
The Impact of Digital Financial Literacy on Consumer Over-Indebtedness: Evidence on Underlying Mechanisms

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ABSTRACT

With the rapid advancement of digitalization, digital financial literacy (DFL) has become increasingly influential in shaping consumer financial behavior. Using data from the 2017 and 2019 China Household Finance Survey and building upon the foundational framework of Lyons and Kass-Hanna (2021), this study adapts and constructs a comprehensive evaluation framework to measure individuals' digital financial literacy along four dimensions: risk awareness and attitudes, basic financial knowledge, digital financial skills, and digital financial experience. Based on this framework, we empirically examine the impact of digital financial literacy on consumers' subjective and objective over-indebtedness. Results indicate a significant negative relationship between digital financial literacy and consumer over-indebtedness, suggesting that improvements in digital financial literacy effectively curb excessive credit use. Further mechanism analysis reveals that digital financial literacy mitigates over-indebtedness by promoting financial planning behavior and increasing participation in commercial insurance. Moreover, individuals with lower incomes and those residing in rural areas exhibit lower levels of digital financial literacy. Enhancing digital financial literacy among these groups is therefore of substantial practical importance for preventing and alleviating consumer over-indebtedness.

Keywords: Digital financial literacy; Consumer over-indebtedness; Financial planning; Commercial insurance participation

I. Introduction

With the rapid development of financial technology, digital innovation in the financial sector has generated increasingly complex financial instruments, and a growing share of financial services is now accessed and delivered through digital channels (Lyons & Kass-Hanna, 2022). This transformation places higher demands on consumers, who must possess more advanced levels of digital financial literacy to effectively use fintech products and gain adequate access to financial services. Understanding the relationship between digital financial literacy and consumer over-indebtedness behavior is therefore crucial for enhancing individual financial well-being, promoting healthy and sustainable consumption, and ensuring the stability of financial markets and society.

The rapid advancement of digital technologies is reshaping the global financial ecosystem. New financial products and services represented by digital finance have the potential to fundamentally alter how consumers make financial decisions and select financial products (OECD, 2020). The proliferation of mobile payments, online credit, and robo-advisory services has shifted consumer's financial decision-making from traditional physical branches and limited information channels to more convenient, open, and diversified digital platforms. This transformation has substantially lowered the

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barriers and costs of accessing credit, thereby enhancing financial inclusion (Hasan et al., 2023) and enabling consumers to meet their credit needs more easily.

While the shift toward digital finance offers undeniable advantages, it simultaneously amplifies the danger of consumers falling into excessive debt. While the shift toward digital finance offers undeniable advantages, it simultaneously amplifies the danger of consumers falling into excessive debt (Yue et al., 2022). The consequences extend beyond personal financial distress; they threaten the broader stability of financial markets and create new hurdles for social governance (Arner et al., 2015). Moreover, digitalization exposes individuals to new risks, including digital financial exclusion, online fraud, and breaches of personal data (Ogunola et al., 2024).

Given this context, our research aims to unpack the specific mechanisms linking digital financial literacy to the phenomenon of consumer over-indebtedness. Specifically, the study addresses three research questions. First, how does digital financial literacy influence consumers' objective debt levels and subjective perceptions of indebtedness? Second, we explore whether financial planning and commercial insurance holdings act as key mediators in the relationship between digital literacy and excessive borrowing. Finally, does the protective effect of digital financial literacy vary depending on their urban-versus-rural residence?

This study contributes meaningfully to both theory and practice. Theoretically, we construct a multi-layered metric for DFL that fills a persistent void in how literacy is defined and measured within digital finance. By zooming in on decision-making within fintech ecosystems, we uncover the specific pathways linking DFL to over-borrowing. This adds a crucial layer to existing theories regarding consumer behavior in credit markets. Practically, our results provide actionable guidance for fostering responsible borrowing habits, curbing debt risks, and refining regulatory frameworks in the digital space.

II. Previous Research and Hypotheses

A. Previous Research on DFL

Digital financial literacy is often treated as a specialized branch of broader financial literacy. The OECD defines financial literacy as “a combination of awareness, knowledge, skills, attitudes, and behaviors necessary to make sound financial decisions and ultimately achieve individual financial well-being.” Yet, traditional metrics often fall short when applied to modern consumer actions, especially within digital environments. Take Apple Pay as a case in point: a user needs to understand how mobile payments work, rather than knowing the diversification benefits of investing in multiple stocks versus a single firm (Lyons & Kass-Hanna, 2021). Evidently, the rise of these digital scenarios has necessitated a distinct concept: digital financial literacy.

Given its inherent complexity, digital financial literacy cannot be understood through a single lens; it demands a multi-layered framework for proper definition and measurement. Although there is no universally accepted definition of digital financial literacy, several international organizations and scholars have proposed influential conceptualizations based on the distinctive features of digital finance. One of the most authoritative frameworks comes from the 2024 OECD/INFE Survey Instrument to Measure Digital Financial Literacy. In this document, the OECD characterizes digital financial literacy as a blend of knowledge, skills, attitudes, and behaviors. Crucially, these elements must empower individuals to navigate digital services safely and effectively, ultimately boosting their financial well-being (OECD, 2024).

While a universally standardized metric remains elusive, Lyons and Kass-Hanna (2021) advanced the academic discussion by introducing a highly influential hierarchical, multi-dimensional index. Their

model reflects the actual logic of how consumers use digital services and how their capabilities evolve over time. At its core, the framework comprises five interlocking elements: basic skills, general awareness, practical know-how, decision-making behaviors, and self-protection mechanisms. This framework breaks through the limitations of traditional single-dimension measurements and provides a systematic baseline for deciphering the internal structure of digital financial literacy. Given its robustness and relevance to consumer behavior, this study adopts and adapts this specific framework to construct our measurement of digital financial literacy, ensuring a comprehensive evaluation of its impact on excessive credit behavior.

B. Previous Research on Over-indebtedness

As Leandro and Botelho (2022) highlight in their systematic review, consumer over-indebtedness is a complex, multifaceted, and inherently interdisciplinary phenomenon that a single characteristic cannot explain. The ripple effects of this debt extend far beyond the wallet. Heavy debt loads often correlate with physical and mental health struggles, financial distress, and a general decline in well-being (Hojman et al., 2016). Such outcomes place a heavy burden on everyone involved—from borrowers to creditors and the broader society. In severe cases, this leads to financial exclusion and poverty (Brennan & Gallagher, 2007), hitting vulnerable groups like the elderly, low-income households, and single parents the hardest (Betti et al., 2007).

Drawing on the Life-Cycle Permanent Income Hypothesis, Betti, Dourmachkin, and their team view debt primarily as a mechanism for smoothing consumption. They argue that over-indebtedness occurs when—whether through bad luck or poor choices—a consumer's current assets fall short of covering the present value of what they owe. When this happens, the original spending plan collapses. The consumer is then forced to slash their spending just to service the debt, which inevitably damages their quality of life. Many definitions of over-indebtedness also adopt a household-level perspective. In this context, Brennan and Gallagher (2007) suggest that a household is over-indebted if it cannot meet its obligations without making a drastic sacrifice in its standard of living.

The mainstream measurement of consumer over-indebtedness generally relies on two dimensions: objective indicators and subjective self-reported measures. The literature has yet to converge on a standardized system of objective indicators. Commonly used measures include total outstanding debt, per capita debt, debt-to-asset ratios, consumption-to-income ratios, the number of delinquent accounts, and credit delinquency rates. No universally accepted threshold exists to definitively classify over-indebtedness, although a consumption-to-income ratio greater than one is often interpreted as an indicator of excessive debt burden. In contrast, some studies adopt subjective approaches that focus on “perceived financial distress,” arguing that individuals are best positioned to assess their own financial circumstances and thus rely on self-reported measures of over-indebtedness (Disney et al., 2008).

C. Previous Research on DFL and Over-indebtedness

A substantial body of research in consumer finance has examined the relationship between financial literacy and consumers' over-credit behavior. The consensus is clear: borrowers with low financial literacy often end up with expensive, high-cost credit. They struggle to process market information or grasp basic concepts, which naturally erodes their confidence when making credit decisions (Lusardi & Mitchell, 2017). Typically, over-indebtedness stems from a toxic mix of knowledge gaps and self-control issues. In contrast, individuals with higher levels of financial literacy are more likely to participate in stock markets and earn higher returns on their investment portfolios (Bianchi, 2018), engage more actively in retirement planning and wealth accumulation, and experience fewer problems with debt repayment (Lusardi & Tufano, 2015). Thanks to these sharper decisions, they suffer less financial distress (Gathergood, 2012), effectively shielding themselves from the trap of over-indebtedness.

Conversely, there is a notable gap in empirical research regarding how digital financial literacy affects over-indebtedness, and the mechanisms behind this relationship are still a black box. On one hand, Kass-Hanna et al. (2022) suggest a positive link, showing that digital literacy improves how consumers handle saving, borrowing, and risk. Similarly, Choung et al. (2023) find that this literacy fosters prudent money management and helps users shield themselves from online fraud, ultimately boosting their financial well-being. Building on this premise, other scholars emphasize the severe consequences of lacking such literacy in today's frictionless financial environment. Panos and Wilson (2020) argue that easy access provided by digital platforms might actually backfire, luring inexperienced users into impulsive spending. While digital finance enhances financial inclusion, it may simultaneously increase the risk of households falling into debt traps if they lack adequate digital financial capabilities (Yue et al., 2022). Consequently, while literacy is theoretically beneficial, the exact mechanisms by which it acts as a brake on over-borrowing in a highly tempting digital landscape require further investigation. A key limitation in current studies is that they tend to treat digital and financial literacies as separate silos, failing to capture the blended skill set needed in today's digital environment.

III. Theoretical Framework and Research Hypotheses

A. Theoretical Foundations

Our analysis draws on three core pillars: Modigliani and Brumberg's (1954) life-cycle theory, Leland's (1968) precautionary saving theory, and behavioral finance insights on bounded rationality and nudging (Thaler & Sunstein, 2008).

Life-cycle theory: Proposed by Modigliani and Brumberg (1954), the theory argues that rational people plan for the long haul. They balance their spending and saving against what they expect to earn over a lifetime, borrowing or lending as needed to keep their consumption smooth and maximize their overall well-being. However, the digital economy throws a wrench in the works: financial products are becoming so complex that making these long-term decisions is harder than ever. As a critical human capital, digital financial literacy reduces information search costs and calculation biases in intertemporal resource allocation, enabling individuals to assess future income and debt-servicing capacity better and to avoid irrational credit expansion driven by short-sightedness or misestimation (Lusardi & Mitchell, 2014).

Precautionary saving theory: Leland (1968) suggests that people naturally build a financial buffer to weather future storms, such as illness, retirement, or a sudden drop in income. However, traditional precautionary saving is inefficient, requiring sacrifices to current consumption. This is where commercial insurance steps in. By offering high protection for a relatively low premium, it provides a smarter alternative to simply hoarding cash. Here, digital financial literacy serves as a crucial navigator. It empowers individuals to spot risks and grasp the leverage of insurance (Lin et al., 2017). By using insurance to absorb shocks, they can snap the dangerous chain that leads from a sudden crisis to drained savings and, ultimately, passive debt (Klapper et al., 2013).

Bounded rationality and nudging theory: Humans are not perfect calculators; we are limited by "bounded rationality" and easily fall prey to the temptation to overspend (Simon, 1955; Kahneman, 2003). Drawing on nudging theory (Thaler & Sunstein, 2008), enhanced digital financial literacy can act as an effective choice architecture that enhances cognitive capacity, optimizes mental accounting (Thaler, 1999), and strengthens awareness of budget constraints. This cognitive shift steers people away from impulsive borrowing and toward smarter resource allocation (Gathergood, 2012; Lusardi & Mitchell, 2014). By encouraging structured planning and the use of insurance, it effectively puts a behavioral brake on excessive debt (Morgan et al., 2019; Panos & Wilson, 2020).

B. Main Effect Analysis

Cognitively, financially literate consumers possess the radar to detect the true costs of credit. They can see through complex terms to spot hidden fees and actual interest rates, effectively sidestepping high-cost traps (Lusardi & Tufano, 2015). In terms of practical skills, digital proficiency acts as an enabler in an increasingly cashless and online society. It streamlines daily money management and reinforces the reality of budget constraints (French et al., 2020). Ultimately, these factors converge at the decision-making stage. Experience with digital finance sharpens risk perception and curbs behavioral flaws like myopia or impulsivity. This leads to more prudent choices, cutting off excessive debt at the source, particularly when facing the temptation of "one-click" online borrowing.

H1: In a highly digitized financial environment, digital financial literacy acts as a significant deterrent to over-indebtedness, reducing it in both objective and subjective terms.

C. Mediating Mechanism Analysis

This study posits that digital financial literacy does not exert a direct and singular effect on credit behavior. Rather, it operates through specific channels to mitigate over-indebtedness. Specifically, digital financial literacy empowers consumers in two distinct ways. First, it enhances their capacity to process financial information and seek professional advice, thereby encouraging proactive financial planning to optimize cash flow and asset allocation. Second, equipped with these superior information processing skills, digitally literate individuals can better evaluate risk-hedging tools and navigate online insurance markets, which directly promotes their participation in commercial insurance. By driving these two channels, digital literacy optimizes household balance sheets and builds a robust financial buffer, effectively shielding consumers from excessive debt.

1. The mediating role of financial planning

Financial planning reflects consumers' proactive ability to manage assets and debts. The improvement of digital financial literacy enhances consumers' capacity and willingness to obtain professional investment advice via digital wealth management platforms (Calcagno & Monticone, 2015). Consumers with financial planning awareness have a clear understanding of their income and expenditures, can live within their means, and can reasonably manage cash flow (Hilgert et al., 2003). They are also more inclined to formulate long-term asset allocation plans (Van Rooij, 2012), thereby optimizing their balance sheets (Hilgert et al., 2003). When facing funding gaps, they are more likely to use savings or liquidate assets rather than borrow unthinkingly (Anderson et al., 2017). In addition, the asset appreciation effect brought by financial planning reduces their reliance on credit funds. This forward-looking financial management behavior can effectively balance income and expenditure, preventing debt accumulation from exceeding repayment capacity. Based on this, the following hypothesis is proposed:

H2: Digital financial literacy reduces both SOI and DOI by enhancing consumers' financial planning capabilities within digital financial ecosystems.

2. The mediating role of commercial insurance participation

The theoretical link between commercial insurance ownership and reduced over-indebtedness is rooted in the dynamics of liquidity constraints and state-contingent wealth allocation (Hubbard et al., 1995). From a theoretical standpoint, one might hypothesize that households could simply rely on precautionary savings as an alternative to manage shocks, or conversely, that holding insurance might induce a false sense of security, leading to less concern about debt. However, I argue that commercial insurance plays a unique and irreplaceable role in curbing over-indebtedness through two main economic mechanisms.

First, commercial insurance prevents the "shock-induced debt trap" by providing leverage that precautionary savings cannot match. According to precautionary savings theory, households build financial buffers against unexpected negative shocks (Deaton, 1991). While precautionary savings may suffice for minor emergencies, they are finite and often insufficient to cover catastrophic tail risks, such as severe medical emergencies or major accidents. When a massive shock depletes a household's finite savings, they are forced to finance the remaining expenditures through high-cost, unsecured credit (such as credit cards or revolving online loans). Due to the compounding interest, this temporary liquidity shock rapidly transforms into chronic over-indebtedness (Lusardi et al., 2011). Commercial insurance acts as state-contingent liquidity; its timely payouts far exceed typical household savings, bypassing the need to enter the high-cost credit market and effectively severing the pathway from "risk shock" to "passive over-indebtedness" (Finkelstein et al., 2012).

Second, insurance serves as a "commitment device" that curbs impulsive borrowing (Bryan et al., 2010). While one might worry that insurance coverage could induce a false sense of security and reduce concern about debt, I argue the opposite. From a behavioral finance perspective (Thaler, 1999), paying regular insurance premiums functions as a financial commitment that forces households to internalize future tail risks into their current budget constraints. This structured financial behavior optimizes mental accounting, reducing the discretionary, unstructured cash flow that is often diverted toward impulsive, debt-financed consumption.

In the modern context, digital financial literacy is the key catalyst for this mechanism (Panos & Wilson, 2020). High digital financial literacy empowers consumers to overcome traditional barriers to insurance (e.g., information asymmetry and complex terms) by efficiently comparing and acquiring InsurTech products online (Gomber et al., 2017; Lin et al., 2019). By leveraging digital platforms to secure insurance, digitally literate consumers not only build a structural defense against tail risks but also cultivate disciplined budget management, thereby reducing both objective and subjective over-indebtedness. Consequently, I propose the following hypothesis:

H3: In an increasingly digitized financial environment, digital financial literacy reduces both SOI and DOI by promoting consumers' participation in commercial insurance (particularly via digital channels) and strengthening their capacity for risk mitigation.

IV. Data Sources and Sample Selection

A. Data Sources

We drew our data from the 2017 and 2019 waves of the China Household Finance Survey (CHFS), a nationally representative dataset covering 29 provinces and municipalities. To align with our research framework, we extracted specific metrics on financial literacy, demographics, insurance, debt, income, and consumption.

We then rigorously screened the raw data to ensure reliability. First, we restricted the sample to household heads aged 16 to 60. Second, we removed entries with missing or nonsensical values (e.g., negative income or assets) and excluded respondents who answered "don't know" or refused to answer key questions. Finally, to prevent outliers from skewing the results, we winsorized continuous variables like debt at the 1% and 99% levels. These steps yielded a final, robust sample of 27,073 observations.

B. Variable Definitions and Measurement

Drawing on Betti et al. (2007) and our theoretical framework, we adopt a dual approach to measure our dependent variable -- consumer over-indebtedness -- capturing both its objective (OOI) and subjective (SOI) dimensions. For OOI, we rely on the debt-to-income ratio (DTI). We calculate total

debt by summing six categories: housing, medical, education, vehicle, credit card, and other personal debts. Crucially, we exclude business-related liabilities to isolate the specific burden of consumer debt. We construct OOI as a binary variable: households with a DTI exceeding 1 are flagged as over-indebted (coded as 1), while others are coded as 0. SOI reflects the respondents' own perception of their financial stress. We set this variable to 1 if the household reports "difficulty repaying debts," "temporary postponement of repayment," or "liquidity problems," and 0 otherwise.

Our core explanatory variable is digital financial literacy, DFL. We constructed a multi-dimensional index of DFL by integrating indicators of financial literacy and digital literacy (Lyons & Kass-Hanna, 2021). The index comprises four dimensions: risk awareness, basic financial knowledge, digital financial skills, and digital financial experience, described in the Appendix, table A1. To overcome the subjectivity and arbitrariness of artificial weighting and to objectively reflect the relative importance of each indicator in the evaluation system, this study employs the entropy method to determine indicator weights. Originating from information theory, the entropy method is a data-driven approach that assigns weights based on the degree of dispersion (or variance) within each indicator. Specifically, an indicator with greater variation among respondents provides more valuable information in distinguishing individual differences; consequently, it yields a lower entropy value and is assigned a higher weight. This ensures that the final index accurately and objectively captures the most differentiating aspects of consumers' digital financial capabilities.¹

We selected two indicators as mediating variables: consumers' financial planning ability (M1) and their level of participation in commercial insurance (M2). The measurement criteria are as follows. Financial Planning: It takes the value 1 if the household uses a financial advisor or consults a professional, and 0 otherwise. Commercial Insurance Participation: It equals 1 if the household has purchased commercial insurance and 0 otherwise.

Drawing upon existing literature, we include additional controls for the following characteristics. Household head characteristics include age, health level, gender, marital status, and membership in Communist Party of China (CPC). Household characteristics include household size, the logarithm of total household debt, child dependency ratio, elderly dependency ratio, and urban/rural classification. All models also include province and year fixed effects.

C. Empirical Model

Given that both the dependent and mediating variables in this study are binary (0 or 1), this paper primarily employs Probit regression models for analysis.

1. Baseline regression model

Incorporating the specific dependent variables, the core explanatory variable, and control variables of this study, the model is specified as:

$$OOI_{ij} = \alpha_0 + \alpha_1 DFL_{ij} + \alpha_{2ij} Controls_{ij} + Province_p + Year_j + \varepsilon_{ij} \quad (1)$$

$$SOI_{ij} = \alpha_0 + \alpha_1 DFL_{ij} + \alpha_{2ij} Controls_{ij} + Province_p + Year_j + \varepsilon_{ij} \quad (2)$$

In the equation above, OOI represents Objective Over-indebtedness and SOI represents Subjective Over-indebtedness, respectively. DFL_{ij} denotes the Digital Financial Literacy level of household head i in year j . $Controls_y$ represents a vector of control variables for household head i in year j . $Province_p$

¹ To check robustness, DFL was also recalculated as the aggregate mean of 11 indicators across four dimensions. Results using this alternative measure (available from the author) are consistent with those reported using the entropy measure.

represents province fixed effects, $Year_j$ represents year fixed effects, and ϵ_{jj} represents a random error term.

2. Mediation effect model

To examine the mechanisms through which different levels of digital literacy affect subjective and objective over-indebtedness, this paper establishes models to test the impact of the core explanatory variable on the mediating variables, and the impact of the core explanatory variable on the dependent variables with the inclusion of the mediators. The models are specified as follows:

$$m_{ij} = \alpha_0 + \alpha_1 DFL_{ij} + \alpha_{2ij} Controls_{ij} + Province_p + Year_j + \epsilon_{ij} \quad (3)$$

$$OOI = \alpha_0 + \alpha_1 DFL_{ij} + \beta m_{ij} + \alpha_{2ij} Controls_{ij} + Province_p + Year_j + \epsilon_{ij} \quad (4)$$

$$SOI = \alpha_0 + \alpha_1 DFL_{ij} + \beta m_{ij} + \alpha_{2ij} Controls_{ij} + Province_p + Year_j + \epsilon_{ij} \quad (5)$$

Where m_{ij} represent the mediating variables: financial planning and commercial insurance participation for household head i in year j , respectively.

V. Empirical Results and Analysis

A. Descriptive Statistics

Descriptive statistics of the main variables are presented in Table 1. As shown in the table, 21.2% of consumers exhibit OOI. Numerically, this figure is lower than international counterparts: for example, Schicks (2014) found an over-indebtedness rate as high as 29.8% among microfinance clients in Ghana. However, given the long-standing tradition of debt aversion in rural China and the government's emphasis on poverty alleviation, the prevalence of OOI warrants attention.

Table 1. Descriptive statistics of the sample

Variables	Mean	SD	Min	Max
OOI	0.212	0.409	0	1
SOI	0.064	0.245	0	1
DFL	0.114	0.121	0	0.84
Age	47.174	8.836	18	60
Gender	0.803	0.398	0	1
Marriage	0.905	0.294	0	1
CPC member	0.353	0.478	0	1
Health	3.486	0.97	1	5
HH size	3.478	1.435	1	12
Lndebt	5.227	5.613	0	14.208
Child dependency ratio	0.139	0.176	0	0.833
Elder dependency ratio	0.058	0.129	0	0.75
Rural resident	0.324	0.468	0	1
Region	1.808	0.826	1	3
Financial planning	0.021	0.143	0	1
Commercial insurance	0.189	0.391	0	1

Note: Sample N = 27,073. For the Digital Financial Literacy (DFL) index, the theoretical range is from 0 to 1, whereas the observed sample maximum is 0.84.

The proportion of SOI is only 6.4%, which is significantly lower than OOI. This suggests that respondents are not exaggerating their financial distress to deliberately avoid or delay repayment. Instead, this discrepancy may reflect a degree of social desirability bias, where respondents are reluctant to admit to financial difficulties and tend to overstate their financial resilience, or it simply indicates that many consumers do not subjectively perceive their objective debt levels as an unmanageable burden. Regarding the DFL index, the mean value is 0.114, indicating that the digital financial literacy level of the sampled rural households is notably low.

B. Baseline Regression Results

Table 2 reports the marginal effects Probit regression results regarding the impact of digital financial literacy on consumer over-indebtedness behavior. The results show that after controlling household head, household, and regional characteristics, the coefficient of DFL is significantly negative at the 1% level. This indicates that higher digital financial literacy correlates with a lower probability of both objective and subjective over-indebtedness. In terms of marginal effects, for every one-standard-unit increase in digital financial literacy, the probability of a consumer falling into the objective over-indebtedness trap decreases by an average of 17.9%, and the probability of falling into the subjective over-indebtedness trap decreases by an average of 22.6%. This result supports Hypothesis H1, suggesting that digital financial literacy acts as a significant "debt brake," helping consumers maintain rationality within a complex digital financial environment.

Table 2. Baseline regression results

Variables	OOI Marginal Effects	SOI Marginal Effects
DFL	-0.179***	-0.226***
Age	-0.000	0.001***
Gender	-0.023***	0.005
Marriage	0.002	-0.022***
CPC member	-0.007	-0.014***
Health	-0.018***	-0.020***
HH size	-0.022***	0.003**
Lndebt	0.062***	0.018***
Child dependency ratio	0.063***	0.019**
Elder dependency ratio	0.055***	0.004
Rural resident	-0.014***	0.021***
Region	0.021	0.070***
r2_p	0.489	0.293

Note: Sample N = 27,073. All models include a constant term and province and year fixed effects.

***Represent 1% significance level. **Represent 5% significance level. *Represent 10% significance level.

B. Endogeneity Treatment

To address endogeneity, this study uses the average digital financial literacy of households in the same district/county as the consumer's household as an instrumental variable for the consumer's digital financial literacy. This instrumental variable satisfies the two required conditions of relevance and exogeneity: First, households within the same district/county are subject to homogeneous policies, infrastructure, and planning related to financial literacy development; meanwhile, frequent interactions among neighbors (the "peer effect") make a household's digital financial literacy prone to being influenced by that of surrounding households, thus meeting the relevance condition. Second, the average digital financial literacy of other households in the district/county does not directly affect the

target household's subjective and objective excessive debt, nor can the target household control this average, thereby satisfying the exogeneity condition.

Table 3 reports the IV regression results. Regarding the exogeneity test, the Wald test rejects the null hypothesis that digital financial literacy is exogenous at the 10% level, indicating endogeneity and justifying the use of the IV method. Regarding relevance, the first-stage coefficient of the IV is significantly negative at the 1% level (0.721), confirming a correlation. Additionally, the first-stage F-statistic is 213.13, well above the critical value of 10, indicating no weak-instrument problem. The second-stage results show that after correcting for endogeneity, the impact of digital financial literacy on both objective and subjective over-indebtedness remains significantly negative at the 1% level, consistent with the previous findings.

Table 3. Instrumental variable regression results

Variables	Stage1	Stage2	
	DFL	OOI	SOI
DFL		-0.142*** (-2.859)	-0.411*** (-9.903)
IV	0.721*** (48.650)		
Age	-0.002*** (-24.427)	0.000 (0.120)	0.000 (0.499)
Gender	0.004** (2.508)	-0.023*** (-4.730)	0.005 (1.245)
Marriage	0.002 (0.859)	0.002 (0.245)	-0.021*** (-4.210)
CPC member	0.017*** (11.318)	-0.007 (-1.479)	-0.010*** (-2.823)
Health	0.007*** (11.225)	-0.019*** (-8.845)	-0.018*** (-11.789)
HH size	0.001** (2.442)	-0.022*** (-12.968)	0.003** (2.256)
Lndebt	0.001*** (7.689)	0.062*** (67.391)	0.019*** (28.687)
Child dependency ratio	-0.013*** (-2.839)	0.063*** (4.716)	0.017* (1.752)
Elder dependency ratio	-0.015*** (-3.213)	0.056*** (3.295)	0.001 (0.105)
Rural resident	-0.010*** (-7.268)	-0.012** (-2.209)	0.011*** (2.817)
Region	-0.027*** (-5.054)	0.024 (1.384)	0.059*** (3.335)
r2_p	0.338		
F statistic	213.13		

Note: Sample N = 27,073. All models include a constant term and province and year fixed effects.

***Represent 1% significance level. **Represent 5% significance level. *Represent 10% significance level.

C. Mediation Effect Test

To test H2 and H3, we employ the causal steps approach to test for mediation. Table 4 reports estimated marginal effects from Probit regression results of the mediation effect of financial planning. Results show that digital financial literacy has a significantly positive effect on financial planning at the 1% level, indicating it improves financial planning capabilities. When financial planning is added to the main regression, the coefficients for both financial planning and digital financial literacy are significantly negative. Compared to the baseline regression results, the marginal effect reduction of digital financial literacy on objective over-indebtedness decreases from 17.9% to 17.3%, and for subjective over-indebtedness from 22.6% to 22.2%. This indicates a partial mediation effect: digital financial literacy improves consumer financial planning capabilities, thereby reducing subjective and objective over-indebtedness. Hypothesis H2 is supported.

Table 4. Mediation effect of financial planning

Variables	Financial Planning Marginal Effects	OOI Marginal Effects	SOI Marginal Effects
DFL	0.100*** (15.334)	-0.173*** (-10.551)	-0.222*** (-11.520)
Financial Planning		-0.047*** (-3.614)	-0.046** (-2.564)
Age	0.000*** (4.283)	-0.000 (-0.189)	0.001*** (3.275)
Gender	-0.008*** (-4.243)	-0.024*** (-4.695)	0.005 (1.279)
Marriage	0.008*** (2.682)	0.002 (0.259)	-0.022*** (-4.386)
CPC member	0.005** (2.312)	-0.006 (-1.303)	-0.013*** (-3.858)
Health	0.002** (2.241)	-0.018*** (-8.660)	-0.019*** (-13.131)
HH size	-0.002*** (-3.013)	-0.023*** (-12.872)	0.003** (2.393)
Lndebt	-0.000* (-1.939)	0.062*** (26.036)	0.018*** (29.391)
Child dependency ratio	0.013** (2.113)	0.063*** (4.787)	0.019** (2.006)
Elder dependency ratio	0.014** (1.977)	0.056*** (3.426)	0.005 (0.419)
Rural resident	-0.017*** (-6.201)	-0.014*** (-2.897)	0.021*** (6.343)
Region	-0.021*** (-3.000)	0.020 (1.198)	0.070*** (4.307)
r2_p	0.122	0.489	0.293

Note: Sample N = 27,073. All models include a constant term and province and year fixed effects.

***Represent 1% significance level. **Represent 5% significance level. *Represent 10% significance level.

Table 5 reports the mediation results for commercial insurance participation. The results show that digital financial literacy has a significantly positive impact on commercial insurance participation at the 1% level. When commercial insurance participation is added to the main regression, both coefficients

are significantly negative. Compared to the baseline regression results, the marginal effect reduction of digital financial literacy on objective over-indebtedness decreases from 17.3% to 16.3%, and for subjective over-indebtedness from 22.6% to 20.9%. This indicates a partial mediation effect: digital financial literacy increases consumer commercial insurance participation, thereby reducing subjective and objective over-indebtedness. Hypothesis H3 is supported.

Table 5. Mediation effect of commercial insurance participation

Variables	Commercial Insurance Marginal Effects	OOI Marginal Effects	SOI Marginal Effects
DFL	0.537*** (27.932)	-0.163*** (-9.810)	-0.209*** (-10.871)
Commercial Insurance Participation		-0.024*** (-5.093)	-0.023*** (-5.695)
Age	-0.001* (-1.698)	-0.000 (-0.235)	0.001*** (3.191)
Gender	-0.022*** (-3.718)	-0.024*** (-4.734)	0.005 (1.250)
Marriage	0.047*** (5.308)	0.003 (0.409)	-0.021*** (-4.253)
CPC member	0.006 (0.971)	-0.006 (-1.341)	-0.013*** (-3.872)
Health	0.021*** (8.260)	-0.018*** (-8.482)	-0.019*** (-12.890)
HH size	0.006*** (2.703)	-0.022*** (-12.747)	0.003** (2.552)
Lndebt	0.003*** (6.170)	0.062*** (26.057)	0.018*** (29.187)
Child dependency ratio	-0.037** (-2.217)	0.062*** (4.667)	0.018* (1.887)
Elder dependency ratio	-0.066*** (-3.323)	0.054*** (3.295)	0.003 (0.271)
Rural resident	-0.052*** (-9.021)	-0.015*** (-3.090)	0.020*** (6.082)
Region	0.019 (1.087)	0.019 (1.152)	0.069*** (4.264)
r2_p	0.074	0.490	0.295

Note: Sample N = 27,073. All models include a constant term and province and year fixed effects. ***Represent 1% significance level. **Represent 5% significance level. *Represent 10% significance level.

D. Heterogeneity Analysis

Given China's entrenched urban-rural dual structure—characterized by significant disparities in economic development and resource accessibility—it is crucial to examine whether the impact of digital financial literacy varies across these contexts. To isolate these heterogeneous effects and inform targeted policymaking, we stratify the total sample into urban (N=18,298) and rural (N=8,834) cohorts.

Table 6 presents the estimated marginal effects from Probit regressions for urban and rural households separately. Regarding OOI, the marginal effect coefficients for digital financial literacy are -0.231 for urban households and -0.183 for rural households. Both are significant at the 1% level, yet the inhibitory effect is notably more pronounced in the urban sample. A similar pattern emerges for

SOI: while literacy significantly reduces debt anxiety in both groups (Urban: -0.292; Rural: -0.190; $p < 0.01$), the magnitude of this impact is again stronger among urban residents.

Table 6. Analysis of urban-rural heterogeneity

Variables	OOI		SOI	
	Urban Marginal	Rural Marginal	Urban Marginal	Rural Marginal
DFL	-0.231*** (-4.491)	-0.183*** (-10.255)	-0.292*** (-4.733)	-0.190*** (-10.627)
Age	0.000 (0.940)	-0.000 (-0.598)	-0.001 (-1.180)	0.001*** (3.763)
Gender	-0.017 (-1.584)	-0.026*** (-4.513)	-0.016* (-1.785)	0.009** (2.359)
Marriage	0.002 (0.154)	0.005 (0.519)	-0.019* (-1.793)	-0.023*** (-4.371)
CPC member	-0.014* (-1.729)	0.001 (0.135)	-0.008 (-1.018)	-0.011*** (-3.051)
Health	-0.022*** (-6.669)	-0.016*** (-5.860)	-0.018*** (-6.264)	-0.019*** (-11.586)
HH size	-0.022*** (-8.103)	-0.024*** (-10.222)	-0.000 (-0.134)	0.003** (2.359)
Lndebt	0.068*** (16.260)	0.060*** (21.615)	0.027*** (19.416)	0.014*** (21.725)
Child dependency ratio	0.081*** (3.407)	0.058*** (3.609)	0.019 (0.948)	0.019* (1.779)
Elder dependency ratio	0.049* (1.812)	0.073*** (3.404)	-0.007 (-0.293)	0.003 (0.240)
Region	-0.020 (-0.369)	0.021 (1.164)	0.009 (0.166)	0.059*** (3.877)
N	8834	18298	8834	18298
r2_p	0.458	0.506	0.307	0.285

Note: All models include a constant term and province and year fixed effects. ***Represent 1% significance level. **Represent 5% significance level. *Represent 10% significance level.

VI. Conclusions and Implications

Leveraging data from the China Household Finance Survey (CHFS) spanning 2017 to 2019, this study develops a comprehensive framework to evaluate digital financial literacy across four dimensions: risk awareness, basic knowledge, digital skills, and experience. We empirically test how these factors influence over-indebtedness and explore the mechanisms at play. Our analysis reveals a robust negative correlation: higher digital financial literacy significantly mitigates excessive credit behavior, curbing both its subjective and objective manifestations. This lends empirical support to the "debt literacy" hypothesis (Lusardi & Tufano, 2015).

The study identifies financial planning and commercial insurance as critical transmission channels. Consumers with higher literacy are better positioned to devise sound financial plans (Ameriks et al., 2003) and utilize insurance. These behaviors optimize asset allocation and create a "financial buffer," thereby preventing the passive accumulation of debt triggered by unexpected shocks. Furthermore, heterogeneity analysis highlights an "inclusive" effect: the marginal benefits of improved literacy are

most pronounced in rural areas, suggesting that digital literacy can effectively compensate for the limitations of traditional financial infrastructure.

Based on our findings, we propose two key policy interventions. First, education must be institutionalized. We recommend embedding digital financial literacy into broader inclusive finance strategies, with targeted outreach programs designed specifically for vulnerable populations—such as rural residents and low-income groups—to effectively bridge the "digital divide." Second, we advocate for the democratization of asset allocation. Financial institutions should be incentivized to innovate low-threshold micro-wealth and insurance products, leveraging digital tools to make professional financial planning affordable for the masses.

Several constraints in this study warrant mention. The use of data from 2017–2019 limits the analysis to a specific window, making it difficult to observe long-term trends. Additionally, the current measurement of digital financial literacy lacks newer elements, such as the understanding of algorithms, and does not fully account for psychological factors like self-control (Gathergood, 2012). Future research could address these gaps by adopting panel data and incorporating behavioral finance frameworks.

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Appendix

Table A1. Operational definition of DFL

Digital Financial Literacy	Dimension	CHFS Questions	Measurement Criteria	Weight
Risk Awareness	Risk Attitude	If you had funds for investment, which investment project would you be most willing to choose?	From 1= risk preference to 5= risk aversion	0.060
	Risk Awareness	Which do you think has a higher risk: stocks or funds?	1=Correct;0=otherwise	0.135
Basic Financial Knowledge	Simple Interest Calculation	Assuming the bank's annual interest rate is 4%, if you deposit 100 yuan for a 1-year fixed term, what will be the principal and interest after 1 year?	1=Correct;0=otherwise	0.095
	Understanding Inflation	Assuming the bank's annual interest rate is 5%, and the inflation rate is 8% per year, what will happen to the purchasing power of 100 yuan deposited in the bank after one year?	1=Correct;0=otherwise	0.076
	Knowledge of Financial Products	How would you rate your overall understanding of stocks, bonds, and funds?	1=Scores 1-3,0=otherwise	0.118
Digital Financial Skills	Computer Usage	Currently, which of the following types of durable goods does your family own?	1=Owning a computer (Desktop/Laptop/Tablet, etc.),0=otherwise	0.027
	Online Smartphone Usage	Do you use a smartphone/the internet?	1=yes; 0=otherwise	0.008
	Online Shopping Experience	Have you made any online purchases in the past year?	1=yes; 0=otherwise	0.021
Digital Financial Experience	Digital Borrowing Experience	Have you ever used an internet platform to borrow money?	1=yes; 0=otherwise	0.340
	Digital Payment Experience	Do you use mobile payments in your daily life?	1=yes; 0=otherwise	0.010
	Digital Wealth Management Experience	Have you ever purchased internet wealth management products?	1=yes; 0=otherwise	0.110