Market Structure, International Banking and New Technology: Case from the Loan Markets in the EU

Georgios P. Kouretas[1] *& Małgorzata Pawłowska*[2]*;*

September 27, 2021

Abstract

The aim of this paper is to investigate whether the market structure and new technology have an impact on bank loan markets in the European Union. The impact of new technology on three types of bank loans (residential mortgage loans, consumer loans, and corporate loans) is quantified separately at the bank level, using the single-equation panel regression model and the interacted panel vector autoregression model. Using a panel data sample for the period 2004–2019, we find that new technology mainly affects the growth of loans for households, in particular, for consumer loans. We also find some heterogeneities between advanced and transitioning European Union banking sectors. Furthermore, the impact of new technology is significantly stronger and prolonged for foreign banks. Finally, our findings confirm the leading role of loans for households in the use of new digital technologies.

Keywords: banks, credit growth, concentration, new technologies, FinTech, EU.

JEL: F36; G2; G3; G5; G21; G34; L1.

[1] Athens University of Economics and Business.

[2] Warsaw School of Economics SGH, e-mail: mpawlo1@sgh.waw.pl Warsaw School of Economics, mpawlo1@sgh.waw.pl, Work in Progress. Please do not quote without permission. The authors gratefully acknowledge the financial support of the National Science Centre of Poland, no. of decision DEC-2017/25/B/HS4/02227.

1. Introduction

Loans are the main banking product used to finance the real economy. Furthermore, servicing bank loans (by enterprises and households) often underlies a systemic crisis [Cecchetti et al., 2011, Laeven et al., 2016, Chen, et al. 2019]. Bank loans in the EU are the most important source of external funding not only for households but also for businesses and play a significant role in shaping the changes in business activity and in transmitting monetary policy impulses to the real economy. Furthermore, currently, we are observing the ongoing revolution of the financial world. Entities creating new business models based on FinTech (including technology based on distributed ledgers or artificial intelligence) completely redefine the way consumers meet their financial needs [Nicoletti, 2017, Blakstad & Allen, 2018, Boobier, 2020].

In recent years, the FinTech sector has been growing faster than traditional finance and therefore will have a huge impact on the lending market. The development of the internet, digital technologies and mobile devices have brought about innovative changes in the financial sector. In the era of a dynamically changing world, the younger generation of consumers is receptive and open to digitization, freely using innovative solutions within electronic channels that allow remote access to financial services (the internet, mobile devices). While the most noticeable change, due to the use of new technologies, took place in the payments segment, FinTech companies gradually took up basic banking services, including lending activities. Like banks, FinTech operators provide consumer, corporate, and mortgage loans [Claessens et al. 2018]. In the digital age, new players may influence the following competitive advantages reserved exclusively for banks in the retail segment. Competitors from the FinTech sector, first, have access to a wider group of customers than traditional banks, and second, they provide their customers with the additional benefits of the greater convenience and lower costs of their financial services. Currently, traditional banks have to adapt their business models, which has significant consequences for the future of the entire financial sector [Petralia et al. 2019].

Despite the increasing number of studies on the development of the FinTech sector, there is still no specific quantitative research on how the above changes affect the development of the bank loan market for different types of loans and how to properly measure this phenomenon. Furthermore, when examining the influence of the FinTech sector on the development of the lending market, it should be distinguished whether we are examining the FinTech sector within the banking sector (new technologies used by traditional banks) or as an external element outside the banking sector. Similarly, FinTech technology can be used by banks as an additional distribution channel, or new banks (neobanks) without traditional branches may be formed. On the one hand, we are witnessing the emergence of ever-larger

banks; on the other hand, we are witnessing the dynamic development of new distribution channels. While the consolidation of the banking sector leads to a reduction in competition due to the emergence of ever-larger banks, the FinTech sector, in turn, stimulates the level of competition not only in the banking sector but also in the entire financial system [cf. Navaretti, Calzolari, Pazzolo, 2017, Pawłowska, Staniszewska, 2021]. An extensive study on competition in the FinTech sector credit market is presented in Claessens et al. (2018). One of the main findings of the study is that the size of FinTech credit is negatively correlated with competition in the banking market and the severity of regulation of that market.

There has been extensive debate on the costs and benefits of bank competition in the connections of monetary policy and macroprudential policy channels [Fungacova et al., 2014, Leroy and Lucotte, 2017], but there is little research concerning the effect of targeted macroprudential instruments and new capital regulations in the context of their impact on bank lending. The contemporary economic system is both complex and heterogeneous [Goodhart and Tsomocos, 2019]. Therefore, a number of questions need to be addressed to develop the banking sector and its potential contribution to the sustainable growth of the economy in the context of digitalization.

This study attempted to assess the impact of FinTech solutions on the development of bank lending for different types of loans. In particular, the impact of the use of digital technologies and mobile devices (smartphones) in banks on the dynamics of bank loans was analyzed. The main research questions are the following: Do the market structure and competition influence the effects of macroprudential policy and microlevel policies in the EU's banks? What is the impact of the new technology on credit growth? Can we capture differences among EU countries and for different types of loans?

To answer the above questions, we attempt to verify Hypothesis H: *new digital technologies mainly affect the development of household loans*.

In this paper, as in other studies [i.e., Kouretas and Pawłowska, 2020], we analyze three categories of bank loans (mortgage, corporate, and consumer loans) and two groups of EU countries. We compare the credit market determinants of loans among the CEE-11 countries (the Czech Republic, Estonia, Lithuania, Latvia, Poland, Slovakia, Slovenia, Hungary, Bulgaria, Romania, and Croatia) and the determinants among the EU-17 countries (Austria, Belgium, Denmark, Finland, France, Greece, Spain, the Netherlands, Ireland, Luxembourg, Germany, Portugal, Sweden, the United Kingdom, Italy, Malta, and Cyprus). Furthermore, on the basis of the available literature, the channels through which new technologies influence the development of bank loans were defined, and variables were distinguished that can be used as

a proxy for the use of new technologies. It should be noted that the analyzed phenomenon was measured empirically on the basis of collected panel data. However, new digital technologies are being adopted by traditional banks, and product innovations in traditional banks include modern payment systems using applications for mobile devices. Additionally, we can identify nonbank FinTech companies for which digital innovation is their core business. To assess the impact of digital technologies on credit growth in two groups of EU countries, two types of variables in the model (inside and outside the banking sector) are defined concerning FinTech. However, in this study, due to the lack of detailed data on the FinTech lending market in the EU, only the impact of new technologies and digitalization on the lending market was addressed. The variables concerning FinTech come from the payment statistics and electronic banking data from the European Central Bank Statistical Data Warehouse and from the International Monetary Fund and Eurostat. Market structure is covered by concentration in the banking sector (indicators CR5 and HHI)[3]. We also analyzed the impact of foreign ownership on digitization [De Haas, van Lelyveld, 2012; Cull et al., 2013].

The main contribution of our research in relation to the existing literature on the apparent link between the banking sector's structure, new technology and credit growth is that we study this phenomenon separately for different types of bank loans. We try to confirm that new technology has an impact on credit growth, particularly for households.

This study consists of three parts and a summary. The first part is the introduction. The second is a broad literature review concerning FinTech and lending, the link between FinTech and market structure, and financial stability. The third part presents the data and empirical models. The summary provides our conclusions. The major contribution of this study to the literature is to find the differences in the credit market determinants for different types of loans (corporate, consumer, and residential mortgage loans) between the CEE-11 countries and the other EU countries in the context of the FinTech sector. This study is the first comprehensive study on the determinants of different loan types in the context of new technology concerning the FinTech sector and fills a gap in the macroprudential literature.

[3] The share of the five largest banks' total assets (CR5); the Herfindahl-Hirschman index (HHI) for assets (the sum of the squares of the market share of individual banks).

2. Motivation and Existing Literature

Advances in information technologies have transformed banking practices and products. Financial innovation known as FinTech has become the main factor in the transformation of the financial sector on a global scale and has impacted the level of competition due to the possibility of increasing the bank's market power, creating new business models, and introducing processes and products. Entities creating new business models based on FinTech (including technology based on distributed ledgers or artificial intelligence) have an impact on the credit market. The offerings of virtual banks include attractive terms and conditions with bank accounts, such as free-of-charge account maintenance, free payment cards, free bank transfers, and free ATM services. Technical solutions also have become one of the important internal factors enabling banks to streamline their management system, improve work quality, and create new distribution channels.

2.1. FinTech: basic definition

FinTech is part of the process of evolving financial innovation, which has theoretically been shown to be risky but of value [e.g., Thakor, 2012, 2020], with supporting recent evidence that it yields substantial value to investors. The Financial Stability Board (FSB) defines FinTech as "technologically enabled financial innovation that could result in new business models, applications, processes, or products with an associated material effect on financial markets and institutions, and the provision of financial services." For the banking sector, FinTech opens new fields of competitiveness. It brings both positive and negative factors that may influence bank operations, especially in money transfers and credit. The positive factors may include chances to increase efficiencies and profit margins. As a negative factor, FinTech companies deprive banks from clients who seek cheaper and faster solutions for borrowing, transferring, and investment advisements. Thakor [2020] made an attempt to scientifically analyze this phenomenon in an illustrative manner. He presented a synthetic definition of FinTech: "... FinTech is the use of technology to provide new and improved financial services" [Thakor, 2020, p. 1]. According to Thakor [2020], the essence of FinTech is to use technology to deliver new or improved financial services. As mentioned before, there is no uniform market definition of the FinTech sector. It is defined by the services and products it cocreates. As the functionality of solutions employing FinTech technologies grows, its definition broadens. It has been found that the number of areas FinTech is entering continues to grow [Pawłowska and Staniszewska, 2020]. The FinTech sector is growing and is being implemented in markets all over the world, although not evenly. The factors influencing the faster development of this sector include the unmet demand for financial services, especially in developing countries. In other economies,

this may be associated with the high cost of traditional bank financing, a favorable regulatory and macroeconomic environment, and demographic factors. The younger part of society shows greater trust and a greater propensity to use the services of FinTech companies [BIS, 2020].

The FinTech sector includes, *inter alia*, innovative supervised entities [e.g., banks, payment institutions, insurance undertakings, investment companies) and unsupervised entities, often startups just launching their activity [PFSA, 2017; 2019]. As happened at the beginning of the introduction of online banking, FinTech technology also can be used by banks in two ways. First, it can serve as an additional distribution channel for them. Second, we can identify nonbank FinTech companies for which digital innovation is their core business. Finally, "FinTech" can be broadly defined as technologically possible financial innovations that lead to the emergence of new business models, processes, or products and have an impact on financial markets, financial institutions, and the provision of financial services [FSB, 2017]. The concepts related to the functioning of the FinTech sector are FinTech credit, which was defined as any lending activity supported by electronic (online) platforms that are not supported by commercial banks. This approach is in line with that of CGFS-FSB [2017]. FinTech credit volumes also are greater in countries with less stringent banking regulations. There is no internationally valid definition of a FinTech loan. It is broadly defined to cover all loans that are supported by electronic (online) platforms and not operated by traditional commercial banks. The above definition of a FinTech loan covers all lending activities supported by online electronic platforms (as "peer-to-peer (P2P) lenders").

Among the entities using digital technologies on the loan and lending market, one should distinguish large enterprises, the so-called BigTechs. The term FinTech refers to enterprises using technological innovations in financial services, while large technology companies (BigTechs) offer financial services as part of their activities, which have a much wider scope [BIS, 2019]. BigTech companies have many lines of business [cf. Vives, 2017, p. 101]. Notably, technological giants such as Amazon, Apple, and Google, which already operate in the lending market, have great potential for the development of financial services because they have access to a huge amount of customer data. Traditional banks collect information on customer credit histories over a long period of time, while BigTech companies can use their advantage on the lending market thanks to nonfinancial data about their customers [BIS, 2020]. It should be noted that the activities of banks are influenced differently by threats and opportunities from BigTech companies than by FinTech companies [Tanda and Schena, 2019, Carletti et al., 2020]. FinTech customers are mainly retailers, while large BigTech technology companies operate mainly in

the financial sectors oriented at markets in China, the United States, Japan, Korea, and Europe, e.g., in the United Kingdom [BIS, 2020][4].

2.2. FinTech and banking sector

Undoubtedly, technical changes have a huge impact on the shape of retail and corporate banking at the moment. Consumers, in both developed and emerging market economies, are increasingly turning to digital financial services that are cheaper and more convenient. This is the reason for a new approach to the relationship between the financial sector and the real economy. This phenomenon influences the business models of banks and the level of competition in the market [Claessens et al., 2018, pp. 29–49]. The changing architecture of the financial sector brings new challenges for regulators and companies operating in the financial market. On the one hand, the 2008 financial crisis and its effects resulted in the adoption of many regulatory actions, both on a global scale and in individual market segments (CRD IV package). On the other hand, the development of digital technologies is a source of new risks for the financial sector and its stability. Undoubtedly, the pace of development of the FinTech sector and its wide scope of activities mean that it influences the structure of the banking sector by changing the borrower-lender relationship. By entering the area of activity previously reserved for banks, FinTech companies exert a huge impact on competition in the financial services sector. Traditional banks adapt their business models to digital technologies. Appropriate use of the new technologies enabled banks to increase their competitiveness, which in consequence enhanced the level of competition in the banking industry. In addition, in the banking sector, a directive was implemented for retail banks to standardize the payment services market of the Payment Services Directive (PSD2), and for investment banks and asset managers, the Markets in Financial Instruments Directive (MiFID2) was implemented, which is the basis of EU regulations aimed at improving the competitiveness of EU financial markets and protecting investors by creating a single market for investment services.

It should be noted that the imperfections of the financial market also play a role in the functioning of FinTech lending. FinTech companies, like banks, provide consumer loans, corporate loans, and mortgage loans. Loans granted through them are growing rapidly, although they are still small compared to the loans granted by traditional intermediaries [Claessens et al., 2018]. In the past, the activity of traditional banks focused on customer relations was considered a factor weakening the asymmetry of information between the fund provider and the recipient

[4] In this study, in quantitative research we do not take into account the influence of companies from the BigTech sector on the loan market.

in the loan market [Akerlof, 1970]. Both *ex ante* (negative selection) risk and moral hazard can be mitigated by banks due to their experience in finding and monitoring borrowers [Diamond, 1991]. However, the increasing use of the internet and platforms based on it has made it possible to match lenders and borrowers directly through peer-to-peer (P2P) lending. In this loan model, the intermediation of financial institutions is not required, and contact between lenders and borrowers is provided by a credit platform.

New technologies influence the bank loan market on both the demand and supply sides. On the supply side, as the computing power of computers increases, the use of application programming interfaces on the internet, big data technology, and cloud computing is increasing. The second aspect is regulatory changes stimulating supply on the lending market (e.g., the PSD2 detective). The demand factors include changes in consumer behavior related to the convenience of investing through online and mobile tools, demographic factors, and the level of the development of the economy and the financial market. Younger consumers may have more confidence in FinTech entities, as they may feel that their products are more socially responsible and have greater social value than those of traditional banking [FSB, 2019, pp. 5-10]. The FinTech sector has great potential to ensure greater financing efficiency [Philippon, 2016]. Research shows that competition from FinTech entities and large technology companies is the main factor in introducing new products and confirms that FinTech loans are more widespread in economies with higher financing costs [Bazot, 2018]. It seems, however, that trust is the factor distinguishing traditional banks and providing them with regular customers [Scardovi, 2017, p. 31, Thakor, 2020].

2.3 Influence of FinTech on market structure

The industrial organization approach to banking (IOAB) is a theory concerned with the issue of measuring competition in the banking sector [cf., Degryse et al., 2009; Vives 2016, Bikker & Leuvensteijn, 2014]. The results of the empirical studies concern the direction of the changes in concentration and competition between banks over time. Ratnovski [2013] stressed that banks in advanced economies have high incentives to take risks. In recent years, there have been ongoing debates concerning the economic role of the market structure and size of banks within the banking industry. Furthermore, financial innovations enabled by digital technology, or "FinTech", have started to play an important role in the provision of many financial services. While technological development in finance is not new, progress has arguably sped up in the digital age and has a huge impact on competition. Changes in competition within the banking sector are taking place mainly through two channels: mergers and acquisitions (M&As) and regulations stimulating barriers to entry and exit. New technologies increase the possibility of

entry and exit in the financial market. Fundamental advances in the internet, mobile communications, and information collection and processing have underpinned a range of recent innovations in finance [FSB, 2017, 2019].

FinTech companies influence the structure of the financial services market through the number and size of market participants, entry and exit barriers, and the availability of information and technology to all market participants. According to the FSB [2019, pp. 3-4], financial innovations may affect the structure of financial services as follows: their impact on the profitability of banks; the entry of large, renowned technology companies (BigTech) into the area of financial services; and the provision of important services by third parties. According to Vives [2017], competitors from the FinTech sector put pressure on banks to adapt their traditional business model to current trends and demands. Compared with FinTech companies, banks have two competitive advantages in the financial market: they can borrow at low rates, and they have access to deposits with explicit or implicit insurance by the government. They enjoy privileged access to a stable customer base [Vives, 2017]. This indicates that entering the intermediation industry with new technologies will depend heavily on government regulations and guarantees related to COVID-19.

Along with the development of the FinTech sector, the number of studies on its impact on the bank loan market and the stability of the financial sector by influencing the structure of the lending market is growing. Research efforts are directed at organizing the ever-expanding literature on the development of the sector [e.g., Thakor, 2020] or focusing on a narrow aspect of this phenomenon; for example, Morse [2015] studied social loans, and Buchak et al. [2017] analyzed the housing loan market. The literature on the subject also deals with the issue of the impact of financial innovations on competition in the lending market [Frost, 2020]. An extensive study of competition in the FinTech loan market was presented by Claessens et al. [2018]. One of the main conclusions of this study is the statement that the size of the FinTech loan is negatively correlated with competition in the banking market and the strictness of regulations there [e.g., Besanko, Thakor, 1992]. A different approach suggests that in a competitive market with low financing costs, borrowers have fewer reasons to engage in riskier ventures and that the stability of the banking sector as a whole increases [Boyd & Nicolo, 2005].

2.4 Influence of FinTech on financial stability

Specific to the financial sector is the link between market structure and stability, long recognized in theoretical and empirical research and, most importantly, in the actual conduct of prudential policy toward banks [Claessens, Laeven, 2004, Vives, 2016]. It should be noted that there is no scientific consensus on whether bank competition leads to greater or lesser stability

in the banking sector [cf. Vives, 2016, Goetz, 2018]. On the one hand, competition may enhance financial stability by pushing unstable banks out of the market. On the other hand, competition can encourage banks to take greater risks to become more profitable [Vives, 2016].

Finally, together with the growth of FinTech operations, its impact on the stability of the banking sector will be increasing [e.g., Thakor, 2020, Frost, 2020]. The types of barriers to entry into the banking market are changing. Regulations allow FinTech providers to join the market, while some of the services are reserved for banks. As a rule, large closed networks reduce opportunities for competition. Theoretically, if a full range of services offered by banks is available for new parties, competition will force old financial institutions to adopt new technologies for improving their services and reducing costs [He et al., 2017, Claessens et al. 2018]. Additionally, the development of the FinTech sector in the European Union has attracted the interest of regulators in its influence on financial stability and market structure [BSBC, 2018].

The Financial Stability Committee addresses the following issues: (1) how the FinTech activities fit into the regulatory framework and are in line with the arrangements resulting from the member authorities' approach to FinTech; and (2) what challenge the FinTech sector poses for regulators and supervisors. Some entities are subject to financial reporting regulations but have limited or no obligations at all. As a result, information on licensed FinTech companies may not be directly available in traditional banking statistics [Zetzsche et al., 2017]. Additionally, regulators focus on how to increase cybersecurity, but efforts to do so are not necessarily public, mainly for national security reasons. Although cyber risk does not only concern FinTech, its activity is based on digital solutions, which increases the possibilities of hackers looking for a weak link in the network [cf. FSB, 2017, pp. 23-32]. FinTech is covered by the existing regulations on macrofinancial and microfinance risks. In the context of macrofinancial issues related to systemic importance institutions (SIFIs), it is recommended that SIFIs should be subject to more intensive supervision, which is expected to reduce the likelihood of bankruptcy or collapse and its ensuing impact on the financial system. In the context of microfinance risks associated with FinTech activities, such as credit risk, leverage, and liquidity, FinTech companies may fall under the shadow banking policy framework [FSB, 2017].

While there is agreement among scientists regarding the profound and pervasive implications of new technologies for the financial sector, there is no consensus on the likely future model of financial services delivery. Some believe that the basis is cooperation between traditional banks and new entities from the FinTech sector, including in the form of mergers

and acquisitions. Others believe that new players from the FinTech sector will dominate selected segments of the financial market. It seems, however, that the factor that distinguishes banks and provides them with regular customers is trust and the fact that, unlike new players, they are institutions of public trust [Thakor, 2020]. Due to their nature, it is easier for them to maintain trust. It is asymmetric in nature; it is harder to get than to lose. However, banks appear to be able to survive a crisis of distrust, while for FinTech lenders, this can be difficult due to the nature of their business. Furthermore, considering the impact of the COVID-19 pandemic on the above issues in 2020, it can be concluded that, on the one hand, it contributed to the economic downturn and the decline in banks' results, and on the other hand, it caused the development of sales channels using new FinTech technologies.

3. Data and Model Specification

In this section, we first describe the data and methods of our empirical research. Our research offers both microlevel and macrolevel assessments of the relationship between the market structure, new technology, and credit growth using dynamic panel data regression and panel VAR. Unlike in other studies concerning the development of the credit market, we analyzed the dynamics of three types of loans separately, instead of the total lending in the EU banking sectors. In the analyzed period, the EU economies were under the influence of the GFC and, subsequently, the euro area sovereign debt crisis (before and after the GFC) and before the pandemic crisis. We took the annual bank-level data collected from the BankScope and Orbis Bank Focus databases and merged them with country-level data concerning the macroeconomic situation, the market structure data, and the new FinTech technology. The unbalanced panel covered the 2004–2019 period and included commercial banks, savings banks, and cooperative banks operating in EU-28 countries. Data at the country level concerned the payment sector, the condition of banks, and the situation in the real sphere of EU economies. Macroeconomic data concerning economic growth (i.e., GDP data) came from Eurostat, and concentration data came from the European Central Bank (ECB) Statistical Data Warehouse. Additionally, data on the FinTech sector came from various publicly available data sources: Eurostat, the ECB Statistical Data Warehouse and the IMF.

We analyzed bank-level data of the following loans, denominated in euros: residential mortgage loans (household lending for house purchase), consumer loans (lending to households for purposes other than house purchase), and corporate loans (lending to nonfinancial corporations).

Finally, we try to identify the channels of influence of new digital technologies in the financial market on the structure of the banking sector and the dynamics of bank lending. Furthermore, in the micro model, we also tested the impact of macroprudential measures (i.e., higher capital requirements) on the credit supply. We proxied the economic cycles using GDP growth in each EU country.[5] Foreign bank presence was calculated as a binary variable (*For*) at the bank level on the microlevel. In both assessments, we evaluated the dependence of credit growth on the following country-level variables:

- market concentration measures, including the concentration ratio for the five largest banks as the share of the five largest banks in total banking sector assets (*CR5*) and the Herfindahl-Hirschman Index for assets (*HHI*);
- new FinTech technology measures. The vector of variables that take into account digital technology is broken down into variables inside the banking sector (*FinTech1*) and outside the sector (*FinTech2*). The following variables are considered to be variables describing new technology: value of payment with a payment card; share of the number of individuals using the internet for online banking in the population, with internet banking understood as electronic transactions, such as bank transfers or direct debits, as well as checking the account balance or history; ATMs allowing authorized users to withdraw cash, with authorization usually made via a payment card and three types of variables used (total number of ATMs, number of ATMs per 1,000 km2, and number of ATMs per 100,000 adults); share of individuals using the internet in the population; number of mobile phone subscriptions per 100 people; internet access from a mobile device, laptop, or notebook (percent of people); and number of secure web servers per 1 million people.

It should be noted that the banking sectors of EU countries are not homogeneous [Pawłowska, 2016]. First, an important feature of the banking sectors of CEE countries was a high level of concentration and foreign presence [Arena et al., 2007], as opposed to the highly developed banking sectors in Western Europe, and postcommunist countries have played the role of a host country for banks from a number of countries in Europe [Pawłowska et al., 2015]. Since the GFC (i.e., 2010–2019), the CEE banking sector has continued to be highly concentrated and characterized by high levels of foreign capital, whereas in the banking sectors of Western European countries, the level of foreign capital is relatively low and the concentration is more

[5] Consumption for households or investment (i.e., gross capital formation) indicators for enterprises would be other interesting alternatives.

diversified. Kouretas and Pawłowska [2020], using the methodology of panel regression GMM, found differences in the determinants of the growth of different types of bank loans (total gross loans, as well as corporate, consumer, and residential mortgage loans) for two groups of countries after the global financial crisis (EU-17 and the CEE-11).

Therefore, in this study, we decided to split the research sample of EU countries into two groups (CEE-11 countries and EU-17 countries): host countries and home countries. The group of EU-17 countries consists of Austria, Belgium, Denmark, Finland, France, Greece, Spain, the Netherlands, Ireland, Luxembourg, Germany, Portugal, Sweden, the United Kingdom, Italy, Malta, and Cyprus (i.e., the EU-15 extended by Cyprus and Malta). The CEE-11 countries are the Czech Republic, Estonia, Lithuania, Latvia, Poland, Slovakia, Slovenia, Hungary, Bulgaria, Romania, and Croatia, i.e., the EU-12 decreased by Cyprus and Malta and extended by Croatia.

3.1 Single-equation panel regression model

To investigate the impact of FinTech financial innovation on the development of bank loans in the EU, we indicate the channels of influence of new digital technologies in the financial market on the structure of the banking sector and the dynamics of bank lending. In particular, the impact of the use of digital technologies and mobile devices (smartphones) in banks on the dynamics of different types of bank loans was analyzed. To verify the following Hypothesis H, i.e., *new digital technologies mainly affect the development of household loans,* the study was broken down into three types of loans: residential mortgage loans (*morloans*), corporate loans (*corloans*), and consumer loans (*conloans*). Empirical measurement of the analyzed phenomenon with the use of econometric technologies was performed on constructed panel data containing individual annual data from banks in the EU for 2004–2019.

To verify the research hypothesis, an econometric model was constructed. The model also allows us to investigate whether foreign ownership stimulates the FinTech sector. Based on the above assumption, the micro baseline model was calculated based on Equation (1) as follows:

$$\Delta\, Loan_{i,t} = \gamma_i + \mu_t + \alpha_0 \Delta\, Loan_{i,t-1} + \sum_{j=1}^{k} \beta_j X_{i,t} + \alpha_1 For_{i,t} + \alpha_2 MS_{c,t} + \alpha_3 Fintech1_{c,t} + \alpha_4 Fintech2_{c,t} + \alpha_5 (For_{i,t} * Fintech1_{c,t}) + \alpha_6 (MS_{c,t} * Fintech1_{c,t}) + \alpha_7 (MS_{c,t} * Fintech2_{c,t}) + \alpha_8 (MS_{c,t} * GDP_{c,t}) + \varepsilon_{i,t} \quad (1)$$

where: $\Delta\, Loan_{it}$ - which is the annual change in the stock of total gross loans (in logs) to particular sector: residential mortgage loans (*morloans*), corporate loans (*corloans*), consumer loans (*conloans*) for each bank *i* and for each year *t*. Loans are express in euro. The coefficient $\gamma_i + \mu_t$ is a constant term; $\varepsilon_{i,t}$ denotes the error in the model; and α_k, β_j(where *k = 0,..., 8* and *j = 1,...,4*) are the regression coefficients.

The following independent variables were adopted:

$X_{i,t}$ – vector of control variables that reflect the results of banks as *Bank-Specific Variables*$_{it.}$ that captures the bank performance and macroprudential instruments to which a bank is exposed to credit risk through ex ante balance sheet composition and market access. In regressions, the following variables were adopted for each bank *i* for each year *t*:

- the ratio of banks' capital to assets ratio (*Tier1*), which is an indicator of bank risk behavior (the higher the capital ratio, the greater the risk aversion);
- bank profitability ratio, *ROA* and *ROE*[6];
- loan to asset ratio (*LTA*);
- loan to deposit ratio (*LTD*);
- banking sector size as a logarithm of the total banking sector assets (*LA*).

Moreover, a binary variable defining foreign ownership was adopted as the measure of foreign capital. It was constructed on the basis of information on the bank's ownership structure, which specifies the bank's ownership type ($For_{i,t}$). The value of the variable is one if the bank is foreign and zero otherwise for each bank *i* and for each year *t*.

$MS_{c,t}$ – vector defining concentration in banking sectors in EU countries; the indicators determining the market structure are concentration ratios derived from ECB statistics, for country c in year t; banking sector concentration is defined as the share of the five largest credit institutions in total assets (CR5), and the Herfindahl-Hirschman ratio for assets is the sum of the squares of the market share of individual banks (HHI) for each year t in country c.

$GDP_{c,t}$ – GDP increase in country *c* in year *t* to capture the cyclical factors and macroeconomic situation.

When examining the influence of the FinTech sector on the development of the lending market, it should be distinguished whether we are examining the FinTech sector within the banking sector (new technologies used by traditional banks) or as an external element outside the banking sector, because the FinTech technology can be used by traditional banks as an additional distribution channel. The vector of variables that take into account the new FinTech technology is broken down into variables inside the banking sector (*FinTech1*) and outside the sector (*FinTech2*). Finally, after examining the correlation7 between the variables as the

[6] ROE was used for the robustness check in the regressions based on Equation (1).

7 The correlation coefficients between all variables in the model are estimated for the sample of EU-17 and CEE-11 and for all EU-28 through the period 2004–2019. However, calculations of Spearman's rank correlation coefficients are not presented.

variables describing the $FinTech1_{c,t}$ sector from *within the banking sector* for each year *t* in a given country *c*, we adopted:

- share of the number of individuals using the internet for online banking in the population (*Internet1*);
- number of ATMs per 1000 km^2 (*ATM*)[8];
- logarithm of the value of payment by payment card (*Card*)[9];

As variables describing the $FinTech2_{c,t}$ sector from *outside the banking sector* for each year *t* in a given country *c,* the following were adopted:

- share of the number of individuals using the internet in the population (*Internet2*)[10];
- number of mobile phone subscriptions per 100 people (*Mobile1*);
- number of mobile access to banking accounts (% of individuals) (*Mobile2*),
- number of secure web servers per 1 million people (*server*).

The model also takes into account the interactions between variables to estimate the influence of the development of the FinTech sector, market structure indicators, and foreign ownership and cyclical factors. There are the following conditions of interaction between the variables in the model: $(For_{i,t} * FinTech1_{c,t})$, $(MS_{c,t} * FinTech1_{c,t})$, $(MS_{c,t} * FinTech2_{c,t})$, $(MS_{c,t} * GDP_{c,t})$.

Finally, Equation (1) was estimated for the CEE-11 and EU-17 countries and for all EU-28 countries, broken down into three types of credit: residential mortgage loans (*morloans*), corporate loans (*corloans*), and consumer loans (*conloans*). For our estimations, we used the GMM system, a two-step robust estimator (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998; Windmeijer, 2005). To check the correctness of the mode, we used several tests proposed by Arellano and Bond (1991) and Arellano and Bover (1995): the Hansen test of overidentifying restrictions, which tests the overall strength of the instruments for a two-step estimator, and the Arellano-Bond tests for AR(1) and AR(2) in the first differences.

Table A1 in the appendix presents the descriptive statistics of the variables selected for the model estimation. Table A2 shows the results of panel regressions using Equation (1) for six estimates for CR5. Columns [1, 2, 3] present estimates in which the dependent variable was

[8] This variable embraces ATMs both with a cash withdrawal function and with a credit transfer function.
[9] This variable covers all payments made with cards issued in the reporting country regardless of the cardholder's residency or the location of the payment.
[10] Individuals using the internet (as % of population). Internet users are individuals who have used the internet (from any location) in the last three months.

a residential mortgage loan. Columns [4, 5, 6] present estimates in which the dependent variable was a consumer loan. Columns [7, 8, 9] present the results of the estimation in which corporate loans were the dependent variable. The estimates, as in the first and second studies, were carried out in three subpanels for the EU-17, CEE-11, and all EU-28 countries. Table 1 shows a positive and significant α_3 coefficient for a housing loan and a consumer loan for the *FinTech1*11 variable defined as the percentage of people using internet banking (*Internet1*). This means that new FinTech technologies had a positive and significant impact on the dynamics of loans in the EU. On the other hand, a negative and significant α_4 coefficient was obtained for a housing loan and a consumer loan for the *FinTech2* variable outside the banking sector: mobile phone subscriptions per 100 people (*Mobile1*). This may mean that new players take some customers away from traditional banks. Moreover, when examining the estimation coefficients with the interaction variables, it was mainly found that the market structure had an impact on consumer loans. In this case, foreign capital turned out to be less important.

In Table A2, a positive and significant coefficient α_2 was also found for the EU-17 (column [2]). This means that concentration, measured in terms of the share of the five largest banks' total assets (CR5), had a positive influence on the growth in mortgage loans mainly in EU-17 countries. On the other hand, in Table A2, a negative and significant coefficient α_2 was found for the CEE-11 (column [4]). Regarding the values of the coefficients for the $X_{i,t}$ vector, concerning the impact of macroprudential policy on credit growth, we found various responses to micro- and macroprudential policy depending on the group of EU countries and the loan type being considered. However, capitalization measured with the *Tier1* ratio had a negative impact mainly on the growth in mortgage loans for EU-17 banks (see Table A2 in columns [3] and [3]). The results confirmed that the deleveraging process in EU banks has an influence on the growth of mortgage loans. We found that this process adversely affected the supply of credit to the real economy. Additionally, profitability impacts the growth of loans in the EU. Profitability was shown to have a positive impact mainly on the growth in mortgage loans for EU-17 banks and on the growth in corporate loans for CEE-11 banks (see Table A2 in column [2]). We also found that the ratio of total deposits to total net loans had a positive and significant influence mainly on mortgage loans. However, the ratio of total net loans to total assets had a positive and significant influence mainly on corporate loans for CEE-11 banks (column [7]). To sum up all of the above results, we have found that there is evidence of an influence of the effects of macroprudential instruments and the new capital regulations on credit growth. Moreover, bank

[11] Similar results were obtained for the ATMs variable located in the ATM's country.

"size", measured in terms of the individual institution's log of total assets (*LA*), positively influenced the growth in mortgage loans for the CEE-11 countries and negatively for the EU-17 countries. This finding confirms the stylized fact that the size of individual banks is an important factor for the growth of different types of loans.

Furthermore, the second specification of the baseline econometric model was estimated. In the second specification, all dependent variables were defined in the same way as in the first model, but instead of the concentration variable (CR5), the model was estimated by the HHI index. The obtained results were carried out to confirm the results of the first specification (see Tables A3). Finally, we found that foreign ownership had an impact mainly for residential mortgage loans, where a significant and negative coefficient α_1 was found for the estimation in Tables A2-A3 (columns [2] and [3]). Surprisingly, we found that foreign ownership and FinTech technology had a negative impact on corporate loans for the CEE-11 in Tables A2-A3 (column [7]).

A useful variable in the model would be the value of FinTech lending in European markets. However, due to significant gaps in the data and the short time series, the variable could not be used in estimates on panel data. Certainly, over time, the values for this variable will be supplemented and more available; then, the FinTech loan value will become a key variable for the analysis of the financial innovation sector. However, more detailed research on the impact of digital technologies on the development of the lending market, due to the complexity of the problem, will require the development of new indicators ensuring proper measurement of FinTech technology [Claessens et al., 2018; BIS, 2019]. An additional problem is the large gaps in data on the FinTech sector for individual national markets. Estimating the impact of COVID-19 on the lending market will be a huge challenge. However, in this context, it seems that traditional banks will be supported by aid programs. In turn, FinTech companies, which are usually startups with a short life cycle, may not receive such aid.

3.2 Results of pVAR model

The linear panel VAR model (panel VAR) can describe the interactions between macroeconomic variables and financial activity indicators and is a standard tool in the literature on macrofinancial linkages. Therefore, to strengthen the results obtained with the use of the GMM model, the results of additional estimates using the pVAR model [Leroy and Lucotte, 2019] are presented in this section. The pVAR model is a combination of the single dynamic equation of the panel model and the VAR model. The VAR models (formulated by Sims [1980]) are multiequation models in which each variable is explained by its own lags and the lags of the other explained variables. To illustrate the differences in credit determinants among

individual EU countries, we compare the response function (impulse response function [IRF][12]), which we estimate under the pVAR model. In the panel vector regression model (VAR panel),[13] the analysis concerns bidirectional, symmetrical, and linear relations between macroeconomic variables. The panel VAR model (pVAR) has the following form[14]:

$$y_{it} = A_0 D_{it} + \sum_{l=1}^{k} A_l y_{it-l} + A_1 X_{it} + \gamma_{i,t}, \quad (2)$$

where y_{it} is the vector of observations on the current values of all k variables in the model; y_{it-l} denotes the matrix of lagged observations, with lag $l > 0$; A_l signifies the matrix of parameters with time constants but bank-specific lagged variables; D_{it} represents the matrix of deterministic equation components (e.g., zero-one variables); $\gamma_{i,t}$ represents the matrix of stationary random variables having an independent normal distribution with zero mean and variance; and A_1 denotes the parameter matrix for variables X_{it} .

It should be noted that Equation 2 accounted for the concentration indicators MS, GDP growth (GDP), and variables that take into account the new FinTech technology (*FinTech2*)[15] on the panel data of 28 European Union countries[16] within the context of pVAR analysis. Spurious or nonsense regression is always an aftermath effect of time series data with a unit root problem. To check stationarity, Fisher-type unit-root tests were used[17].

Additionally, the responses to various disturbances of the model described by Equation (2) are compared by implementing the IRF on the panel data of 28 EU countries for three types of loans: residential mortgage loans *(morloans*), corporate loans *(corloans*), and consumer loans *(conloans*). Their values differ among groups of EU-28 countries and change over time to such an extent that they may affect the mechanism of connections between the real and financial spheres. Their impact on credit growth at various levels of banking sector concentration is presented only for the CR5 index, but similar results are obtained for the HHI. Figure 1 in the appendix illustrates the course of the IRF for three types of loans (residential mortgage, consumer, and corporate loans) with 95% confidence intervals for EU banks. The results show that the values of the response function to the demand impulse are not significant in the case of

[12] The IRFs illustrate how shocks (sudden changes, η_t, current in period *t*, as well as lagged) affect the changes in value *y*, that is, the IRF plot shows the responses of the variables *y* to various impulses in the model disturbance.
[13] Usually, for the purposes of identifying the VAR model, Cholesky decomposition is used.
[14] It should be noted that pVAR models are estimated in packets using the GMM estimator [Holtz-Eakin, Newey, and Rosen, 1988].
[15] As variable *FinTech2* we used the number of mobile access to the banking account (% of individuals) (*Mobile2*).
[16] The same panel data as in case estimation Equation 1.
[17] However, it could be inferred from that MS, GDP and FinTech1 were not stationary in their native form, whereas they became stationary after first differencing. We used the first differences of variables in the Model (2) as well as the first differences of variables concerning three types of loans: *morloans, corloans,* and *conloans*.

corporate loans, while the function follows a similar course in the case of mortgage and consumer loans.

Conclusion

This paper has investigated whether the market structure and digitalization have an impact on credit markets in European banks. This phenomenon was analyzed separately for residential mortgage loans, consumer loans, and corporate loans. Our research contains both microlevel and macrolevel assessments. First, based on a single equation model with bank-level data, we investigated the differences in credit determinants in the context of the situation in the banking sector concerning concentration indicators, foreign ownership, and new technology (FinTech) in the period 2004–2019 between the CEE-11 countries and the EU-17 countries. Second, we studied the impact of the market structure and FinTech in the EU banking sectors as quantified by the impulse response function in an interacted panel VAR setup. A comparative analysis of the determinants of CEE-11 bank loans in relation to those in all EU-28 and EU-17 countries allowed for a positive verification of the research hypothesis, which concerned that new digital technologies mainly affect the development of household loans. Thus, the results of the quantitative survey showed that the use of new technologies in banks has the greatest impact on the dynamics of loans to households, both housing and consumer loans.

This paper contributes to the existing literature in many ways. First, the methods, which were performed separately for residential mortgage loans, consumer loans, and corporate loans, are demonstrative of a sectoral approach in the analysis of macroprudential policy. Second, we confirm the leading role of loans to households in propagating shocks to the financial sector through FinTech. Our study also reveals that there are some heterogeneities between the advanced and transitioning European Union banking sectors.

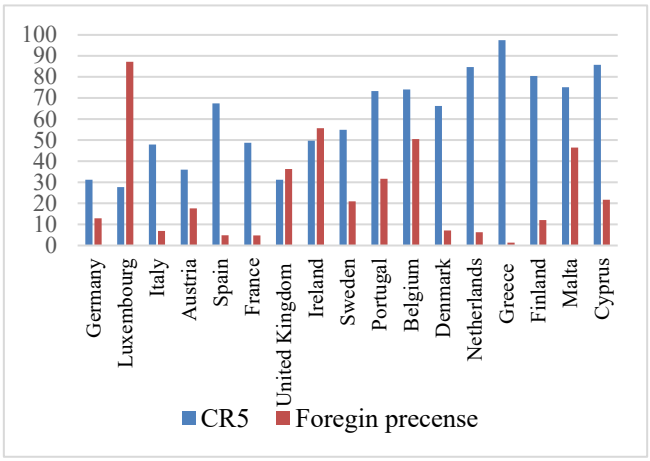
It should be noted that the faster development of the FinTech sector took place in countries where financial services were relatively expensive and unavailable for many customers in the loan and lending market. Furthermore, the COVID-19 pandemic can be said to have caused even faster development of digital technologies and the FinTech sector. On the one hand, the development of the pandemic contributed to the economic slowdown and a decline in the results of traditional banks, and on the other hand, it caused the development of sales channels using FinTech technologies. Thus, new players in the FinTech sector bring many benefits to their customers and the entire financial sector but generate new types of risk. Therefore, it seems that as the sector develops, it will affect the stability of the financial system and will pose

increasingly more challenges for traditional banks and regulators. Our findings confirm the leading role of household loans (especially consumer loans) in intensifying macroeconomic volatility due to the development of new technology and support sectoral- and country-specific approaches in macroprudential policy. Additionally, this paper provides valuable insights for banking supervisors about the impact of market structure and FinTech on the growth of bank loans (residential mortgage, consumer, and corporate loans) in the EU. However, the increase in the amount of statistical data in this area, which would improve the monitoring of this phenomenon and the analysis of the competitive advantage of FinTech providers over traditional banking services, remains an important issue. A further direction of research should be a deeper interpretation of the obtained results based on extended panel data and econometric models such as panel VAR.

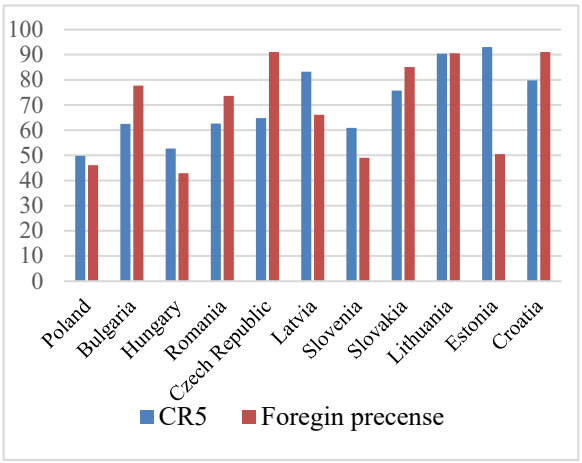
Appendix 1

Figure **1.** Banking Concentration and Foreign Presence for EU-28 in 2019 (%)

A: **EU-17**



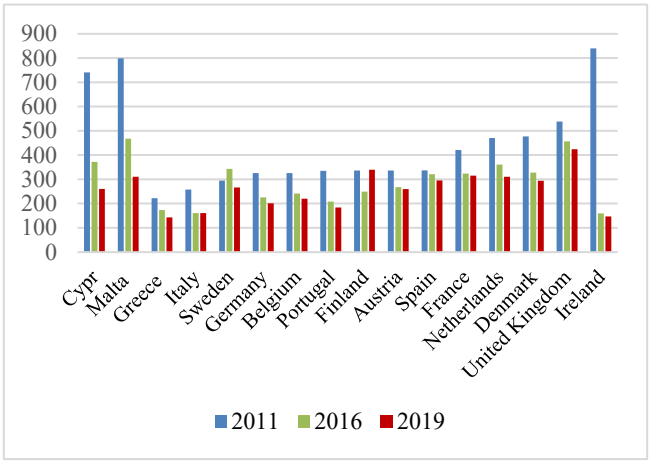
B: CEE-11



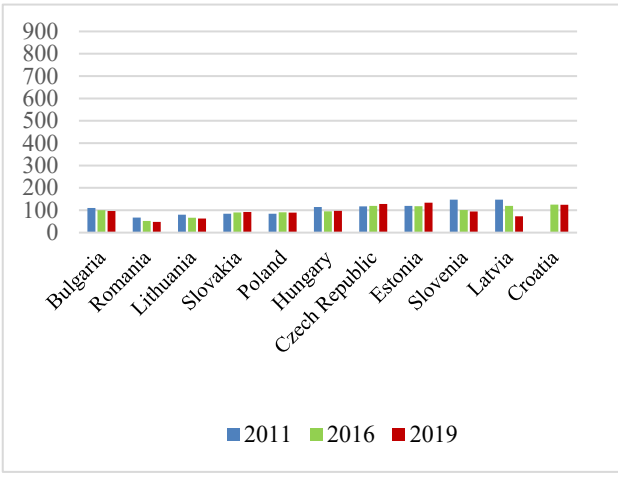
Source: own calculations on the basis of ECB data.

Figure **2.** Assets of the Banking Sectors in relation to GDP in the years 2011, 2016, 2019 (in %)

A: **EU-17**



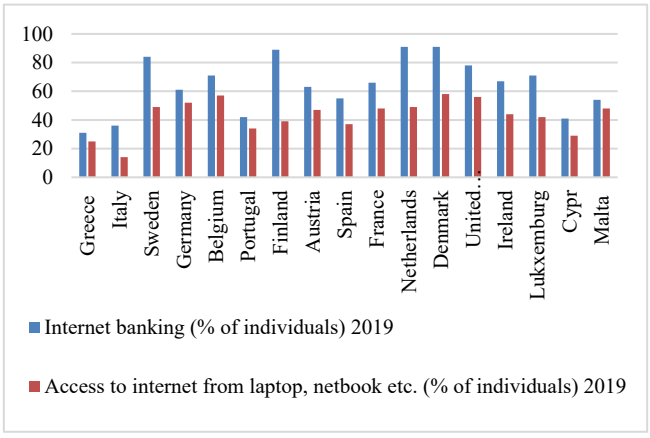
B: CEE-11



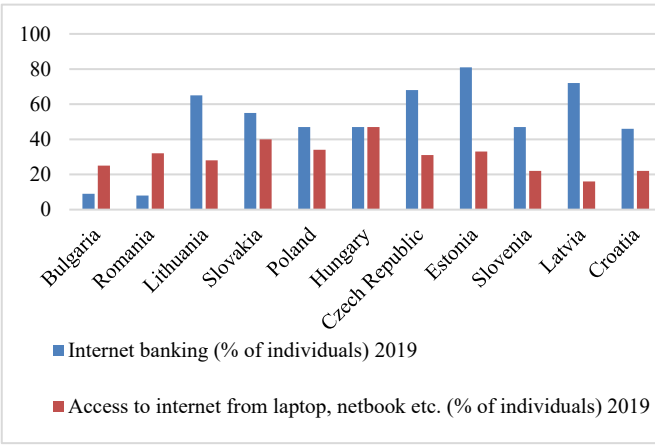
Source: own calculations on the basis of ECB data. Note: Luxemburg in 2019 about 1500%.

Figure **3.** Access to internet and Internet banking (% of individuals) 2019 (in %)

A: **EU-17**



B: CEE-11



Source: own calculations on the basis of IMF data.

Appendix 2

Table A1: Construction of variables and summary statistics of CEE-11, EU-17 and EU-28 of banking sectors data and real economy data. This table provides summary statistics (mean and standard deviation (SD)) for all variables in the model. Data are observed yearly from 2004-2019.

		CEE-11		EU-17		EU-28	
Variables	Definitions	Mean	SD	Mean	SD	Mean	SD
Dependent Variables							
morloans	%annual change in residential mortgage loans (in euro)	0.0547	2.197	0.0579	2.940	0.021	0.729
conloans	%annual change in consumer loans (in euro)	0.0629	1.817	-0.0039	2.740	0.008	0.677
corloans	%annual change in corporate loans (in euro)	0.0944	2.073	0.0401	0.3803	0.047	0.378
Independent Variables							
For	Dummy equal to 1 if bank is foreign-owned	0.564	0.496	0.123	0.329	0.151	0.358
ROA	Return on Assets	0.306	9.129	0.476	3.396	0.468	4.103
Tier 1	Tier 1 capital/Risk-weighted assets	17.875	11.929	19.107	19.097	18.998	18.593
Size	Total assets of banks	6.738	2.014	6.711	2.079	6.715	2.075
LTD	Loans to deposit ratio	76.116	51.204	76.644	50.641	76.997	50.441
LTA	Loans to assets ratio	56.669	18.338	57.839	19.258	57.830	19.239
Market Structure Variables							
CR5	Share of the 5 largest credit institutions in total assets	59.437	11.830	35.781	14.947	37.783	15.554
HHI	Herfindahl-Hirschman index is the sum of the squares of the market share of individual banks for assets	0.105	0.055	0.043	0.035	0.048	0.039
Macrovariables							
GDP	the gross domestic product growth rate yoy	3.216	3.539	1.551	2.201	1.577	2.393
GDP percapita	the gross domestic product per capita	8535.6	4025.0	31426	9002.6	30447.	10552.5
Uneployment	% annual change in unemployment rate	5.23	1.90	4.97	2.78	4.998	2.73
New technology variables from inside the banking sector							
ATM	Number of Automated Teller Machines (ATMs).	8966.52	7906.62	44593.1	31732.4	41915.2	32002.9
Card	Number of credit cards	14.409	0.913	16.066	1.201	15.921	1.268
Internet2	Internet banking (% of individuals)	33,170	18,295	49,735	16,063	48,44	16,84
Mobile1	Number of mobile and internet banking transaction	35.829	14.501	50.321	19.608	49.209	19.647
Mobile2	Using mobile for access to banking account (% of individuals)	125.914	14.846	127.641	16.819	127.512	16.686
New technology variables from outside the banking sector							
Internet1	individuals using the Internet	33.17	18.295	49.735	16.063	48.44	16.84
Mobile3	Access to internet from mobile phone (% of individuals)	55.45	21.49	41.76	23.47	49.209	19.65
Server	number of secure servers	4979.0	8052.6	7019.4	11517.3	6860.0	11298.2

Source: own calculations on the basis of ECB, IMF, World Bank, Eurostat data. The dependent variables in the model have been winsorised at the 1% and 99% level.

Table A.2. Model results: GMM estimator for CR5

	CEE – 11	EU-17	EU	CEE – 11	EU-17	EU	CEE – 11	EU-17	EU
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	morloans			*conloans*			*corloans*		
Y_{t-1}	-0.254*	-0.261***	-0.310***	-0.247***	-0.535***	-0.467***	-0.521***	-0.577***	-0.577***
	(0.148)	(0.099)	(0.082)	(0.087)	(0.115)	(0.111)	(0.079)	(0.102)	(0.092)
ROA	-0.033	0.208***	0.182**	-0.053	0.106	0.001	0.157***	0.156	0.184
	(0.068)	(0.075)	(0.081)	(0.087)	(0.119)	(0.078)	(0.041)	(0.169)	(0.156)
Tier1	-0.020	0.077	0.050	0.020	-0.013	0.022	-0.033	0.070**	0.060**
	(0.032)	(0.052)	(0.048)	(0.043)	(0.033)	(0.054)	(0.024)	(0.035)	(0.026)
LTA	-0.000	0.014	0.010	-0.085***	0.001	-0.015	0.046***	0.008	0.001
	(0.012)	(0.017)	(0.017)	(0.023)	(0.017)	(0.033)	(0.013)	(0.045)	(0.042)
LTD	0.000**	-0.000	0.000	-0.001	-0.001	-0.003	0.003	0.002	-0.001
	(0.000)	(0.000)	(0.000)	(0.001)	(0.002)	(0.004)	(0.003)	(0.006)	(0.006)
LA	-0.802	-1.740***	-1.972***	0.548	-1.243	-0.754	-0.578	-1.051	-1.787**
	(0.488)	(0.499)	(0.542)	(1.040)	(1.152)	(1.015)	(0.409)	(1.104)	(0.738)
For	-1.128	-1.195*	-1.110**	-0.529	3.479	1.138	0.458	-0.055	-0.196
	(0.691)	(0.702)	(0.445)	(0.525)	(2.708)	(1.133)	(0.296)	(3.880)	(1.373)
MS	-0.058	0.178***	0.160***	-0.227***	0.051	0.138	0.051	0.058	0.072
	(0.049)	(0.045)	(0.058)	(0.073)	(0.057)	(0.104)	(0.044)	(0.091)	(0.089)
*MS*GDP*	0.000	0.001	0.001**	-0.002*	-0.000	-0.000	0.001**	0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
FinTech1	0.002	-0.021*	-0.017	0.001	-0.051	-0.025	-0.007	0.002	-0.001
	(0.008)	(0.012)	(0.013)	(0.015)	(0.042)	(0.028)	(0.007)	(0.015)	(0.013)
FinTech2	-0.121	0.062	0.045	0.032**	0.002	-0.008	0.058	-0.011	-0.008
	(0.090)	(0.040)	(0.035)	(0.013)	(0.011)	(0.018)	(0.050)	(0.053)	(0.057)
*FinTech1*For*	0.018	0.009	0.010	-0.312***	0.019	0.063	-0.013*	0.009	0.005
	(0.013)	(0.010)	(0.007)	(0.090)	(0.038)	(0.065)	(0.007)	(0.059)	(0.032)
*FinTech1*MS*	0.002	-0.001**	-0.001*	0.004***	-0.000	-0.001	-0.001	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
*FinTech2*MS*	-0.000	-0.000	-0.000	0.000	-0.000	-0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No. of obs	229	1,803	2,032	473	1,867	2,340	453	1,225	1,678
No. of ID	88	787	875	179	815	994	169	486	655
AR1 test (GMM)	0.354	0.271	0.483	0.287	0.491	0.349	0.710	0.341	0.143
AR2 test (GMM)	0.714	0.066	0.106	0.334	0.228	0.193	0.156	0.275	0.185
Hansen test	0.812	0.124	0.102	0.401	0.162	0.383	0.506	0.321	0.359

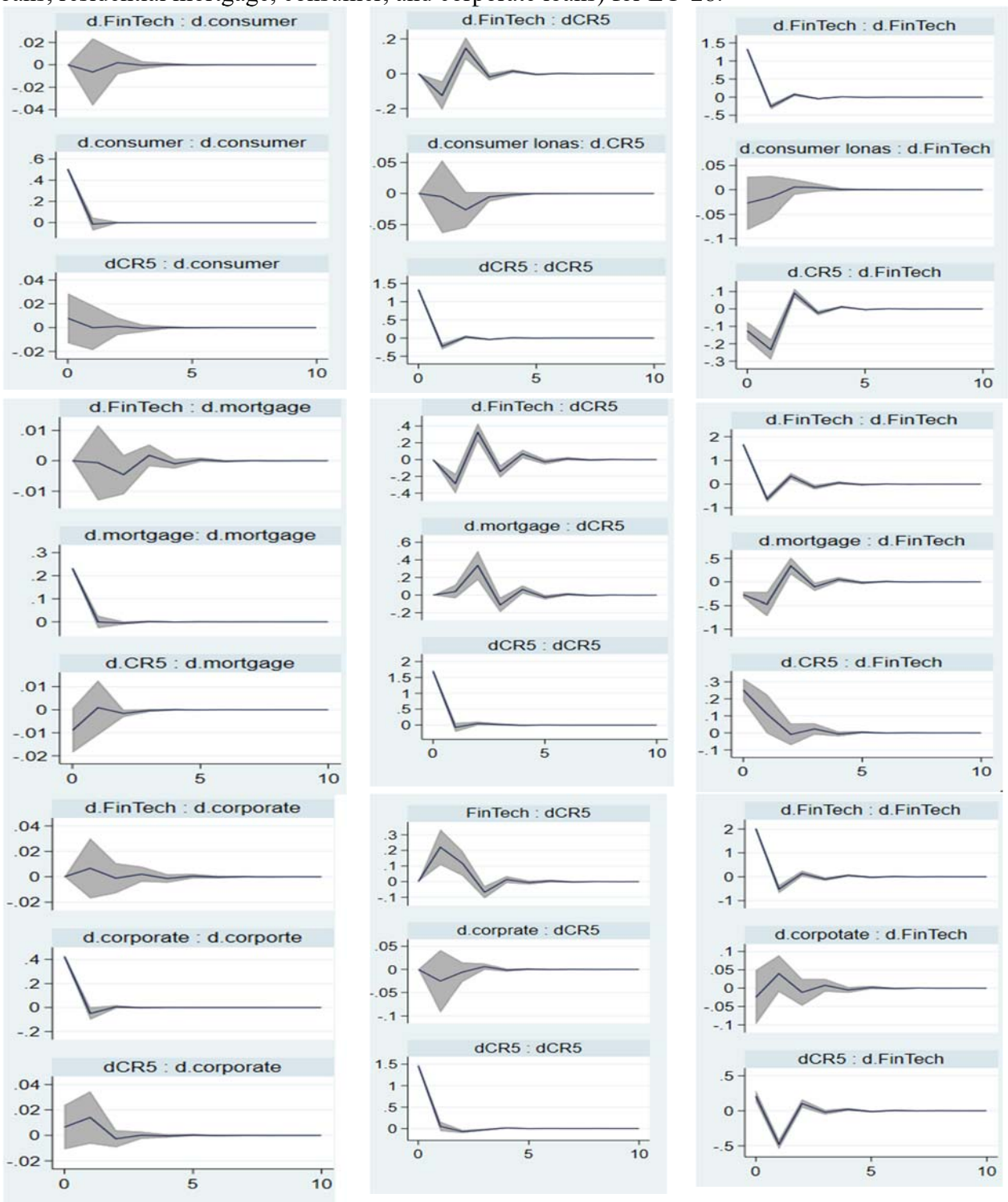
Source: own calculations. Note: the dependent variable Y is growth rate of :residential mortgage loans (*morloans*), consumer loans (*conloans*), corporate loans (*corloans*). For is foreign bank dummy variable MS is CR5 ratio (share of the 5 largest credit institutions in total assets). *Tier1, ROA, LTA, LTD, LA* denote banking control variables defined in table A1. GMM is two-step generalized method of moments estimation, two-step difference GMM estimator. AR(1)—Arellano-Bond test for AR(1) in first differences. AR(2)—Arellano-Bond test for AR(2) in first differences. The Hansen test—the test for over-identifying restrictions in GMM. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table A.3. Model results: GMM estimator for HHI

	CEE – 11	**EU-17**	**EU**	**CEE – 11**	**EU-17**	**EU**	**CEE – 11**	**EU-17**	**EU**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		morloans			*conloans*			*corloans*	
Y_{t-1}	-0.229*	-0.338***	-0.359***	-0.218**	-0.557***	-0.490***	-0.218**	-0.600***	-0.580***
	(0.115)	(0.081)	(0.073)	(0.090)	(0.120)	(0.117)	(0.090)	(0.113)	(0.097)
ROA	0.016	0.245***	0.222**	0.151	0.064	0.165	0.151	0.225	0.232
	(0.064)	(0.085)	(0.087)	(0.144)	(0.158)	(0.147)	(0.144)	(0.187)	(0.187)
Tier1	-0.017	-0.026	-0.038***	-0.050	0.009	0.043	-0.050	0.071	0.081*
	(0.036)	(0.018)	(0.013)	(0.058)	(0.048)	(0.053)	(0.058)	(0.051)	(0.044)
LTA	0.001	-0.002	-0.004	-0.120***	0.006	-0.006	-0.120***	0.007	0.015
	(0.013)	(0.022)	(0.017)	(0.026)	(0.037)	(0.039)	(0.026)	(0.040)	(0.031)
LTD	0.001***	0.000	0.000	-0.001	-0.000	-0.002	-0.001	-0.003	-0.004
	(0.000)	(0.000)	(0.000)	(0.001)	(0.005)	(0.002)	(0.001)	(0.014)	(0.010)
LA	-0.480	-1.694**	-1.779***	0.937	-1.668	-1.049	0.937	-1.102	-1.554*
	(0.427)	(0.707)	(0.633)	(1.053)	(1.730)	(1.242)	(1.053)	(1.259)	(0.862)
For	-0.991*	-0.531	-0.393	-0.044	5.781	1.109	0.157	-0.041	0.160
	(0.584)	(0.485)	(0.543)	(0.703)	(4.556)	(1.278)	(0.639)	(0.338)	(0.396)
MS	-10.901	46.616**	52.177**	-39.737	49.496	-5.308	-0.044	0.615	0.152
	(32.617)	(20.362)	(21.433)	(33.215)	(44.755)	(52.679)	(0.703)	(2.958)	(1.076)
*MS*GDP*	0.642	-0.168	0.136	0.157	-0.278	0.269	-39.737	2.545	6.276
	(0.557)	(0.248)	(0.250)	(0.639)	(0.523)	(0.630)	(33.215)	(40.535)	(44.328)
FinTech1	-0.001	0.006	-0.001	-0.004	0.004	-0.007	-0.008	-0.007	-0.006
	(0.006)	(0.008)	(0.012)	(0.014)	(0.013)	(0.016)	(0.017)	(0.041)	(0.022)
FinTech2	-0.044	-0.001	0.016	-0.123**	-0.000	0.016	-0.004	0.010	0.003
	(0.035)	(0.015)	(0.026)	(0.050)	(0.036)	(0.036)	(0.014)	(0.015)	(0.012)
*FinTech1*For*	0.018	0.001	-0.001	-0.008	-0.097	-0.029	-0.123**	-0.047	-0.034
	(0.013)	(0.008)	(0.008)	(0.017)	(0.081)	(0.031)	(0.050)	(0.032)	(0.038)
*FinTech1*MS*	0.329	-0.192*	-0.202	0.724**	-0.128	-0.135	0.724**	0.104	0.079
	(0.224)	(0.103)	(0.187)	(0.360)	(0.278)	(0.203)	(0.360)	(0.242)	(0.223)
*FinTech2*MS*	-0.103	-0.210*	-0.246**	0.098	-0.222	0.197	0.098	-0.096	-0.094
	(0.212)	(0.114)	(0.105)	(0.130)	(0.231)	(0.360)	(0.130)	(0.197)	(0.218)
No. of obs	229	1,803	2,032	473	1,867	2,340	453	1,225	1,678
No. of ID	88	787	875	179	815	994	169	486	655
AR1 test (GMM)	0.033	0.149	0.109	0.404	0.415	0.141	0.150	0.479	0.384
AR2 test (GMM)	0.673	0.481	0.293	0.223	0.444	0.242	0.209	0.283	0.294
Hansen test	0.957	0.475	0.312	0.420	0.449	0.493	0.582	0.645	0.774

Source: own calculations. Note: the dependent variable Y is growth rate of :residential mortgage loans *(morloans*), consumer loans (*conloans*), corporate loans (*corloans*). For is foreign bank dummy variable MS is HHI (the Herfindahl-Hirschman index). *Tier1, ROA, LTA, LTD, LA* denote banking control variables defined in table A1. GMM is two-step generalized method of moments estimation, two-step difference GMM estimator. AR(1)—Arellano-Bond test for AR(1) in first differences. AR(2)—Arellano-Bond test for AR(2) in first differences. The Hansen test—the test for over-identifying restrictions in GMM. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Figure 1. The impulse response function (IRF) for three types of loans (consumer loans, residential mortgage, consumer, and corporate loans) for EU-28.



Source: own calculations using the STATA program. IRF at 95th percentiles; impulse: response.

References

Akerlof G. [1970], The market for 'lemons': quality uncertainty and the market mechanism, „The Quarterly Journal of Economics", 84(3), 488–500.

Arellano M., Bond S.R. [1991], Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations, *Review of Economic Studies,* 58, 277–297.

Arena, M., Reinhart, C., Vázquez, F.F., [2007], The lending channel in emerging economies: are foreign banks different? *IMF Working Papers, 07.*

Boobier T. [2020], *AI and the Future of Banking*, Wiley.

Bazot G., [2018], Financial Consumption and the Cost of Finance: Measuring Financial Efficiency in Europe (1950–2007), Journal of the European Economic Association, European Economic Association, 16[1], 123-160.

BCBS [2018], *Sound practices: implications of fintech developments for banks and bank supervisors*, Basel Committee on Banking Supervision, https://www.bis.org/bcbs/publ/d431.pdf.

Bikker J.A., Leuvensteijn, M., [2014], A new measure of competition in the financial industry. Routledge, London.

BIS [2019], *Bigtech in finance: opportunities and risks*, Annual Economic Report, Chapter III, Bank for International Settlements, https://www.bis.org/publ/arpdf/ar2019e3.pdf.

BIS [2020], *Central banks and payments in the digital era*, „BIS Annual Economic Report", Chapter III, Bank for International Settlements, https://www.bis.org/publ/arpdf/ar2020e3.pdf.

Besanko D., Thakor A.V. [1992], *Banking deregulation: allocation consequence of relaxing entry barriers*, „Journal of Banking & Finance", 16, 909–932.

Blakstad S., Allen R. [2018], FinTech *Revolution Universal Inclusion in the New Financial Ecosystem*, Palgrave Macmillan.

Buchak G., Matvos G., Piskorski T., Seru A. [2018], *Fintech, regulatory arbitrage, and the rise of shadow banks*, „Journal of Financial Economics", 130(3), 453–483.

Boyd, J., Nicoló, G.D. [2005], The theory of bank risk taking and competition revisited. *J. Financ, 60 (3),* 1329–1343.

Carletti E., Claessens S., Fatás A., Vives X., [2020], *The bank business model in the post-Covid-19 world*, Centre for Economic Policy Research, 18 June, https://voxeu.org/article/bank-business-model-post-covid-19-world.

Cecchetti S., Mohanty M., Zampolli F. [2011], The real effects of debt, *BIS Working Papers* No. 352.

Claessens P., Laeven L. [2004], What drives bank competition? Same international evidence, *Journal of Money, Credit, and Banking*, 36(3), 564–583.

Claessens, S., Frost, J., Turner, G., & Zhu F. [2018]. FinTech credit markets around the world: size, drivers and policy issues. BIS Quarterly Review, September, 29–49.

CGFS-FSB [2017], *FinTech credit, market structure, business models and financial stability implications*, Committee on the Global Financial System of Bank for International Settlements, Financial Stability Board, https://www.bis.org/publ/cgfs_fsb1.pdf.

Cull R., M. S. Martinez Pería [2013], Bank Ownership and Lending Patterns during the 2008–2009. Financial Crisis Evidence from Latin America and Eastern Europe, *Journal of Banking and Finance,* 2013, vol. 37 (12), 4861–4878.

Degryse, H., Ongena, S., [2008], Competition and regulation in the banking sector: A review of the empirical evidence on the sources of bank rents. In Thakor, A. V., Boot, A. (Eds.), Handbook of Financial Intermediation and Banking Elsevier Science, 483–554.

De Haas R., van Lelyveld I. [2012], Foreign banks and credit stability in Central and Eastern Europe. A panel data analysis, *Journal of Banking and Finance*, 2006, vol. 30 (7), 1927–1952.

He D., Leckow R., Haksar V., Mancini-Griffoli T., Jenkinson N., Kashima M., Khiaonarong T., Rochon C., Tourpe H. [2017], *Fintech and financial services: initial considerations*, IMF Staff Discussion Note, SDN/17/05.

Holtz-Eakin, D., W. Newey, H. S. Rosen, [1988], Estimating vector autoregressions with panel data. Econometrica 56, 1371-1395.

Diamond D. [1991], *Monitoring and reputation: the choice between bank loans and directly placed debt*, „Journal of Political Economy", 99, 689–721.

Frost J. [2020], *The economic forces driving fintech adoption across countries*, BIS Working Papers, 838, February.

FSB [2017], *Financial stability implications from FinTech: supervisory and regulatory issues that merit authorities' attention*, Financial Stability Board, https://www.fsb.org/wp-content/uploads/R270617.pdf.

FSB [2019], *FinTech and market structure in financial services: market developments and potential financial stability implications*, Financial Stability Board, https://www.fsb.org/wp-content/uploads/P140219.pdf.

Fungacova, Z., Solanko, L., Weill, L., [2014], Does competition influence the bank lending channel in the Euro area? J. Bank. Finance 49, 356–366.

Goetz, M.R. [2018]. Competition and bank stability. *J. Financ. Intermed. 35,* 57–69 Part A, July.

Goodhart Ch., Tsomocos, D.P. [2019], Financial Regulation and Stability: Lessons from the Global Financial Crisis, Edward Elgar Publishing, Cheltenham, UK & Northampton, MA, USA.

Kouretas G., Pawłowska M. [2020], *Does change in the market structure have any impact on different types of bank loans in the EU?*, „Journal of International Financial Markets, Institutions and Money", 65(C), 101165.

Kouretas G., Pawłowska M., Szafrański G. [2020], *Market structure and credit procyclicality: lessons from loan markets in the European Union banking sectors*, „Economic Modelling", 93, 27–50.

Laeven L., Ratnovski L., Tong H. [2016], Bank size, capital, and systemic risk: Some international evidence, *Journal of Banking & Finance* No. 69, 25-34.

Leroy A., Lucotte Y., *Is there a competition-stability trade-off in European banking?*, Journal of International Financial Markets, Institutions and Money, Volume 46, January 2017, 199-215.

Morse A. [2015], *Peer-to-Peer Crowdfunding: Information and the Potential for Disruption in Consumer Lending*, „Annual Review of Financial Economics", 7(1), 463-482.

Nicoletti, B. [2017]. *The future of Fintech: Integrating finance and technology in financial services*. Palgrave Studies in Financial Services Technology, Palgrave Macmillan, Cham, Switzerland.

Pawłowska M. [2016], Does the Size and Market Structure of the Banking Sector have an Effect on the Financial Stability of the European Union? *The Journal of Economic Asymmetries* (4), 112-127.

Pawłowska M., Staniszewska A. [2021], Impact of Fintech on the Level of Competition in the EU Banking Sector, [w:] Z. Ftiti, H. Ameur, W. Louhichi (red.), Financial and Economic Systems. Transformations and New Challenges, World Scientific, 537–560.

Petralia K., Philippon T., Rice T., Véron N. [2019], *Banking Disrupted?*, Financial Intermediation in an Era of Transformational Technology, International Center for Monetary and Banking Studies (ICMB), CEPR.

Philippon T. [2019], *The Great Reversal: How America Gave Up on Free Markets*, Belknap Press.

Ratnovski L. [2013], *Competition policy for modern banks*, IMF Working Paper, 13/126, https://ssrn.com/abstract=2270288.

Scardovi, C. [2017], Digital transformation in financial services. Springer: London.

Sims C. A. [1980], Macroeconomics and Reality, Econometrica Vol. 48, No. 1, 1-48.

Vives X. [2016], *Competition and Stability in Banking: the Role of Regulation and Competition Policy*, Princeton University Press.

Vives X. [2017], *The impact of FinTech on banking*, w: Barba Navaretti G., Calzolari G., Pozzolo A.F. (red.), *FinTech and Banking. Friends or Foes?*, https://blog.iese.edu/xvives/files/2018/02/EE_2.2017.pdf.

Tanda A., Schena C.-M. [2019], *FinTech, BigTech and Banks. Digitalisation and Its Impact on Banking Business Models,* Palgrave Macmillan, London.

Thakor, A.V. [2020], FinTech and Banking, Journal of Financial Intermediation, January, vol. 41(C), DOI:10.2139/ssm.3332550.

Zetzsche D., Buckley R., Arner D., Barberis J.N. [2017], *From FinTech to TechFin: the regulatory challenges of data-driven finance*, European Banking Institute Working Paper, 6.