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The effects of digitization on credit provision

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Abstract

This study examines the effects of digitization in the lending industry on credit provision. Where previous research is focussed on the rise of online lending firms and platforms, this research focuses on banks. Digitization is expected to have a negative effect on the amount of credit provided by banks because of the increase in competing firms offering credit due to digitization. A panel data set on German, French, United Kingdom and United States commercial banks is used covering a period from 1990 to 2019. To test for the relationship between competition, digitization, and credit provision, a fixed effects regression is performed, controlling for time invariant bank-level factors. Moreover, several robustness checks are performed. No evidence is found for a negative effect of competition on bank credit. Moreover, no evidence is found for the negative effect of digitization on the relation between competition and bank credit.

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1. Introduction

Over the last decades, large changes have been visible due to the shift towards digitization, which implies the digitization of information, and innovation (LaPlante & Watson, 2018). For example, the United-States experienced a wave of innovation during the 1990s, including a doubling of the number of patents gathered by U.S. firms between 1990 and 2001, an increase in technology alliances and acquisitions, and new forms of financing (Baily & Lawrence, 2001; Carlsson, 2004). The digitization over the last decade has also been at the origin of a lot of other changes, as for example of a transformation in how individuals engage, do business, and who is on the playing field. These changes have resulted in a rewriting of the rules of competition. Moreover, the combination of digitization with technological innovations like big data or advanced analytics resulted in an even larger impact. The most important driving force behind this shift towards digitization and innovation is the combination of the rapid rise of internet and the substantial decrease in the cost related to the storing and processing of massive quantities of data (LaPlante & Watson, 2018).

The internet is one of the most important developments in new ways to communicate and in information technologies (Cortiñas, Chocarro & Villanueva, 2010). In a relatively short period of time, the internet has had a visible impact on the daily lives of many individuals (Litan & Rivlin, 2001). The internet could influence an entire economy by increasing the connectedness between actors and ideas, leading to new combinations of ideas and making it more likely that new capabilities emerge (Carlsson, 2004).

For clarification, it may be relevant to distinguish between information and knowledge. Information is defined as a collection of data, which became digital in all of its forms due to the rise of the internet in the so-called new, digital, economy. Knowledge, on the other hand, is defined as a theory or hypothesis which enables the organization and interpretation of this information. Where the collection of information has changed extensively due to digitization, the information itself was not new. However, the search for information and knowledge is facilitated by digitization and the internet, which eases the accumulation of these two factors (Carlsson, 2004). Due to these developments in communication and information technologies, of which the internet is considered the most important one, the interaction between companies or service providers, and consumers of customers changes extensively (Cortiñas et al., 2010).

In general, these trends of digitization and innovation are argued to have three significant effects on firms. The first, and most important effect is that the demands and expectations of customers or consumers have changed significantly. This is for example apparent from consumers demanding more tailored products, shorter delivery times and digital communication which minimizes human-to-human interaction (LaPlante & Watson, 2018; Cortiñas et al., 2010). As result of these higher expectations, capturing and retaining customers becomes more important (Monferrer-Tirado et al., 2016) Secondly, increased efficiency, productivity, and cost savings are resulting from the fact that firms have access to

many new capabilities. Amongst these capabilities are for example improved modeling and insight extraction with the use of big data, and the process digitization and automation for cost savings. However, these new opportunities are, next to the existing firms in a sector, also available to potential entrants, which might have an advantage over legacy firms in being able to grow faster at lower cost. This results in the third impact, being a surge in new market entrants (LaPlante & Watson, 2018).

More specifically, the general impacts of digitization and innovation are also noticeable in the financial services sector, in which customers have significantly different expectations regarding the relationships with their financial institutions, financial technology solutions, or Fintech, have made a rapid entrance to the field, and non-traditional firms using Fintech are continuing to grow. Even though these trends are visible across all products and services offered by firms in the finance industry, many of the innovations that led to the large changes happened in the credit and lending space (LaPlante & Watson, 2018). Consumer demands have changed, resulting in expectations of convenient, fast and cost-effective products. Moreover, changes in demographics also played a more important role in the changes in the lending business, since consumers increasingly consist of individuals being used to have access to for example the internet or mobile devices (LaPlante & Watson, 2018).

When observing existing studies regarding the impact of digitization on the economy in general and the financial services sector in particular, it appears that many existing studies focus on the market efficiency impact of the internet (e.g. Smith, Bailey & Brynjolfsson, 2000). Moreover, another large number of studies is devoted to the impact of the digitization and the internet on alternative forms of financing, like crowd funding, peer-to-peer lending or Fintech companies (e.g. LaPlante & Watson, 2018; Drasch, Schweizer & Urbach, 2018). However, a small number, if any, of studies focusses on the impact of the internet on the traditional banking and financial services industries. One could question what the effects of the observed changes in the collection of information are. Actually, in the long run, knowledge-intensive industries, including the financial services industry, are expected to benefit and transform the most due to digitization and the internet (Carlsson, 2004). This is one of the reasons why it is interesting to examine the long-term effects of digitization in the banking industry. As the changes resulting from digitization are likely to be most visible in the lending industry, this research focusses on the lending function of banks (LaPlante & Watson, 2018).

The research question examined in this research is as follows: ‘What are the effects of digitization on credit provision in the banking industry?’. The aim of this study is gaining insight in and contributing to existing literature on the effects of digitization on the banking industry. The financial services sector experienced large changes due to the digitization of information and the introduction and rise of the internet. By specifically focusing on the effects on credit supply, also called credit provision, which to my knowledge has not been studied before, this research adds knowledge to the small, but existing number of studies examining the effects of digitization in the banking industry.

Using yearly bank-level and country-level data, covering the time period from 1990 till 2019, several regression analyses are performed. The data sample consists of commercial banks originated in

France, Germany, the United Kingdom, and the United States. Two different digitization steps are examined, being the introduction of the internet and the rise of Fintech companies. The effect of digitization on bank credit is expected to be negative through an acceleration of the negative effect of competition on the credit provision by banks. Actually, competition itself is expected to have a negative effect on bank credit. Elaborating on the results of the regression analyses, no evidence is found for a negative effect of competition on credit provision by banks. Moreover, no evidence is found for a negative impact of digitization on the relation between competition and bank credit.

The results of this study might be relevant for governments in regulating the requirements for the commercial banks in the related countries. As a result of the introduction of the internet and the different changes due to this introduction, credit might be provided more easily or less easy, which might have effects for the desired regulation. Moreover, digitization is likely to persist in the future, and more changes are likely to emerge, which makes it relevant to examine the effects of the digitization of the past, to better understand and maybe predict the effects of digitalization in the future. Banks might use this knowledge to evaluate their performance and potentially change their strategies with respect to the digitization in the future.

The remainder of this thesis is organized as follows. Section two consists of a discussion of the most relevant literature on the topic of competition and digitization in the lending industry and its influence on the credit provision of banks. Elaborating on this literature review, two hypotheses is formulated. Section three discusses the data and data collection that is performed to answer the research question. Moreover, the underlying methodological approach and the methods that are used are discussed. Section four presents the results of the regression analyses and discusses these with regard to the expectations and existing literature. Finally, section six concludes and includes a discussion of the limitations of the thesis and the potential for further research.

2. Literature review

In this section, existing literature on the topic of digitization and credit provision are discussed and contrasted. Accordingly, based on this literature review two hypotheses are formulated regarding the impact of competition and digitization on credit provision by traditional banks.

2.1 The New Economy

The digitization of information, combined with the internet, could influence an entire economy. Because of the internet, the level of connectivity between actors and ideas has increased widely and as a result of this, new combinations of ideas emerge and have emerged. Moreover, in the long-term the digitization of information and the internet result in entirely new products, being goods and services. This total of new combinations of ideas, ultimately resulting in new products, is referred to as the New or Digital Economy. This new economy is about new activities and products rather than about an increase in productivity. However, what can be seen as the real new factor in the new economy is the increase in the use of the internet (Carlsson, 2004). In general, the penetration rate of the internet has been growing rapidly over time and its speed of access is continually increasing (Litan & Rivlin, 2001). With use of the internet, all information forms become digital in the new economy, while in the old economy, information flows were physical (Carlsson, 2004).

2.2 The financial services industry

Digitization and the internet have had and are expected to have extensive effects for different industries (Carlsson, 2004; Laplante & Watson, 2018). In the medium term, the effects of digitization and the internet are most visible for retail, manufacture and travel industries. In the long run, knowledge-intensive industries are expected to benefit and transform the most due to digitization and the internet. Amongst these knowledge-intensive industries are for example education, the government, and the industry of interest for this research: the financial services industry. For these industries, the combination of the digitization of information with the internet can for example result in a reduction in costs, increases in productivity and the responding time to changing consumer demand by producers can be reduced (Carlsson, 2004).

For the financial services industry some effects of digitization are already visible. The more or less short-term effects of the internet are noticeable in cost savings and productivity increases. Moreover, with the rise of the internet, a growing number of vendors providing web-based self-service technology is visible. The usage of these self-service type transactions, which is applicable for most online banking customers, results in a reduction in costs for the banks of interest. This reduction in costs is related to the effect of the internet on market efficiency, which is the most studied impact of the internet. Overall, the results of these studies suggest that the internet has resulted in increased competition and an improvement in the functioning of the price mechanism. This improvement in functioning of the price mechanism implies that the new economy may be more efficient than the old economy (Carlsson, 2004).

As an example of this efficiency increase is for example, as reported by Lehman Brothers, the large difference in costs for a transfer between bank accounts depending on whether this is executed by a bank teller (US\$ 1.27), cash machine (27 cents) or with use of the internet (1 cent) (Grant, 1996).

However, even though the internet is likely to have a severe effect on the way banks do business in the future, it remains unclear whether the internet has a positive or negative effect on the value or revenue of a specific bank. In other words, it is not clear whether the internet will create or destroy value for the traditional banks in the long term (Carlsson, 2004).

Even though it is not known what the influence on banks' value or revenue is, it is argued that the long term, and more important effects of the internet include entirely new products. For some industries there is already some transformation of existing products and activities visible. Regarding the financial services industry, there is a change in the way in which accounts are managed and bills are paid due to the introduction of online financial services (Carlsson, 2004). Moreover, the variety of services offered by banks via the internet also includes the possibility to make online transactions as for example transferring funds or applying for a loan (Berger, 2003). While these are examples of digitization leading to changes in delivery, in fact electronic rather than some other way, entirely new products which not existed prior to the internet also emerge. Amongst these new products are for example open innovations, in which customers are helped with finding solutions to technical problems via the internet. Further, a new product, related to the topic of interest of this research, is the aid offered to startup firms in finding alternative sources of finance instead of the conventional venture capital (Carlsson, 2004). Finally, the importance of the Fintech industry is rapidly increasing and fulfills customer-demanded needs by using technology-enabled opportunities (Dräsch, Schweizer & Urbach, 2018). Fintech firms have several advantages over traditional banks, including being more quick and agile than traditional banks in utilizing innovative technology solutions to serve customers (Ansari & Krop, 2012; Christensen, 2013). This is why Fintech companies are far ahead with respect to innovation, and thus are expected to play a key role in the financial services industry in the future (Dapp, 2014).

2.3 Bank credit

The banking industry itself before has pioneered in adapting new technologies over the past (Jiménez & Díaz, 2019):

The first self-service technology in the financial sector appeared in the 70s when banks installed the first ATMs. Later, in the 80s, telephone banking appeared; the 90s saw the dawn of internet banking and by the year 2000 mobile phone banking was being developed (Jiménez & Díaz, p. 31).

Internet banking and mobile phone banking are the most recent developments in the banking industry, which are the result of digitization. The internet could be considered as the most important step of digitization, as it changed the way information is stored and used completely (Carlsson, 2004).

Accordingly, internet banking, through which it is for example possible to apply for a loan, is a relative important technology adopted in the banking industry (Berger, 2003).

2.4 Competition

With regard to lending, banks are traditional balance sheet lenders, in which existing balance sheet availability is used to originate loans, rather than functioning as an intermediary to originate loans (LaPlante & Watson, 2018). The effects of digitization and the internet on this way of credit provision by commercial banks are unknown and ambiguous. Where on the one hand, costs might be reduced, on the other hand competition increases due to new entrants. Actually, a steady increase in domestic competition is visible in many jurisdictions (LaPlante & Watson, 2018).

Where some authors suggest this increase in competition could be harmful for traditional banks, others suggest the increase in competition might not be conflicting with traditional banks' customers. There is argued that the increased competition tends to focus on the market segments the commercial banks have left after the financial crisis. Most importantly is the gap in lending to the small to medium enterprises, which is filled by the new firms. Since banks were not lending to these firms after the financial crisis, new online lending firms filling up this gap would be no harm to commercial banks with regard to their customers (LaPlante & Watson, 2018).

Contrary to this view, other studies state that the increased competition, despite the fundamental changes in digitization leading to technology-driven banking services and new customer demands, could be harmful for banks. Banks tend to be relatively slow in the practice of innovation processes when compared to alternative, digital, lenders like Fintech firms (Drasch et al., 2018). In Europe, for example, the majority of bank processes, around 60 to 80 per cent, were still not digitized in 2014 (Olanrewaju, 2014). This could potentially be due to the fact that recently successful firms, and thus banks, tend to focus on their current technology, are uncertainty avoiding, not open to new approaches, and lack creativity (O'Connell, 2011).

2.5 Hypotheses formation

Building on the existing literature discussed before, two hypotheses are formulated. First of all, a general hypothesis regarding competition and bank credit is formulated. Standard economic theory predicts that larger market power, and thus less competition, results in a lower supply of loans. However, when taking asymmetric information and agency costs into account, a positive or nonlinear relation between market power and credit supply is predicted (Beck, Demirgüç-Kunt & Maksimovic, 2004). Both negative and positive effects of bank competition exist (Cetorelli & Peretto, 2000). On the one hand competition results in reduced amounts of credit provision, while on the other hand it increases efficiency of lending by increasing incentives to screen customers. This results in a nonlinear relationship between competition and credit supply, in which an oligopoly is stated as most optimal banking market structure

(Beck et al., 2004). As an increase in competition is suggested to result in a lower amount of credit provided by banks, this leads to the following hypothesis:

H1: Bank credit is negatively affected by the number of competitors

Next to this, digitization might accelerate this negative effect of competition. Even though the combination of digitization with the internet could be leading to reduced costs, due to for example reduced transaction costs, creating potential for a larger total of outstanding loans, this positive effect might be outweighed by the negative effect of the increase in competition. Due to digitization, the barriers to entry have reduced, which is also noticeable in the rapidly increasing amount of alternative, digital, lending institutions. Actually, the growth that the digital lending market is expected to experience from 2016 to 2024 is 48 percent (LaPlante & Watson, 2018). Even though traditional banks still carry out loan origination mostly like as it was decades ago, the potential cost reductions and increased competition from alternative lenders incentivize the banks to automate their processes (American Bankers Association, 2018). Traditional banks try to remain competitive by developing new, digital strategies. However, research by the Deutsche Bank shows that these digital strategies adopted by banks are not enough to remain competitive in the medium to long term (Dapp, 2015). Banks tend to be relatively slow with regard to innovation (Drasch et al., 2018). Moreover, new market entrants are argued being able to scale up more rapidly and at lower cost than firms, banks in this case, that are already in the market (Laplante & Watson, 2018). As the traditional banks are behind in innovating based on the development of the internet and digitization, this might harm their position in the market (Kim & Mauborgne, 1997).

In contrast to this view, other research stress that the new alternative lenders tend to focus on lending to the market segment that banks withdrew from after the financial crisis, which thus implies that the competitive pressure on the traditional banks would be less than argued before (LaPlante & Watson, 2018). This effect might be more prevailing in emerging markets, since these have relatively low financial inclusion rates, which is why there is potential for the alternative lenders to increase the accessibility to credit in underserved segments in these markets (LaPlante & Watson, 2018; World Bank Group, 2018). However, alternative, digital, lending fulfils a similar role in developed economies, in which populations with less access to credit also exist (LaPlante & Watson 2018).

Next to the increased competition as a result of digitization potentially affecting the credit provided by traditional banks, digitization might also increase overall access to credit. The rise in use of mobile devices and mobile-based products in emerging economies, which were traditionally under-banked, increases overall access to credit and might result in new consumers (Laplante & Watson, 2018). However, even though this increase in credit demand is likely to have positive effects for banks, this might be outweighed by the negative effects of the increase in competition (Dräsch et al., 2018).

Even though increased access to credit might lead to a less negative effect of digitization, it is questionable whether this prevents the negative effect resulting from competition and from the fact that banks are relatively slow in implementing digital strategies and services. The increased competition and banks' lack of ability to keep up with the pace of innovation by their competitors is expected to be harmful for the positions of banks.

Overall, the negative effects of digitization due to competition are expected to outweigh the positive effects, which implies that digitization is treated as an accelerator of the negative effect of competition on credit provision. This leads to the following hypothesis, expecting a positive effect of digitization on the relation between competition and credit provision by banks:

H2: Digitization has a negative effect on the relation between the number of competitors and credit provided by banks

This implies that when a digitization event or period takes place, the effect of competition on credit provided by banks is more negative than in other time periods. As digitization is a general term which includes several different steps, different steps of digitization are examined in this thesis. The most important step in digitization in the banking industry is the rise of the internet. The introduction and use of the internet have resulted in many changes for banks and the way these do business. The second step of digitization that is examined is the rise of Fintech firms. As argued before, digitization in general is suggested to increase competition and to result in a rise in the number of market entrants due to new opportunities caused by digitization (LaPlante & Watson, 2018). This increase in competitors might then result in a loss of customers for the banks and thus in less outstanding loans. This suggests that the internet has a negative effect on credit provided by banks.

3. Research design

In this section, the methodology and data that is used are discussed. This includes a discussion of the data sample and data sources. Next to this, this section includes the operationalisation of the dependent, independent and control variables. Finally, the regression model is estimated and the statistical methods to perform the regression analyses are discussed.

3.1 Methodology and data

For being able to answer the research question, historical data on bank-level and country-level data is obtained. The data covers banks originated in France, Germany, the United Kingdom and the United States. All these countries have experienced significant growth in the digital lending market, which might have impacted the traditional lending by “traditional” banks in these countries through increases in competitors (Laplane & Watson, 2018). Due to limited availability of data on the banks, yearly data is obtained for the time period 1990 to 2019, which is the longest period possible via the accessible databases. This time frame, which is as wide as possible, is chosen because it includes the introduction of several steps of the digitization of information, which then can be analysed. Moreover, since a period as long as possible is covered it is possible to observe more long-term effects instead of short-term effects. The bank-level data includes the level of credit provision, as being the dependent variable of interest in this research, and several control variables. The country-level data includes several control variables as for example data on the introduction of the internet in a specific country, country GDP, GDP growth, and the inflation rate. The data on these country-level variables is obtained via the World Bank database. The other variables needed, so both bank-level and country-level data, are obtained using the Thomson Reuters’ Eikon database. To obtain the data via Thomson Reuters’ Eikon, first a sample of all commercial banks in France, Germany, the United Kingdom and the United States is made in Orbis Bank Focus. Via the ISIN-codes (International Securities Identification Number-codes), which are unique codes in which each ISIN-code represents a specific firm, the data that is needed is obtained from the Thomson Reuters’ Eikon database. Since the Thomson Reuters’ Eikon only provides data for listed companies, the initial sample made in Orbis Bank Focus consisted of 210 banks. From this number of banks, Thomson Reuters’ Eikon contained data on 138 individual banks.

There were made some adjustments to the raw data. For several banks, no world scope data is available in Thomson Reuters’ Eikon. The majority of these banks is originated in the United-States. In some cases, the ISIN-codes were recognized as incorrect, which is why in these cases no data could be obtained. Accordingly, these banks were removed from the sample. Moreover, since the data on the dependent variables is crucial in being able to perform the regression analyses, banks lacking observations on one of the dependent variables were also removed from the dataset. The adjustments resulted in a final data sample of 78 individual banks originated in four different countries and 2,189 observations. The panel is balanced, which is why no interpolating for missing values is needed.

To avoid the influence of outliers, first all observations on one of the dependent variables equal to zero were considered as missing. Considering banks always provide loans, it seems impossible for a bank to have credit provision equal to zero, potentially leading to distorted results in the regression. To avoid this, these observations were considered as missing. Probably the specific banks did not provide data on these variables, which resulted in a value of zero in the dataset. For the variable commercial and installment loans this leads to 10 changes, for net loans to 18 changes, and for total loans to 34 changes. Compared to the total number of observations these changes are relatively small. Finally, to avoid the influence of outliers, all variables, except for the number of competitors, are winsorized at the 5 percent and 95 percent percentiles.

3.2 Dependent variable

The dependent variable examined in this research is credit provision, which is measured by the yearly percentage change in consumer and installment loans, which is defined by loans made to customers. This includes, but is not restricted to, auto loans, home improvement loans, credit cards, personal loans and home equity loans. Since data on consumer and installment loans is relatively limited, two robustness checks are performed. As a first robustness check, credit provision is measured by the yearly percentage change in net loans instead of the change consumer and installment loans. Net loans is equal to the total amount of money loaned to customers, deducted for loan losses. As a second robustness checks regarding the dependent variable, credit provision is measured by the percentage change in total loans. Total loans equal the total amount of money loaned to customers before reserves for loan losses but after unearned income.

3.3 Independent variables

The most important independent variable of interest for this research are the number of competitors and the variables capturing the digitization. Firstly, the number of competitors is added to the regression model. The number of competitors is measured by the number of listed, commercial banks per country as apparent in the Thomson Reuters' Eikon database. Moreover, regarding digitization, rather than focussing on microeconomic research and including all different steps of digitization, there is focussed on two different steps of digitization. The internet is considered as being an important step of digitization. Existing research shows that internet banking has been implemented widely in a short time. However, the implementation strategies differ substantially by bank size. Even though implementation strategies differ, most of transactional sites serving internet banking were set up since the beginning of 1998 (Berger, 2003; Furst, Lang & Nolle, 2001, 2002). This results in the variable capturing digitization being measured by a dummy variable being equal to 1 if the year is equal to or greater than 1998, and equal to zero otherwise. Moreover, as a more recent development, the rise of Fintech companies is also treated as a step of digitization and is also examined. Even though the term Fintech, the use of technology in delivering financial solutions, is originated to the early 1990s, in this research, new start-ups and existing

technology firms that have begun offering financial products and services to the general public are considered as Fintech. Even though it is difficult to determine when this period of Fintech evolution started, the year 2008 is considered the starting point of this evolution. The global financial crisis seems a turning point which has led to the growth of Fintech firms (Arner, Buckley & Barberis, 2016). This also corresponds to the launch of pioneering firms in Fintech, like for example Lending Club as peer-to-peer lending company, which has launched in 2007 (Lending Club, n.d.). This results in a second independent variable capturing digitalization, being equal to one from year 2008 till 2019, and equal to zero otherwise.

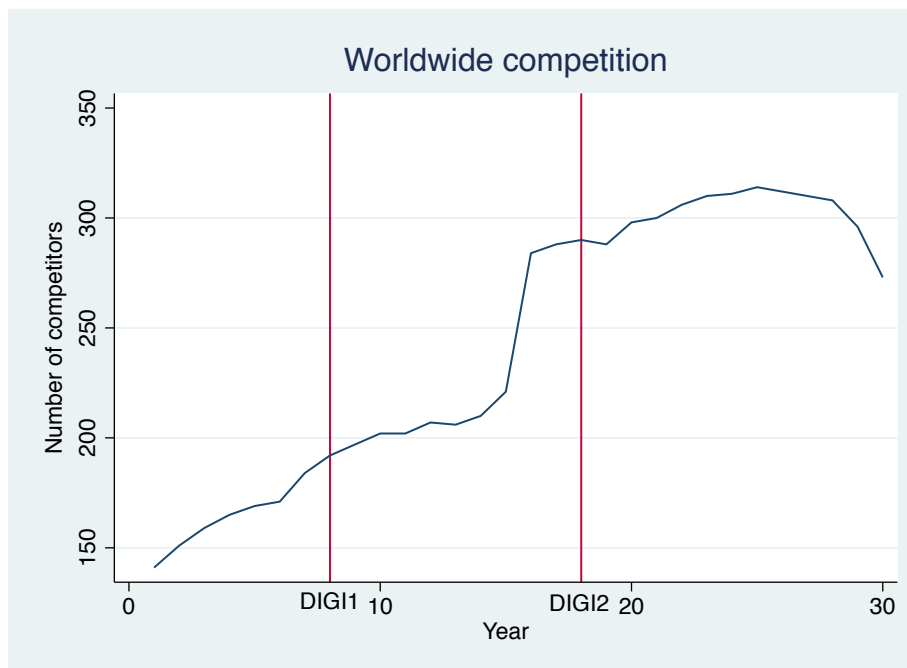


Figure 1. Worldwide competing banks during the period of 1990-2019

Figure 1 depicts the increase of the number of worldwide competing banks over time. The vertical lines DIGI1 and DIGI2 stand for the beginning of the digitization step, so DIGI1 began in 1998, and DIGI2 in 2008. As visible in Figure 1, the number of competitors has increased extensively over the last 30 years. However, this growth of competition banks stagnated over the last 10 years and has even become negative over the last couple of years.

3.4 Control variables

Several control variables are added to the regression model. Firstly, as the adaption of internet banking technologies is potentially depending on bank size, bank size is added to the model as a control variable. Bank size is measured by the logarithm of total assets, and is expected to affect bank credit negatively since smaller banks are found to expand their lending more quickly (Everaert et al., 2015). Moreover, the average inflation rate is added to the model as it is expected to have a negative influence on bank credit. This negative effect is expected since a lack of price stability results in less financial transactions

and reduces bank capital (Everaert et al., 2015). There is also controlled for financial leverage, which is measured by the total loan to total deposits ratio. If banks operate with a funding gap, implying that the amount of total loans is larger than the total amount of deposits, this could result in adverse shocks affecting credit supply (Van den End, 2013). Financial leverage is expected to be negatively correlated with credit since it implies that a bank is more financially stretched when its financial leverage is higher, resulting in more difficulties in providing loans (Everaert et al., 2015). Further, bank capital ratio, measured by the equity to total assets ratio, is added to the regression model and is expected to be positive (Bustamante, Cuba & Nivin, 2019). As indicator of the banks' risk, the non-performing loan coefficient (as a share of total loans) is added to the model. The coefficient of this variable is expected to be positive, which implies that banks take risks to remain profitable and thus lend more money when having a higher ratio of non-performing loans (Altunbas, Gambacorta & Marques-Ibanez, 2010). Further, to control for country differences, there is controlled for country GDP. Country GDP is expected to be positively related to credit provision (Hoffman, 2001; Calza, Manrique & Sousa, 2003; Cotarelli, Dell'Ariccia & Vladkova-Hollar, 2005). Finally, country GDP growth is added to the model as control variable. Even though digitization could have an effect on credit provision, there might exist unobserved correlation between these variables. Where on the one hand digitization and the internet could have a direct effect on credit provision, an indirect effect might also exist. Innovations, of which the probability increases by the rise in connectivity among actors in an economy due to digitization and the internet, result in economic growth (Schumpeter, 1911; Carlsson, 2004). As a result, this rise in economic growth could lead to an increase in credit provision, which implies that digitization could have an indirect effect on credit provision via economic growth. Accordingly, country GDP growth serves as a control variable for this potential problem. Country GDP growth is expected to have a positive effect on the amount of bank credit (Athanasoglou, Sophocles & Matthaios, 2005).

3.5 Descriptive statistics

Table 1 depicts the descriptive statistics of dependent, independent, and control variables used in this research. All numbers are in U.S. dollars, hereafter USD. Considering the dependent variables, the mean of the change in commercial loans (CREDIT) is considerably higher than that of the other two dependent variables, being the change in net loans (CREDIT2) and the change in total loans (CREDIT3). Commercial loans are a part of net loans and total loans and since commercial loans represent loans to consumers, this amount is relatively small compared to net loans and total loans. This might be an explanation of the fact that the mean change in commercial loans is considerably larger than the mean of the other two variables, since it is only a small part of net loans and total loans which is why no effect might be visible in net or total loans. The mean change in total loans and the mean change in net loans are close to each other, which is as expected. The standard deviations of all three dependent variables are relatively high, which implies that large differences between banks exist. This might be due to the

size of each specific banks, where the larger banks provide larger amounts of loans compared to banks of a smaller size. Since bank size is in the regression model, there is controlled for this.

Table 1

Descriptive statistics

Variable	Variable name	Mean	Standard deviation	Min	Max	Number of observations
<i>Dependent variables</i>						
Commercial loans	CREDIT	67.513	929.709	-97.662	19382.66	442
Net loans	CREDIT2	12.535	55.172	-63.356	1379.656	778
Total loans	CREDIT3	12.721	56.479	-61.239	1375.885	728
<i>Independent variables</i>						
Competition	COMP	13.20	9.788	2	31	2,189
Digitization1	DIGI1	0.733	0.442	0	1	2,189
Digitization2	DIGI2	0.34	0.49	0	1	2,189
<i>Control variables</i>						
Bank size	BSIZE	15.577	2.956	11.080	20.624	1,034
Inflation rate	INF	2.18	1.018	0.119	4.235	2,189
Financial leverage	FLEV	116.060	47.612	58.54	239.59	720
Bank capital	CAPITAL	17.129	20.842	2.45	76.84	934
NPL ratio	NPL	2.432	2.534	0	9.07	493
Country GDP	GDP	38,709.61	11253.77	22433.56	59957.73	2,189
GDP growth	GROWTH	2.233	1.336	-0.629	4.447	2,189

The panel dependent variable presents the descriptive statistics of the variables measuring credit provision. The panel independent variables presents the descriptive statistics of the dummies capturing digitization steps. DIGI1 implies the introduction of the internet. DIGI2 implies the rise of Fintech companies. The panel control variables presents all control variables.

The independent variables consist of competition and the two digitization steps. As the digitization steps are dummy variables, these need no discussion. The average number of competing

banks per country is around 13. This seems relatively small, but due to limited availability of data this number of competing banks only contains listed commercial banks.

The mean values of the control variables seem relatively reliable. For example, the average size of a bank, calculated by the logarithm of total assets is 15.577, which implies a value of total assets of 5,821,101 USD. Comparing this to another study on bank credit, this seems reliable since in this study the average bank size was equal to 10.4 (Bustamante, 2019). This research was conducted in Peru, so it is likely that the average bank size of banks in Germany, France, the United Kingdom and the United States is larger. Moreover, the average inflation rate over the period from 1990 to 2010 is 2.18%, the average GDP per capita is around 39,000 USD, and the mean GDP growth is 2.23%, which all seem reliable. The mean financial leverage ratio is above 100, in which total loans exceed total deposits. This is relatively high and implies that the average bank probably does not have significant reserves for expected and unexpected events. This implies that these banks face a funding gap, and are dependent on market funding (Van den End, 2013). Finally, the mean non-performing loan ratio is around 2.4%.

3.6 Regression model and statistical method

To estimate the relationship between digitization and credit provision, the following model is estimated:

$$\begin{aligned} CREDIT_{it} = & \beta_0 + \beta_1 DIGI_{it} + \beta_2 COMP_{it} + \beta_3 BSIZE_{it} + \beta_4 INF_{it} + \beta_5 FLEV_{it} + \beta_6 CAPITAL_{it} \\ & + \beta_7 NPL_{it} + \beta_8 GDP_{it} + \beta_9 GROWTH_{it} + \beta_{10} COMP_{it} * DIGI_{it} + \alpha_i + \lambda_t \\ & + \varepsilon \end{aligned} \quad (1)$$

Where,

CREDIT = change in commercial and installment loans (%)

β_0 = constant variable

DIGI = dummy variable, equal to 1 if digitization step took place

COMP = number of competitors

BSIZE = bank size, natural logarithm of total assets

INF = inflation rate

FLEV= financial leverage ratio

CAPITAL = bank capital ratio

NPL = non-performing loan coefficient

GDP = country GDP per capita

GROWTH = country GDP growth

COMP * DIGI = interaction term

α = bank fixed effects

λ = year fixed effects

ε = error variable

Further, i refers to bank and t refers to time. The final analysis includes several robustness checks in which the dependent variable, being credit provision, is measured by the change in net loans and the change in total loans instead of the change in commercial and installment loans.

A panel data regression is performed to test the hypotheses and examine the relation between competition, digitization and credit provision. Panel data is chosen over the use of pooled cross-sectional data since using panel data leads to the benefit of being able to control for unobserved firm or country characteristics. This is due to the fact that panel data includes multiple observations on the same units of observation over time, which is different from pooled cross-sectional data which includes different units of observation over time. Moreover, panel data allows to study lags or the result of decision making (Wooldridge, 2013). This is important for this study since the impact of digitization may not be visible immediately, but may also or only be visible after some time has passed. To account for unobservable heterogeneity, a fixed effects regression is performed, including year and bank fixed effects. As a result of a fixed effects regression, there is controlled for all time-invariant firm characteristics, which reduces the effects of omitted variables on the dependent variables of interest (Fratzscher, König & Lambert, 2016). Year fixed effects are included to control for economy-wide yearly fluctuations (Liu, Wei & Xie, 2014). Finally, random effects estimations are performed as robustness checks.

To determine whether the fixed effects regression is applicable to the dataset, a Hausman test is performed, which tests for significant differences in the coefficients, resulting from the fixed effects and random effects regression, on the independent variables that vary over time. If there are no significant differences found in the coefficients, in practice both the random effects regression and the fixed effects regression can be used. If the Hausman test appears to be significant, in which the null hypothesis is rejected, only the fixed effects regression is consistent (Wooldridge, 2013).

4. Results

This section presents the results found in the performed regressions. These results are analysed and discussed in light of the expectations as formulated in the hypothesis. First, to check for multicollinearity, a correlation matrix is depicted and discussed.

To ensure that no multicollinearity problems exist with the data to be used, Table 2 depicts the correlation matrix of the independent variables used in the regression model and analysis. Multicollinearity issues are indicated by an absolute correlation of 0.7 or higher (Liu et al., 2014). A few of the correlation coefficients depicted in Table 2 exceed this value. First, the correlation between two of the different dependent variables, being the change in net loans and the change in total loans is relatively high, being almost equal to 1. However, this is rather logical since the dependent variables are related to each other. Moreover, this will not cause correlation problems since these dependent variables are only used in separate regressions. Further, the correlation between GDP and the number of competitors and the different digitization steps is also relatively high. Since these correlations are high and since GDP is a non-stationary variable, GDP is excluded from the final analysis to avoid multicollinearity issues. However, there is still controlled for country GDP by the inclusion of country GDP growth as control variable, which appears to not result in correlation or non-stationarity problems. Finally, the correlation coefficients of the correlation between the interaction terms, capturing the interaction between digitization and competition, are relatively high. However, these correlations can not be avoided. None of the other correlation coefficients exceeds the absolute value of 0.7. The other correlation coefficients are, relatively small or of moderate value, which is why these are not further discussed. These are assumed to not result in multicollinearity problems for the regression analysis and results.

The Hausman test appears to be insignificant for all three dependent variables, which is why the fixed effects regression are presented as main results. However, the results of the random effects regressions of the main dependent variable is also discussed, and the table depicting the results is presented in the appendix. The tables containing the results of the fixed effects regressions of the robustness checks in which the dependent variable is measured by the change in net loans and the change in total loans are also presented in the appendix.

The results of the fixed effects regression of model (1), with the change in consumer and installment loans as dependent variable, are presented in Table 3. Table 3 first includes the results of the regressions using a baseline model without control variables, which presents the relationship between bank credit provision (CREDIT), the number of country competitors (COMP), the period of introduction of the internet (DIGI1) and the period of the rise of Fintech companies (DIGI2). The baseline model elaborates on this and includes the control variables, but excludes the interaction between the number of competitors and the digitization dummy variables. Finally, the results of model (1) are presented, including the interactions between competition and both dummy variables capturing the two digitization steps.

Table 3

Fixed effects regression of model (1), including time fixed effects

CREDIT	No controls	Baseline	Model (1)
COMP	16.212 (12.562)	18.204 (19.170)	23.814 (137.811)
DIGI1	-139.724 (514.670)	-587.516 (1123.752)	-367.857 (1589.142)
DIGI2	9.084 (416.878)	-17.447 (572.282)	-134.218 (708.669)
COMP*DIGI1			-13.190 (147.119)
COMP*DIGI2			7.491 (26.402)
BSIZE		78.570 (263.380)	70.698 (266.403)
INF		-42.418 (219.146)	-19.303 (234.787)
FLEV		-0.158 (4.462)	0.114 (4.597)
CAPITAL		-6.534 (40.804)	-5.257 (41.201)
NPL		-2.207 (47.113)	-1.818 (47.304)
GROWTH		46.405 (124.335)	51.795 (128.736)
No. of observations	442	346	346
No. of firms	39	36	36
R ² within	0.0641	0.0920	0.0923
R ² between	0.0281	0.0183	0.0154
R ² overall	0.0482	0.0576	0.0611

Note. *, **, *** Denote significance at the 10%, 5% and 1% levels, respectively.

As formulated before in hypothesis 1, the number of competitors is expected to have a negative effect on bank credit. This implies that a negative coefficient of the variable measuring competition is expected. The second hypothesis of this study expects a negative effect of digitization on the relation between bank competition and bank credit provided. This implies that the coefficients of both interaction variables, being COMP*DIGI1 and COMP*DIGI2 in Table 3, are expected to be negative.

Concluding from the results of the fixed effects regression as depicted in Table 3, no negative effect of competition on bank credit is found. For both the models without controls and the baseline model, and more importantly model (1), the coefficient of the variable capturing competition is positive. However, as this coefficient is not significant in any of the three models, actually no effect of competition on bank credit provision is found. In other words, based on the results as presented in Table 3, no evidence for a relation between the number of competitors and the change in consumer and installment loans, or credit provision, is found. It might be that the positive and negative effects of competition have equalled each other out, resulting in no effect. Moreover, it might be that competition has no effect on bank credit since new entrants focus on customers that banks did not lend to in the first place (LaPlante & Watson, 2018).

Moreover, there is also no evidence found regarding the second hypothesis of this study. First, both coefficients of the dummy variables measuring the different digitization steps are insignificant. Moreover, it is remarkable that the coefficients of the digitization variables appear to be relatively large, especially in the case of the digitization variable measuring the period of the introduction of the internet (DIGI1). However, as both periods are relatively large, this might be an explanation for this finding. The error terms of both digitization variables are relatively large as well. This might be due to the fact that some of the variables are on country level, which results in banks from the same country having the same value of a certain variable in a specific year. To minimize the impact of this on the results, three other regressions are performed to control for this, which are discussed below after the discussion of Table 3. Considering the interaction terms in model (1), no significant effect is found. The coefficient of the interaction between the competition variable and the first digitization variable (DIGI1), is negative, which is as expected. However, since this effect not found to be significant, and thus no empirical evidence for a relation between competition and bank credit, measured by the change in consumer and installment loans, is found.

The control variables are also found to have no significant effect on credit provision. This is contradictory to the expectations since all control variables are found to have an effect on credit provision in earlier studies. Regarding the coefficients of the control variables, even though insignificant, inflation, financial leverage in the baseline model, and GDP growth are found to have the expected signs. However, since these are not found to be significant, there is no evidence found of a relationship between the control variables and the dependent variable, bank credit.

The within R-squared of the regression without controls is 0.0641, which implies that 6.41 per cent of the variation within a bank in bank credit is explained by the variables in this model. By adding

the control variables to this model, the within R-squared increases with an absolute value of about 3 per cent. Finally, the within R-squared of model (1) is 0.0923, which implies that 9.23 per cent of the variation within a bank in bank credit is explained by the variables of model (1). The overall R-squared, which is a weighted average of the within and the between R-squared, is 0.0611. This is the result of the relatively low between R-squared of model (1). Overall, model (1), with the change in consumer and installment loans as dependent variable, has a relatively low goodness of fit and explanatory power.

As the standard errors of the coefficients presented in Table 3 appear to be relatively large, Table 4 depicts the results of the fixed effects regression of model (1) using cluster-robust standard errors. Time fixed effects are omitted because of collinearity problems with the two digitization variables. Cluster-robust standard errors are used because the observations of some variables, being the number of country competitors, inflation and GDP growth, are clustered within countries. The values of these variables are the same for banks originated in the same country, which is why clustered standard errors are added as a robustness check of the results presented in Table 3.

First, as depicted in Table 4, competition is found to have a positive, and significant, effect on the change in consumer and installment loans in all three models. This is contrary to the expectation of a negative coefficient, as formulated in hypothesis 1. Next to this, the coefficients are found to be relatively large. For example, the value of the coefficient of the measuring competition is equal to 15.440, which implies that when the number of country competitors increases with 1, the change in bank credit increases with around 15 per cent. This unexpected positive effect and the relatively large coefficients might be due to the omitted variable problems, which might be the omission of the time fixed effects (Wooldridge, 2013). Another explanation for the positive coefficients would be that the positive effects of an increase in competition outweigh the negative effects.

The digitization steps are still found to have no significant effect on bank credit. However, for model (1), the interaction between competition variable and DIGI2, capturing the rise of Fintech companies, is found to be positive and significant. This is not as expected, since a negative coefficient of the interaction variables were expected. The positive coefficient of this interaction variable implies that during the digitization step of Fintech companies, the effect of the number of competitors on bank credit is found to be 6.874 per cent higher than it is in the period before the rise of Fintech companies. This implies that an even more positive effect of competition is found in the digitization period of Fintech.

With regard to the control variables, some significant effects are found. The inflation rate and the bank capital ratio are both found to have a negative effect on bank credit. Regarding the average inflation rate, this negative coefficient is as expected. However, the negative coefficient of bank capital is contrary to the expectation of a positive coefficient. This, as stated before, might be due to the omission of time fixed effects (Wooldridge, 2013).

Overall, the values of the different within and overall R-squared's presented in Table 4 are found to be lower than that of the fixed effects regression of model (1) without clustered standard errors and

with time fixed effects. It might be that the exclusion of the time fixed effects results in unexpected signs of the coefficients and also a lower explanatory power of the models.

Table 4

Fixed effects regression of model (1), cluster robust, excluding time fixed effects

CREDIT	No controls	Baseline	Model (1)
COMP	13.338*** (1.944)	15.770** (2.817)	15.440*** (2.595)
DIGI1	-15.505 (9.864)	-10.123 (14.590)	59.398 (35.774)
DIGI2	82.125 (46.490)	76.835 (58.615)	-31.472 (37.695)
COMP*DIGI1			-5.359 (2.809)
COMP*DIGI2			6.874*** (0.590)
BSIZE		-5.379 (11.174)	2.066 (11.046)
INF		-32.963*** (2.523)	-28.247*** (2.602)
FLEV		-0.476 (0.345)	-0.267 (0.368)
CAPITAL		-18.712*** (0.741)	-16.620*** (1.348)
NPL		-15.997 (7.299)	-17.245 (7.912)
GROWTH		-9.897 (6.433)	-9.809 (7.545)
No. of observations	442	346	346
No. of firms	39	36	36
R ² within	0.0084	0.0110	0.0114
R ² between	0.0290	0.0190	0.0072
R ² overall	0.0049	0.0086	0.0086

Note. *, **, *** Denote significance at the 10%, 5% and 1% levels, respectively.

When comparing both the explanatory power of Table 3 and of Table 4, the value of the within and overall R-squared are for all three models higher in Table 3. It might be that the exclusion of time fixed effects results in a lower explanatory power, which is not outweighed by the positive effect of clustering of the standard errors.

As a robustness check, the results of the random effects regression of model (1) and the baseline model with and without control variables are depicted in Table 5, which is in the appendix. In these regressions, the dependent variable, bank credit, is still measured by the change in commercial and industrial loans. As visible in Table 5, no significant effects are found for any of the variables. This holds for all three different models. When comparing this to the results of the fixed regression with the change in consumer and installment loans as dependent variable, the random effects regression corroborates the results of the fixed effects regression. However, even though both the fixed effects model and the random effects model roughly result in the same findings, these findings are contrary to what is expected. Considering the R-squared, the fixed effects model explains the within variation of the individual banks slightly better (9.23 per cent) than the random effects model (8.84 per cent). However, the value of the between R-squared is higher for the random effects model (3.94 per cent instead of 1.54 per cent of the fixed effects regression model). Finally, the overall R-squared is found to be higher in the random effects model (8.73 per cent) than in the fixed effects model (6.11). However, since the within R-squared is most important for the fixed effects model, which is the main model in this study, the goodness of fit of the fixed effects model is considered to be better in the fixed effects model.

Finally, two robustness checks are performed in which the dependent variable, bank credit provision, is measured by the change in net loans or the change in total loans. Table 6 depicts the results for the baseline model, with and without control variables, and the final model (1), in which bank credit is measured by the change in net loans. In the model without controls, a negative coefficient of the competition variable is found, which is as expected in hypothesis 1. However, since this coefficient is not significant, there is concluded that no effect of competition on the change in net loans is found. The first digitization variable is found to have no effect on the change in net loans, and the second digitization variable is found to have a significant negative effect. This implies that in the period before the rise of the Fintech companies the change in net loans was higher than this change during the period of the rise of Fintech companies. Further, in the baseline model and model (1), the negative coefficient of the competition variable disappears, and still no relation of this variable with the dependent variable is found. For both the baseline model and model (1), bank size and the non-performing loan coefficient are found to have a negative effect on the change in net loans. As bank size was expected to have a negative effect on bank credit, these results corroborate the expectations. The negative effect of the non-performing loan coefficient is not as expected. The non-performing loan coefficient was expected to be positive since banks with a higher percentage of non-performing loans are stated to increase their loans to

increase profits. However, in this study a negative effect is found, which could be the result of banks not being able to provide extra loans to compensate for the increase in the non-performing loan coefficient.

Table 7 depicts the relation between bank credit, measured by the change in total loans, and the number of competitors, digitization, the interaction between the number of competitors and digitization, and the different control variables. The outcomes of the regressions using the change in total loans as dependent variable lead to more or less the same results as the first robustness check before with the change in net loans as dependent variable. In the model without control variables, the number of competitors has a negative, but insignificant, coefficient, which becomes positive in the baseline model and model (1). Moreover, the second digitization step (DIGI2) has only a negative, significant effect in the model without control variables. Finally, the bank size variable and the non-performing loans variable are found to have both a negative and significant effect on the change of total loans. The size of the coefficients of these significant variables are also comparable to that in the robustness check with the change in net loans as dependent variable. This is rather logical since both dependent variables are closely related to each other.

When comparing the results of these two robustness checks to the main regression analysis, no differences that are of large interest for this study are found. Actually, no differences in the main variables of interest were found. There can be concluded that the results of the main fixed effects regression are robust to different measures of the dependent variable, being bank credit.

5. Conclusion

This thesis examines the effects of digitization on bank credit provision. Over the last decades, the trend in digitization is visible through entire economies. Where the short-term effects might already be visible and studied, the long-term effects are also important to examine. In the long-term, knowledge-intensive industries are expected to experience the most changes due to digitization, which is why is focussed on the financial services industry in this research. Even though all lines of business are expected to be affected, the lending space is suggested to transform the most. While many existing research is focused on the alternative lending firms arising since the trend of digitization, less attention is paid to the effects for the traditional, commercial banking industry. This is why in this study the effects of digitization on bank credit provision are examined. A data sample of commercial listed banks from France, Germany, the United Kingdom, and the United states is used. The effects of digitization, with the focus on the introduction of the internet and Fintech firms as two digitization steps, on the relation between competition and bank credit provision is examined.

The first hypothesis of this study assumed a negative relation between competition and credit provision by banks, or bank credit in other words. Next to this, the second hypothesis expected a negative influence of digitization on the relation between competition and bank credit. Both the first and second hypothesis are not corroborated by the results of the primary regression analysis. Actually, no significant results were found. Competition might have no effect on bank credit due to the fact that new entrants focus on new customers, which the banks that were already in the market did not provide loans to in the first place, as suggested by LaPlante & Watson (2018). This might also be an explanation of why no accelerating effect of digitization on the relation between competition and bank credit is found. Considering the robustness checks, both hypotheses are also not corroborated, which implies that the results of the main analysis are robust. However, even though the results are robust, these are not as expected and formulated in both hypotheses. To conclude, no empirical evidence is found for the relation between competition and bank credit, or credit provision. Moreover, no empirical evidence is found for the influence of digitization on this relation between competition and credit provision by banks.

This research is subject to several limitations. First of all, as considered most important, is the limited availability of data. Due to restrictions on the data that could be obtained, a relatively small number of banks remained in the data sample. This might have resulted in a relatively low variation in the data, having several effects on the results of the regression analyses. As stated before, no significant results were found, which might be the result of a lack of data variation and the analyses being based on a data sample that might be too small. Improvements on this point are possible by combining data from other databases, if accessible, to get a more complete picture of the banking industry in the countries of interest. This would increase the sample size and thus increase the variation in the data, and might lead to more reliable results (Wooldridge, 2013). Furthermore, since the data obtained from the World Bank only consists of yearly data, the bank-level data obtained from Thomson Reuters' Eikon is also yearly.

Even though yearly data is suitable to be used, quarterly data might result in more reliable results. Quarterly data would be more likely to give a more detailed view on the effects of digitalization on bank credit.

The regression model might also be improved in future research. The number of control variables might be increased to increase the explanatory power of the model. Since the explanatory of the model is relatively low, the addition of control variables might be an improvement for this study. Moreover, the omittance of variables may lead to distorted results, which might also be the case in this study since a relatively small number of significant results is found. Moreover, a multi-level regression might be applicable to the dataset used in this study. This might improve the analysis by increasing the understanding of the relationship between the independent variables and bank credit provision. Since three of the independent variables, the number of competitors, the inflation rate, and GDP growth, were measured on country-level, a multi-level regression model might be an improvement and addition to the current analysis.

Opportunities for future research in the field of digitalization are extensive. For example, the recent rise of the Fintech companies is interesting to examine. Up till now, availability of data on Fintech companies was limited, but this is likely to be extended in the future. Moreover, these Fintech companies appear to be cooperating and merging with banks, which make it interesting to examine the effects for banks.

Finally, future research could elaborate on this thesis in extending the research to the effect of digitalization on loan default. Due to limited data availability this was not applicable for this study. However, since digitalization has led and still leads to many changes, the way in which the credibility of potential borrowers is determined has changed extensively. This might have effects on the amount of non-performing loans of banks. Future research could investigate whether the use of digital estimation techniques in determining credibility of customers has an effect on loan defaults.

6. References

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7. Appendix

7.1 Correlation Matrix

Table 2

Correlation matrix

		1	2	3	4	5	6	7	8	9
1	CREDIT	1.0000								
2	CREDIT2	0.1027**	1.0000							
3	CREDIT3	0.1026**	0.9986***	1.0000						
4	COMP	0.0658	0.0435	0.0458	1.0000					
5	DIGI1	0.0269	0.0216	0.0211	0.4459***	1.0000				
6	DIGI2	0.0523	0.0021	0.0060	0.4660***	0.4922***	1.0000			
7	BSIZE	-0.0374	-0.0782**	-0.0832**	-0.3037***	-0.0844***	-0.003	1.0000		
8	INF	-0.0191	0.1156**	0.1138**	-0.1225***	-0.4510***	-0.3969***	-0.1640***	1.0000	
9	FLEV	0.0054	-0.0117	-0.0099	-0.4545***	-0.2584***	-0.2873***	0.4497***	-0.0548	1.0000
10	CAPITAL	0.0091	0.0403	0.0436	0.1093***	-0.1610***	0.1323***	-0.5811***	-0.0336	-0.4434***
11	NPL	-0.0423	-0.1042**	-0.1013**	-0.2995***	-0.0285	0.2094***	0.2702***	-0.1931***	0.0288
12	GDP	0.0581	0.0489	0.0496	0.7891***	0.6748***	0.7561***	-0.1971***	-0.2803***	-0.4440***
13	GROWTH	-0.0082	0.0343	0.0320	-0.0095	-0.0965***	-0.3593***	-0.1345***	0.0577***	-0.0661*
14	INT1	0.0654	0.0463	0.0480	0.9686***	0.6288***	0.5261***	-0.2872***	-0.1893***	-0.4646***
15	INT2	0.0726	0.0278	0.0314	0.8218***	0.3874***	0.7869***	-0.1490***	-0.2683***	-0.3626***

		10	11	12	13	14	15
10	CAPITAL	1.0000					
11	NPL	-0.2564***	1.0000				
12	GDP	0.1355***	-0.1941***	1.0000			
13	GROWTH	0.0020	-0.3291***	0.1052***	1.0000		
14	INT1	0.1355***	-0.2922***	0.8483***	-0.0431**	1.0000	
15	INT2	0.1105***	-0.0795	0.8026***	-0.1986***	0.8138***	1.000

Note. *, **, *** Denotes significance at the 10%, 5% and 1% levels, respectively. INT1 implies the interaction between competition and DIGI1. INT2 implies the interaction between competition and DIGI2.

7.2 Random effects regression

Table 5

Random effects regression of model (1)

CREDIT	No controls	Baseline	Model (1)
COMP	4.981 (5.535)	7.223 (10.319)	20.118 (118.831)
DIGI1	-28.605 (477.639)	-98.260 (910.421)	105.700 (1267.236)
DIGI2	-22.202 (381.82)	-48.701 (489.805)	-138.725 (602.042)
COMP*DIGI1			-19.066 (127.399)
COMP*DIGI2			5.944 (22.574)
BSIZE		-27.875 (36.424)	-28.339 (36.586)
INF		-45.949 (175.281)	-22.874 (195.368)
FLEV		0.952 (1.605)	1.014 (1.627)
CAPITAL		-20.027 (20.891)	-19.313 (21.121)
NPL		-8.703 (29.349)	-8.490 (29.901)
GROWTH		27.672 (103.321)	35.825 (109.154)
No. of observations	442	346	346
No. of firms	39	36	36
R ² within	0.0604	0.0880	0.0884
R ² between	0.0192	0.0438	0.0394
R ² overall	0.0565	0.0870	0.0873

Note. *, **, *** Denote significance at the 10%, 5% and 1% levels, respectively.

7.3 Robustness checks

Table 6

Fixed effects regression of model (1): robustness check net loans

CREDIT2	No controls	Baseline	Model (1)
COMP	-0.390 (0.557)	0.436 (1.107)	0.916 (6.358)
DIGI1	-0.043 (16.750)	49.197 (52.762)	78.757 (77.315)
DIGI2	-28.712** (14.118)	-20.609 (28.366)	-37.244 (35.034)
COMP*DIGI1			-1.642 (6.761)
COMP*DIGI2			1.182 (1.452)
BSIZE		-27.760** (13.125)	-28.729** (13.205)
INF		-4.156 (11.506)	-0.711 (12.313)
FLEV		-0.076 (0.211)	-0.070 (0.212)
CAPITAL		1.888 (2.175)	2.290 (2.234)
NPL		-4.155* (2.428)	-4.071* (2.435)
GROWTH		-6.753 (6.379)	-6.012 (6.507)
No. of observations	778	414	414
No. of firms	64	41	41
R ² within	0.0494	0.0946	0.0964
R ² between	0.0205	0.0167	0.0180
R ² overall	0.0175	0.0170	0.0173

Note. *, **, *** Denote significance at the 10%, 5% and 1% levels, respectively.

Table 7

Fixed effects regression of model (1): robustness check total loans

CREDIT3	No controls	Baseline	Model (1)
COMP	-0.356 (0.583)	0.262 (1.003)	1.089 (6.117)
DIGI1	0.027 (17.172)	48.109 (50.514)	79.008 (74.194)
DIGI2	-28.210* (16.704)	-19.197 (26.563)	-35.256 (33.429)
COMP*DIGI1			-1.939 (6.480)
COMP*DIGI2			1.094 (1.369)
BSIZE		-27.974** (12.528)	-28.892** (12.603)
INF		-4.314 (10.970)	-1.105 (11.700)
FLEV		-0.088 (0.202)	-0.079 (0.203)
CAPITAL		1.458 (2.091)	1.823 (2.143)
NPL		-4.312* (2.346)	-4.220* (2.354)
GROWTH		-6.419 (6.080)	-5.668 (6.200)
No. of observations	728	437	437
No. of firms	61	42	42
R ² within	0.0487	0.0922	0.0939
R ² between	0.0208	0.0146	0.0156
R ² overall	0.0183	0.0157	0.0160

Note. *, **, *** Denote significance at the 10%, 5% and 1% levels, respectively.