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Title: **The effect of banks' IT investments on the digitalization of their customers**

Short-Form Title: **Banks' IT and digitalization**

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Abstract*

Banks all over the world are investing in new banking technologies at a time when bank customers are progressively going digital in several dimensions of their economic and social interactions. Together with their existing perceptions of digital services, new banking technologies may path the way to accelerate the digitalization of bank customers, thereby achieving private and social efficiency gains. This paper exploits the fact that banks' IT investments are mostly allocated to digital technologies to examine if such investments affect the digitalization of bank customers. The results show that banks' IT investments have a significant positive impact on the adoption of financial digitalization by customers. Banks' IT investments also increase the likelihood that bank customers undertake their financial transactions through digital channels rather than in the physical branch. This represents a change in the relationship banking channel. These findings shed light on the impact of banks' IT investments on end-users and not just on bank productivity and efficiency.

Policy implications

- Regulators should consider the impact of banks' technological advances on financial digitalization. In the new digital financial era, which is driven by new banking technologies, regulators should be aware of the potential impact of technological changes driven by the banking industry.
- Enhancers of technological transformations at companies – in both banking and other sectors – should consider the impact of these changes on end-users and not on just on firm efficiency.
- Since banks' IT investments in new technologies affect customers' digitalization, financial authorities should adopt policies that foster digitalization but also guarantee the highest level of security by protecting consumers from privacy violations and digital fraud.
- The positive externalities of banks' investments in technology should prompt public authorities to consider classifying the amount spent as an investment rather than an expense, which would foster these technological investments and allow banks to free up capital.

1. Introduction

Over the past two decades, technological innovations have transformed individuals' lives and the economy. New terms, such as “the technological revolution” and “the new economy”, have been coined in order to capture how innovations have given rise to new services, new job definitions and new managerial functions across various economic sectors. These innovations have occurred as a result of breakthrough technologies, such as artificial intelligence and blockchain, and also of incremental technologies, such as the diffusion and increased accessibility of digital channels. This process is changing how businesses operate and also how consumers and firms interact.

The financial sector is particularly affected by these changes, which were latent before the crisis, and have gained a new dimension in the last ten years. The International Monetary Fund has recognized that “rapid advances in technology are transforming the financial services landscape” (IMF, 2017 pp.5) and, as is evident from the global reshaping of the industry, banks and other financial institutions have understood the importance of ongoing technological changes. The banking industry has shown the most pronounced growth in investmentsⁱ in information technologies (IT), with its 3% growth rate being above the median for all industries (Computer Economics, 2019). Furthermore, the financial services industry has the largest IT investment per user across all industries. Banks' IT investments are mostly allocated to digital technologies that can directly improve customers' experiences (Zhu, Wymer and Chen, 2002; Hauswald and Marquez, 2003; Asadi *et al.*, 2017; Pérez-Martín, Pérez-Torregrosa and Vaca, 2018) .

At the same time, the preferences of bank customers have also changed substantially. As the technological acceptance and innovation theories have emerged, customers adopt new technologies based on a number of perceptions (Davis, Bagozzi and Warshaw, 1989; Venkatesh, 2000; Venkatesh and Davis, 2000; Venkatesh and Bala, 2008). Digital financial services are used when they are perceived as safe (Casaló, Flavián and Guinalíu, 2007; Yoon and Barker Steege, 2013), convenient (Huang *et al.*, 2003; Laukkanen, 2016) and being of high quality (Dabholkar, 1996; Broderick and Vachirapornpuk, 2002). However, if these digital services are perceived as costly (Gerrard, Cunningham and Devlin, 2006) and complex (Sathye, 1999; Mallat, 2007), customers may decide not to use them. Socio-economic factors such as age (Laforet and Li, 2005; Luo *et al.*, 2010; Estrella-Ramon, Sánchez-Pérez and Swinnen, 2016; Kesharwani, 2019), income (Verissimo, 2016) and geographic location (Xue, Hitt and Chen, 2011) also play a role in the digitalization process.

Although the banking industry is changing as a result of massive IT investments and the increased use of digital capabilities, there is a dearth of research regarding the role of IT investments in the digitalization of the bank customer. Such investments affect firm efficiency

(Chowdhury, 2003; Beccalli, 2007; Casolaro and Gobbi, 2007), but because they are focused on technologies that improve customers' experiences, they may also have an impact on end-users. Thus, this article uses customer-level data to examine whether the digitalization of bank customers is affected by the total IT investments of their bank. Our analysis aims at contributing to the extant literature on technology acceptance and the effects of banks' IT investments by explaining how bank customers go digital as a result of bank investment in IT. An empirical investigation of the potential impact on bank customers is important from both an academic and a practical perspective. Our results suggest that banks' investments in IT positively affect the digitalization of bank customers.

The remainder of the paper is organized as follows. Section 2 examines the drivers of bank customers' digitalization. Section 3 discusses the influence of technological changes on bank customers. Section 4 provides an overview of the relevant theory and presents the main hypothesis. The empirical analysis is presented in Section 5, and section 6 presents the results. Finally, section 7 discusses the findings and policy implications.

2. The era of financial digitalization: the digital bank customer

The Organisation for Economic Co-operation and Development (OECD) defines digitalization as the adoption or increase in use of digital or computer technology by a consumer (OECD, 2017 pp.9). Concurrently with the increase in technological spending, the habits of bank customers have changed dramatically over the past 15 years (EY, 2019). In 2018, more than 60% of internet users in OECD countries used online banking, and 76% of bank customers made or received at least one digital payment using their account.

Customer digitalization through online banking has been examined within the framework of different technology adoption theories. Davis, Bagozzi and Warshaw, (1989) developed the technology acceptance model (TAM), which suggests that the decision to adopt a new technology is based on the perceived usefulness and ease of use. Venkatesh and Davis, (2000) and Venkatesh, (2000) presented the extended TAM2 model, which takes into account that perceptions are also shaped by their reasons for using the technology and the consequences of using new technologies. Venkatesh and Bala (2008) also included individual differences, system characteristics, social influence and facilitating conditions as determinants of perceived usefulness and perceived ease of use. All these theories conclude that consumer perceptions drive the adoption of new technologies. Furthermore, other theories, such as the diffusion of innovations (DIT) and task-technology fit (TTF) theories, complement the TAM model by also considering a number of technological components of the service.

Empirically, a number of papers have shown that customers' perceptions of safety are key drivers of the adoption of e-banking (Casaló, Flavián and Guinalíu, 2007; Yoon and Barker

Steege, 2013). Service convenience (Huang *et al.*, 2003; Laukkanen, 2016) and perceived quality (Dabholkar, 1996; Broderick and Vachirapornpuk, 2002) have also been revealed as common determinants of financial digitalization. Furthermore, inhibitors of the adoption of digital banking channels have been explored, and research suggests that perceived cost (Gerrard, Cunningham and Devlin, 2006) and difficulty of use (Sathye, 1999; Mallat, 2007) deter individuals from going digital. Moreover, Carbó-Valverde, Cuadros-Solas and Rodríguez-Fernández, (2019) have shown that the adoption of digital banking services starts with information-based services (e.g. checking the account balance) and is followed by transactional services (e.g. online or mobile money transfers).

In addition, certain socio-economic factors have been found to play a particularly important role in the digitalization process. Specifically, age seems to be a relevant factor in explaining customers' digitalization. Harris *et al.*, (2016) have found that although consumers of all ages are equally interested in currently emerging technologies such as online banking, younger users are more interested in the newest technologies. Young people are also early adopters of online banking (Laforet and Li, 2005; Luo *et al.*, 2010; Estrella-Ramon, Sánchez-Pérez and Swinnen, 2016). In a similar vein, Laukkanen, (2016) has shown that both age and gender are significant predictors of the adoption of digital banking. Relatedly, Kesharwani, (2019) has shown that differences exist between digital natives and digital immigrants with respect to the use of technology. Furthermore, income (Veríssimo, 2016) and the area in which the consumer lives affect the digitalization process (Xue, Hitt and Chen, 2011).

3. The role of new banking technologies in the adoption of digital banking

Previous research has examined technological changes in the banking sector and the effects of these changes (see among others Berger, 2003; Berger and DeYoung, 2006; Koetter and Noth, 2013). However, most of these studies have focused on the effects on bank performance and efficiency, rather than on end-users.

Relationships between banks and customers have also changed alongside with technology. Hauswald and Marquez, (2003) argued that IT improvements that reduce information asymmetries across lenders have beneficial competitive effects for their customers, so that customers benefit from technological progress. Hernández-Murillo, Llobet and Fuentes, (2010) have shown that banks' adoption of new technologies such as online banking services is partly triggered by their competitors (rival precedence). Banks adopt online banking services earlier in markets where their competitors have already adopted this technology. He, (2015) has also provided evidence of banks' reactions to rivalry in the case of the adoption of mobile banking.

Some anecdotal evidence suggests that banks offer new digital services in order to strengthen customer relationships (Crosman, 2012). Moreover, it has been empirically

documented that banks' implementation of new technologies affects their customers (DeYoung, Lang and Nolle, 2007; Hernando and Nieto, 2007; Campbell and Frei, 2010; He, 2015). The provision of online banking is associated with higher customer retention rates (Hitt and Frei, 2002; Campbell and Frei, 2010; Xue, Hitt and Chen, 2011). Campbell and Frei, (2010) have identified a positive relationship between the use of online banking and customer retention, as well as a net substitution effect from offline channels towards digital channels. Consistent with these findings, Xue, Hitt and Chen, (2011) have shown that customers significantly increase their banking activity by acquiring more products and performing more transactions following their adoption of online banking. There are also related improvements in banks' profitability (DeYoung, Lang and Nolle, 2007). Hernando and Nieto, (2007) have found similar results using data from Spanish banks. He (2015) has argued that banks are motivated to offer new digital services in order to reduce customer attrition rate through building multi-product customer relationships.

4. Do banks' investments in information technology (IT) foster the digitalization of bank customers?

As discussed in section 2, customer perceptions are important drivers of the adoption of new technologies. Furthermore, as literature based on the role of new banking technologies suggests, customers' digitalization may be positively affected by banks' implementation of new technologies. While banks' IT investments are mostly allocated to digital technologies that can directly improve customers' experiences, such as artificial intelligence, cloud technology, data and analytics, mobile technology and biometrics (Zhu, Wymer and Chen, 2002; Hauswald and Marquez, 2003; Asadi *et al.*, 2017; Pérez-Martín, Pérez-Torregrosa and Vaca, 2018; MacFeely, 2019), we argue that the implementation of these new banking technologies through IT investments may affect the digitalization of bank customers.

As a result of the above, the following main hypothesis is formulated:

H1: Bank customers' digitalization process is positively affected by the total IT investment of their bank.

In order to test this hypothesis, unlike prior studies that have examined the impact of IT investments on several bank metrics, we do not use data at the bank level. Instead, we employ customer-level data that allow us to relate the level of financial digitalization of customers to the IT investments of their main bank.

5. Methods

5.1. Data

As in other studies dealing with banking digitalization, the primary data for this study were collected from a consumer survey (see among others Gerrard, Cunningham and Devlin, 2006; Venkatesh and Bala, 2008; Harris *et al.*, 2016; Laukkanen, 2016; Asadi *et al.*, 2017). The survey was conducted specifically for this research in November and December 2016 in Spain. It

is based on the Survey of Consumer Payment Choice (SCPC), which is conducted by the Federal Reserve Bank of Boston and is one of the main methodological references in the field (e.g. Kahn and Liñares-Zegarra, 2016; Schuh and Stavins, 2016). All survey participants were asked to voluntarily provide information about their digital preferences, in addition to identifying the bank at which they had their main bank account. The survey participants were drawn from a population of Spanish consumers between the ages of 18 and 75, resulting in a sample size of 2,819 bank customers. The information on IT investments was obtained from the 33 banking institutions at which the survey participants reported holding accounts. These institutions are representative of the Spanish banking system, accounting for approximately 90% of the industry in terms of total assetsⁱⁱ.

According to OECD statisticsⁱⁱⁱ, Spain is a representative testing ground for research on banking digitalization. The general level of digitalization is similar to that in other developed economies. Consequently, the main findings – with the necessary caveats – are likely to be extrapolated (with the necessary caveats) to other jurisdictions, or are at least useful for informing related research to be conducted in other countries. The ratio of male to female survey respondents was balanced. The largest percentage of participants fell into the age bracket of 40–50 years old (23.6%)^{iv}. Most of the survey participants lived in cities with between 50,000 and 250,000 inhabitants (28.9%). In terms of monthly income, there was a balance across the different group scales considered. Overall, we are confident that the sample is not biased towards specific consumer profiles.

5.2. Variables

5.2.1 Dependent variables

Becoming a digital bank customer entails more than simply using a digital channel for the first time. In this sense, there are several ways to determine whether a particular bank customer is digitalized. Hence, in line with prior studies, we take into account the following dimensions of the digitalization process (Sathye, 1999; Campbell and Frei, 2010; Estrella-Ramon, Sánchez-Pérez and Swinnen, 2016; Szopiński, 2016):

- Adoption of online banking: This is measured as *Digital bank customer*, a dummy that takes the value 1 if the customer has a bank account that they have accessed online in the last year.
- Digital channel vs. branch: A digital bank customer is expected to be less attached to the physical branch of their bank. To determine the extent to which bank customers have replaced access through branches with the digital channel, we use the variable *Digitally dominant*, calculated as the ratio of the number of transactions conducted online to the number of transactions conducted in a physical branch over the last quarter.

- Digital online intensity: While having access to an online bank account is the first step in becoming a digital customer, it is important to examine the financial activities that a customer conducts online. Although online banking allows the customer to access a range of services, we consider the four core financial activities that all financial entities offer: checking account balances, paying bills, making transfers, and information-checking activities such as receiving communications. Survey participants were asked whether they had conducted any of these activities online. *Active digital customer* is a dummy that takes the value 1 if the customer has conducted any of the abovementioned activities via online or mobile banking in the last year. *Diversified digital customer* is computed as the ratio of the number of financial activities that the customer has conducted online (from 0 to 4) to the total number of activities that could be conducted online (4).

<INSERT TABLE 1 ABOUT HERE>

Table 1 presents the summary statistics for all the variables considered. Most of the survey participants (78%) had access to their bank account through the online channel. Furthermore, the mean of the variable *Digitally dominant* is larger than 1, which shows that, on average, respondents conducted more transactions online than in a physical branch over the last quarter. However, the average of *Diversified digital customer* is 0.49, which means that, on average, bank customers do not access the whole range of services that is available online. The surveyed banks allocated 7.04% of their budgets to IT investments. This table also shows that the survey respondents were frequent internet users, using an average of two digital devices. As for customers' perceptions of digital banking, respondents perceived online banking as a low-cost, convenient, easy to use and high-quality service.

5.2.2. Independent variables

The main dependent variable in our model is “bank IT investments”, a bank-level indicator computed as the ratio of IT expenses to total non-interest expenses. Information on bank-specific IT spending was hand-collected from the disclosure notes of the income statements in the banks' annual reports^v. While the specific accounting item used to report technological expenses may vary across banks^{vi}, we checked in the notes that specific IT expenses were considered. In so doing, we obtained information on bank-specific IT spending from direct sources, as has been done in related studies (Chowdhury, 2003; Shu and Strassmann, 2005; Beccalli, 2007), rather than obtaining it indirectly from the estimation of stochastic cost and profit functions. The main source of this information were the 2016 income statements of the banks under consideration. However, for robustness purposes, we also computed this variable using the average bank IT expenses during the period 2014–2016.

5.2.3 Control variables

Socio-economic characteristics are controlled for by taking into account gender (Laforet and Li, 2005; Laukkanen, 2016), age (Laforet and Li, 2005; Luo *et al.*, 2010; Estrella-Ramon, Sánchez-Pérez and Swinnen, 2016), monthly household income (Laforet and Li, 2005; Veríssimo, 2016) and number of inhabitants (Laforet and Li, 2005; Hernando and Nieto, 2007). We control for the fact that effects on customers' digitalization may differ depending on the extent of their current digitalization by including the last internet connection of the customer and the number of digital devices they own (Laforet and Li, 2005; Szopiński, 2016). Similarly, because the customer relationships with their bank may drive their digitalization, we include the number of bank accounts of the customer and the number of banks at which they hold an account (Szopiński, 2016). Furthermore, we consider customer perceptions of the level of their bank digital safety (Casaló, Flavián and Guinalíu, 2007; Luo *et al.*, 2010), cost (Gerrard, Cunningham and Devlin, 2006), convenience (Laforet and Li, 2005), difficulty (Sathye, (1999) and quality (Broderick and Vachirapornpuk, 2002). Finally, since adoption of digital banking may differ in areas with a high branch density (Xue, Hitt and Chen, 2011), we control for the change in number of bank branches (Δ bank branches). This variable also takes into account whether the closure of bank branches may force some bank customers to go digital. Thus, for each bank customer, we compute the annual percentage change in the number of bank branches of their main bank located in their province.

5.3. Econometric specification

The following model is specified:

$$\text{Bank customer digitalization} = \beta_0 + \beta_1 \text{BANK IT INVESTMENTS} + \beta_2 X_{\text{socio-economics}} + \beta_3 X_{\text{general degree of digitalization}} + \beta_4 X_{\text{banking profile}} + \beta_5 X_{\text{perception of digital banking}} + \beta_5 \Delta \text{bank branches} + e_i$$

(1)

BANK IT INVESTMENTS denotes our main independent variable, X_i denotes the set of vectors of control variables included in the model, and e_i is the new error term. We estimate equation (1) using Ordinary Least Squares (OLS). In those cases in which the dependent variable is binary (adoption of online banking and active digital customer), we employ a probit model. Furthermore, as per the standard practice, the standard errors reported are robust to heteroscedasticity.

6. Results

Column 1 of Table 2 presents the estimation results for the likelihood of an individual becoming a digital bank customer. Column 2 shows the results for the replacement of the bank branch by the digital channel as the means of conducting basic financial activities.

Regarding the adoption of online banking (column 1), the variable that reflects the bank level of IT investments is positive and statistically significant. This indicates that after controlling for a set of customer-level features as well as the change in the physical network of bank branches, those customers whose main bank has invested more in technology are more likely to use online banking. This result supports our hypothesis. Banks' IT investments have a positive effect on the digitalization of the bank customer, particularly with regard to the adoption of online banking.

<INSERT TABLE 2 ABOUT HERE>

Table 2 also shows that younger customers with higher incomes who have reached a higher level of (general, not only financial) digitalization are more likely to adopt online banking. We also find that having more bank accounts does not make a customer more digitalized, while adopters of online banking are likely to work with a larger number of banks. Regarding customers' perceptions of online banking, we find that customers who perceive digital channels as safe, convenient and as providing a quality service are more likely to adopt online banking.

Column 2 of Table 2 examines whether customers preferentially conduct basic financial activities via the digital channel rather than the physical bank branch. This column reports the estimation results for the ratio of online activities to branch activities on a quarterly basis. The positive and statistically significant coefficient of Bank IT Investments shows that IT investments increase customers' preference for the digital channel over the branch. This finding supports our main hypothesis, since the change from the physical to the digital channel is partially triggered by banks' IT investments. In addition, the general level of digitalization of the customer and socio-demographic characteristics such as age and income play a role in explaining the replacement of the physical channel by the digital channel. Women are found to be more attached to the physical branch than men. Furthermore, these results show that the persistence of the "branch-dominant" customer is partially explained by these customers' perceptions of the digital channel. Customers who perceive the digital channel as risky, not very convenient, difficult to use and providing a low-quality service are more likely to continue using the physical branch instead of the digital channel.

<INSERT TABLE 3 ABOUT HERE>

Table 3 reports the results on the determinants of the intensity of the use of the digital channel. Column 1 shows that as Bank IT Investments increase, bank customers are more likely to go online to conduct the basic financial activities of checking account balances, paying bills, making transfers and receiving communications. Column 2 shows that the coefficient of Bank IT Investments is not statistically significant. Thus, while IT investments positively affect the willingness of customers to conduct financial activities online, they do not seem to affect their likelihood of becoming a fully digital bank customer who conducts most of their financial

activities online. Taking these results together, it seems that while banks' IT investments encourage their customers to go digital, these investments are not likely to prompt customers to further increase their digitalization. Other socio-economic factors, such as the level of income, general level of digitalization and perceptions of digital banking, seem to affect the likelihood that they will become a fully digital bank customer.

Overall, these results suggest that banks foster the digitalization of their customers (as stated in our hypothesis), but investing more resources in technology does not seem to drive customers to become fully digital.

6.1. Robustness

In order to check the robustness of the results, we conduct a number of tests. Firstly, in order to ensure that our results are not biased by substantial one-off changes in bank IT investments in 2016, our main independent variable is also computed taking into account bank IT expenses during the period 2014–2016. No qualitative differences from our baseline results are found. The full results are not reported for the sake of brevity. Moreover, since some customers have more than one bank account, we re-run our regressions for those customers with a single bank account, and no differences are found. In addition, it is important to ensure that the results are not affected by some large banks being over-represented in the sample. Thus, we re-run the regressions excluding those customers from the banks with the largest market share in Spain, namely Santander and BBVA. The results are similar to those reported in Tables 2 and 3. Finally, it could be argued that the potential effect of changes in bank branches on the level of digitalization is more likely to arise from branch closures than from expansions in the physical network. Thus, instead of employing the change in number of bank branches as a variable, we include a dummy variable that takes the value 1 in case of a branch closure. No changes in the sign or economic significance of the results are observed.

7. Conclusions and policy implications

The digital channel has overtaken traditional channels as the main way in which customers interact with their financial institutions. Customers adopt digital channels based on their perceptions of these channels' safety (e.g. Casaló, Flavián and Guinalíu, 2007; Yoon and Barker Steege, 2013), convenience (e.g. Huang *et al.*, 2003; Laukkanen, 2016) and quality (e.g. Dabholkar, 1996; Broderick and Vachirapornpuk, 2002). Moreover, their perceptions of the cost of the service (e.g. Gerrard, Cunningham and Devlin, 2006) and the difficulty of using it (e.g. Sathye, 1999; Mallat, 2007) are barriers to go digital. Certain socio-economic factors such as age, income and the area in which the consumer lives also affect the digitalization process (e.g. (Luo *et al.*, 2010; Laukkanen, 2016; Veríssimo, 2016; Kesharwani, 2019)

Banks are increasing their spending on technology, particularly on digital technologies that can directly improve customers' experiences. The implementation of new banking technologies affects customers (DeYoung, Lang and Nolle, 2007; Campbell and Frei, 2010; Hernández-Murillo, Llobet and Fuentes, 2010; Xue, Hitt and Chen, 2011; He, 2015). While banks' IT investments are mostly allocated to digital technologies, there is no empirical evidence regarding the possible effect of these investments on the digitalization of the bank customer.

This paper examines whether technological changes in the banking sector in the form of IT investments affect the digitalization of bank customers. Using customer-level data, the paper relates the level of financial digitalization of customers to the technological investments of their main bank. We find that banks' investments in technology have a positive effect on the digitalization of the bank customer. Furthermore, as banks' IT investment increases, bank customers are more likely to shift from the offline towards the digital channel. However, banks' IT investments do not seem affect the likelihood of customers to become fully digital and conduct most of their financial activities online. These results extend academic knowledge about the impact of banks' IT investments by focusing not only on banks' performance but also on the customer. Consequently, this paper contributes to two main bodies of literature. First, it adds to the literature on banking technology by demonstrating the broader impact of banks' IT investments. Second, it contributes to the literature on customers' digitalization by showing that banks can foster customers' financial digitalization.

As do similar studies of customers' adoption of new technologies, our study has certain limitations. While the methodology employed ensures the representativeness of the survey, it would be ideal to have an insight on the timing of the digitalization process and to determine how banks could accelerate the digitalization of their customers.

Our results have managerial implications for banking and other sectors. In particular, banks might realign their IT strategy to focus on those technologies that have a larger effect on their customers.

Our findings also have policy implications. Regulators should consider the impact of banks' technological advances on the financial digitalization of societies. In the new digital financial era, which is driven by new banking technologies, regulators should be aware of the potential impact of technological changes driven by the banking industry. It is important to establish a new standard-setting body for the prudential regulation of digital financial services based on both financial stability and financial inclusion (Jones and Knaack, 2019). Policy makers should assist banks in helping their customers to go digital, but they must ensure that the highest level of security is guaranteed in order to protect consumers from privacy violations and digital fraud. Moreover, regulators should consider the positive externalities that arise from IT investments in order to promote and facilitate banks' investments in new technologies. The positive externalities of banks' investments in technology should prompt public authorities to

consider classifying the amount spent as an investment rather than an expense, which would foster these technological investments by allowing banks to free up capital. Finally, some general policy implications arise from the need to design policies that foster technological advances. Such policies should be based on the direct impact of technology on people and not only on firm-level efficiency goals.

Table 1. Summary statistics

	Mean	Median	Std. Dev.	Min	Max
Digitalization					
Digital bank customer	0.78	1	0.40	0	1
Digitally dominant	1.30	1	1.66	0	13
Active digital customer	0.73	1	0.44	0	1
Diversified digital customer	0.49	0.5	0.40	0	1
IT Investments					
Bank IT Investments	7.04	6.74	2.44	0	21.54
Socio-economics					
Gender	1.50	2	0.50	1	2
Age	45.43	45	14.83	18	75
Household monthly income	4.08	4	1.98	1	7
Location (n° inhabitants)	377267.70	58168	810390.10	45	3141991
General degree of digitalization					
Last internet connection	4.60	5	1.11	1	5
N° digital devices	1.91	2	1.14	0	50.5
Banking profile					
N° accounts	1.98	2	1.26	1	20
N° banks	1.55	1	0.77	1	7
Perception on digital banking					
Risk	3.08	4	1.65	0	5
Cost	1.14	1	1.14	0	5
Convenience	1.64	1	1.33	0	5
Difficulty	1.90	2	1.28	0	5
Quality	1.49	2	1.19	0	5
Bank branches					
Δbank branches	-3.42	-4.58	15.77	-100	233.33
Note: Gender: 1=male 2=female Monthly Household Income (€): 1=0-600 2=600-1000 3=1000-1500 4=1500-2000 5=2000-3000 6=3000-5000 7=>5000€ Last Internet connection: 1=Never 2=More than a month 3=Last month 4=Last week 5=Yesterday Risk: 1=Unsafe 2=Low-safety 3=Neutral 4=Fairly Safe 5=Very safe Cost: 1=No Cost 2=Relatively costless 3=Neutral 4=Costly 5=Very costly Convenient: 1=Very Convenient 2=Convenient 3=Neutral 4=Not very convenient 5=Not convenient Difficulty: 1=Very Easy 2=Easy 3=Neutral 4=Difficult 5=Very Difficult Quality: 1=High-quality 2=Quality 3=Neutral 4=Deficient 5=Very Deficient					

Table 2. Impact of Banks' IT Investments on the adoption of online banking and the replacement of the physical branch

VARIABLES	Adoption of Online Banking	Digital channel vs Branch
	Digital bank customer	Digitally dominant
BANK IT INVESTMENTS	0.0161*** (0.00638)	0.0213** (0.0104)
Gender (Women)	0.0334 (0.0413)	-0.221*** (0.0458)
Age	-0.0440** (0.0216)	-0.00942*** (0.00262)
Monthly household income	0.0645*** (0.0116)	0.0482*** (0.0165)
Inhabitants	4.98e-08 (3.91e-08)	-2.74e-10 (2.59e-08)
Last internet connection	0.206*** (0.0172)	0.102*** (0.0179)
N° digital devices	0.363*** (0.0569)	0.147** (0.0567)
N° accounts	-0.00915 (0.0119)	0.00427 (0.00422)
N° banks	0.301*** (0.113)	0.104** (0.0382)
Safe	0.259*** (0.0118)	0.220*** (0.0148)
Cost	0.0133 (0.0249)	0.0278 (0.0316)
Convenience	-0.0591*** (0.0157)	-0.0696*** (0.0218)
Difficulty	-0.0425 (0.0345)	-0.0806*** (0.0210)
Quality	0.0998*** (0.00851)	0.0982*** (0.0188)
Δbank branches	0.00119 (0.00129)	0.00214 (0.00162)
Observations	2,819	2,819
R ² /PseudoR ²	0,3237	0.189
Log Pseudolikelihood	-961.69	-

Note: Robust standard errors in parentheses. A constant term (not reported) is included in all regressions. *, **, *** Coefficients are statistically significant different than zero at least at 10 %, 5% and 1% levels.

Table 3. Impact of Banks' IT Investments on the digital online intensity

VARIABLES	Digital online intensity	
	Active digital customer	Diversified digital customer
BANK IT INVESTMENTS	0.0201** (0.00807)	-0.000788 (0.000970)
Gender (Women)	-0.109 (0.106)	-0.0501** (0.0184)
Age	-0.0114*** (0.00348)	-0.000599 (0.000927)
Monthly household income	0.0481*** (0.0140)	0.0170*** (0.00298)
Inhabitants	3.70e-08 (5.46e-08)	7.79e-09 (7.02e-09)
Last Internet connection	0.669*** (0.0573)	0.0553*** (0.00735)
N° digital devices	0.312*** (0.0938)	0.0752*** (0.0102)
N° accounts	-0.000819 (0.00657)	0.000279 (0.00179)
N° banks	0.250*** (0.0383)	0.0702*** (0.00924)
Risk	0.315*** (0.0118)	0.0878*** (0.00649)
Cost	0.0232 (0.0333)	0.00941 (0.00771)
Convenience	-0.0736*** (0.0250)	-0.0223*** (0.00431)
Difficulty	-0.0586* (0.0319)	-0.0179*** (0.00301)
Quality	0.0960*** (0.0190)	0.0352*** (0.00545)
Δbank branches	0.00307*** (0.000989)	3.64e-05 (0.000237)
Observations	2,819	2,819
PseudoR ²	0.436	0.475
Log Pseudolikelihood	-800.60	-

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ⁱ The terms “investment” and “expense” are used interchangeably throughout the text. The accounting distinction between an investment and an expense is not relevant for our purposes. As Beccalli (2007) states, the term “investment” does not assume any accounting qualification.

ⁱⁱ The diversity of the financial system is represented in this sample, as it includes large banks (Santander, BBVA and Banco Sabadell), medium-sized banks (Bankia, Bankinter and Unicaja), cooperative banks (Grupo Caja Rural) and foreign banks established in Spain (Deutsche Bank, ING and Triodos Bank). None of these banks accounts for more than 15% of the total sample.

ⁱⁱⁱ In 2018, approximately 56% of Spanish internet users had access to online banking. Considering the historical data itself, the adoption of online banking has increased by almost 62% in the last decade. Similarly to other developed economies, this digital jump has been made possible due to internet diffusion – 86.4% of households have internet access – and the popularization of the smartphone – 80% of Spaniards own a smartphone.

^{iv} This is consistent with the official statistics provided by the Spanish Statistical Office (INE), which report the average age of the Spanish population as approximately 43 years.

^v Banks tend to disclose this information as part of “Other administrative expenses”. Together with the technology-related expenses, banks also report information on expenses related to advertising, marketing and communication, consulting, professional services and administrative and logistic services.

^{vi} For example, BBVA, Santander and Caixabank use the term “Technology and systems”, while Bankia and Unicaja use the term “IT”.