212	-0.896
	(0.728)	(1.765)	(1.089)	(1.267)
log(Asset-to-bank divisions)	-22.248	-16.332	-30.700***	-35.144***
	(13.712)	(15.422)	(8.485)	(11.960)
Deposit-to-GRP	-7.408	-52.641***	1.410	5.991
	(9.727)	(18.204)	(11.441)	(12.455)
log(Asset-to-GRP)	22.670*	21.785	29.439***	33.979***
	(13.556)	(15.644)	(8.521)	(11.733)
log(Loan-to-asset)	2.214	3.191	3.273	3.129
	(2.182)	(3.328)	(2.304)	(2.335)
Constant	69.102	163.718	-128.078	-209.140*
	(78.939)	(140.648)	(78.519)	(123.118)
Time FE	✓	✓	✓	✓
Observations	592	266	265	265
R-squared	0.716	0.626	0.778	0.787
Number of id	70	70	70	70

Note: Robust standard errors in parentheses $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. We use lagged values of all independent variables. Time fixed effects are included in all specifications. We choose the panel model in favor of fixed effects in according to Hausman test (p-value is around 0, the null hypothesis about the non-systematic difference in coefficients is rejected).

Table A4. Regression equation (2): bank profitability (QML-FE estimation)

VARIABLES	(1) ROA	(2) ROA	(3) ROA	(4) ROA
ROA_{t-1}	0.1413**	0.2565***	0.2558***	0.2455***
	(0.0656)	(0.0747)	(0.0802)	(0.0806)
bank branches	0.0003	0.0008**	0.0019***	0.0021***
	(0.0004)	(0.0004)	(0.0005)	(0.0005)
bank branches * ICT	-0.0013***		-0.0022***	-0.0021***
	(0.0004)		(0.0004)	(0.0005)
bank branches * HDI without income		-0.0332***	-0.0722***	-0.0958***
		(0.0123)	(0.0154)	(0.0203)
bank branches * ICT * HDI without income				-0.0223*
				(0.0119)
ICT	0.0184		0.0219	0.0217
	(0.0155)		(0.0213)	(0.0214)
HDI without income		0.9549**	0.9406**	1.0854***
		(0.4163)	(0.4057)	(0.4163)
Population density	0.0024	0.0017	-0.0010	-0.0019
	(0.0046)	(0.0052)	(0.0052)	(0.0053)
log(GRP per capita)	-0.0667	-0.1872***	-0.1603***	-0.1836***
	(0.0537)	(0.0555)	(0.0571)	(0.0589)
GRP growth rate	0.0227	0.0337	0.0566	0.0576
	(0.0411)	(0.0469)	(0.0471)	(0.0470)
Inflation	-0.3346	-0.4149	-0.4521*	-0.4849*
	(0.2543)	(0.2548)	(0.2517)	(0.2548)
Financial intermediation	-0.0257**	-0.0387***	-0.0403***	-0.0441***
	(0.0103)	(0.0107)	(0.0105)	(0.0107)
Density of bank divisions	-0.2392	0.5175***	0.4437**	0.5395**
	(0.1954)	(0.1884)	(0.2045)	(0.2118)
deposit_liability	-0.0002	-0.0317	-0.0231	-0.0300
	(0.0005)	(0.0283)	(0.0278)	(0.0284)
loan_asset	0.0042***	0.0064***	0.0067***	0.0072***
	(0.0015)	(0.0017)	(0.0017)	(0.0017)
log(Asset-to-bank divisions)	0.0100	0.1281***	0.0984*	0.1249**
	(0.0486)	(0.0486)	(0.0516)	(0.0538)
log(Asset-to-GRP)	-0.0212	-0.1390***	-0.1081**	-0.1352**
	(0.0480)	(0.0483)	(0.0514)	(0.0535)
Constant	0.8140*	1.3938***	1.3164***	1.4309***
	(0.4672)	(0.5188)	(0.4977)	(0.4993)
Time & Fed. districts FE	✓	✓	✓	✓
Observations	575	524	516	516
Number of id	68	69	68	68

Note: Standard errors in parentheses $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$