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The Role of Education and Digital Technology Advancements in Internet Banking Adoption across European Countries

Abstract. *The COVID-19 pandemic has led to a globally accelerated adoption of Internet banking services due to disruptions in the face-to-face banking services and coupled with the advancement of digital technologies. The aim of this research is to analyse the factors that can be leveraged to increase the use of Internet banking services, by focusing on 33 European countries over 5 years (2018-2022). To achieve this objective, we examined the literature to identify the factors that can lead to a decrease in the internet banking adoption barriers. As per our findings, we discovered that education, coupled with smart finance devices and the expansion of digital banks, contributed to an increase in the Internet banking adoption level. To test the impact of these variables in the 33 European countries, we developed four regression models using both simple OLS and panel data models. This strategy takes into account the unique characteristics of each country and the particular variations over time, providing a clearer understanding of how Internet banking services are being adopted across Europe. The research findings highlight that education and the rise of digital banks contribute to the increase in the internet banking adoption level, while Internet of Things (IOT) Smart Finance has a negative impact. Therefore, this study manages to confirm a series of factors that can lead to a decrease of the internet banking adoption barriers across European countries.*

Keywords: *Internet banking, educational level, Digital banking, IoT Smart Finance, pooled OLS, panel data.*

JEL Classification: O33, I25, L86, R11.

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1. Introduction

A well-functioning banking system is essential for the efficient allocation of capital in any nation state. The advent of digital technology has had a profound impact on the banking sector, prompting a reorientation in the way that commercial banks serve their customers. The transformation was further accelerated by the global pandemic, which contributed to the rapid evolution and led to a steady decline in physical bank branches in the European Union, in contrast to the worldwide trends (World Bank, 2024). In this context, individuals' participation in the digital world is increasingly becoming a consequence of unconscious processes rather than the result of deliberate choices. Therefore, several categories of consumers might become prone to digital banking exclusion (Weber et al., 2024; Grigorescu et al., 2023), as in 2023 only 63.87% of EU adult citizens used internet banking services (Eurostat, 2024).

In the pandemic and post-pandemic context, the European banks started to invest massively in improving their technological capabilities. By focusing on a wide range of technologies, such as artificial intelligence, big data, blockchain, and cloud computing, banks seek to achieve optimal operations and efficiency, while simultaneously enhancing customers' experience and establishing a competitive advantage. Moreover, a significant number of banks that operate exclusively online have emerged, offering all services through digital platforms and transforming the industry.

Several recent studies focusing on Internet, digital, and neobanking through the theoretical lenses of innovation resistance (Baklouti & Boukamcha, 2024; Arif et al., 2020) found that the most important categories of barriers are: usage, value, risk, and image. The usage barrier refers to the assertion that individuals might be inhibited by innovation, which might be perceived as difficult to understand and therefore use. The second category, the value barrier, relates to the perceived usefulness considering that users tend to deny innovation until they can understand its benefits. The risk barrier relates to the users perceived risk, mostly regarding cybersecurity aspects, while the image barrier focuses on the unfavourable impressions of the innovation.

Despite the important insights provided by the numerous articles focusing on Internet banking adoption, as highlighted by Chauhan et al. (2022) in a systematic review, most studies are examining a single country or narrow region, thus lacking a comprehensive view on the factors that allow the overcoming of those barriers. Moreover, the continuance to online banking in the post-pandemic context seems to be uncertain (Dangaiso et al., 2024). Therefore, this study seeks to explore the factors that decrease the users' resistance to Internet banking in the context of European banking markets, where the differences between nations are significant (Eurostat, 2024).

To achieve the research objective, we analysed 33 European countries during the period 2018-2022, taking into consideration several factors that should allow the overcoming of these barriers at the macroeconomic level. Afterwards, we propose

four regression models, including panel and pooled OLS methods, allowing us to test the proposed hypotheses.

Throughout this paper, the term 'internet banking' will refer to the activity of providing banking services directly to the customer's home or private address (Yiu et al., 2007).

The structure of this paper is the following: after this introduction, section two provides a comprehensive review of the existing relevant literature regarding the factors that improve internet banking adoption. Section three presents the methodological approaches employed, while section four discusses the findings and their importance. Finally, section five presents the conclusions of the study along with the limitations and future research opportunities.

2. Literature review

The adoption of Internet banking has been studied in the last decade through various theoretical lenses (Ashique & Rameshkumar, 2024; Yousafzai, 2012), pointing to two streams: (1) explaining acceptance and use and (2) understanding resistance factors (Dos Santos & Ponchio, 2021). While both approaches are important for understanding the individuals' intentions and behaviour, the understanding of the resistance factors is particularly relevant in the current context as digital services, such as internet banking, become more pervasive. One of the most widely spread theories that focuses on the resistance factors is the Innovation Resistance Theory (IRT) introduced by Ram & Sheth, 1989. Given its general applicability, it has been used in various fields of research, being the preferred choice in understanding the internet banking adoption barriers, as a specific instance of the broader phenomenon of resistance to innovation (Baklouti & Boukamcha, 2024).

The COVID-19 pandemic led to changes in the individuals' behaviour and perception of Internet banking services. A study conducted in Greece (Bechlioulis & Karamanis, 2023) analysed the impact of the first national lockdown on Internet banking, highlighting that more days of lockdown were associated with an increased likelihood of further internet banking. Similarly, the Turkish banking sector recorded unprecedented growth in terms of the utilisation of digital banking services during the pandemic. A comparable result was obtained in the context of Romania, where researchers observed a positive relationship between the pandemic and the use of online and internet banking, mediated by the perceived utility, ease of use, and the customers' attitude (Baicu et al., 2020). Although the increase in the number of internet banking users might not be generalisable in the EU context, the sanitary crisis caused profound changes in the customers' behaviour (Grigorescu et al., 2023).

Thus, the pandemic provided a valuable context to understand the factors that can decrease the barriers of adopting internet banking services and foster the users' continuance intentions. In this regard, the literature highlighted as main elements the education (Sheikh & Khan, 2024; Naeem & Ozuem, 2021), the emergence of digital banks (Shanti et al., 2024), and the Internet of Things (IoT) proliferation (Gupta, 2023; Mishra & Guru Sant, 2021).

2.1 Internet banking and education

A proper level of education seems to decrease the resistance in terms of the usage, value, and risk barriers of Internet banking adoption.

Prior literature focusing on the usage intention of the Internet banking services examined this topic through various theoretical lenses (Sheikh & Khan, 2024; Rahi et al., 2021), indicating that the awareness, perceived usefulness, trust, and security concerns are the most important factors. In this context, education and digital literacy emerge as key factors that contribute to the increase in the usage intentions (Sheikh & Khan, 2024; Grigorescu et al., 2023).

By analysing the information available on the Internet banking usage in the European Union for a period of 18 years, Grigorescu et al. (2023) reported that individuals with a higher level of education, regardless of gender, exhibit a more convergent electronic banking behaviour. Conversely, those with a lower level of education, particularly women, are the most exposed to exclusion from the digital transformation. By examining the perception of different populations, the variations between the education level and the usage of Internet banking seem to be significant (Sheikh & Khan, 2024; Nel & Boshoff, 2021). The highest values for using Internet banking were recorded for graduates and post-graduates, while the lowest values have represented school dropouts. A similar hypothesis is presented by Arif et al. (2020), who suggests that higher levels of education could explain why women are more likely to adopt Internet banking as compared to the males in the examined research sample.

The value barrier refers to the absence of a compelling value proposition, which decreases the users' incentives (Ram & Sheth, 1989), thus the Internet banking adoption is dependent on the perceived benefits. By examining the attitudes of bank customers, Nel and Boshoff (2021) found that the value barrier had the strongest impact on the negative attitude towards Internet banking. Thus, it is vital to address it to ensure a high degree of acceptance among individuals.

In this regard, Naeem and Ozuem (2021) observed through different perspectives (training provided by the banks to their customers and the self-improvement of digital skills), the role of education in addressing the value barrier.

The risk barrier in Internet banking adoption is often linked to the incorrect use of the service, loss of connection, and security concerns (Baklouti & Boukamcha, 2024; Arif et al., 2020). Thus, education, namely digital literacy, can be leveraged to grasp a better understanding of the information security concerns and improve the users' cybersecurity awareness. Therefore, we hypothesise that:

Hypothesis 1: The education level influences the adoption of Internet banking services across European countries.

2.2 Internet banking and IoT

Besides education, the individuals' digital literacy can be nurtured by a series of factors, such as their exposure to technology, their socioeconomic status, the

digital resources available, and their overall attitude towards technology in general. The global introduction of IoT and more specifically, IoT devices wielded for smart finance, offered a significant opportunity to improve the digital literacy of a variety of users with different needs and reduce their technological anxiety (Zallio et al., 2020), being a frequent theme in the digital literacy field (Tinmaz et al., 2022). Moreover, the IoT is a frequently mentioned technology in the DigComp 2.2 framework, due to its capabilities to improve the citizens confidence and safety in digital technologies (Vuorikari et al., 2022).

The use of IoT devices can contribute to improving convenience by allowing customers to save time and effort and increasing the overall ease of use while reducing some of the associated risks (Gupta, 2023). Thus, we argue that IoT could lead to decreases in the usage, value, and risk barriers.

As argued by Ram and Sheth (1989, p. 7), "innovations that require changes in customers' routine require a relatively long development process before gaining customer acceptance". Thus, by voluntarily including IoT devices in day-to-day life that can be used for wearable payments (Mishra & Guru Sant, 2021), individuals might embrace easier the use of these technologies for the adoption of Internet banking services, given the increased perceived value.

In terms of the risk barrier, IoT-based smart finance devices can leverage the capabilities of emerging technologies such as blockchain and artificial intelligence to ensure seamless transactions and improve security (Wen & Han, 2024). Given that the perceived security seems to have a positive impact on the usage intention and associated value in mobile banking (Hafez, 2022), we argue that IoT could lead to decreases in the usage, value, and risk barriers, and advance the following hypothesis:

Hypothesis 2: The IoT proliferation influences the adoption of Internet banking services across European countries.

2.3 Internet banking and digital banks

Digital banks, also known as Internet-only banks, started to emerge as a result of BigTech entry into the financial services industry. These operate exclusively online, promising their customers a higher degree of innovation and user-friendly experience.

In Europe, the most popular digital bank, in terms of the numbers of users, is Revolut, who managed to attract 35 million customers as of end-2023 (Statista, 2024a). Becoming popular for the convenient exchange rates before 2020 and recording an exponential increase in the number of users during the pandemic that continued up to now (Statista, 2024b), Revolut gained a significant share of banking customers in European countries, stimulating individuals' interest towards the online banking services.

Although digital banks do not have better performance compared to their traditional peers, their digital business models are mainly defined by two main directions: fast and easy, having a digital onboarding process designed to improve

security (Citterio et al., 2024). Thus, digital banks help individuals grasp a better understanding of the value brought by Internet banking services. As suggested by Arif et al. (2020), to reduce the value barrier, customers should have a complete understanding of the Internet banking services and banks should provide accessible and cost-effective ways for conducting the transactions online. Thus, the emergence of digital banks as means to provide significant values over the existing traditional banking and their increase in visibility, might address the value barriers. In a similar vein, digital banks could also contribute to the decrease of the image barrier. This psychological barrier, defined as referring to unfavourable associations (Ram & Sheth, 1989), has been frequently associated with the "hard to use" image of the Internet banking services in the literature (Baklouti & Boukamcha, 2024; Nel & Boshoff, 2021; Arif et al., 2020). Thus, given the ease-of-use frameworks that govern the digital banks, we argue that the image barrier might be decreased by the proliferation of online-only banks.

Based on the literature presented, we infer that:

Hypothesis 3: The increasing prevalence of digital banks influences the adoption of Internet banking services across European countries.

3. Research Methodology

This study aims to examine the factors that lead to decrease in the resistance barriers surrounding Internet banking adoption. Based on the presented literature, we discovered that the most important barriers could be addressed by three main factors, namely education, the proliferation of IoT Smart Finance, and the rise of digital banks. Therefore, we proposed the following model to test the previously defined research hypotheses:

$$\text{Internet banking adoption} = \propto + \beta_1 \text{Education} + \beta_2 \text{Digital banks} + \beta_3 \text{Internet of Things} + \beta_4 \text{Gross domestic product} + \varepsilon$$

The research adopts a quantitative approach to investigate the factors that can determine the increase in Internet banking adoption in European Union countries. Firstly, we present the data used in this exploratory analysis and the validation process, followed by the statistical techniques wielded to test the proposed hypotheses.

Data collection

The data used for testing the proposed hypotheses refers to 33 European countries, the list being presented in appendix 1, between 2018-2022, with a total sample of 158 valid cases. As proxies for the presented factors, we used a series of variables collected from European statistical databases and EU composite indicators, as presented in Table 1. There are seven missing cases since in four countries (France

– 2020, Iceland – 2022, Switzerland – 2018, 2020, and 2022, and United Kingdom – 2021 and 2022) the values of the indicators were not available.

Table 1. The variables, their descriptions, and the resources used

Factor	Indicator	Description	Unit of Measure	Source
Dependent variable				
Internet banking adoption	IB	Percent of individuals using Internet banking services	Percent	https://doi.org/10.2908/TIN00099
Independent variable				
Education	TDS	Total days of schooling, expressed in thousands	Thousand days	https://www.statista.com/outlook/co/socioeconomic-indicators/united-states#education
	GEE	Government expenditure on education	Percent	
Digital banks emergence	DB	Net interest income value of digital-only banks	Million USD	https://www.statista.com/outlook/fmo/banking/digital-banks/worldwide
Internet of Things proliferation	IOT	IoT Smart Finance revenue value	Million USD	https://www.statista.com/outlook/tmo/internet-of-things/smart-finance/worldwide
Control variable				
Gross domestic product	GDP	GDP per capita	Euro per capita	https://doi.org/10.2908/SDG_08_10

Source: Authors' own processing based on the collected data.

Internet banking adoption (**IB)** refers to the percentage of the population accessing banking services via the Internet, such as fund transfers, bill payments, and e-commerce. This indicator provides information regarding the level of digitalisation of banking services and the public's trust in using the Internet banking services.

The total days of schooling (**TDS**) represents the average period of schooling of a person over their lifetime. This indicator only considers individuals over the age of 25. It is an important indicator of the educational level of a country's population.

Digital banks emergence **(DB)** denotes the net interest income earned by banks that operate exclusively online. These banks do not have physical operational branches, with all activities being conducted through online platforms and applications. The integration of recent advancements of digital technologies, such as augmented reality, artificial intelligence, and the Internet of Things, allows for the provision of banking services exclusively online, which, until the emergence of this type of bank, could only be offered by traditional financial institutions.

Government expenditure on education (**GEE**) represents the governmental expenditures on education, expressed as a percentage of the GDP. The higher this percentage, the more it reflects a state's concern to ensure the highest level of education.

Internet of Things Smart Finance (**IOT**) refers to the use of IoT technologies in the financial industry. These technologies mainly include a series of devices and sensors that facilitate the transformation of traditional banking processes into smart

and connected activities. The IoT applications in the financial sector include smart insurance devices, automated teller machines (ATMs), point-of-sale (POS) devices, and smart banking and asset tracking devices.

Gross domestic product (**GDP**) reflects the population's prosperity and life standard. In economies with a higher level of high prosperity, the access to technology and digital infrastructure is particularly higher, which might contribute to an increase in the Internet banking adoption level.

4. Results and discussion

The descriptive statistics of the variable used are presented in Table 2. Three of the variables (DB, IOT, and GDP) were log transformed in order to normalise distributions and non-linear relationships, decrease variance, manage outliers, and compare trends. In the case of net interest income of the digital banks, the IoT Smart Finance revenue value, and the GDP per capita, based on the fact that these variables are expressed in millions of dollars, the values can vary significantly across observations, leading to disproportionate influence in the results. As it can be observed from the descriptive statistics, the log transformation reduced the skewness of the variables with log transformations, contributing to increasing the accuracy, stabilising the variance, and leading to a better model generalisation.

Table 2. Descriptive statistics

Variables	N	Min.	Max.	Mean	Std. Deviation	Skewness	Kurtosis
IB	158	6.87	96.13	61.02	22.85	-0.47	-0.37
TDS	158	2.90	5.19	4.37	0.45	-1.18	1.56
GEE	158	3.04	7.94	4.99	1.15	0.66	-0.09
DB	158	1.30	30030.00	1914.43	4580.33	3.97	17.87
DBLN	158	0.26	10.31	5.38	2.31	0.10	-0.66
IOT	158	40.00	11520.00	1748.29	2706.69	2.04	2.98
IOTLN	158	1.61	4.06	2.79	0.65	0.17	-0.70
GDP	158	5200.00	86540.00	28905.63	19256.42	1.22	1.02
GDPLN	158	3.72	4.94	4.37	0.29	-0.07	-0.56

***Note**:* Skewness standard error: 0.19; Kurtosis standard error: 0.38.

Source: Authors' own processing using PASW Statistics 18.

The analysis of the correlation coefficients between the variables shows strong correlations (>=0.6) between IB and IOTLN and IB and GEE, respectively, and a series of moderate correlations ([0.4;0.6)) between (1) IOTLN and DBLN, (2) GDPLN and DBLN, (3) IB and TDS. The remaining correlations are weak, with values below 0.4.

In order to test the proposed hypotheses, we developed four regression models, which were tested in Stata 14.2: (1) a linear regression model - pooled OLS without

GDP as a control variable, (2) a linear regression model - pooled OLS with GDP as a control variable, (3) a panel data regression without GDP as a control variable, and (4) a panel data regression with GDP as a control variable. The decision to use both pooled OLS and panel data regressions was made since, given the large number of countries analysed, country characteristics such as politics, level of digitalisation, and trust in the banking sector may have a particular influence on the level of Internet banking adoption. Another reason for using a panel model is to be able to analyse both differences between countries and developments over time. This model allows us to take into account not only country-specific characteristics, but also time-related factors, such as the pandemic. Moreover, by testing the models with and without GDP as a control variable, we were able to reduce the impact of the independent variables and thus contribute to define a more robust model.
The equations of the used regression models are as follows:

$$IB = \alpha + \beta_1 TDS + \beta_2 GEE + \beta_3 DBLN + \beta_4 IOTLN + \varepsilon \quad (1)$$

$$IB = \alpha + \beta_1 TDS + \beta_2 GEE + \beta_3 DBLN + \beta_4 IOTLN + \beta_5 GDPLN + \varepsilon \quad (2)$$

$$IB_{it} = \alpha_i + \beta_1 TDS_{it} + \beta_2 GEE_{it} + \beta_3 DBLN_{it} + \beta_4 IOTLN_{it} + \varepsilon_{it} \quad (3)$$

$$IB_{it} = \alpha_i + \beta_1 TDS_{it} + \beta_2 GEE_{it} + \beta_3 DBLN_{it} + \beta_4 IOTLN_{it} + \beta_5 GDPLN_{it} + \varepsilon_{it} \quad (4)$$

Note: i = 1, ..., 33 (country); t = 2018, ..., 2022 (year)

For the pooled OLS models we performed a series of tests to examine whether the dataset is suitable for regression analysis. Thus, we checked if the dataset respects the assumptions of homoscedasticity, normality of errors, linearity, and orthogonality.

Given that heteroscedasticity can lead to inefficient coefficient estimates, we tested the pooled OLS models using the Breusch-Pagan / Cook-Weisberg test, which yielded the following p-values: model 1 - p-value=0.0825 and model 2 - p-value=0.0953, both above the 0.05 threshold, thus confirming that the variance of the error term is constant for both models. Similarly, for examining whether serial correlation is present in the pooled OLS proposed models, we used the Durbin-Watson test for the pooled OLS models (Table 4). The results are shown in Table 3 and given that both values are around the value 2, we can conclude that the observations are independent.

To assess the normality of errors, for the pooled OLS models, we used the Shapiro-Wilk W test on the errors' residuals and for both models we obtained a value greater than the 0.05 threshold (model 1 - 0.58 and model 2 - 0.12878).

As multicollinearity can lead to unreliable coefficient estimates and inflated standard errors, we computed the VIF values for the pooled OLS models, which vary between 1.17 and 1.66 in model 2 and 1.47 and 2.41 for model 2. As the values are below 5, this indicates that multicollinearity is not a concern for the dataset.

To examine whether the panel data models should take into account fixed or random effects, we wielded the Hausman test the results highlighting a p-value of 0.0000 (<0.05), thus indicating that the differences between the coefficients of the two models are systematic and the fixed effects model is more suitable due to the

correlation values between the independent variables and the country-specific error (Table 3).

Table 3. Hausman test coefficients

Variables	Model 3				Model 4			
	(b) fixed effects model	(B) random effects model	(b-B)	sqrt(diag (V_b-V_B)) S.E.	(b) fixed effects model	(B) random effects model	(b-B)	sqrt(diag(V_b-V_B)) S.E.
DBLN	4.95	4.99	-0.04	0.33	3.93	4.36	-0.43	0.36
TDS	46.78	20.23	26.54	21.92	37.05	11.62	25.43	20.61
GEE	1.28	3.19	-1.91	0.53	2.86	2.88	-0.02	0.60
IOTLN	-21.91	-9.75	-12.16	11.91	-43.79	-11.35	-32.44	12.11
GDPLN	-	-	-	-	107.04	36.80	70.25	21.21

Model 3: Panel model Predictors: (Constant), IOTLN, TDS, GEE, DBLN; Dependent Variable: IB	Ho: difference in coefficients not systematic ● chi2(5) = 18.18 ● Prob > chi2 = 0.0011
Model 4: Panel model Predictors: (Constant), IOTLN, TDS, GEE, DBLN, GDPLN; Dependent Variable: IB	Ho: difference in coefficients not systematic ● chi2(5) = 27.39 ● Prob > chi2 = 0.0000

Source: Authors' own processing using Stata 14.2.

Moreover, for ensuring the validity of the results, even in the presence of non-homogeneous error variances and correlations in the panel data, we applied robust standard errors.

As it can be observed from Table 4, the pooled OLS models R^2 value highlight a strong predictability power, while the panel data models indicate a weak (model 3) and a moderate (model 4) relationships. Given that in both cases the use of GDP as a control variable improved the predictability power of the model, this outcome suggests that GDP per capita plays an important role in explaining the variation of the dependent variable. Therefore, Models 2 and 4 seem to better capture the underlying factors influencing the Internet banking adoption, reducing omitted variable bias and enhancing the models' robustness.

Each model reveals different insights into the factors that contribute to the adoption of Internet banking services, and by incorporating GDP as a control variable, the explanatory power of the models is enhanced. The robust fixed-effects panel models (Models 3 and 4) are better suited for capturing the structural influences, thus providing more reliable estimates.

The regression models' coefficients (Table 4) reveal that all the independent variables are statistically significant, with the exception of GEE (model 3). The most significant impact is observed across all models in the case of DBLN, consistent with

H_3. This result can be explained through the fact that Internet banking is a basic service of banks operating exclusively online.

Significant values are also observed in the case of GEE and TDS, supporting the acceptance of H_1. As can be noticed, the variable coefficients have similar values, despite their weak level of correlation (0.38). This outcome suggests that both factors have an important influence on the adoption of Internet banking services, although their significance levels range from highly to marginally significant across the proposed models.

The result regarding IOT reveals some interesting insights regarding the inverse significant relationship with IB. Although it supports the acceptance of H2, the result suggests that the expansion of the IOT smart finance market may lead to a decrease in the adoption of Internet banking. A possible explanation for this result could be that individuals are exposed to resource diversification, system fragmentation, or competing technologies.

Table 4. Regression Models Coefficients

Variables	Model 1	Model 2	Model 3	Model 4	Hypothesis
(Constant)	-46.64*** (13.27)	-139.59*** (20.63)	-115.48 (99.85)	-481.78*** (103.07)	-
GEE	10.61*** (0.97)	8.09*** (1.00)	2.28 (1.77)	2.86** (1.23)	H_1: supported
DBLN	0.43*** (0.56)	2.29*** (0.64)	4.95*** (0.87)	3.92*** (0.80)	H_3: supported
TDS	12.35*** (2.70)	10.05*** (2.50)	46.78* (24.24)	37.05* (18.97)	H_1: supported
IOTLN	-8.31*** (2.08)	-5.63*** (1.96)	-21.91* (11.20)	-43.79*** (12.54)	H_2: supported
GDPLN		27.37*** (4.91)		107.04*** (25.30)	-
R Square	0.68	0.73	0.38	0.55	-
Durbin-Watson	2.03	2.04			-
F Change	81.48	84.18	14.03	26.91	-

Notes: Dependent Variable: IB
Model 1: Linear regression model pooled OLS
Predictors: (Constant), IOTLN, TDS, GEE, DBLN
Model 2: Linear regression model pooled OL
Predictors: (Constant), GDPLN, IOTLN, TDS, GEE, DBLN
Model 3: Robust fixed effects panel model
Predictors: (Constant), IOTLN, TDS, GEE, DBLN
Model 4: Robust fixed effects panel model
Predictors: (Constant), GDPLN, IOTLN, TDS, GEE, DBLN
***p < 0.01, ** p < 0.05, * p < 0.1
Standard errors are provided within parentheses.

Source: Data processed by authors using Stata 14.2.

By comparatively analysing the proposed models (Models 1 to 4), it can be observed that the government spending on education (**GEE**) has a significantly positive impact on the dependent variable in the first two models, with a high

significance. However, it can be noticed that the effect slightly decreases when introducing the control variable in the pooled OLS Model 2. In the panel data Model 3 the effect becomes insignificant and negligible, while regaining significance in the robust fixed-effects model. Given that this variable's impact diminishes significantly when controlling for country-specific factors, this outcome indicates that government expenditure on education (**GEE**) alone does not directly cause a higher Internet banking adoption, but rather it contributes to the development of the underlying conditions that support an enabling environment for Internet banking growth. This finding is consistent with earlier research showing that higher levels of education and digital literacy help reduce barriers to Internet banking, contributing to increasing the individuals' adoption of Internet banking services (Sheikh & Khan, 2024; Grigorescu et al., 2023; Naeem & Ozuem, 2021; Rahi et al., 2021).

In terms of the second component of education, the number of total days of schooling (**TDS**), the significance of the variable tends to become marginal in panel data models. Nevertheless, the effect increases in the fixed-effect models suggest that once the structural differences between countries are considered, the education level of the population becomes a stronger predictor of Internet banking adoption level. In accordance with previous studies (Arif et al., 2020; Nel & Boshoff, 2021; Grigorescu et al., 2023), these outcomes suggest that individuals with higher levels of education are more likely to use Internet banking because given the better understanding, increased trust, and confidence in the underlaying security features. Therefore, improving educational levels can help overcome the barriers of usage, value, and risk (Ram & Sheth, 1989; Naeem & Ozuem, 2021), ultimately creating conditions that foster Internet banking growth.

The rise of the digital banks (**DBLN**), proxied through the net interest income value of digital-only banks, remains stable in terms of significance; however, its effect size varies across the proposed models. While in the first model a small positive effect can be noticed, it increases substantially when introducing the control variable (**GDPLN**), suggesting a stronger link. Similarly, in the data panel models, an increase in the effect can be observed, revealing its importance even when taking into account country-specific factors. These results confirm the findings of Citterio et al. (2024), and Arif et al. (2020) with suggests that digital banks can contribute at decreasing the Internet banking resistance due to their ease of use, increased trust, and convenient, user-friendly options. By improving the ease of use in terms of accessing the bank account and perform transactions, digital banks can help overcome the value and image barriers that often hold consumers back from using Internet banking (Ram & Sheth, 1989; Nel & Boshoff, 2021).

The variable associated with the use of the Internet of Things Smart Finance (**IOTLN**) has a robust negative effect on Internet banking adoption, with effect sizes that vary significantly across the models. While in the last model it has the largest magnitude, being highly significant, by not including the control variable, its significance becomes marginal. This outcome suggests that the relation might be underestimated in simpler models, pointing to potential challenges in the IoT-driven economies. The negative coefficient suggests that, as consumers increasingly adopt

IoT technologies in finance, they are using traditional Internet banking services less frequently. This could be because IoT-based financial solutions are more convenient, more automated, and offer innovative features that make classic Internet banking seem less attractive or necessary. However, this shift toward IoT also brings security risks, as IoT devices are more vulnerable to cyberattacks, an aspect that could influence users' trust in these alternative digital services. While IoT can contribute at improving the convenience of financial services and help individuals overcome certain barriers (Mishra & Guru Sant, 2021; Gupta, 2023), the IoT broad adoption can steer consumers toward newer financial solutions. At the same time, because IoT technologies may raise concerns about security and privacy (Hafez, 2022; Wen & Han, 2024), these findings support the ideas behind the Innovation Resistance Theory (Ram & Sheth, 1989). They show that new forms of resistance and trust issues can arise along the expansion of advanced technologies. To address this, it may be necessary to better understand how IoT-based services affect user perceptions, an area highlighted by research on digital literacy, trust, and digital competency frameworks (Tinmaz et al., 2022; Vuorikari et al., 2022; Zallio et al., 2020).

The gross domestic product per capita (**GDPLN**) has a significant positive impact on the adoption of Internet banking, its effect increasing considerably in the fixed-effect model. This outcome indicates that GDP has a dominant influence on the adoption level, underscoring the importance of macroeconomic factors in promoting Internet banking usage among individuals (Bechlioulis & Karamanis, 2023; Grigorescu et al., 2023).

5. Conclusions

Based on four regression models, both pooled OLS and panel data, we investigated the effect and significance of the variables across a dataset of 33 European countries, using Stata. All the proposed models support the hypothesis developed, confirming that the identified factors have a statistically significant impact on the Internet banking usage level across individuals, despite accounting for the economic size of the country.

Our research contributes at developing the Internet banking adoption literature by focusing on the barriers that hinder the usage of such services. Given the results obtained, we uncovered several elements that contribute at the decrease of such barriers and highlighted the complex nuances surrounding IoT smart finance.

The rise of digital banks, characterised by business models focused on accessibility and rapid digital onboarding processes, has significantly contributed to reducing perceived barriers to adopting online banking services, enhancing both their value and image. The growing popularity of banks like Revolut, which has attracted a considerable number of users across Europe (Statista, 2024a), suggests that these institutions have the potential to redefine consumers' perceptions of the usefulness and ease of use of Internet banking services. By addressing traditional psychological barriers, they stimulate the widespread adoption of these financial technologies.

For regulators, the findings of this study underscore the importance of understanding the economic contexts before implementing policies designed to foster financial inclusion. For financial service providers, the more reliable insights gained from such models can inform decisions about product design, user education, and investment in digital infrastructure. In turn, technology firms can use these findings to guide innovation toward more secure, user-friendly platforms that meet the varying needs of a diverse and evolving customer base.

Focusing on the European banking industry, where the adoption rates of Internet banking vary significantly across countries, the main limitation of the current research is determined by its reliance on macro-level variables and aggregate data, which might not fully capture the nuanced factors, such as cultural differences. Moreover, another limitation refers to the inclusion of only European countries in the study. While other regions might exhibit different dynamics in Internet banking adoption, as for the variations in digital infrastructure and financial inclusion. Nevertheless, expanding the research to other regions could provide a more comprehensive perspective on the global dynamics in the adoption of digital banking services and emerging technologies in the banking sector.

The research offers valuable perspectives for both European regulators and the banking sector. While our study emphasised that the education level and the increased popularity of digital banks improve the adoption level of Internet banking across the examined dataset, it also highlighted the significant negative impact of IoT smart finance, which can lead to a decrease in the Internet banking adoption. This research emphasises the importance of adapting to changes in consumer behaviour and new market requirements, while addressing the factors that might contribute to digital banking exclusion. Given the unexpected outcome in terms of IoT smart finance, future research could focus on investigating the underlying elements that might create additional concerns among users.

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Appendix 1. List of countries

Countries			
Austria	France	Luxembourg	Slovenia
Belgium	Germany	Malta	Spain
Bulgaria	Greece	Netherlands	Sweden
Croatia	Hungary	Norway	Switzerland
Cyprus	Iceland	Poland	Türkiye
Czechia	Ireland	Portugal	United Kingdom
Denmark	Italy	Romania	
Estonia	Latvia	Serbia	
Finland	Lithuania	Slovakia	