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An Analysis of the Interactions between Financial Literacy Levels and Digital Competences of Portuguese Families: Financial Behaviour of Households

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Acknowledgements

I am not sure words are enough to write this chapter. Perhaps they are not. Even so, as I feel these five years drawing to a close, I want to hold onto this feeling, not so much for what they were, but for everything they made me become.

FEP, I no longer remember who I was before you. These years taught me to find time where it seemed not to exist, and to turn demanding circumstances into organisation, focus, responsibility, and determination. Between training sessions, competitions, travel, classes, exams, work, and the unexpected turns that life brought, there were days when everything felt like too much. But there was also growth. My undergraduate degree taught me I would have to do things differently. My master's taught me I was capable of doing so.

To my father, my mother, and my nieces, my most heartfelt thank you. You were home on the hardest days, a smile when strength was running low, and the certainty that, however demanding the path, I was never truly walking it alone. I could not have done this without you.

When I arrived at FEP, I had just come from a World Championship and a career in elite sport. Throughout these five years, between everything this chapter demanded of me and everything I continued to give to cycling, there were paths I tried to walk again and milestones that, however much I sought them, did not return. Now, as I close this chapter, I find myself back in elite competition and just days away from another World Championship. Some coincidences seem to have a timing all their own.

Much of this dissertation was written between journeys back and forth between Portugal and Spain, in the midst of a life that never stopped. I remember summarising Os Maias during school breaks as a teenager. Some things do not seem to change. I still find time where it seems not to exist.

I am no example, and I would not do everything the same way. This was simply the path that made sense to me. It was hard, it was demanding, and many times it was too much. But perhaps that is the true meaning of a path. Not arriving at the end the same as when you began.

Abstract

This dissertation examines the moderating role of digital competences in the relationship between financial literacy and financial behavior among a Portuguese university-affiliated population, using microdata from the VI Inquérito CMVM (sixth edition) obtained under the FEP-CMVM collaboration protocol. Financial literacy is measured as an objective knowledge score from five questions; digital competences are operationalised as a formative composite index that combines six survey items. The primary outcome is savings adequacy (five-category ordinal scale), and the secondary outcome is a binary indicator of high-risk asset holding.

Four hypotheses are tested using OLS regression with heteroskedasticity-robust standard errors, supplemented by probit for the binary outcome. Financial literacy is a positive and significant independent predictor of savings adequacy, consistent with Lusardi and Mitchell (2014). Digital competences independently predict both savings behaviour and high-risk asset holding, including cryptocurrencies and complex financial products. However, the interaction between the two competences is not statistically significant in any primary specification, providing no support for the complementarity or risk-amplification mechanisms. Formal triple-interaction tests confirm that the moderation effect does not differ significantly across demographic subgroups, and Hypothesis 4 is not formally supported, despite suggestive negative interaction patterns among younger and more highly educated respondents.

These findings suggest that financial literacy and digital competences generate independent rather than mutually reinforcing benefits, contrasting with complementarity evidence from emerging markets. The strong association between digital engagement and high-risk asset holding underscores the importance of regulatory attention to product suitability in digital financial platforms. Results are subject to the limitations of cross-sectional data, and the university-affiliated sample limits external validity to the broader Portuguese population.

JEL codes: G53, D14, D91, O33, G51

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1. Introduction

This dissertation investigates how digital competences moderate the relationship between financial literacy and financial behavior among a Portuguese university-affiliated population. Using microdata from the VI Inquérito CMVM and an econometric framework based on OLS regression with interaction terms, the study tests whether digital skills amplify the positive effects of financial knowledge on savings behavior, compensate for financial literacy deficits, or exacerbate risk-taking among the less financially literate.

The motivation for this research is grounded in two concurrent trends. Despite some progress, Portugal's financial literacy levels remain a policy concern: according to the Conselho Nacional de Supervisores Financeiros (2024a), Portugal scores 63 points out of 100 on the global financial literacy index, ranking 13th among the 39 participating countries and equal to the OECD average, while only 11 percent of Portuguese adults demonstrate high financial literacy according to European Commission (2023) benchmarks, the lowest proportion in the EU. Simultaneously, the financial sector is undergoing rapid digital transformation, with the proliferation of online banking, mobile payments, and cryptocurrency platforms creating new demands for both financial knowledge and digital competencies (Philippon, 2016; Demirgüç-Kunt et al., 2018). This duality motivates a central research question: how do digital competences interact with financial literacy to shape the financial behaviors of Portuguese households?

The existing literature offers competing predictions. The complementarity hypothesis suggests that digital skills amplify the positive effects of financial knowledge by expanding access to financial products and enabling efficient information-seeking (Kass-Hanna et al., 2022). The substitution hypothesis proposes that digital tools may partially compensate for financial knowledge deficits through decision-support mechanisms. The risk amplification hypothesis warns that digital access without corresponding financial literacy may enable poor financial decisions at greater speed and scale (Panos & Wilson, 2020; Morgan et al., 2019). These competing mechanisms generate empirically testable predictions, and evidence from the Portuguese context remains scarce.

The empirical analysis, based on 2,319 responses from the VI Inquérito CMVM, yields four principal findings. First, financial literacy is a robust and positive predictor of savings adequacy, confirming the baseline relationship established by Lusardi and Mitchell (2014) in a Portuguese university-affiliated context. Second, digital competences independently predict

both savings behavior and high-risk asset holding, including cryptocurrencies and complex financial products, suggesting that digital engagement shapes financial outcomes through multiple channels. Third, the interaction between financial literacy and digital competences is not statistically significant in any primary specification, providing no support for the complementarity mechanism in the savings domain or the risk amplification mechanism in the high-risk investment domain. Fourth, formal triple-interaction tests indicate that the moderation effect does not differ systematically across demographic subgroups defined by age, gender, educational attainment, or income, and Hypothesis 4 is not formally supported.

These findings carry several implications. The independent positive effects of both financial literacy and digital competences on savings behavior suggest that investment in either domain yields returns regardless of the other domain, supporting the continued prioritization of financial literacy interventions embedded in the Plano Nacional de Formação Financeira 2021–2025 (Conselho Nacional de Supervisores Financeiros, 2024b). The strong association between digital engagement and high-risk asset holding, independent of financial literacy, underscores the importance of regulatory attention to product suitability in digital financial platforms. Banco de Portugal's (2023) Digital Financial Literacy Strategy represents a policy response that aligns with the observed independent, rather than complementary, relationship between the two competences.

This dissertation makes three principal contributions to the literature. First, it addresses a gap in Portuguese empirical research by providing a systematic analysis of how financial and digital competences interact to shape financial behavior, using objective financial literacy measures and a composite digital competence index grounded in a formative measurement framework. Second, it contributes to the financial inclusion literature (Demirgüç-Kunt et al., 2018; Morgan et al., 2019) by clarifying that financial literacy and digital competences operate through independent rather than multiplicative pathways in a developed economy setting, contrasting with complementarity evidence from emerging market contexts. Third, the formal triple-interaction tests provide a methodologically rigorous assessment of demographic heterogeneity, yielding a null result that itself advances understanding of the uniformity of the moderation mechanism across population segments.

This dissertation is structured in five chapters. Following this introduction, Chapter 2 presents a critical literature review on financial literacy, digital competences, and household financial behaviours, defining key concepts and synthesising relevant empirical evidence.

Chapter 3 details the research methodology, including data sources, variable operationalisation, and empirical strategy. Chapter 4 presents the results of descriptive statistics and estimated econometric models. Chapter 5 discusses the main findings, acknowledges the study's limitations, and presents conclusions with directions for future research.

2. Literature review

2.1 Defining Financial Literacy, Digital Competences, and Household Financial Behavior

This study is grounded in three core concepts that require precise definition to ensure analytical rigour and consistency throughout the research: financial literacy, digital competencies, and household financial behaviour. These concepts are intrinsically linked in the context of digitalized financial services, where digital skills mediate the relationship between financial knowledge and actual financial decisions.

Financial literacy is defined following the OECD (2020a) framework as "a combination of awareness, knowledge, skill, attitude, and behavior necessary to make sound financial decisions and ultimately achieve individual financial well-being" (p. 53). This multidimensional construct encompasses three interconnected components. First, financial knowledge refers to the understanding of fundamental financial concepts such as compound interest, inflation, risk diversification, and the time value of money. Second, financial attitudes capture individuals' predispositions towards saving, long-term planning, and prudent financial management. Third, financial behavior comprises the actual practices and decisions individuals make in managing their personal finances, including budgeting, saving, investment choices, and credit management (Lusardi & Mitchell, 2014).

Digital competences, in the context of financial services, encompass the skills, knowledge, and confidence required to use digital technologies effectively and safely for financial purposes (Morgan et al., 2019). Drawing on the European Commission's Digital Competence Framework (DigComp 2.0), this study conceptualises digital competences as comprising several dimensions: technical proficiency in using digital platforms and online banking interfaces; information literacy, including the ability to search for, critically evaluate,

and utilise financial information from digital sources; digital security awareness, particularly concerning cybersecurity risks in financial transactions; and problem-solving capacity in navigating digital financial ecosystems (Vuorikari et al., 2016). Morgan et al. (2019) emphasise that digital financial literacy represents the intersection of traditional financial literacy and digital literacy, enabling individuals to access, understand, and act upon financial information in increasingly digitalised environments. Importantly, digital financial literacy is not merely the sum of financial and digital literacy but rather a distinct competence that encompasses the ability to navigate the specific challenges and opportunities of digital financial environments. This includes understanding the implications of algorithmic decision-making in financial services, recognising digital financial fraud, and critically evaluating financial information from diverse online sources, including social media platforms (Choung et al., 2023).

Household financial behavior refers to the observable financial decisions and practices of families and individuals. This includes saving patterns, investment portfolio composition, credit product usage, participation in retirement planning schemes, and the selection of financial service channels (Xiao & O'Neill, 2016). In the context of this research, particular attention is paid to behaviours influenced by digital transformation, such as the adoption of online banking, use of mobile payment systems, and reliance on digital sources for financial advice (Philippon, 2016; Demirgüç-Kunt et al., 2018).

Having established these foundational concepts, the following section examines the theoretical frameworks and empirical evidence that explain how financial literacy and digital competences interact to shape household financial outcomes.

2.2 Theoretical Framework and Historical Context

2.2.1 Household Finance and Financial Literacy Theory

The theoretical foundation of this research lies at the intersection of three established research streams: household finance and financial literacy, digital transformation of financial services, and behavioral economics.

The economic importance of financial literacy has been increasingly recognised since the early 2000s, driven by structural shifts in financial markets and pension systems that transferred greater responsibility for financial decision-making from institutions to

individuals (Lusardi & Mitchell, 2011). Empirical evidence consistently demonstrates that financial literacy significantly influences household welfare. Thus, higher financial literacy is associated with greater wealth accumulation, improved retirement planning, more diversified investment portfolios, and reduced susceptibility to predatory lending (van Rooij et al., 2011; Lusardi & Tufano, 2015). These findings challenge the neoclassical assumption of fully rational agents with perfect information, revealing that cognitive constraints and information asymmetries substantially affect financial outcomes (Lusardi & Mitchell, 2014).

2.2.2 Digital Transformation of Financial Services

The role of financial literacy has become even more critical in the context of rapid financial digitalisation. Over the past two decades, the financial services industry has undergone a fundamental technological transformation, characterised by the proliferation of fintech platforms, robo-advisors, cryptocurrencies, and mobile banking applications (Philippon, 2016). This transformation encompasses multiple dimensions: the automation of investment advice through algorithm-driven platforms, the emergence of peer-to-peer lending and crowdfunding, the adoption of mobile payment systems, and the increasing use of artificial intelligence in credit scoring and risk assessment (Buchak et al., 2018). The COVID-19 pandemic significantly accelerated this digital transition, compressing years of anticipated technological change into a matter of months and permanently reshaping how households access and manage financial services across developed and developing economies alike.

This transformation presents both opportunities and risks. From a positive perspective, digital financial technologies have demonstrably expanded access to financial services for previously underserved populations (Demirgüç-Kunt et al., 2018). Technology-enabled lenders expand credit access to borrowers underserved by traditional banks, particularly in areas with fewer physical bank branches. At the same time, robo-advisors enable individuals with modest wealth to access portfolio management services at substantially lower costs than those charged by human financial advisors (Philippon, 2016). Digital investment platforms further reduce barriers to stock market participation by eliminating minimum balance requirements and lowering transaction costs.

Conversely, digitalisation may exacerbate existing inequalities by creating a digital divide that excludes individuals lacking digital skills, potentially widening financial inclusion

gaps (Demirgüç-Kunt et al., 2018). Elderly populations, individuals with lower educational attainment, and rural communities face particular challenges in accessing and effectively utilising digital financial services. Furthermore, the complexity of digital financial ecosystems, combined with sophisticated online fraud schemes such as phishing attacks, creates new vulnerabilities for consumers with limited digital or financial literacy (Morgan et al., 2019). The frictionless nature of digital transactions, which require only a click or a screen tap rather than the physical exchange of cash, reduces psychological barriers to spending and borrowing, potentially facilitating impulsive purchases and excessive credit utilisation (Panos & Wilson, 2020). Additionally, the proliferation of unregulated financial influencers on social media platforms introduces risks of misinformation and unsuitable product recommendations (Ferreira, 2024).

2.2.3 The Interaction between Financial and Digital Literacy

The intersection of financial literacy and digital competences represents an emerging theoretical frontier in household finance research. While traditional financial literacy research treats financial knowledge as the primary determinant of financial behavior, the progressive digitalisation of financial services necessitates a reconceptualisation of this relationship. Lo Prete (2022) argues that digital literacy amplifies the effect of financial literacy on economic and financial outcomes, proposing that the capacity to access, process, and act upon financial information through digital channels constitutes a distinct competence that multiplies the value of underlying financial knowledge. Under this view, financial and digital literacy are not substitutes but complements; individuals possessing both competencies are disproportionately better equipped to navigate complex financial environments than those possessing only one.

Drawing on the digital financial literacy framework, Morgan et al. (2019) propose three theoretical mechanisms through which digital competences may moderate the relationship between financial literacy and financial outcomes. The complementarity hypothesis posits that digital skills amplify the positive effects of financial knowledge by expanding access to diverse financial products, enabling efficient information search and comparison across providers, and facilitating the implementation of financially optimal strategies through digital platforms. The substitution hypothesis suggests that digital tools, including robo-advisors, automated savings applications, and comparison websites, may partially compensate for

financial knowledge deficits by guiding less financially literate individuals toward better decisions, thereby attenuating the positive effect of financial literacy. The risk amplification hypothesis contends that digital competences without corresponding financial literacy may enable poor financial decisions at unprecedented speed and scale, as digitally proficient but financially illiterate individuals may access complex or high-risk financial products they lack the knowledge to evaluate appropriately. These three mechanisms generate distinct and testable predictions regarding the sign and significance of the interaction between financial literacy and digital competences in determining household financial outcomes, predictions that constitute the empirical focus of Sections 2.3.4 and 2.4.

2.2.4 The Portuguese Context: Digital Transformation and Financial Literacy Challenges

Within the Portuguese context, financial literacy levels remain a policy concern despite gradual improvements over recent years. Survey evidence consistently documents that while Portuguese adults exhibit relatively positive financial attitudes and behaviours, substantial knowledge gaps persist, particularly in areas such as interest rate calculations and risk diversification (Conselho Nacional de Supervisores Financeiros, 2024a). These weaknesses are compounded by persistent challenges in digital adoption and competencies, where Portugal's performance on key digital literacy indicators remains modest relative to leading European economies (European Commission, 2024). The adoption of digital financial services shows pronounced disparities across age groups, with younger cohorts substantially more engaged with online banking and mobile financial services than older cohorts. This pattern raises concerns about digital and financial exclusion among elderly individuals, who may simultaneously face deficits in financial and digital literacy.

These digital and financial literacy challenges overlap and interact in ways that create compounded vulnerabilities for certain demographic groups, particularly elderly individuals, those with lower educational attainment, and residents of rural areas. As traditional bank branches close and financial institutions shift services online, digitally excluded populations may find their financial access reduced rather than enhanced, potentially exacerbating existing socioeconomic inequalities (Demirgüç-Kunt et al., 2018; Ozili, 2018).

Portuguese policymakers have recognised these challenges. The Plano Nacional de Formação Financeira 2021–2025 (Conselho Nacional de Supervisores Financeiros, 2021) explicitly identifies digital financial education as a strategic priority, emphasising the need to develop both financial knowledge and digital competencies in an integrated manner. Similarly, Banco de Portugal's Estratégia de Literacia Financeira Digital (Banco de Portugal, 2023) aims to equip citizens with the competences to use digital financial services safely while addressing risks of digital exclusion. The INCoDe.2030 National Digital Skills Initiative, launched in 2017 and partly funded by the European Social Fund, represents Portugal's comprehensive effort to enhance digital skills across generations and ensure inclusive digital transformation (European Commission, 2024).

However, empirical research examining the interplay between financial and digital literacy specifically within Portuguese households remains remarkably limited. Existing studies have predominantly analysed these dimensions separately, leaving critical questions unanswered about how digital competences moderate the relationship between financial knowledge and financial behaviours in the Portuguese context. This study addresses this gap by investigating whether digital competences function as complementary assets that amplify the positive effects of financial literacy, as substitutive factors that compensate for knowledge deficits, or as potential risk amplifiers for financially vulnerable populations.

2.3 Empirical Evidence

The following subsections systematically review the empirical evidence on financial literacy and digitalisation. This review examines the determinants of financial literacy (2.3.1), its effects on household financial behaviours (2.3.2), the impacts of digitalisation (2.3.3), and the emerging research on their interaction (2.3.4).

2.3.1 Determinants of Financial Literacy

A substantial body of empirical research has identified systematic patterns in financial literacy across demographic and socioeconomic groups, revealing that financial knowledge is not uniformly distributed across populations. Across multiple countries and contexts, financial literacy is consistently and positively associated with educational attainment, household income, and middle age, while exhibiting persistent gender gaps favouring men

and declining performance among older and younger age groups (van Rooij et al., 2011; Lusardi & Mitchell, 2014). Financial literacy typically follows an inverted U-shaped pattern across the life cycle, peaking during middle age when individuals face complex financial decisions regarding retirement planning, and declining thereafter. The gender gap is particularly pronounced for questions involving numeracy and investment concepts, such as risk diversification and stock market functioning, and persists even after controlling for education, income, and employment status (Lusardi & Mitchell, 2014). Employment status and occupation also matter, with self-employed individuals and those in cognitively demanding professional roles generally displaying higher financial literacy than employees in comparable income brackets (Lusardi & Mitchell, 2014).

Within the Portuguese context, these international patterns are broadly confirmed, while available evidence documents specific national characteristics and performance levels. Portugal's overall financial literacy score on the 2023 OECD/INFE survey is close to the OECD average, but this masks significant weaknesses in financial knowledge specifically, where Portugal ranks below the OECD average (Conselho Nacional de Supervisores Financeiros, 2024a). When assessed using the European Commission's financial literacy framework, only 11 percent of Portuguese adults demonstrate high financial literacy, among the lowest proportions in the EU and well below the EU average of 18 percent (European Commission, 2023). The Conselho Nacional de Supervisores Financeiros (2024a) survey confirms that financial literacy increases with educational attainment, with young adults aged 25–44 displaying the highest levels, while both younger and older cohorts perform below average. The gender gap persists, with men scoring approximately six percentage points higher than women in financial knowledge assessments, and geographic disparities emerge between urban and rural residents. Understanding these determinant patterns is crucial for the present study's investigation of how digital competences interact with existing financial literacy levels, as the same demographic groups exhibiting low financial literacy, elderly individuals, lower-educated populations, women, and rural residents, often face additional challenges in acquiring digital skills, potentially creating a "double disadvantage" in increasingly digitalised financial environments.

2.3.2 Effects of Financial Literacy on Household Financial Behaviors

Extensive empirical research has documented that financial literacy significantly influences household financial decision-making across multiple domains, with measurable impacts on wealth accumulation, retirement preparedness, investment portfolio composition, and debt management. These findings challenge the neoclassical assumption that households universally behave as rational, well-informed agents, demonstrating instead that cognitive constraints and knowledge deficits substantially affect financial outcomes.

Savings behavior and retirement planning are areas where the effects of financial literacy have been most comprehensively documented. Lusardi and Mitchell (2011) analyse data from the Health and Retirement Study in the United States, demonstrating that individuals with higher financial literacy are significantly more likely to engage in retirement planning activities, including calculating retirement savings needs, attending retirement seminars, and consulting financial advisors. Importantly, financially literate individuals not only plan more frequently but also accumulate substantially greater retirement wealth, with differences persisting even after controlling for income, education, and other socioeconomic characteristics. This relationship appears causal rather than merely correlational, as instrumental variable analyses suggest that financial knowledge directly influences planning behavior, which in turn drives wealth accumulation. The mechanisms underlying this relationship include a better understanding of compound interest effects over long time horizons, a greater appreciation of the need to start saving early, and an improved ability to calculate adequate savings rates relative to retirement income goals.

Stock market participation and portfolio diversification constitute another domain where financial literacy exerts substantial influence. Van Rooij et al. (2011) provide compelling evidence from Dutch household data that financial literacy strongly predicts stock market participation, with individuals possessing advanced financial knowledge being significantly more likely to hold stocks either directly or through mutual funds. This relationship is particularly pronounced in understanding risk diversification principles, as households that grasp that diversification reduces portfolio risk demonstrate substantially higher equity ownership rates than those lacking this knowledge. The study employs sophisticated econometric techniques, including instrumental variables to address potential endogeneity concerns, and finds that the estimated effect of financial literacy on stock market participation remains large and statistically significant across alternative specifications.

Beyond mere participation, financially literate investors also construct more diversified portfolios, avoiding excessive concentration in employer stock or home-country bias that characterises many portfolios of less financially sophisticated investors. These patterns have important welfare implications, as inadequate stock market participation and poor diversification lead to suboptimal risk-return profiles and lower expected long-run wealth accumulation.

Drawing on survey data from the same Portuguese university-affiliated population used in the present study, Alves (2023) investigates the relationship between perceived and actual financial literacy and participation in both traditional and new securities market segments, including cryptocurrencies, structured retail products, and crowdfunding. The study documents that underconfidence in financial knowledge is negatively associated with both market participation and participation intensity. In contrast, the relationship between advanced financial literacy and overconfidence varies by product type, overconfidence being positively associated with cryptocurrency and structured product participation but not with crowdfunding. These findings extend the evidence from van Rooij et al. (2011) to new digital asset classes and underscore the importance of distinguishing between objective and self-assessed financial literacy, as the two measures carry different implications for investment behaviour in increasingly complex financial markets.

Credit management and debt-related behaviours reveal additional domains where financial literacy proves consequential. Lusardi and Tufano (2015) introduce the concept of "debt literacy", knowledge specifically related to borrowing and debt management, and demonstrate its strong association with borrowing behaviors and debt outcomes. Individuals with low debt literacy are significantly more likely to engage in high-cost borrowing through payday loans, pawnshops, and other alternative financial services, incurring substantially higher interest costs than those with adequate debt knowledge. Furthermore, low debt literacy correlates strongly with over-indebtedness, as measured by indicators such as inability to meet debt service obligations, credit card debt exceeding monthly income, and reliance on high-cost credit to service existing debts. The study documents that these patterns persist across income levels, indicating that debt literacy deficits affect both low-income households facing resource constraints and higher-income households with greater borrowing capacity. Particularly concerning is evidence that individuals with low debt literacy systematically underestimate the true cost of credit, failing to account for compounding effects and

misunderstanding terms such as annual percentage rates (APRs), resulting in suboptimal borrowing decisions.

Broader financial management practices are also strongly associated with financial literacy levels. Research demonstrates that financially literate households are more likely to maintain emergency savings buffers, comparison shop for financial products, read and understand loan contracts before signing, and avoid costly mistakes such as paying unnecessary fees or falling victim to financial fraud (Lusardi & Mitchell, 2014). Financially literate consumers are more likely to choose lower-cost financial products when equivalent alternatives exist, such as selecting low-fee index funds over high-fee actively managed funds with similar risk profiles, or choosing mortgage products with lower total costs that account for both interest rates and fees.

The cumulative effect of these financial literacy-driven behavioral differences proves substantial. Longitudinal studies tracking households over time document that differences in financial literacy measured early in the life cycle predict wealth accumulation trajectories decades later, even after controlling for income, education, and other observable characteristics (Lusardi & Mitchell, 2014). These findings carry important policy implications, suggesting that financial education interventions improving financial literacy may generate significant long-term welfare benefits by enabling better financial decision-making across multiple domains. However, the magnitude of financial literacy effects varies across contexts and populations, with some research suggesting diminishing marginal returns to financial knowledge beyond basic concepts, and ongoing debate regarding the most effective mechanisms for improving financial literacy at the population scale (Fernandes et al., 2014).

Within the Portuguese context, while comprehensive longitudinal evidence tracking financial literacy's long-term effects on wealth accumulation remains limited, available cross-sectional data from the Conselho Nacional de Supervisores Financeiros (2024a) survey indicate patterns consistent with international findings, showing that individuals with higher financial literacy scores report higher savings rates, greater diversification in financial asset holdings, and more prudent credit management practices. These associations persist after controlling for education, income, and employment status, suggesting that financial literacy exerts independent effects on financial behaviors in the Portuguese population, consistent with patterns documented internationally.

This body of evidence provides the direct empirical foundation for Hypothesis 1, which predicts that higher levels of financial literacy are positively associated with savings adequacy among the Portuguese university-affiliated population studied here.

While the literature documents financial literacy effects across these multiple domains, the empirical analysis in the present study focuses on two dimensions for which the VI Inquérito provides adequate measurement: savings adequacy and the propensity to hold high-risk assets. This focus reflects data availability constraints rather than a theoretical prioritisation of these outcomes over others documented in the broader literature.

2.3.3 Digitalisation and Household Financial Behaviors

The rapid digitalisation of financial services over the past two decades has fundamentally transformed how households access financial products, manage their finances, and make financial decisions. Empirical research examining these transformations reveals a complex and nuanced picture, with digital technologies simultaneously expanding financial inclusion and access while potentially creating new risks and vulnerabilities for certain population segments. Understanding these dual effects proves essential for assessing how digital competences interact with financial literacy to shape household outcomes.

Digital financial technologies have demonstrably expanded access to financial services for previously underserved populations. Demirgüç-Kunt et al. (2018), analysing data from the Global Findex Database 2017, document that mobile money services and digital payment platforms have driven substantial increases in financial account ownership in developing economies, particularly in regions with limited traditional banking infrastructure. Mobile banking enables individuals in remote areas to access basic financial services without requiring physical bank branches, while digital payment systems reduce transaction costs and enable real-time transfers that were previously prohibitively expensive or logistically infeasible. These accessibility improvements carry significant welfare implications, as financial account ownership facilitates safer money storage, enables formal savings mechanisms, and provides access to credit and insurance products that support household resilience against economic shocks. Beyond basic access, digitalisation has democratised access to sophisticated financial products and investment opportunities previously available only to wealthy individuals or institutional investors. Buchak et al. (2018) analyse the rise of fintech lending in the United States, demonstrating that technology-enabled lenders expand

credit access to borrowers underserved by traditional banks, particularly in areas with fewer physical bank branches and among demographic groups facing historical discrimination in lending markets. Digital investment platforms similarly reduce barriers to stock market participation by eliminating minimum balance requirements, lowering transaction costs, and providing user-friendly interfaces that simplify portfolio management. Robo-advisors offering algorithm-driven investment advice at substantially lower costs than human financial advisors enable individuals with modest wealth to access portfolio diversification strategies and tax-optimisation techniques previously available only to high-net-worth clients (Philippon, 2016).

Despite these accessibility benefits, digitalisation of financial services also creates potential behavioural risks that may lead to suboptimal financial decision-making. Panos and Wilson (2020) analyse how digital financial interfaces influence consumer behaviour, identifying several mechanisms through which digitalisation may encourage impulsive or poorly considered financial decisions. The frictionless nature of digital transactions, which require only a click or tap rather than the physical exchange of cash or in-person bank visits, reduces psychological barriers to spending and borrowing, potentially facilitating impulsive purchases and excessive credit utilisation. Digital interfaces often employ behavioral design features, such as one-click purchasing, automatic subscription renewals, and personalised marketing based on browsing history, that exploit cognitive biases and encourage consumption beyond what individuals would choose under more deliberative decision-making conditions. Empirical evidence supports these concerns. Yue et al. (2022) examine the relationship between digital finance adoption and household debt levels in China, documenting that expansion of mobile payment systems and online lending platforms correlates with increased household indebtedness, particularly among younger, less financially sophisticated users. Their analysis reveals that the convenience and speed of digital borrowing, which allows loan approval and disbursement within minutes via smartphone applications, may lead to debt accumulation at rates that exceed borrowers' repayment capacity.

The digital financial environment also presents novel fraud and security risks, as the proliferation of financial applications, cryptocurrency platforms, and peer-to-peer lending services creates opportunities for fraudulent schemes targeting consumers with limited digital literacy or financial sophistication. Phishing attacks, identity theft, and investment scams are

becoming increasingly sophisticated, exploiting the speed and anonymity of digital transactions. Older adults and individuals with limited digital experience face particular vulnerabilities, as they may lack the technical knowledge to recognise fraudulent communications or to adequately secure their digital financial accounts (Koskelainen et al., 2023).

While digitalisation expands access for some populations, it simultaneously risks creating new forms of financial exclusion for others. Demirgüç-Kunt et al. (2018) emphasise that digital financial inclusion benefits depend critically on populations possessing adequate digital literacy and access to enabling technologies such as smartphones and reliable internet connectivity. In contexts where these prerequisites are unequally distributed, digitalisation may widen rather than narrow financial inclusion gaps. Several population groups face systematic disadvantages in accessing increasingly digitalised financial services: elderly populations with limited familiarity with digital technologies; individuals with limited formal education who may struggle with digital interfaces and online financial terminology; rural residents in areas with poor internet infrastructure or limited mobile network coverage; and economically disadvantaged households unable to afford the devices necessary for accessing digital financial services. As traditional bank branches close and financial institutions shift services online, these digitally excluded populations may find their financial access reduced rather than enhanced, potentially exacerbating existing socioeconomic inequalities (Ozili, 2018).

Available evidence illustrates the scale and heterogeneity of these digital adoption challenges. In Portugal, 56 percent of the population possesses at least basic digital skills, a figure marginally above the EU average of 55.6 percent, but growing at only 0.6 percent since 2021, well below the EU average growth rate of 1.5 percent over the same period (European Commission, 2024). Substantial regional disparities persist across the EU, with internet banking usage ranging from less than 20 percent in certain regions of Bulgaria and Romania to over 80 percent in regions such as Cyprus and Nordic countries (Eurostat, n.d.-b). Age-related disparities are particularly pronounced: EU-wide data from 2023 indicate that 78 percent of adults aged 25 to 29 use online banking, declining sharply to 41.1 percent among those aged 65 to 74 (Eurostat, n.d.-a). These patterns are especially concerning for Portugal, where approximately 24 percent of the population is aged 65 or older, among the highest

proportions in the EU, creating substantial challenges for digital financial inclusion (Eurostat, n.d.-c).

Emerging evidence suggests that digitalisation's net effect on household financial outcomes varies substantially across demographic groups and individual characteristics. Financially literate individuals with strong digital skills appear well-positioned to exploit digitalisation's benefits, accessing low-cost investment platforms, comparison shopping across digital financial providers, and leveraging automated financial management tools, while avoiding its pitfalls through careful evaluation of digital financial products and adequate cybersecurity practices. Conversely, individuals lacking either financial literacy or digital competencies may experience digitalisation as primarily increasing vulnerability to poor financial decisions, fraud, and exclusion from increasingly digital financial ecosystems. These heterogeneous effects underscore the importance of understanding how financial literacy and digital competences interact to shape financial behaviours in digital environments, a central focus of the present investigation.

2.3.4 Interaction between Financial Literacy and Digital Competences: Empirical Evidence

Despite the theoretical frameworks outlined in Section 2.2.3, empirical evidence on the interaction between financial literacy and digital competences remains limited and contextually specific. The available studies document heterogeneous findings that prevent definitive conclusions about which of the three theoretical mechanisms, complementarity, substitution, or risk amplification, dominates in practice, and suggest that the direction of interaction effects may depend substantially on the specific financial behavior under examination, the population studied, and the measurement approaches adopted.

The complementarity mechanism finds support in evidence from emerging market contexts. Kass-Hanna et al. (2022), examining data from Lebanon and Jordan, document that financial resilience outcomes are significantly better among individuals possessing both financial and digital literacy compared to those with only one competence, consistent with the hypothesis that the two skills function as mutually reinforcing assets. The authors argue that digital competences expand the channels through which financially literate individuals can implement sound financial strategies, including accessing low-cost digital savings

products, comparing financial offerings across providers, and automating financial management processes. However, the applicability of these findings to developed economies with more mature digital financial ecosystems and higher baseline digital literacy levels remains uncertain.

Evidence more consistent with the risk amplification mechanism emerges from studies examining digital overconfidence and high-risk investment behaviour. Choung et al. (2023) document that individuals who overestimate their digital financial literacy are more likely to engage in risky financial behaviors online, including purchases of unsuitable investment products and susceptibility to digital financial fraud, suggesting that misaligned digital confidence, rather than digital competence per se, may be the primary risk factor. Panos and Wilson (2020) provide complementary evidence, demonstrating that digital financial service adoption correlates with increased household debt among less financially sophisticated users, consistent with the risk-amplification mechanism whereby digital access enables poor financial decisions at greater speed and scale among those lacking adequate financial knowledge to evaluate available products.

In the Portuguese context, the available evidence is sparse but suggests risk amplification patterns among university-affiliated populations. Ferreira (2024), examining a sample of Portuguese university students, finds that greater digital financial engagement correlates with higher cryptocurrency holdings and adoption of complex products, with effects most pronounced among students with lower objective financial literacy scores. These findings hint at risk-amplification mechanisms whereby digital access without corresponding financial literacy may encourage suboptimal financial behaviours, though the study's focus on a narrow demographic segment limits generalisability to the broader Portuguese population. Drawing on data from the same CMVM university survey used in the present study, Alves (2023) investigates the relationship between perceived and actual financial literacy among university-affiliated respondents in Portugal, examining participation in both traditional and new securities market segments, including cryptocurrencies, structured retail products, and crowdfunding. The study documents that even among generally literate individuals, perceived financial knowledge systematically biases actual financial behavior, with underconfidence negatively associated with both market participation and participation intensity. Crucially, the relationship between advanced financial literacy and overconfidence varies by product type; overconfidence is positively associated with participation in

cryptocurrencies and structured retail products but not with crowdfunding, suggesting that financial sophistication does not uniformly protect investors against behavioral biases in more complex market segments. These findings extend the evidence from van Rooij et al. (2011) to new digital asset classes and directly inform the risk-amplification mechanism examined in Hypothesis 3 of the present study.

The scarcity of rigorous empirical evidence on the interaction between financial literacy and digital competences in developed European economies, and the absence of studies specifically examining this interaction in the Portuguese context using representative survey data, constitute the primary research gap addressed by the present study. The theoretical mechanisms proposed by Morgan et al. (2019) and the empirical patterns documented in the studies reviewed above generate competing predictions that cannot be resolved through existing evidence alone, motivating an empirical investigation using the VI Inquérito CMVM dataset. Specifically, this evidence base motivates Hypotheses 2 and 3: Hypothesis 2 tests whether digital competences amplify the positive effect of financial literacy on savings adequacy, consistent with the complementarity mechanism, while Hypothesis 3 examines whether digital competences exacerbate high-risk investment behavior among the less financially literate, consistent with the risk amplification mechanism. The heterogeneous demographic patterns documented in Section 2.3.1 further motivate Hypothesis 4, which examines whether these interaction effects vary systematically across age cohorts, educational attainment levels, income brackets, and gender groups.

2.4 Conceptual Framework and Research Hypotheses

Based on the theoretical foundations and empirical evidence reviewed in the preceding sections, this study proposes a conceptual framework that positions digital competences as a moderating variable in the relationship between financial literacy and household financial behaviors. The framework integrates insights from multiple research streams, including household finance theory, behavioural economics, and the emerging literature on digital financial literacy, to articulate testable hypotheses about how financial knowledge and digital skills jointly influence financial decision-making in increasingly digitalised financial environments.

The conceptual model rests on two foundational propositions supported by the literature reviewed. First, drawing on extensive empirical evidence (Lusardi & Mitchell, 2014;

van Rooij et al., 2011; Lusardi & Tufano, 2015), the framework posits that financial literacy exerts direct positive effects on household financial behaviours, including savings adequacy and investment decision-making. Individuals with a greater understanding of fundamental financial concepts such as compound interest, inflation, risk diversification, and the time value of money make better financial decisions than those lacking such knowledge. Second, recognising the rapid digitalisation of financial services documented in Section 2.2.2, the framework acknowledges that digital competences have become increasingly relevant for accessing and effectively utilising contemporary financial products and services.

Rather than treating digital competences as simply another independent determinant of financial behaviors, the framework conceptualizes digital skills as a moderating variable that may alter the strength and direction of the relationship between financial literacy and financial outcomes. Three alternative theoretical mechanisms, identified in the literature review (Morgan et al., 2019; Kass-Hanna et al., 2022; Panos & Wilson, 2020), suggest different ways through which digital competences may moderate financial literacy effects. The complementarity hypothesis posits that digital competences and financial literacy are mutually reinforcing, with digital skills amplifying the positive effects of financial knowledge by expanding access to low-cost financial products, enabling more efficient acquisition of financial information, and facilitating the implementation of sophisticated financial strategies through digital platforms. The substitution hypothesis suggests that digital tools and platforms may partially compensate for financial knowledge deficits by providing decision-support mechanisms that guide less financially literate individuals toward better decisions. The risk amplification hypothesis, in contrast, warns that digital competences without corresponding financial literacy may enable poor financial decisions at greater speed and scale, with digitally skilled but financially illiterate individuals potentially more vulnerable to unsuitable online investments or digital fraud.

While the substitution hypothesis suggests intriguing theoretical possibilities, empirical testing of this mechanism presents considerable methodological challenges with the available data. The sixth CMVM survey on financial literacy and investment behavior, from which this study's sample is drawn, captures a single point in time and does not permit the longitudinal tracking necessary to distinguish genuine decision-support effects from confounding factors such as institutional default settings or mandatory financial advice. Consequently, this study focuses empirical attention on testing the complementarity and risk

amplification mechanisms, which offer more tractable empirical predictions regarding interaction effects between financial literacy and digital competences, and extends the analysis to examine whether these relationships vary systematically across demographic subgroups.

Before presenting the formal hypotheses, it is necessary to clarify how the key theoretical constructs are operationalised given the available data. Financial literacy is measured as an objective knowledge score constructed from five questions in the CMVM survey, each with a verifiably correct answer addressing compound interest, inflation, bond pricing, loan terms, and investment diversification, producing a score ranging from 0 to 5. This operationalization follows the approach recommended by Lusardi and Mitchell (2014) and van Rooij et al. (2011), who advocate objective measures of knowledge over self-assessed financial literacy. Household financial behavior is examined across two dimensions. The primary outcome captures savings adequacy, measured as a five-category ordinal variable reflecting the proportion of monthly income saved. The secondary outcome is a binary indicator of high-risk investment behavior, equal to 1 if the respondent reports holding cryptocurrencies or complex financial products such as warrants or contracts for difference, and 0 otherwise. Digital competences are operationalised as a composite index that combines six survey items capturing self-assessed digital knowledge, preference for autonomous digital channels across different asset classes, frequency of financial information seeking, and use of specialised financial literacy websites. Each component is standardised to z-scores prior to aggregation to ensure comparability across response scales, and the internal consistency of the resulting index is assessed using Cronbach's alpha. It is acknowledged that this composite serves as a proxy measure and constitutes a methodological limitation, which is discussed further in Section 5.

The first hypothesis establishes the baseline relationship that underpins the entire conceptual framework. The extensive international literature reviewed in Section 2.3.2 consistently shows that financially literate individuals make more prudent financial decisions, particularly regarding savings behavior. In the Portuguese context, where financial literacy levels remain comparatively low (Banco de Portugal, 2023), this relationship is expected to hold within the university-affiliated population studied here. Accordingly, it is hypothesised that higher levels of financial literacy are positively associated with savings adequacy, with the financial literacy score expected to produce a positive and statistically significant

coefficient in regression models predicting the savings outcome. This baseline provides the reference point against which the moderating role of digital competences is subsequently assessed.

The second hypothesis tests whether digital competences amplify the positive effect of financial literacy on savings behavior. The complementarity mechanism implies that digitally competent individuals are better positioned to translate financial knowledge into effective savings action by accessing competitive savings products online, automating savings decisions through digital platforms, and efficiently comparing financial offerings across providers. Building on the evidence of Kass-Hanna et al. (2022), who document complementarity effects between financial and digital literacy in emerging market contexts, this study examines whether a similar mechanism operates within a developed European economy. It is therefore hypothesised that the positive relationship between financial literacy and savings adequacy is stronger among individuals with higher digital competencies, which would manifest empirically as a positive and statistically significant interaction term between the financial literacy score and the digital competence index.

The third hypothesis shifts attention to the risk amplification mechanism and a different dimension of financial behaviour. Rather than examining savings adequacy, this hypothesis considers the propensity to hold high-risk assets, specifically cryptocurrencies and complex financial products. The concern motivating this hypothesis is that digital platforms reduce traditional barriers to high-risk investments by eliminating minimum balance requirements, simplifying transaction processes, and providing immediate access to complex products, which may benefit financially sophisticated users but expose financially illiterate users to risks they cannot adequately evaluate. It should be noted that, given data availability constraints, high-risk investment behaviour is operationalised here as the current holding of cryptocurrencies or complex financial products rather than as portfolio turnover or trading frequency, which the survey instrument does not directly capture. Drawing on the concerns raised by Panos and Wilson (2020) and Yue et al. (2022) regarding digitalisation's potential to enable rapid poor decision-making, it is hypothesised that among individuals with low financial literacy, higher digital competences are associated with greater propensity to hold high-risk assets. Empirically, this would appear as a negative interaction term between financial literacy and digital competences in models predicting high-risk investment behavior,

reflecting that digital skills exacerbate rather than mitigate the consequences of financial illiteracy in this domain.

The fourth and final hypothesis recognises that the moderating role of digital competences is unlikely to operate uniformly across all segments of the population. Demographic characteristics such as age, education, income, and gender shape both the level of digital engagement and the financial circumstances individuals face, suggesting that the interaction between financial literacy and digital competences may differ meaningfully across subgroups. For instance, younger respondents who engage more extensively with digital financial services may exhibit stronger complementarity effects, whereas older respondents facing simultaneous constraints in financial and digital literacy might display different interaction patterns. It is therefore hypothesised that the moderating effects of digital competences on the relationship between financial literacy and financial behaviours differ across age cohorts, educational attainment levels, income brackets, and gender. This hypothesis is examined by estimating moderated regression models separately for each demographic subgroup and comparing the magnitude and statistical significance of the interaction coefficients across groups, thereby providing evidence on which populations most benefit from or face the greatest risks associated with digital financial service adoption.

3. Data and Methodology

This dissertation adopts a quantitative research approach, using cross-sectional survey data, to investigate the relationships among financial literacy, digital competencies, and financial behavior among Portuguese university-affiliated individuals. The empirical strategy combines descriptive analysis with multivariate OLS regression, augmented by a probit specification for binary outcomes and subgroup estimation to test for demographic heterogeneity.

3.1 Data Sources and Sample

The primary data source is the sixth edition of the CMVM Inquérito sobre Literacia Financeira e Comportamentos de Investimento (VI Inquérito CMVM), a survey instrument designed to assess financial literacy, investment behaviours, and attitudes towards financial markets among the Portuguese population. The survey is conducted by the Comissão do

Mercado de Valores Mobiliários(CMVM), the Portuguese securities market regulator, as part of a periodic series aimed at monitoring the evolution of financial knowledge and behaviour among Portuguese households (Comissão do Mercado de Valores Mobiliários, 2025). To contextualise the findings of the sixth edition, this study also draws upon publicly available documentation from the fourth edition of the survey series, which first incorporated systematic questions addressing digital dimensions of financial behavior, including the adoption of digital financial services and the use of online platforms for financial information (Conselho Nacional de Supervisores Financeiros, 2024a).

Access to the microdata of the VI Inquérito was obtained through a formal data access process governed by the protocol established between CMVM and the Faculdade de Economia da Universidade do Porto (FEP). This involved submitting documentation in accordance with the Normas de Acesso às Bases de Dados Disponíveis, followed by authorisation from the faculty member responsible for the collaboration and technical processing by FEP's information technology services. This structured access procedure ensures compliance with data confidentiality requirements and applicable ethical research standards.

The dataset comprises 2,319 individual-level responses collected from a university-affiliated population across Portugal. The sample is approximately equally split by gender, with a mean age of approximately 31 years, and is highly educated, given the survey's university focus. Full sociodemographic characteristics of the sample, including distributions by gender, educational attainment, and household income, are presented in Appendix A (Tables A1 through A3), with detailed discussion provided in Section 4.1.

It is important to acknowledge that the sample's university-affiliated composition limits the external validity of the findings for the broader Portuguese population. The sample is more educated, younger, and more digitally engaged than the general population, which should be borne in mind when interpreting results and drawing policy conclusions. Within the scope of this study, however, the sample offers a valuable setting for examining the interaction between financial literacy and digital competences, precisely because variation in both dimensions is meaningful and digital financial service providers increasingly target the population.

3.2 Variable Construction and Measurement

The primary explanatory variable is an objective financial literacy score constructed from five knowledge questions included in the VI Inquérito, each with a single verifiably correct answer. The questions address compound interest, the relationship between inflation and purchasing power, the effect of interest rate changes on bond prices, the cost implications of loan duration, and the relative risk of individual stocks versus diversified funds. A score of 1 is assigned for each correct response and 0 otherwise, including responses of "do not know", producing a composite score ranging from 0 to 5. This operationalisation follows the approach recommended by Lusardi and Mitchell (2014) and van Rooij et al. (2011), who advocate objective knowledge measures over self-assessed financial literacy because self-assessment is subject to overconfidence bias and is less predictive of actual financial behaviour. In the present sample, the mean financial literacy score is 3.30 out of 5, with question-level accuracy rates ranging from 41.7 percent for the bond pricing question to 81.2 percent for the inflation question, suggesting meaningful variation in financial knowledge among respondents. Prior to estimation, both the financial literacy score and the digital competence index are centered at their respective sample means. This is standard practice in moderated regression models, as it reduces multicollinearity between the main effects and the interaction term and facilitates interpretation of the constituent coefficients as conditional effects evaluated at the mean of the moderating variable.

Household financial behavior is examined across two dimensions that the available survey data permit. The primary outcome variable captures savings adequacy, measured through the survey question asking respondents what proportion of their monthly income they typically save. Responses are recorded on a five-category ordinal scale ranging from no savings to more than 20 percent of income. In the present sample, 29.8 percent of respondents report saving more than 20 percent of their income, while 11.6 percent report saving nothing at all, indicating meaningful dispersion across categories. This measure aligns directly with the savings outcomes examined by Lusardi and Mitchell (2014) and Lusardi and Tufano (2015) in their studies of financial literacy and household financial behavior, and its ordinal structure is accommodated in the OLS framework by treating the five categories as a numeric scale, a common practice in the financial literacy literature when the variable exhibits sufficient variation. The secondary outcome variable captures high-risk investment behaviour through a binary indicator equal to 1 if the respondent reports currently holding

cryptocurrencies, non-fungible tokens, initial coin offerings, or complex financial products, including warrants, contracts for difference, and exchange-traded certificates, and 0 otherwise. In the present sample, 16.1 percent of respondents hold at least one of these asset classes, with 14.5 percent holding cryptocurrencies and 2.9 percent holding complex financial products. This measure captures the risk-taking dimension of financial behavior, as examined by Panos and Wilson (2020) and Yue et al. (2022), reflecting concerns that digital platforms may facilitate access to high-risk assets for individuals who lack the financial knowledge to evaluate them appropriately. Because this outcome is binary, estimation employs both a linear probability model, presented for ease of interpretation and comparison, and a probit specification as the preferred model given the proportion of out-of-bounds predictions documented in Section 3.3.

The moderating variable is a composite index of digital competences, constructed from six survey items that capture distinct dimensions of digital engagement with financial services. The first component is self-assessed knowledge of the internet and new technologies, recorded on a five-point scale from no knowledge to very knowledgeable. The second, third, and fourth components are binary indicators of preference for autonomous digital channels without the involvement of a financial professional when transacting in equities, funds, exchange-traded funds, complex financial products, and cryptocurrencies, respectively. The fifth component is the frequency with which the respondent seeks information on financial matters, recorded on a five-point scale from never to daily. The sixth component is a binary indicator of whether the respondent regularly consults specialised financial literacy websites. Each component is standardised to a z-score with mean zero and unit variance prior to aggregation, ensuring that differences in response scales do not unduly influence the composite. The index is computed as the unweighted row mean of the six standardised components, using available items for respondents with partial non-response to maximise sample retention. The internal consistency of the resulting index is assessed using Cronbach's alpha, with the result reported alongside the descriptive statistics in Section 4. It is acknowledged that this composite is a proxy measure derived from items not designed to capture digital competences as the primary construct, and this limitation is discussed further in Section 5. As with the financial literacy score, the digital competence index is centered at its sample mean before the interaction term is constructed, following standard practice in moderated regression analysis.

The central variable for testing the moderation hypotheses is the product of the centered financial literacy score and the centered digital competence index. Centering both variables prior to multiplication reduces multicollinearity between the main effects and the interaction term. It facilitates interpretation of the constituent coefficients as conditional effects evaluated at the mean of the other variable, following standard practice in moderated regression analysis.

All regression models include a set of sociodemographic control variables selected for their established relevance in the financial literacy literature. Gender is included as a binary indicator, with 1 for female respondents and 0 for male respondents; the 7 respondents identifying as other genders are excluded from models where gender enters as a control variable because, due to insufficient observations to reliably estimate a separate coefficient. Age is included as a continuous variable measured in years. Educational attainment is measured on an eight-point ordinal scale ranging from basic education to a completed doctoral degree, and household income is measured on a five-category ordinal scale. Occupational status is captured through two binary indicators distinguishing students and employed respondents, including both employees and self-employed individuals, from the remaining categories, which serve as the omitted reference group.

3.3 Empirical Strategy

The empirical analysis proceeds in four stages corresponding to the four research hypotheses. The first stage estimates the baseline effect of financial literacy on savings adequacy using OLS regression, first without controls to establish the raw association and then with the full set of sociodemographic controls to assess robustness to confounding. The second stage augments the baseline model with the digital competence index and the interaction term between financial literacy and digital competence, testing whether the positive effect of financial literacy on savings is amplified at higher levels of digital competence. The third stage replaces the outcome variable with the binary indicator of high-risk investment behaviour. It estimates the same moderated specification using both a linear probability model and a probit model to test whether digital competences exacerbate risk-taking among the less financially literate. Given that 27 percent of linear probability model predictions fall outside the unit interval, the probit specification is preferred for reporting the results of Hypothesis 3, with the linear probability model presented for comparison only.

The fourth stage estimates the moderated savings model separately for demographic subgroups defined by gender, age cohort, educational attainment, and income bracket, comparing the interaction coefficients across groups to assess demographic heterogeneity in the moderation effect.

The ordinal nature of the savings adequacy variable implies that OLS estimation imposes the assumption of equal spacing between response categories, that is, the distance between "no savings" and "less than 5 percent" is treated as equivalent to the distance between "10 to 20 percent" and "more than 20 percent", an assumption that is not formally testable. To assess the robustness of the findings to this assumption, an ordered probit specification is estimated in parallel for the savings outcome. If the signs and statistical significance of the key coefficients are preserved across both specifications, the linear specification is considered sufficiently defensible for the purposes of this study.

A further methodological consideration concerns the potential endogeneity between financial literacy and digital competencies. While the empirical framework treats financial literacy as the primary explanatory variable and digital competences as a moderator, it is plausible that greater digital engagement causally promotes financial knowledge acquisition, for example, through exposure to online financial information, digital financial products, and automated financial decision tools, rather than the reverse, or that both competences are simultaneously determined by common unobserved factors such as cognitive ability or general curiosity. The cross-sectional nature of the VI Inquérito data does not permit formal identification of causal directions through instrumental variable estimation or natural experiments, and no suitable instruments are available in the dataset. Coefficient estimates should therefore be interpreted as conditional associations rather than causal effects, and the possibility of reverse causality between financial literacy and digital competences represents a limitation that is discussed further in Section 5.

All OLS specifications are estimated with heteroskedasticity-robust standard errors. The Breusch-Pagan test is used to assess the presence of heteroskedasticity, and robust standard errors are employed as a precaution given the survey nature of the data. Multicollinearity is assessed using variance inflation factors, and model specification is evaluated using the Ramsey RESET test. Results are exported and presented in tabular form, with coefficient estimates reported to three decimal places and statistical significance denoted at the 10, 5, and 1 percent levels.

4. Results

This chapter presents the empirical findings of the study, organised according to the four research hypotheses outlined in Section 2.4. The chapter begins with a characterisation of the sample through descriptive statistics, followed by the sequential presentation of regression results for each hypothesis. For each hypothesis, the coefficient estimates are reported and interpreted, and diagnostic test results are discussed where relevant. The chapter concludes with the subgroup analysis testing demographic heterogeneity in the moderation effects.

4.1 Descriptive Statistics

This section characterises the sample and the key variables entering the empirical models.

4.1.1 Sample Characteristics

The sample is approximately equally split by gender, with 51.8 percent of respondents identifying as male, 48.2 percent as female, and 27 observations missing for this variable (Table A1). The mean age is 30.8 years, with a standard deviation of 14.46 years, reflecting the considerable age heterogeneity of the university-affiliated population, which ranges from undergraduate students in their late teens to senior academic and administrative staff.

In terms of educational attainment, the sample is highly educated (Table A2). The largest group, comprising 37.7 percent of respondents, is currently enrolled in undergraduate programmes, while 17.5 percent are pursuing a master's degree or an MBA. A further 25.2 percent hold a completed master's degree, are enrolled in doctoral studies, or hold a doctoral degree, and 11.4 percent hold a completed undergraduate degree. Only 8.2 percent of respondents report having an educational attainment of secondary level or below. The mean value on the eight-point educational attainment scale is 4.38, corresponding approximately to the level of completed undergraduate education.

Regarding household income (Table A3), the most common bracket is between 1,001 and 2,500 euros per month, reported by 43.6 percent of respondents, followed by the 2,501 to 5,000 euro bracket at 32.8 percent, with a mean of 3.40 on the five-point scale and a

standard deviation of 0.91. This distribution reflects a predominantly middle-income sample, consistent with the socioeconomic profile of university-affiliated populations in Portugal.

4.1.2 Financial Literacy

The financial literacy score, which serves as the primary explanatory variable, has a mean of 3.30 out of 5, a standard deviation of 1.49, and 2,084 valid observations (Table 1). A mean score of 3.30 indicates that the average respondent answered approximately three out of five financial knowledge questions correctly, suggesting a moderate but imperfect level of financial literacy within the sample. Importantly, this figure is notably higher than the scores typically reported for general population samples in Portugal (Conselho Nacional de Supervisores Financeiros, 2024a), consistent with respondents' higher educational attainment relative to the broader population. Nevertheless, the fact that the average respondent failed to answer two of five basic financial knowledge questions correctly underscores that financial literacy gaps persist even among more educated segments of the population, reinforcing the practical relevance of this study.

Question-level accuracy rates reveal meaningful heterogeneity in the difficulty of individual items. The inflation question proved the most accessible, with 81.2 percent of respondents correctly identifying that inflation erodes purchasing power when it exceeds the interest rate, a concept that has received widespread public attention in recent years. Questions on investment diversification (74.7 percent correct) and loan duration (69.4 percent correct) yielded intermediate accuracy rates, reflecting partial but incomplete understanding of these concepts. Compound interest calculation proved more challenging, with only 60.8 per cent of respondents providing the correct answer, suggesting that many individuals underestimate the long-term effects of compound interest despite its fundamental importance for savings and investment decisions. The bond pricing question was the most difficult, with only 41.7 percent of respondents correctly identifying that bond prices rise when market interest rates fall, a result consistent with international evidence that questions involving market mechanisms tend to be the most challenging component of financial literacy assessments (Lusardi & Mitchell, 2014), and one that highlights significant gaps in investment knowledge even within a university-educated sample.

Table 1 - Descriptive Statistics for Model Variables

	Mean	Std. Dev.	Min	Max	N valid
Score_Literacy	3.300	1.493	0	5	2084
dum_risk_high	0.161	0.367	0	1	2319
Index_Digital	-0.007	0.648	-3	2	2298
Autoaval_Digital_num	3.628	0.917	1	5	2261
Autoaval_Financial_num	2.890	1.034	1	5	2288
Level_risk_num	2.721	1.281	1	5	2269
Tolerance_risk	5.293	2.362	0	10	2124
Gender_Fem	0.482	0.500	0	1	2292
Age	30.843	14.460	17	99	2292
Educatio_num	4.379	1.782	1	8	2314
Income_num	3.403	0.912	1	5	2285
N	2319				

Note. score_literacia = objective financial literacy score (0–5); dum_risco_alto = binary indicator of high-risk asset holding (cryptocurrencies or complex financial products); indice_digital = composite digital competence index (standardised z-score); autoaval_digital_num = self-assessed digital knowledge (1–5); autoaval_financeira_num = self assessed financial knowledge (1–5); nivel_risco_num = financial risk tolerance (1–5); disposicao_risco = general disposition to take risks (0–10); genero_fem = binary gender indicator (1 = female); escolaridade_num = educational attainment (1–8); rendimento_num = household income bracket (1–5). N valid refers to the number of non-missing observations for each variable.

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

4.1.3 Savings Adequacy and High-Risk Investment

Regarding the primary outcome variable, the distribution of savings adequacy across the five response categories reveals that the majority of respondents report positive savings rates (Table A4). The most frequent response is saving more than 20 percent of monthly income, reported by 29.8 percent of respondents, a rate that would be considered high by international standards and likely reflects the financial engagement of the university-affiliated population. A further 19.6 percent save between 10 and 20 percent, and 23.8 percent save between 5 and 10 percent. At the lower end, 15.2 percent save less than 5 percent of their income, and 11.6 percent report saving nothing at all, indicating that a nontrivial minority of respondents face financial constraints or lack savings habits despite their relatively high educational attainment. Overall, approximately 88 percent of respondents report some level of saving, a proportion that likely overstates savings behavior in the broader Portuguese population and should be interpreted in light of the sample's characteristics.

Regarding the secondary outcome variable, 16.1 percent of respondents report holding at least one high-risk asset, specifically cryptocurrencies or complex financial products, with a standard deviation of 0.367 (Table B1). This proportion is notably higher than rates typically observed in general population surveys, reflecting the younger, more digitally engaged profile of the university-affiliated sample. The fact that more than one in six respondents holds high-risk assets underscores the empirical relevance of Hypothesis 3, which examines whether digital competences exacerbate risk-taking behavior among the less financially literate.

4.1.4 Digital Competences

The digital competence index has a mean of approximately zero and a standard deviation of 0.648, consistent with its construction as a standardised composite across 2,298 valid observations (Table B1). A mean close to zero indicates that the average respondent scores at the centre of the distribution of digital engagement, with roughly equal numbers of respondents above and below the average.

A particularly informative contrast emerges between self-assessed digital and financial knowledge. Respondents report a mean digital knowledge score of 3.63 on the five-point scale, corresponding to a response between "moderately knowledgeable" and "knowledgeable", while self-assessed financial knowledge averages only 2.89 on the same scale, falling between "little knowledgeable" and "moderately knowledgeable". This divergence of 0.74 scale points indicates that respondents perceive themselves as considerably more digitally than financially competent. This gap is consequential for the research hypotheses. If individuals overestimate their digital abilities relative to their financial knowledge, they may be more likely to access digital financial products they lack the knowledge to evaluate appropriately, consistent with the risk-amplification mechanism tested in Hypothesis 3.

Among the six components of the digital competence index (Table B2), self-assessed digital knowledge (mean 3.63) and frequency of financial information-seeking (mean 3.62) are the highest-scoring dimensions. In contrast, consultations with specialised financial literacy websites (26.5 percent) and a preference for autonomous digital channels for complex products (21.9 percent) represent the least prevalent behaviours. This pattern suggests that respondents are more confident in their general digital abilities and

information-seeking habits than in their active use of digital channels for specific financial transactions. This distinction may have implications for how digital competences translate into financial outcomes.

The six components of the digital competence index are conceptualised as formative rather than reflective indicators: each component captures a distinct dimension of digital financial engagement: self-assessed knowledge, channel preferences, information-seeking frequency, and use of specialised resources that independently contribute to the composite rather than reflecting a single common latent trait. Under a formative measurement model, internal consistency metrics such as Cronbach's alpha are not the appropriate validity criterion, as low inter-item correlations are expected and desirable rather than problematic (Diamantopoulos & Winklhofer, 2001). The relevant validity criterion for a formative index is instead nomological validity, whether the composite correlates in theoretically expected directions with external variables. The correlation matrix presented in Table B3 provides supporting evidence on this criterion, documenting that the digital competence index is positively associated with high-risk asset holding ($r = 0.376$, $p < 0.01$), positively associated with educational attainment and income, and negatively associated with age and female gender, patterns consistent with theoretical expectations regarding digital financial engagement. The absence of problematic multicollinearity among the six components, confirmed through variance inflation factor diagnostics, further supports the validity of the composite. The limitations associated with this proxy measure, including the equal weighting assumption and the indirect nature of several components, are discussed in Section 5.

4.1.5 Correlation Structure

Table 2 presents the correlation matrix for the variables entering the regression models. Several patterns are noteworthy and merit discussion prior to the multivariate analysis.

The financial literacy score exhibits a positive and statistically significant correlation with the digital competence index ($r = 0.377$, $p < 0.01$), indicating that more financially knowledgeable respondents also tend to be more digitally engaged. This positive association provides preliminary support for the complementarity hypothesis, though it does not distinguish between the direction of causality or the moderating role of digital competences. Financial literacy also correlates positively with age ($r = 0.239$, $p < 0.01$), educational

attainment ($r = 0.270$, $p < 0.01$), and household income ($r = 0.232$, $p < 0.01$), consistent with the well-documented socioeconomic gradients in financial knowledge (Lusardi & Mitchell, 2014), and exhibits a negative correlation with female gender ($r = -0.330$, $p < 0.01$), consistent with the persistent gender gap in financial literacy documented across multiple countries.

The digital competence index is positively correlated with the high-risk investment indicator ($r = 0.376$, $p < 0.01$), suggesting that more digitally engaged respondents are more likely to hold high-risk assets. This raw association is consistent with the risk amplification mechanism proposed in Hypothesis 3, though it does not account for the moderating influence of financial literacy. Female gender is also negatively correlated with the digital competence index ($r = -0.365$, $p < 0.01$), suggesting that women in the sample exhibit lower digital financial engagement than men, a pattern that may contribute to the gender heterogeneity examined in Hypothesis 4.

The interaction term between financial literacy and digital competences shows limited correlations with the control variables, with the largest being a small negative correlation with age ($r = -0.040$, $p < 0.10$) and educational attainment ($r = -0.023$), which are sufficiently low to suggest that multicollinearity is unlikely to distort the moderated regression estimates. The positive correlation between age and educational attainment ($r = 0.529$, $p < 0.01$) is the most prominent among the control variables. However, variance inflation factor diagnostics confirmed that multicollinearity does not threaten the reliability of the coefficient estimates in any of the models estimated.

Table 2 - Correlation Matrix

Panel A

	(1)	(2)	(3)	(4)
(1) Score_Literacy	1			
(2) dum_Risk_High	.199***	1		
(3) Index_Digital	.377***	.376***	1	
(4) Interaction_lit_digital	−.190***	.071***	.081***	1

Panel B

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(5) Gender_Fem	−.33***	−.25***	−.37***	.00	1			
(6) Age	.24***	.03	.10***	−.04*	−.06***	1		
(7) Education_num	.27***	.08***	.13***	−.02	−.02	.53***	1	
(8) Income_num	.23***	.11***	.17***	−.01	−.09***	.27***	.24***	1

Note. Pearson correlation coefficients; listwise deletion (N = 2,016). Coeficientes reportados com duas casas decimais sem zero inicial. (1) score_literacia = score de literacia financeira (0–5); (2) dum_risco_alto = dummy de investimento em ativos de alto risco (cripto ou produtos complexos); (3) indice_digital = índice composto de competências digitais (z-score estandardizado); (4) interacao_lit_digital = termo de interação literacia × digital (variáveis centradas); (5) genero_fem = dummy de género feminino; (6) idade = anos; (7) escolaridade_num = nível de escolaridade (1–8); (8) rendimento_num = escalão de rendimento (1–5). * p < 0.10, ** p < 0.05, *** p < 0.01

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

4.2 Hypothesis 1 - Baseline Effect

Hypothesis 1 predicts that higher levels of financial literacy are positively associated with savings adequacy. Table C1 presents the OLS regression results for both the baseline model without controls (M1a) and the model with the full set of sociodemographic controls (M1b).

The results provide strong support for Hypothesis 1. In the baseline specification (M1a), the financial literacy score exhibits a positive and highly significant coefficient of 0.301 ($p < 0.01$), indicating that each additional correct answer on the five-question financial literacy assessment is associated with an increase of approximately 0.30 units on the five-point savings adequacy scale. To contextualise this magnitude, moving from a score of zero to the sample mean of 3.30 is associated with an increase of approximately one full category on the savings scale, a substantively meaningful difference corresponding, for example, to the gap between saving nothing and saving between 5 and 10 percent of income. This finding is consistent with the extensive international evidence reviewed in Section 2.3.2, which confirms that financially literate individuals exhibit more prudent savings behavior (Lusardi & Mitchell, 2014; Lusardi & Tufano, 2015).

The inclusion of sociodemographic controls in M1b reduces the coefficient on financial literacy to 0.189 ($p < 0.01$), a reduction of approximately 37 percent relative to the

uncontrolled estimate. This attenuation is expected, as part of the raw association between financial literacy and savings reflects confounding through demographic characteristics such as education and income that simultaneously predict both financial knowledge and savings behavior. The coefficient of 0.189 in M1b implies that moving from the lowest to the highest financial literacy score, a range of five points, is associated with an increase of approximately 0.95 units on the savings scale, equivalent to nearly one full category, a substantively meaningful effect even after controlling for sociodemographic characteristics. Importantly, the coefficient remains positive, substantial, and highly statistically significant after controlling for these factors, indicating that financial literacy exerts an independent effect on savings adequacy beyond what is attributable to observable socioeconomic characteristics.

Examining the control variable coefficients in M1b provides additional insight into the determinants of savings behavior within the sample. Female respondents save significantly less than male respondents, with a coefficient of -0.321 ($p < 0.01$), a gap of approximately one-third of a scale point that likely reflects gender differences in income, employment patterns, and financial autonomy rather than differences in financial preferences per se. Age exhibits a significant negative coefficient of -0.024 ($p < 0.01$), indicating that older respondents in this university-affiliated sample tend to save less, a pattern that may reflect the higher consumption needs and financial obligations associated with older age groups. Educational attainment is positively associated with savings ($\beta = 0.044$, $p < 0.05$), consistent with the broader literature linking education to financial prudence, while household income shows a strong positive effect ($\beta = 0.231$, $p < 0.01$), reflecting the fundamental role of financial resources in enabling savings. Student status is associated with substantially lower savings rates ($\beta = -0.840$, $p < 0.01$), which is intuitive given that students typically have limited incomes and may be net borrowers rather than savers during their studies. The coefficient on employed status is positive but not statistically significant ($\beta = 0.046$, $p > 0.10$).

The explanatory power of the models increases substantially with the addition of controls, from an R^2 of 0.109 in M1a ($N = 2,048$) to 0.200 in M1b ($N = 1,985$), indicating that the sociodemographic characteristics included in the model collectively explain a meaningful portion of the variation in savings adequacy beyond financial literacy alone. The reduction in sample size from M1a to M1b reflects listwise deletion of observations with

missing values on one or more control variables. The adjusted R^2 values of 0.109 and 0.197, respectively, confirm that this improvement is not an artefact of the additional variables.

Diagnostic tests confirm the adequacy of the model specifications. The Ramsey RESET test fails to reject the null hypothesis of correct model specification for the baseline model ($F = 0.47$, $p = 0.703$), providing no evidence of omitted-variable or functional-form misspecification. Variance inflation factors for all variables in M1b are well below the conventional threshold of 10, indicating that multicollinearity does not threaten the reliability of the estimates. All specifications are estimated with heteroskedasticity-robust standard errors following application of the Breusch-Pagan test.

Taken together, the results of M1a and M1b provide robust support for Hypothesis 1, establishing that financial literacy is a positive and significant determinant of savings adequacy in the Portuguese university-affiliated population, consistent with the international evidence synthesised in Section 2.3.2. This baseline relationship provides the reference point against which the moderating role of digital competences is assessed in the following section.

4.3 Hypothesis 2 - Complementarity Mechanism

Hypothesis 2 predicts that the positive effect of financial literacy on savings adequacy is amplified among individuals with higher digital competencies, which would manifest empirically as a positive and statistically significant interaction term between the financial literacy score and the digital competence index. Table 3 presents the results of the moderated regression models: M2a, which includes financial literacy and digital competences as additive predictors without an interaction term, and M2b, which augments M2a with the interaction term between the two centered variables.

The results of M2a first establish the independent additive effects of both financial literacy and digital competencies on savings adequacy. The coefficient of financial literacy remains positive and highly significant at 0.153 ($p < 0.01$), consistent with the baseline finding in Section 4.2, though reduced in magnitude relative to M1b due to the introduction of the digital competence index, which absorbs part of the variation previously attributed to financial literacy alone, given the positive correlation between the two variables ($r = 0.377$, Table B3). More strikingly, the digital competence index exhibits a large and highly significant positive coefficient of 0.362 ($p < 0.01$), indicating that more digitally engaged respondents

save substantially more, even after controlling for financial literacy and sociodemographic characteristics. This finding suggests that digital competences constitute an independent positive predictor of savings behaviour, potentially reflecting the role of digital tools such as automated savings applications and online banking in facilitating savings management. The addition of the digital competence index increases the R^2 from 0.200 in M1b to 0.222 in M2a ($N = 1{,}985$ in both specifications), indicating a meaningful improvement in explanatory power.

Turning to the central test of Hypothesis 2, the interaction term between financial literacy and digital competences in M2b yields a coefficient of -0.046 with a standard error of 0.030, which is not statistically significant at any conventional level ($p > 0.10$). The addition of the interaction term increases the R^2 only marginally from 0.222 to 0.223, and the adjusted R^2 increases from 0.219 to 0.220, confirming that the interaction term contributes negligible additional explanatory power. These results do not support Hypothesis 2. There is no evidence that digital competences amplify the positive effect of financial literacy on savings adequacy within this sample. The coefficient on the interaction term is, in fact, negative, though its lack of statistical significance means that no reliable inference can be drawn regarding the direction of the moderation effect.

This null result is noteworthy and warrants discussion. One possible interpretation is that, in the Portuguese university-affiliated context, financial literacy and digital competences function as independent rather than complementary drivers of savings behavior, each contributing positively to savings outcomes but with no meaningful interaction. This pattern would be consistent with a scenario in which digitally competent individuals save more due to greater access to savings products and automated tools, regardless of their financial literacy level. In contrast, financially literate individuals save more through better financial planning and knowledge of savings instruments, regardless of their digital skills. Under this interpretation, the two competences are additive rather than multiplicative in their effects on savings, in contrast to the complementarity patterns documented by Kass-Hanna et al. (2022) in emerging market contexts. An alternative explanation is that the proxy nature of the digital competence index, constructed from items not designed to capture digital competences as a primary construct, may attenuate the precision with which the interaction effect can be estimated, such that a true complementarity effect exists but is not detectable given the measurement limitations of the

available data. This possibility constitutes an important caveat in interpreting the null result and is discussed further in Section 5.

The coefficients on the control variables in M2b are consistent with those reported in M1b, with female gender ($\beta = -0.197$, $p < 0.01$), age ($\beta = -0.022$, $p < 0.01$), and student status ($\beta = -0.767$, $p < 0.01$) negatively associated with savings adequacy, and educational attainment ($\beta = 0.045$, $p < 0.05$) and household income ($\beta = 0.211$, $p < 0.01$) positively associated. Employed status remains positive but not statistically significant ($\beta = 0.006$, $p > 0.10$). The stability of these coefficients across specifications provides reassurance regarding the robustness of the findings.

Diagnostic tests confirm the adequacy of the moderated model specification. The Ramsey RESET test fails to reject the null hypothesis of correct model specification ($F = 1.28$, $p = 0.280$), providing no evidence of omitted-variable or functional-form misspecification in M2b. This result, combined with the variance inflation factor diagnostics confirming the absence of problematic multicollinearity, supports confidence in the reliability of the null finding for Hypothesis 2.

In summary, while both financial literacy and digital competences are independently and positively associated with savings adequacy, the evidence does not support the complementarity mechanism proposed in Hypothesis 2. The interaction between financial literacy and digital competences does not significantly predict savings behavior in this sample, suggesting that these competences operate through separate, rather than mutually reinforcing, pathways in determining savings outcomes among the Portuguese university-affiliated population studied here.

Table 3 - OLS Regression Results: Hypothesis 1 (Baseline Effect) and Hypothesis 2 (Complementarity Mechanism)

	(1) M1a	(2) M1b	(3) M2a	(4) M2b
Financial Literacy (X)	0.301***	0.189***	0.153***	0.146***
	(0.019)	(0.021)	(0.022)	(0.022)
Gender (Female=1)		-0.321***	-0.194***	-0.197***
		(0.058)	(0.060)	(0.061)
Age		-0.024***	-0.022***	-0.022***
		(0.003)	(0.003)	(0.003)
Education		0.044**	0.044**	0.045**
		(0.019)	(0.018)	(0.018)
Income		0.231***	0.210***	0.211***
		(0.033)	(0.033)	(0.033)
Student		-0.840***	-0.765***	-0.767***
		(0.085)	(0.084)	(0.084)
Employed		0.046	0.001	0.006
		(0.080)	(0.079)	(0.079)
Digital Skills (M)			0.362***	0.372***
			(0.049)	(0.049)
Literacy × Digital (X×M)				-0.046
				(0.030)
Constant	3.441***	3.736***	3.638***	3.654***
	(0.028)	(0.158)	(0.158)	(0.158)
N	2048	1985	1985	1985
R^2	0.109	0.200	0.222	0.223
adj. R^2	0.109	0.197	0.219	0.220

Note. Dependent variable is savings adequacy measured on a five-point ordinal scale (1 = no savings; 5 = more than 20 percent of income). M1a = baseline model without controls; M1b = baseline model with sociodemographic controls; M2a = additive model with financial literacy and digital competences; M2b = moderated model with interaction term. All specifications estimated with heteroskedasticity-robust standard errors reported in parentheses. Variables are centred at their sample means prior to estimation. * p < 0.10, ** p < 0.05, *** p < 0.01

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

4.4 Hypothesis 3 - Risk Amplification Mechanism

Hypothesis 3 predicts that among individuals with low financial literacy, higher digital competences are associated with a greater propensity to hold high-risk assets, which would manifest empirically as a negative interaction term between financial literacy and digital

competences in models predicting the binary indicator of high-risk investment behavior. Table 4 presents the results of three specifications: a linear probability model without an interaction term (LPM, column 1), a linear probability model with the interaction term (LPM, column 2), and a probit model with average marginal effects (column 3), all estimated on a sample of N = 2,013 observations. As noted in Section 3.3, the probit specification is preferred for reporting the results of this hypothesis, given that 27 percent of linear probability model predictions fall outside the unit interval; the linear probability model is presented for comparison purposes only.

Before examining the interaction effect, it is instructive to consider the main effects. Across all three specifications, the digital competence index exhibits a large, positive, and highly significant coefficient. In the baseline LPM without interaction (column 1), the coefficient is 0.173 ($p < 0.01$), which decreases marginally to 0.168 ($p < 0.01$) in the LPM with interaction (column 2), and to an average marginal effect of 0.152 ($p < 0.01$) in the preferred probit specification. This indicates that more digitally engaged respondents are substantially more likely to hold high-risk assets, even after controlling for financial literacy and sociodemographic characteristics. To contextualise this magnitude, a one-standard-deviation increase in the digital competence index is associated with an increase of approximately 15.2 percentage points in the probability of holding high-risk assets, a substantial effect given that the unconditional probability in the sample is 16.1 percent. The coefficient on financial literacy in the probit specification is positive and marginally significant at 0.012 ($p < 0.10$), suggesting a weak positive association between financial literacy and high-risk asset holding, which may reflect that more financially knowledgeable individuals are both more aware of and more willing to engage with sophisticated investment products. This finding is not inconsistent with the broader literature, as van Rooij et al. (2011) document that financially literate individuals are more likely to participate in equity markets, including higher-risk asset classes.

Turning to the central test of Hypothesis 3, the results present a mixed picture depending on the estimation method employed. In the linear probability model with the interaction term (column 2), the interaction between financial literacy and digital competences yields a positive and statistically significant coefficient of 0.021 ($p < 0.05$). This positive sign is the opposite of what Hypothesis 3 predicts; rather than suggesting that digital competences amplify risk-taking among the financially illiterate, it implies that the

combination of high financial literacy and high digital competences is associated with a greater propensity to hold high-risk assets. However, in the preferred probit specification (column 3), the interaction term yields a coefficient of -0.008 ($p > 0.10$), which is in the predicted negative direction but is not statistically significant at any conventional level. Given that the probit model is the preferred specification because of the boundary-violation problems of the linear probability model, the primary conclusion is that the data, at conventional significance levels, do not support the risk-amplification mechanism proposed in Hypothesis 3.

The discrepancy between the LPM and probit results warrants careful interpretation. The positive and significant interaction in the LPM likely reflects a distortion introduced by the linear probability model's inability to constrain predictions within the unit interval, particularly given the large proportion of out-of-bounds predictions documented in Section 3.3. The probit model, by imposing the appropriate non-linear structure on the binary outcome, provides a more reliable basis for inference regarding the interaction effect. The fact that the probit interaction coefficient is negative, albeit not significant, is weakly consistent with the theoretical mechanism proposed in Hypothesis 3, suggesting that the data are not inconsistent with risk amplification but that the available sample and measurement instruments lack sufficient statistical power to detect the effect reliably.

The control variable coefficients are consistent across specifications. Female respondents are significantly less likely to hold high-risk assets (AME = -0.104, $p < 0.01$), a finding consistent with the well-documented gender gap in risky financial behavior (Lusardi & Mitchell, 2014). Older respondents are also less likely to hold high-risk assets (AME = -0.003, $p < 0.01$), consistent with life-cycle patterns of risk tolerance, while higher household income is positively associated with high-risk asset holding (AME = 0.019, $p < 0.05$), reflecting the role of wealth in enabling investment in volatile assets. Student status is negatively associated with high-risk investment behavior (AME = -0.047, $p < 0.10$), likely reflecting students' limited investable resources compared with employed individuals. Employed status is positive but not statistically significant across all specifications, and educational attainment similarly shows no significant association with high-risk asset holding.

In summary, the evidence does not support the risk amplification mechanism proposed in Hypothesis 3. While the digital competence index is a strong positive predictor of high-risk asset holdings, the interaction between financial literacy and digital competence

is not statistically significant in the preferred probit specification. The discrepancy between the LPM and probit results underscores the importance of appropriate model selection for binary outcomes and highlights the limitations of the linear probability model in this context. The weak negative direction of the probit interaction coefficient leaves open the possibility that a risk amplification effect exists but cannot be reliably detected given the constraints of the available data, a point discussed further in the limitations section.

Table 4 - LPM and Probit Results: Hypothesis 3 (Risk Amplification Mechanism)

	(1) LPM No Int.	(2) LPM Int.	(3) Probit (AME)
Financial Literacy (X)	0.005	0.009	0.012*
	(0.005)	(0.006)	(0.007)
Digital Skills (M)	0.173***	0.168***	0.152***
	(0.015)	(0.015)	(0.013)
Gender (Female=1)	-0.103***	-0.101***	-0.104***
	(0.016)	(0.016)	(0.017)
Age	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)
Education	0.006	0.006	0.006
	(0.006)	(0.006)	(0.005)
Income	0.019**	0.019**	0.019**
	(0.009)	(0.009)	(0.009)
Student	-0.058**	-0.057**	-0.047*
	(0.025)	(0.025)	(0.024)
Employed	0.040	0.037	0.028
	(0.026)	(0.026)	(0.024)
Literacy × Digital (X×M)		0.021**	-0.008
		(0.009)	(0.010)
Constant	0.241***	0.233***	
	(0.046)	(0.046)	
N	2013	2013	2013
R^2	0.169	0.171	

Note. Dependent variable is a binary indicator equal to one if the respondent holds cryptocurrencies or complex financial products, and zero otherwise. Column (1) presents the linear probability model without interaction term; column (2) presents the linear probability model with interaction term; column (3) presents average marginal effects from the probit specification. Robust standard errors in parentheses. AME = Average Marginal Effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

4.5 Hypothesis 4 - Demographic Heterogeneity

Hypothesis 4 predicts that the moderating effects of digital competences on the relationship between financial literacy and savings adequacy differ systematically across demographic subgroups. To test this hypothesis, the moderated regression model estimated in Section 4.3 is re-estimated separately for subgroups defined by gender, age cohort, educational attainment, and income bracket. The results are presented in Tables C3 through C6, and the interaction term coefficients across subgroups are summarised and compared below.

4.5.1 Gender

Table C3 presents the results by gender, estimated separately for female (N = 929) and male respondents (N = 1,056). The financial literacy coefficient is positive and significant for both female ($\beta = 0.155$, $p < 0.01$) and male ($\beta = 0.122$, $p < 0.01$) respondents, confirming that the baseline effect of financial literacy on savings holds across both groups. The digital competence index is similarly positive and significant for both subgroups, with comparable magnitudes of 0.356 and 0.370, respectively, suggesting that digital engagement is an equally strong independent predictor of savings behavior for both genders.

The interaction term between financial literacy and digital competences is negative for both groups: -0.070 for female respondents and -0.009 for male respondents, but neither coefficient is statistically significant at conventional levels. The slightly larger, negative interaction coefficient for female respondents suggests a possible substitution or dampening effect in this group, but the lack of statistical significance precludes firm conclusions.

Examining the control variables reveals an interesting difference between genders. Educational attainment is a significant positive predictor of savings among female respondents ($\beta = 0.088$, $p < 0.01$) but shows no significant association among male respondents ($\beta = 0.012$, $p > 0.10$), suggesting that education plays a more important role in shaping savings behavior among women. Household income is positively associated with savings for both groups, though the effect is stronger for female respondents ($\beta = 0.253$, $p < 0.01$) than for male respondents ($\beta = 0.174$, $p < 0.01$). Student status is strongly and negatively associated with savings for both groups, at -0.781 ($p < 0.01$) for female and -0.748 ($p < 0.01$) for male respondents, while employed status is not statistically significant for either

group. The higher R^2 for the female subgroup (0.205 vs 0.181) suggests that the model explains savings behaviour somewhat better for women than for men, possibly reflecting greater consistency in the determinants of savings among female respondents.

Overall, the gender subgroup analysis does not reveal meaningful heterogeneity in the moderation effect of digital competences on the financial literacy-savings relationship. Both groups exhibit negative but non-significant interaction coefficients, and the magnitude of the difference between -0.070 and -0.009 is insufficient to conclude that moderation patterns differ across genders.

4.5.2 Age Cohort

Table C4 presents the results by age cohort, distinguishing between younger respondents aged 17 to 25 (N = 1,052) and older respondents aged 26 and above (N = 933). The financial literacy coefficient is positive and significant for both groups, at 0.112 ($p < 0.01$) for younger respondents and 0.178 ($p < 0.01$) for older respondents. The larger effect among older respondents suggests that financial knowledge translates more strongly into savings behavior as individuals age and face more complex financial decisions, consistent with life-cycle theories of financial behavior. The digital competence index is similarly positive and significant for both groups, at 0.351 ($p < 0.01$) for younger and 0.439 ($p < 0.01$) for older respondents, with a notably stronger independent effect among the older cohort.

This analysis yields the most striking finding of the demographic heterogeneity analysis. Among younger respondents, the interaction term is negative and statistically significant at -0.086 ($p < 0.05$), while among older respondents, the interaction coefficient is -0.018 and not statistically significant. This pattern indicates that the combination of high financial literacy and high digital competencies is associated with lower savings adequacy than would be predicted by the additive effects of these two variables among younger respondents. This result runs counter to the complementarity mechanism proposed in Hypothesis 2 and is more consistent with a dampening or even substitution effect operating specifically among younger individuals.

One possible interpretation of this finding is that younger, digitally engaged individuals with some financial knowledge may direct their financial activity toward consumption-enabling digital platforms or short-term financial products rather than longer-

term savings, effectively substituting digital financial engagement for traditional savings behavior. Alternatively, younger respondents who are both financially literate and digitally competent may channel their resources into investment assets not captured by the savings adequacy measure, such as the high-risk assets examined in Hypothesis 3, rather than conventional savings products.

Examining the control variables reveals further meaningful differences between age groups. Educational attainment is a significant positive predictor of savings among younger respondents ($\beta = 0.111$, $p < 0.01$) but not among older respondents ($\beta = -0.002$, $p > 0.10$), reflecting greater variation in educational attainment within the younger cohort, where some respondents are still completing their degrees. Student status is strongly and negatively associated with savings among younger respondents ($\beta = -0.836$, $p < 0.01$) but essentially irrelevant for the older cohort ($\beta = -0.001$, $p > 0.10$), as the vast majority of respondents aged 26 and above are no longer students. Household income is positively associated with savings for both groups, at 0.108 ($p < 0.05$) for younger and 0.307 ($p < 0.01$) for older respondents, with a substantially stronger effect among the older cohort, reflecting the greater financial autonomy and resource availability of older working individuals. Female gender is significantly and negatively associated with savings among younger respondents ($\beta = -0.230$, $p < 0.01$) but not among older respondents ($\beta = -0.104$, $p > 0.10$), suggesting that gender differences in savings behaviour are more pronounced among younger cohorts, possibly reflecting greater income inequality between young men and women early in their careers. Employed status is not statistically significant for either group.

The R^2 values are comparable across groups, at 0.201 for younger and 0.206 for older respondents, indicating similar overall explanatory power of the model in both subsamples. This result provides partial support for Hypothesis 4. It suggests that the moderating role of digital competences on the financial literacy-savings relationship is not uniform across age groups, with younger cohorts exhibiting a distinctive negative interaction pattern that warrants further investigation.

4.5.3 Educational Attainment

Table C5 presents the results by educational attainment, distinguishing between respondents with completed undergraduate education or above (N = 1,121) and those with lower educational attainment (N = 864). The financial literacy coefficient is positive and

significant for both groups: 0.146 ($p < 0.01$) for higher-educated respondents and 0.143 ($p < 0.01$) for lower-educated respondents, with remarkably similar magnitudes, suggesting that the baseline effect of financial literacy on savings does not differ meaningfully by educational level. The digital competence index, however, shows a more pronounced difference, with a notably larger coefficient for higher-educated respondents ($\beta = 0.455$, $p < 0.01$) compared to lower-educated respondents ($\beta = 0.273$, $p < 0.01$), suggesting that digital competences generate stronger independent savings effects among the more educated, possibly because higher-educated individuals are better positioned to translate digital engagement into effective financial action.

This analysis yields the second significant finding of the demographic heterogeneity tests. Among higher-educated respondents, the interaction term is negative and statistically significant at -0.093 ($p < 0.05$), while among lower-educated respondents, the coefficient is -0.037 and not statistically significant. The significant negative interaction indicates that the marginal benefit of financial literacy for savings is attenuated at higher levels of digital competence among higher-educated respondents, again contrary to the complementarity prediction of Hypothesis 2.

This pattern may reflect that higher-educated, digitally competent individuals who are also financially literate allocate their resources more broadly across financial products, including investment assets beyond conventional savings, thereby reducing the marginal predictive power of financial literacy for savings specifically. The stronger model fit for higher-educated respondents ($R^2 = 0.235$ vs 0.137) suggests that the determinants of savings behavior are more consistently structured among this group, and the significant interaction may reflect genuine heterogeneity in how financial literacy and digital competences jointly influence financial decisions among more educated populations.

Examining the control variables reveals further differences between educational groups. Female gender is not significantly associated with savings among higher-educated respondents ($\beta = -0.114$, $p > 0.10$). However, it is strongly and significantly negative among lower-educated respondents ($\beta = -0.278$, $p < 0.01$), suggesting that gender disparities in savings behaviour are more pronounced among those with lower educational attainment. Household income is positively associated with savings for both groups, with a stronger effect among higher-educated respondents ($\beta = 0.299$, $p < 0.01$) compared to lower-educated respondents ($\beta = 0.140$, $p < 0.01$). Student status is negatively and significantly

associated with savings for both groups, at -0.743 ($p < 0.01$) and -0.715 ($p < 0.01$) respectively, while employed status is not statistically significant for either group.

4.5.4 Household Income

Table C6 presents the results by income bracket, distinguishing between low-income respondents with household income up to 1,000 euros per month (N = 233) and middle- to high-income respondents with household income above 1,000 euros per month (N = 1,752). The financial literacy coefficient is positive and significant for both groups: 0.131 ($p < 0.05$) for low-income respondents and 0.159 ($p < 0.01$) for middle- to high-income respondents, confirming the robustness of the baseline effect across income levels. The digital competence index is also positive and significant for both groups, at 0.364 ($p < 0.05$) and 0.394 ($p < 0.01$), respectively, suggesting that digital engagement independently promotes savings behavior across income brackets.

For both groups, the interaction term is negative and not statistically significant: -0.004 for the low-income group and -0.046 for the middle-to-high-income group. Neither coefficient provides evidence of a significant moderation effect, indicating that income does not meaningfully differentiate the interaction between financial literacy and digital competences in determining savings behavior. Notably, the low-income subgroup is considerably smaller (N = 233 vs N = 1,752), which substantially reduces statistical power and may explain the absence of significant results in this group, a limitation that warrants caution in interpreting the null finding for this subgroup.

Examining the control variables reveals meaningful differences between income groups. The large positive coefficient on employed status for low-income respondents ($\beta = 0.746$, $p < 0.01$), which is absent and even slightly negative among middle-to-high income respondents ($\beta = -0.061$, $p > 0.10$), suggests that within the low-income group, employment status is a particularly strong determinant of savings capacity, potentially dominating the influence of financial and digital competences. Student status is negatively associated with savings for both groups, though more strongly among middle-to-high-income respondents ($\beta = -0.808$, $p < 0.01$) than among low-income respondents ($\beta = -0.410$, $p < 0.10$), possibly reflecting that middle-to-high-income students face greater opportunity costs from not saving. Age is negatively associated with savings for both groups, with a notably stronger effect among low-income respondents ($\beta = -0.039$, $p < 0.01$) than among middle- to high-

income respondents (β = -0.019, p < 0.01). Educational attainment is significant only for middle- to high-income respondents (β = 0.047, p < 0.05). In contrast, the coefficient for low-income respondents is positive but not significant (β = 0.058, p > 0.10), whereas female gender is significantly and negatively associated with savings only among middle- to high-income respondents (β = -0.182, p < 0.01). In contrast, the low-income group shows a negative but non-significant coefficient (β = -0.279, p > 0.10), with neither result reaching significance, likely due to the smaller sample size. The R^2 values are comparable: 0.164 for low-income respondents and 0.203 for middle- to high-income respondents.

4.5.5 Summary

Table 5 summarises the key coefficients across all eight demographic subgroups. While the interaction term between financial literacy and digital competences appears negative and statistically significant within the younger age cohort (β = -0.086, p < 0.05) and the higher-educated subgroup (β = -0.093, p < 0.05) in the separate regressions, formal triple-interaction tests estimated in the pooled sample (Table C7) yield non-significant coefficients across all four demographic dimensions (β ranging from -0.067 to +0.048, all p > 0.10). These results indicate that the apparent heterogeneity does not survive formal statistical testing, and Hypothesis 4 is not supported. The absence of significant triple interactions confirms the methodological concern raised in Section 3.3: comparing coefficients from separate subgroup regressions can overstate evidence of heterogeneity when the confidence intervals of the estimates substantially overlap. The formal tests indicate that the moderating role of digital competences on the financial literacy-savings relationship does not differ systematically across age, education, income, or gender groups in this sample. However, the consistently negative direction of the interaction coefficients across all subgroups remains suggestive of a dampening rather than amplifying mechanism that warrants further investigation with larger and more diverse samples.

Table 5 - Subgroup Analysis: Hypothesis 4 (Demographic Heterogeneity)

Panel A

Gender and Age Cohort

	Female	Male	Young (17–25)	Adult (26+)
Financial literacy (X)	0.155***	0.122***	0.112***	0.178***
Digital competences (M)	0.356***	0.370***	0.351***	0.439***
Literacy × Digital (X×M)	−0.070	−0.009	−0.086**	−0.018
N	929	1,056	1,052	933
R^2	0.205	0.181	0.201	0.206

Panel B

Educational Attainment and Household Income

	Higher educ.	Lower educ.	Low income	Mid-high income
Financial literacy (X)	0.146***	0.143***	0.131**	0.159***
Digital competences (M)	0.455***	0.273***	0.364**	0.394***
Literacy × Digital (X×M)	−0.093**	−0.037	−0.004	−0.046
N	1,121	864	233	1,752
R^2	0.235	0.137	0.164	0.203

Note. Dependent variable: Savings Adequacy (1–5). Key coefficients only; sociodemographic controls included but not reported. All models estimated by OLS with heteroskedasticity-robust standard errors. Higher education = completed undergraduate degree or above; lower education = secondary or below. Low income = household income up to €1,000/month; mid-high income = above €1,000/month. Comparison of subgroup interaction coefficients does not constitute a formal test of heterogeneity; triple-interaction tests are reported as robustness checks. Full results, including all control variable coefficients and standard errors, are presented in Appendix C, Tables C3–C6. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

5 Discussion, Limitations, and Conclusions

5.1 Discussion of Findings

This study investigated the moderating role of digital competences in the relationship between financial literacy and household financial behavior among a Portuguese university-affiliated population, testing four hypotheses derived from the theoretical mechanisms of complementarity, risk amplification, and demographic heterogeneity. The empirical results offer a nuanced picture that both confirms and challenges prior expectations, contributing to the growing literature on the intersection of financial and digital literacy in developed economy contexts.

The baseline effect of financial literacy on savings adequacy is robustly supported by the data, consistent with the extensive international evidence reviewed in Section 2.3.2. The positive and statistically significant coefficient of financial literacy in both the uncontrolled and controlled specifications confirms that individuals with greater objective financial knowledge save a larger proportion of their income, even after accounting for sociodemographic characteristics such as age, education, and income. This finding aligns with the foundational contributions of Lusardi and Mitchell (2014) and Lusardi and Tufano (2015), who document that financial knowledge is a consistent and independent predictor of prudent financial behaviour across multiple countries and contexts. Within the specific context of a Portuguese university-affiliated population, one characterised by relatively high educational attainment yet persistent financial knowledge gaps, as documented in Section 4.1, the result underscores that financial literacy retains explanatory power even among more educated and engaged segments of the population.

The complementarity mechanism proposed in Hypothesis 2 is not supported by the data. While digital competences emerge as a strong and independent positive predictor of savings adequacy, suggesting that digitally engaged individuals save more, possibly through greater access to digital savings tools and automated financial management, the interaction between financial literacy and digital competences does not achieve statistical significance. This null result contrasts with the complementarity patterns documented by Kass-Hanna et al. (2022) in emerging-market contexts and suggests that the two competences may operate through separate, rather than mutually reinforcing, pathways in the Portuguese setting. One plausible explanation is that in a developed economy with a mature digital financial infrastructure, the marginal benefit of digital competences for savings does not depend on the level of financial literacy. Digitally engaged individuals can effectively use automated savings tools regardless of their financial knowledge, while financially literate individuals can identify sound savings products through multiple channels, including non-digital ones. The proxy nature of the digital competence index, constructed from items not originally designed to capture this construct, may also attenuate the precision with which a true complementarity effect could be detected, and this measurement limitation should be borne in mind when interpreting the null finding.

The risk amplification mechanism tested in Hypothesis 3 also fails to achieve statistical significance in the preferred probit specification, though the direction of the interaction coefficient is consistent with the predicted negative sign. The discrepancy

between the linear probability model, which yields a positive and significant interaction contrary to the hypothesis, and the probit model, which yields a non-significant negative coefficient, underscores the importance of model selection for binary outcomes and the limitations of the linear probability model when predictions fall outside the unit interval. The weak negative direction of the probit interaction is consistent with concerns raised by Panos and Wilson (2020) and with Portuguese evidence from Alves (2023) and Ferreira (2024), suggesting that digital access may facilitate exposure to high-risk assets among the less financially literate. However, the available data do not provide sufficient statistical power to formally confirm this mechanism. The strong positive main effect of digital competences on high-risk asset holding, whereby more digitally engaged respondents are substantially more likely to hold cryptocurrencies or complex financial products regardless of their financial literacy level, is itself a noteworthy finding, suggesting that digital engagement is a primary driver of participation in these asset classes, with financial literacy playing only a secondary moderating role.

The demographic heterogeneity analysis provides partial and tentative support for Hypothesis 4. Within the younger age cohort and the higher-educated subgroup, the interaction between financial literacy and digital competences is negative and statistically significant, suggesting that, in these groups, the combination of the two competences is associated with lower, rather than higher, savings adequacy relative to the additive prediction. This counterintuitive pattern may reflect reallocation of resources toward non-savings financial activities, such as high-risk investment or consumption through digital platforms, among individuals who are both financially knowledgeable and digitally proficient, rather than a genuine dampening of savings propensity. However, as noted in Section 4.5 and consistent with the methodological caution urged by the supervisor, comparing coefficients from separate subgroup regressions does not constitute a formal test of heterogeneity. The triple-interaction tests required to establish that the moderation effect differs across subgroups formally are pending and will be incorporated as a robustness check. Pending those results, the subgroup findings should be interpreted as suggestive rather than definitive evidence of demographic heterogeneity in the moderation effect.

Taken together, the results paint a picture of financial literacy and digital competences as independently beneficial for savings behaviour but not jointly reinforcing in the Portuguese university-affiliated context. The absence of complementarity and the tentative risk amplification signal in the high-risk investment domain suggest that digital

financial inclusion may not automatically translate into better financial outcomes, a finding with direct relevance for financial education policy in an increasingly digitalised financial environment.

5.2 Limitations and Future Research

Several methodological constraints inherent to this study must be acknowledged, as they directly affect the interpretation of the findings and the generalisability of the conclusions.

The most fundamental limitation concerns the cross-sectional design of the VI Inquérito CMVM, which precludes causal inference and limits the analysis to conditional associations rather than causal effects. This constraint is particularly consequential for the central research question, as the direction of causality between financial literacy and digital competencies is theoretically ambiguous. While this study treats financial literacy as the primary explanatory variable and digital competences as a moderator, it is equally plausible that digital engagement promotes the acquisition of financial knowledge, or that both competences are simultaneously determined by unobserved characteristics such as cognitive ability or general curiosity. As discussed in Section 3.3, no suitable instrumental variables are available in the dataset to address this endogeneity formally. Future research employing panel data or natural experiments, such as exogenous expansions of digital financial service availability, would permit more credible identification of causal effects and directional relationships between the two competences.

The measurement of digital competences represents a second important limitation. The composite index constructed in this study is a proxy measure derived from six survey items not originally designed to capture digital competences as a primary construct. Although the index is conceptualised within a formative measurement framework, wherein the six components independently contribute to the composite rather than reflecting a single common latent trait, the equal weighting assumption implicit in the row-mean aggregation is untested. It may not accurately reflect the relative importance of each dimension. More sophisticated approaches, such as partial least squares path modelling or MIMIC estimation, could assign differential weights to each component, yielding a more precise operationalization of digital financial competence. Additionally, future research employing purpose-designed digital literacy measurement instruments, such as those aligned with the

DigComp framework (Vuorikari et al., 2016), would yield more reliable and theoretically grounded measurement of this construct.

The university-affiliated composition of the sample constitutes a third significant limitation. The sample is more educated, younger, and more digitally engaged than the broader Portuguese population, which substantially restricts the external validity of the findings. The null results for the complementarity and risk amplification mechanisms may reflect the specific characteristics of this population; for instance, high educational attainment may reduce the marginal benefit of digital competences for savings by providing alternative channels for acquiring and acting on financial knowledge, rather than the absence of these mechanisms in the population at large. Replication of the analysis using nationally representative samples, such as those collected under the Banco de Portugal financial literacy surveys covering the general Portuguese adult population, would provide a more comprehensive assessment of the mechanisms examined here.

A fourth limitation concerns the formal testing of demographic heterogeneity in Hypothesis 4. As noted in Sections 4.5 and 5.1, the comparison of interaction coefficients estimated in separate subgroup regressions does not constitute a rigorous test of whether the moderation effect differs across demographic groups, as the confidence intervals of the subgroup-specific estimates may substantially overlap. The appropriate test, estimating triple interaction terms between financial literacy, digital competences, and each subgroup indicator in the pooled sample, was not conducted within the scope of the present analysis and is identified as a priority for the robustness analysis. Pending those results, the subgroup findings reported in Section 4.5 should be interpreted as suggestive patterns rather than formally established heterogeneity.

Finally, the ordinal nature of the savings adequacy variable introduces an additional methodological consideration. The OLS specifications estimated in this study impose the assumption of equal spacing between response categories, which is not formally testable with the available data. An ordered probit specification estimated in parallel would provide a robustness check on this assumption; if the signs and significance of the key coefficients are preserved, the linear specification is defensible. This robustness check is identified as a further priority for subsequent analysis.

These limitations collectively suggest a rich agenda for future research. Studies employing longitudinal data, nationally representative samples, purpose-designed digital literacy instruments, and formal heterogeneity tests would substantially advance

understanding of how financial literacy and digital competences jointly shape household financial outcomes in increasingly digitalised financial environments. The present study contributes to this agenda by providing initial evidence from a Portuguese context and identifying the specific mechanisms and population segments that warrant further investigation.

5.3 Conclusions

This dissertation investigated the moderating role of digital competences in the relationship between financial literacy and household financial behaviour among a Portuguese university-affiliated population, contributing empirical evidence to an emerging literature at the intersection of financial literacy, digital competences, and household finance in developed economy contexts.

The principal findings can be summarised as follows. Financial literacy is a robust, independent positive predictor of savings adequacy, confirming the foundational premise of the financial literacy literature and demonstrating that financial knowledge retains explanatory power even in a relatively educated and digitally engaged population. Digital competences are similarly a strong independent predictor of both savings adequacy and high-risk asset holding, suggesting that digital engagement shapes financial behaviour through multiple channels, facilitating savings through access to digital financial tools while simultaneously enabling participation in more complex and volatile asset classes. However, the interaction between financial literacy and digital competences does not achieve statistical significance in any of the primary specifications, indicating that the two competences operate through independent rather than mutually reinforcing pathways in this context. Neither the complementarity mechanism nor the risk amplification mechanism is formally confirmed, and formal triple-interaction tests indicate that the moderation effect does not differ systematically across demographic subgroups.

These findings carry several implications for policy and practice. First, financial education programmes and digital literacy initiatives appear to generate independent benefits for household financial behavior, suggesting that investment in either domain yields returns even in the absence of the other. This finding supports the continued prioritisation of financial literacy interventions in Portugal, including those embedded in the Plano Nacional de Formação Financeira, without requiring that they be conditional on digital skill development. Second, the strong positive association between digital competences and high-

risk asset holding, independent of financial literacy, underscores the importance of regulatory attention to the accessibility of complex financial products through digital platforms. As digital channels lower barriers to participation in cryptocurrency markets and complex financial instruments, regulatory frameworks must ensure that product suitability assessment keeps pace with the speed of digital financial innovation. Third, the absence of a significant complementarity effect in a developed-economy context, in contrast to emerging-market evidence, suggests that the mechanisms through which financial and digital literacy interact may be context-dependent, and that conclusions from studies in one economic setting should not be uncritically transposed to others.

From a research perspective, this study contributes to the growing literature on digital financial literacy by providing one of the first empirical tests of the interaction between financial literacy and digital competences in the Portuguese context, using objective financial literacy measures and a composite digital competence index grounded in a formative measurement framework. The null findings for the interaction mechanisms are themselves informative, clarifying that the independent effects of financial and digital literacy do not necessarily combine multiplicatively in developed economy settings with mature digital financial infrastructure. Future research employing longitudinal data, nationally representative samples, purpose-designed digital literacy instruments, and formal identification strategies would substantially advance understanding of the causal pathways through which financial knowledge and digital competences jointly shape household financial outcomes in an increasingly digitalised world.

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7. Appendices

7.1 Appendix A - Descriptive Statistics

Table A 1 - Gender Distribution

	N	%
0	1187	51.8
1	1105	48.2
Total	2292	100.0
N	2292	

Source. Author's own elaboration based on VI Inquérito CMVM (2025).

Table A 2 - Educational Attainment Distribution

	N	%
1	9	0.4
2	181	7.8
3	872	37.7
4	264	11.4
5	406	17.5
6	228	9.9
7	140	6.1
8	214	9.2
Total	2314	100.0
N	2314	

Source. Author's own elaboration based on VI Inquérito CMVM (2025).

Table A 3 - Household Income Distribution

	N	%
Até 500€	68	3.0
501-1000€	212	9.3
1001-2500€	996	43.6
2501-5000€	749	32.8
Mais 5000€	260	11.4
Total	2285	100.0
N	2285	

Source. Author's own elaboration based on VI Inquérito CMVM (2025).

Table A 4 - Savings Adequacy Distribution

	N	%
Não poupa	264	11.6
<5%	346	15.2
5-10%	540	23.8
10-20%	445	19.6
>20%	676	29.8
Total	2271	100.0
N	2271	

Source. Author's own elaboration based on VI Inquérito CMVM (2025).

7.2 Appendix B - Descriptive Statistics and Correlations

Table B 1 - Descriptive Statistics for Model Variables

	Mean	Std. Dev.	Min	Max	N valid
Score_Literacy	3.300	1.493	0	5	2084
dum_risk_high	0.161	0.367	0	1	2319
Index_Digital	-0.007	0.648	-3	2	2298
Autoaval_Digital_num	3.628	0.917	1	5	2261
Autoaval_Financial_num	2.890	1.034	1	5	2288
Level_risk_num	2.721	1.281	1	5	2269
Tolerance_risk	5.293	2.362	0	10	2124
Gender_Fem	0.482	0.500	0	1	2292
Age	30.843	14.460	17	99	2292
Educatio_num	4.379	1.782	1	8	2314
Income_num	3.403	0.912	1	5	2285
N	2319				

Note. score_literacia = objective financial literacy score (0–5); dum_risco_alto = binary indicator of high-risk asset holding (cryptocurrencies or complex financial products); indice_digital = composite digital competence index (standardised z-score); autoaval_digital_num = self-assessed digital knowledge (1–5); autoaval_financeira_num = self assessed financial knowledge (1–5); nivel_risco_num = financial risk tolerance (1–5); disposicao_risco = general disposition to take risks (0–10); genero_fem = binary gender indicator (1 = female); escolaridade_num = educational attainment (1–8); rendimento_num = household income bracket (1–5). N valid refers to the number of non-missing observations for each variable.

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

Table B 2 - Digital Competence Index: Component Statistics

	Mean	Std. Deviation	Valid N
autoaval_digital_num	3.628	0.917	2261
dum_canal_acoes_digital	0.394	0.489	2223
dum_canal_complexos_digital	0.219	0.413	2114
dum_canal_cripto_digital	0.324	0.468	2099
freq_info_num	3.619	1.141	2281
dum_sites_lit	0.265	0.441	2181
N	2298		

Note. autoaval_digital_num = self-assessed knowledge of the internet and new technologies (1 = no knowledge; 5 = very

knowledgeable); dum_canal_acoes_digital = preference for autonomous digital channel when transacting in equities, funds, and ETFs (1 = yes; 0 = no); dum_canal_complexos_digital = preference for autonomous digital channel for complex financial products (1 = yes; 0 = no); dum_canal_cripto_digital = preference for autonomous digital channel for cryptocurrencies (1 = yes; 0 = no); freq_info_num = frequency of financial information-seeking (1 = never; 5 = daily); dum_sites_lit = regularly consults specialised financial literacy websites (1 = yes; 0 = no). Binary variables are presented as proportions. N refers to valid observations per component.

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

7.3 Appendix C - Regression Results

Table C 1 - OLS Regression Results: Hypothesis 1 (Baseline Effect) and Hypothesis 2 (Complementarity Mechanism)

	(1) M1a	(2) M1b	(3) M2a	(4) M2b
Financial Literacy (X)	0.301***	0.189***	0.153***	0.146***
	(0.019)	(0.021)	(0.022)	(0.022)
Gender (Female=1)		-0.321***	-0.194***	-0.197***
		(0.058)	(0.060)	(0.061)
Age		-0.024***	-0.022***	-0.022***
		(0.003)	(0.003)	(0.003)
Education		0.044**	0.044**	0.045**
		(0.019)	(0.018)	(0.018)
Income		0.231***	0.210***	0.211***
		(0.033)	(0.033)	(0.033)
Student		-0.840***	-0.765***	-0.767***
		(0.085)	(0.084)	(0.084)
Employed		0.046	0.001	0.006
		(0.080)	(0.079)	(0.079)
Digital Skills (M)			0.362***	0.372***
			(0.049)	(0.049)
Literacy × Digital (X×M)				-0.046
				(0.030)
Constant	3.441***	3.736***	3.638***	3.654***
	(0.028)	(0.158)	(0.158)	(0.158)
N	2048	1985	1985	1985
R^2	0.109	0.200	0.222	0.223
adj. R^2	0.109	0.197	0.219	0.220

Note. Dependent variable is savings adequacy measured on a five-point ordinal scale (1 = no savings; 5 = more than 20 percent of income). M1a = baseline model without controls; M1b = baseline model with sociodemographic controls; M2a = additive model with financial literacy and digital competences; M2b = moderated model with interaction term. All specifications estimated with heteroskedasticity-robust standard errors reported in parentheses. Variables are centred at their sample means prior to estimation. * p < 0.10, ** p < 0.05, *** p < 0.01

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

Table C 2 - LPM and Probit Results: Hypothesis 3 (Risk Amplification Mechanism)

	(1) LPM No Int.	(2) LPM Int.	(3) Probit (AME)
Financial Literacy (X)	0.005	0.009	0.012*
	(0.005)	(0.006)	(0.007)
Digital Skills (M)	0.173***	0.168***	0.152***
	(0.015)	(0.015)	(0.013)
Gender (Female=1)	-0.103***	-0.101***	-0.104***
	(0.016)	(0.016)	(0.017)
Age	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)
Education	0.006	0.006	0.006
	(0.006)	(0.006)	(0.005)
Income	0.019**	0.019**	0.019**
	(0.009)	(0.009)	(0.009)
Student	-0.058**	-0.057**	-0.047*
	(0.025)	(0.025)	(0.024)
Employed	0.040	0.037	0.028
	(0.026)	(0.026)	(0.024)
Literacy × Digital (X×M)		0.021**	-0.008
		(0.009)	(0.010)
Constant	0.241***	0.233***	
	(0.046)	(0.046)	
N	2013	2013	2013
R^2	0.169	0.171	

Note. Dependent variable is a binary indicator equal to one if the respondent holds cryptocurrencies or complex financial products, and zero otherwise. Column (1) presents the linear probability model without interaction term; column (2) presents the linear probability model with interaction term; column (3) presents average marginal effects from the probit specification. Robust standard errors in parentheses. AME = Average Marginal Effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

Table C 3 - Subgroup Analysis by Gender. Dependent variable: Savings Adequacy (1–5)

	(1) Female	(2) Male
Financial Literacy (X)	0.155***	0.122***
	(0.030)	(0.033)
Digital Skills (M)	0.356***	0.370***
	(0.076)	(0.070)
Literacy × Digital (X×M)	-0.070	-0.009
	(0.045)	(0.047)
Age	-0.025***	-0.020***
	(0.005)	(0.003)
Education_num	0.088***	0.012
	(0.029)	(0.024)
Income_num	0.253***	0.174***
	(0.047)	(0.046)
dum_Student	-0.781***	-0.748***
	(0.126)	(0.115)
dum_Employer	-0.097	0.102
	(0.126)	(0.101)
Constant	3.271***	3.812***
	(0.246)	(0.202)
N	929	1056
R^2	0.205	0.181
adj. R^2	0.198	0.175

Note. Each column presents results for the respective gender subgroup estimated using OLS with heteroskedasticity-robust standard errors reported in parentheses. The interaction term is the product of the centred financial literacy score and the centred digital competence index. * p < 0.10, ** p < 0.05, *** p < 0.01

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

Table C 4 - Subgroup Analysis by Age Cohort. Dependent variable: Savings Adequacy (1–5)

	(1) Young (17-25)	(2) Adults (26+)
Financial Literacy (X)	0.112***	0.178***
	(0.028)	(0.036)
Digital Skills (M)	0.351***	0.439***
	(0.073)	(0.071)
Literacia × Digital (X×M)	-0.086**	-0.018
	(0.042)	(0.049)
Education_num	0.111***	-0.002
	(0.042)	(0.021)
Income_num	0.108**	0.307***
	(0.044)	(0.047)
dum_Student	-0.836***	-0.001
	(0.106)	(0.203)
dum_Employed	-0.051	0.070
	(0.170)	(0.101)
Gender_Fem	-0.230***	-0.104
	(0.086)	(0.084)
Constant	3.396***	2.420***
	(0.248)	(0.201)
N	1052	933
R^2	0.201	0.206
adj. R^2	0.195	0.200

Note. Younger respondents are aged 17–25; older respondents are aged 26 and above. Each column presents results estimated using OLS with heteroskedasticity-robust standard errors reported in parentheses. The interaction term is the product of the centred financial literacy score and the centred digital competence index. * p < 0.10, ** p < 0.05, *** p < 0.01

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

Table C 5 - Subgroup Analysis by Educational Attainment. Dependent variable: Savings Adequacy (1–5)

	(1) Higher Education or Above	(2) Below Higher Education
Financial Literacy (X)	0.146***	0.143***
	(0.030)	(0.033)
Digital Skills (M)	0.455***	0.273***
	(0.067)	(0.082)
Literacy × Digital (X×M)	-0.093**	-0.037
	(0.043)	(0.048)
Age	-0.023***	-0.020***
	(0.003)	(0.006)
Income_num	0.299***	0.140***
	(0.043)	(0.051)
dum_Student	-0.743***	-0.715***
	(0.113)	(0.155)
dum_Employed	-0.031	0.060
	(0.088)	(0.195)
Gender Fem	-0.114	-0.278***
	(0.075)	(0.099)
Constant	3.627***	3.919***
	(0.171)	(0.294)
N	1121	864
R^2	0.235	0.137
adj. R^2	0.230	0.129

Note. Higher-educated respondents are those with completed undergraduate education or above (escolaridade_num ≥ 4); lower-educated respondents are those with secondary education or below (escolaridade_num < 4). Each column presents results estimated using OLS with heteroskedasticity-robust standard errors reported in parentheses. The interaction term is the product of the centred financial literacy score and the centred digital competence index. * p < 0.10, ** p < 0.05, *** p < 0.01

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

Table C 6 - Subgroup Analysis by Household Income. Dependent variable: Savings Adequacy (1–5)

	(1) Low Income (up to 1000€)	(2) Medium-High Income (>1000€)
Financial Literacy (X)	0.131**	0.159***
	(0.062)	(0.024)
Digital Skills (M)	0.364**	0.394***
	(0.160)	(0.052)
Literacy × Digital (X×M)	-0.004	-0.046
	(0.097)	(0.032)
Age	-0.039***	-0.019***
	(0.010)	(0.003)
Education_num	0.058	0.047**
	(0.068)	(0.019)
dum_Student	-0.410*	-0.808***
	(0.241)	(0.091)
dum_Employed	0.746***	-0.061
	(0.273)	(0.084)
Gender_Fem	-0.279	-0.182***
	(0.177)	(0.065)
Constant	4.126***	4.330***
	(0.500)	(0.137)
N	233	1752
R^2	0.164	0.203
adj. R^2	0.134	0.199

Note. Low-income respondents are those with household income up to 1,000 euros per month (rendimento_num ≤ 2); middle-to-high income respondents are those with household income above 1,000 euros per month (rendimento_num ≥ 3). Each column presents results estimated using OLS with heteroskedasticity-robust standard errors reported in parentheses. The interaction term is the product of the centred financial literacy score and the centred digital competence index. The considerably smaller sample size for the low-income subgroup (N = 233) reduces statistical power and should be borne in mind when interpreting results for this group. * p < 0.10, ** p < 0.05, *** p < 0.01.

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).

Table C 7 - Formal Tests of Demographic Heterogeneity: Triple Interaction Terms. Dependent variable: Savings Adequacy (1–5)

	(1) Gender	(2) Age	(3) Education	(4) Income
triple_lit_dig_genero	-0.061			
	(0.065)			
triple_lit_dig_idade		-0.067		
		(0.064)		
triple_lit_dig_escol			-0.056	
			(0.064)	
triple_lit_dig_rend				0.048
				(0.102)
N	1985	1985	1985	1985

Note. Each column presents the coefficient of the triple interaction term (financial literacy × digital competences × subgroup dummy) from a pooled OLS regression estimated on the full sample. The triple interaction coefficient is the formal test of whether the moderation effect of digital competences on the financial literacy-savings relationship differs significantly across demographic subgroups. Gender dummy = 1 for female respondents; age dummy = 1 for respondents aged 17–25; education dummy = 1 for respondents with completed undergraduate education or above; income dummy = 1 for respondents with household income up to €1,000 per month. All models include the constituent main effects and two-way interactions, with heteroskedasticity-robust standard errors reported in parentheses. A significant coefficient would confirm formal heterogeneity; the absence of significance indicates that the apparent differences across subgroups in the separate regressions do not survive formal statistical testing. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source. Author's own elaboration based on VI Inquérito CMVM (Comissão do Mercado de Valores Mobiliários, 2025).