Italian Economic Journal
https://doi.org/10.1007/s40797-025-00324-7

RESEARCH PAPER

Financial Knowledge and Financial Fragility: Longitudinal Evidence from Italy

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Received: 21 June 2024 / Accepted: 24 February 2025

Abstract
This paper analyses the role of financial knowledge on individuals' financial fragility during the COVID-19 pandemic. Using novel longitudinal data on Italian adults for the period 2020–2023 and addressing potential endogeneity issues, we find that more financially knowledgeable individuals are less likely to face difficulties in coping with unexpected expenses. Furthermore, we show that higher levels of pre-pandemic financial resilience are associated with lower financial fragility during the COVID-19 crisis. These results are robust to estimation approaches, sample composition, and measures of financial knowledge. The effect of financial knowledge on financial fragility is found to be heterogeneous across different subgroups of the population and is more beneficial for women and individuals more severely hit by the pandemic, with lower incomes and lower pre-pandemic resilience. Finally, we uncover the existence of true state dependence in the probability of being financially fragile and provide evidence that financial knowledge might also play a significant role in reducing the trapping effect of financial fragility.

Keywords Financial fragility · Financial knowledge · Financial literacy · State dependence · COVID-19 pandemic · Longitudinal data

JEL Classification D14 · G41 · G50 · G53 · C33

1 Introduction

The outbreak of the COVID-19 pandemic had a dramatic impact on individuals' economic and financial well-being, highlighting the harmful consequences of low financial resilience and stressing the need for an in-depth analysis of the link between financial

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Published online: 09 April 2025

vulnerability and the capacity to withstand unexpected shocks. Despite public support measures and relief programs provided a buffer to alleviate the adverse effects of the pandemic, a growing number of households faced difficulties in repaying their debts, experienced arrears in paying bills or rent, and had problems in making ends meet or coping with unexpected expenses.

An extensive literature has shown that financial knowledge plays a crucial role in guiding individuals' economic and financial decisions, represents a valuable tool in coping with financial problems, and has been particularly important during the pandemic (Klapper and Lusardi 2020; Clark et al. 2021; Hasler et al. 2023). Individuals with higher levels of financial literacy are more able to develop budgeting strategies and avoid over-indebtedness (Lusardi and Mitchell 2014) and show a greater propensity for financial planning and a higher probability of responding to future and unexpected financial needs (Bottazzi and Oggero 2023).

Only a few studies have so far investigated the impact of the COVID-19 outbreak on financial fragility and analysed the main factors shaping their resilience to adverse economic events (Clark et al. 2021; Chhatwani and Mishra 2021; Clark and Mitchell 2022; Cziriak 2022). Financial fragility is a multifaceted concept that goes beyond the assessment of the available assets to cope with financial difficulties. It accounts for the ability to access cash or credit in an emergency and the general state of household balance sheets (Lusardi et al. 2011; Clark et al. 2021). Financial fragility also encompasses factors, like the capacity to rely on family and friend networks or other informal credit sources, which are more challenging to measure as they are often based on perceptions and self-assessments and relate to cultural and social norms (Hasler et al. 2018; Demertis et al. 2020). The analysis of the factors that may protect individuals' financial well-being has become increasingly relevant since the onset of the COVID-19 crisis, as many people have suffered acute income shocks and their financial stability has been strongly threatened by the loss of their main source of income (Sconti 2024; Vaahtoniemi et al. 2023).

In this paper, we use panel data from a nationally representative survey commissioned by the Italian Committee for the Planning and Coordination of Financial Education Activities (EduFin Committee) and investigate the main determinants of financial fragility in Italy during the pandemic. Our study is the first to exploit longitudinal data to assess the impact of financial knowledge on individuals' capacity to cope with unexpected expenses during the COVID-19 crisis. We contribute to the existing literature in at least two ways. First, the availability of panel data enables us to properly control for different potential sources of endogeneity arising from unobserved heterogeneity and correlation between financial knowledge and time-varying unobservables. Second, by exploiting longitudinal data, we are able to account for the dynamics of financial fragility over time and provide novel evidence on the existence of true state dependence in the probability of being financially fragile. These two significant contributions allow us to complement the empirical findings obtained in recent cross-sectional studies on the link between financial literacy and financial resilience (e.g., Bottazzi and Oggero 2023).

The Italian case is particularly interesting to the aims of our analysis because the health emergency due to the pandemic and the ensuing disruptions in economic activities hit Italy earlier and more severely than other European countries (Christelis et al.

2021). Moreover, Italian adults are characterised by relatively low levels of financial knowledge (Lusardi and Oggero 2017; D'Alessio et al. 2020), which may heighten their vulnerability to unexpected shocks.

Our main results show that more financially knowledgeable individuals are less susceptible to financial fragility and are better protected against income shocks associated with the COVID-19 crisis. Moreover, the impact of financial knowledge on financial fragility is heterogeneous across subgroups and is more beneficial for women and individuals more severely hit by the pandemic, with lower incomes and lower pre-pandemic financial resilience. Moving to a dynamic framework, we find that financial fragility is characterised by genuine state dependence and provide evidence that financial knowledge might also reduce the trapping effect of financial fragility.

The remainder of the paper is organised as follows. Section 2 overviews the relevant literature and develops the research hypotheses. Section 3 describes the data and defines the variables, while Sect. 4 presents the econometric methods. Section 5 discusses the main empirical results, and Sect. 6 reports robustness checks and additional analyses. The dynamic analysis of financial fragility is presented in Sect. 7. Section 8 concludes the paper.

2 Literature Review

2.1 Financial Knowledge and Financial Fragility

Previous literature has provided strong evidence that higher levels of financial knowledge are associated with sound financial behaviours, preventing excessive debt accumulation and enabling better financial decision-making. Financially knowledgeable individuals have higher savings rates and are more likely to seek professional financial advice, plan for retirement and participate in financial markets (Jappelli and Padula 2013; Lusardi and Mitchell 2011; van Rooij et al. 2011). On the contrary, inadequate financial competencies are associated with higher borrowing costs, repayment difficulties, and over-indebtedness (Gathergood 2012; Lusardi and Tufano 2015; Lusardi et al. 2018).

Theoretical and empirical studies have also investigated the role of financial literacy on individuals' and households' financial fragility (Hasler and Lusardi 2019; Klapper and Lusardi 2020). Lusardi et al. (2011) find that financial fragility is more severe among low-income households, families with children, those with low educational attainment and no financial education, and those who have suffered significant wealth losses or are unemployed. Klapper et al. (2013) show that households with higher financial literacy are significantly less likely to experience a negative income shock during the financial crisis, suggesting that financial literacy may better equip individuals to deal with macroeconomic shocks. Hasler et al. (2018) point out that financial fragility is highly pervasive even in times of higher economic stability and show that a lack of financial competencies reduces individuals' ability to cope with unexpected expenses. Lusardi et al. (2021) highlight that financial literacy tends to be lower among groups often hit the hardest by economic crises: females, lower-income

individuals, the unemployed or disabled, the young, and the less educated. Lower levels of financial literacy may thus exacerbate these impacts, suggesting that financially illiterate individuals are also less prepared to handle unexpected shocks.

The COVID-19 crisis provides a unique opportunity to test individuals' ability to withstand acute shocks that adversely affect their financial well-being and to analyse the factors associated with higher exposure to financial fragility. Clark et al. (2021) show that, during the pandemic period, people who were more financially literate were better protected against such shocks. This is probably due to the fact that more financially literate individuals made better saving and spending decisions in the past, so they could withstand economic shocks more easily and make better decisions in times of crisis. Demertis et al. (2020) demonstrate that one in three EU households was already financially fragile in the pre-pandemic period and suggest that policies aimed at increasing structurally the level of financial preparedness and financial literacy may contribute to improving resilience in case of unexpected adverse shocks. Accordingly, Clark and Mitchell (2022) explore the factors associated with financial resilience and fragility during the pandemic and demonstrate that greater pre-pandemic resilience is associated with lower levels of financial fragility during the COVID-19 crisis. At the same time, Hasler et al. (2023) highlight the importance of financial literacy as a predictor of financial outcomes, particularly in times of crisis, and point out that individuals with higher financial knowledge are more likely to be financially resilient, to feel unconstrained by debt, and to plan for retirement. Bottazzi and Oggero (2023) further demonstrate that financial literacy can be considered an enabling factor for financial resilience, reducing the probability of financial fragility and over-indebtedness of Italian adults amid the pandemic. In this regard, recent studies have provided robust evidence across countries suggesting that higher levels of financial literacy significantly increase financial well-being during the COVID-19 crisis by improving individuals' ability to save, plan for retirement, and manage their debt (Lusardi and Streeter 2023; Estrada-Mejia et al. 2023; Beckmann and Kiesl-Reiter 2023; Vaahtoniemi et al. 2023; Bucher-Koenen et al. 2024).

Extant literature has also pointed out that the incidence of financial fragility significantly varies across economic and demographic groups: females, young people, less educated individuals, unemployed, lower-income households, and households with children are found to be more financially fragile (Wiersma et al. 2020; Clark et al. 2021). Nevertheless, socio-economic and psychological factors may also moderate the linkage between financial competencies and financial fragility. To account for potential heterogeneity in the effect of financial literacy, previous studies have investigated the psychological, economic, and socio-demographic factors that may interact with financial abilities and exert a differential impact on financial fragility. Hasler et al. (2018) emphasise that financial literacy reduces the likelihood of being financially fragile among women more significantly than among men, and that it is particularly beneficial for individuals with low income and limited educational attainment. Kass-Hanna et al. (2022) also find that financial literacy increases women's ability to come up with emergency funds to cover unplanned expenses by more than that of men. Chhatwani and Mishra (2021) demonstrate that financial confidence and wealth enhance the benefits of financial literacy on financial fragility. Angrisani et al. (2023) explore the heterogeneous effects of financial literacy on financial outcomes

across distinct demographic groups and point out that higher financial competencies tend to benefit women more than men and that low-income individuals with higher literacy can better meet unexpected shocks and manage debt. Cziriak (2022) shows that financial knowledge mitigates the adverse effects of the pandemic on the ability to handle unexpected expenses and provides protection to the financial well-being of households, especially those that experienced more severe income losses since the onset of the COVID-19 crisis. Similarly, Kleimeier et al. (2023) find that negative personal experiences during the pandemic are associated with higher objective and subjective financial fragility. They also provide evidence that individuals' financial competencies and non-cognitive abilities (i.e., internal locus of control, psychological resilience) play a significant mitigating role and help to counteract financial distress during the COVID-19 pandemic. These results align with the findings of Clark and Mitchell (2022), who point out that individuals with higher financial resilience in the pre-pandemic period are significantly less likely to be financially fragile during the COVID-19 crisis.

In light of the above, we thus formulate the following research hypotheses:

H1. *Financial knowledge reduces individuals' financial fragility during the COVID-19 crisis, strengthening their resilience to unexpected economic shocks.*
H2. *The effect of financial knowledge varies with individual characteristics and is particularly beneficial in reducing the financial fragility of more vulnerable population groups.*

2.2 The Dynamics of Financial Fragility

Previous studies have also provided evidence of the persistence of financial difficulties over time. Böheim and Taylor (2000) show that prior experience of housing finance problems has a significant and positive association with the current financial distress. Analogously, May and Tudela (2005) analyse whether changes in households' conditions and previous payment difficulties affect their current ability to service mortgage debts. They demonstrate that economic payment problems are persistent over time and have a genuine behavioural effect on households. Giarda (2013) and Brown et al. (2014) show that past financial hardships play a key role in explaining the probability of experiencing financial distress and demonstrate that demographic and regional differences affect the likelihood of suffering financial problems. In particular, income level, regional employment rate, and individuals' saving ability contribute to mitigating current financial issues. Additionally, Athreya et al. (2019) demonstrate that a significant number of consumers in the US encounter financial distress during their lives; however, most of these distress events are concentrated on a small proportion of individuals who experience significant and persistent debt repayment problems. French (2023) finds that the persistence of financial hardship over time can be explained by a mutually-enforcing negative cycle through worse health status, while neither income nor wealth shocks affect financial distress. A significant degree of true state dependence in over-indebtedness and income poverty is found by Mussida and Sciulli (2024), who show that being in arrears is characterised by a significant but declining trap effect

and exerts substantial feedback effects on future poverty. Similarly, Loschiavo et al. (2024) analyse persistence in different financial fragilities of Italian households and provide evidence of a strong true state dependence in financial and liquidity poverty.

Based on the findings of previous studies, we posit our third research hypothesis as follows:

H3. *Individuals' financial fragility persists over time due to genuine state dependence and unobserved heterogeneity.*

3 Data and Variables

3.1 Data

We use data from a novel longitudinal survey jointly carried out by the EduFin Committee and the market research company BVA Doxa to gauge Italian adults' financial knowledge and competencies. The survey is representative of individuals older than 18 years and responsible for the household's budget and financial decision-making, and it was first carried out in May–June 2020 on a sample of 5009 subjects extracted from a proprietary BVA Doxa panel. Three more waves of the survey were conducted in 2021, 2022, and 2023 on samples of individuals already interviewed in the first wave and new respondents. The survey thus provides unique longitudinal information on adults' financial knowledge, well-being and resilience in Italy during the COVID-19 crisis. To the aims of our analysis, we consider an unbalanced panel composed of 4,405 individuals interviewed in the first wave and then reinterviewed in at least one of the other three waves for a total of 14,827 individual-wave observations.[1]

3.2 Variables

3.2.1 Financial Fragility

Following Lusardi et al. (2011) and Clark et al. (2021), we measure financial fragility in terms of individuals' ability to cope with a hypothetical medium-sized financial shock. Specifically, we consider the following question: "*If an unexpected expense arose, how confident are you that you could come up with €2,000 within a month?*". Respondents could reply, "*I am certain I could come up with €2,000*"; "*I could probably come up with €2,000*"; "*I could probably not come up with €2,000*"; "*I am certain I could not come up with €2,000*"; or "*Don't know*". Based on the replies to this question, we set "Don't know" responses to missing and define a binary indicator (*Financially fragile,*

[1] It is worth remarking that an unbalanced panel of individuals interviewed in at least two waves allows us to define an estimation sample that is more representative of the population of interest, includes more observations, and is thus less prone to survivorship bias (Raymond et al. 2010, Albarran et al. 2019). Moreover, to ensure that the distribution of the observed sample aligns with that of the reference population, all the descriptive statistics presented in our analysis are based on data weighted by age, municipality size, region, level of education, presence of children aged 0–14, income, and occupation status (see EduFin Committee and BVA Doxa 2020).

Table 1 Financial fragility and financial knowledge during the pandemic

Panel A: Financial fragility	
Able to come up with € 2000 within a month?	
Certainly	41.09
Probably	32.02
Probably not	14.23
Certainly not	12.66
Financially fragile (FF)	26.89
Panel B: Financial knowledge	
Proportion of correct answers	
Simple interest	74.21
Inflation	70.67
Risk diversification	65.44
Mortgages	60.90
Compound interest	57.22
Risk-return relationship	75.19
Average values	
Number of correct answers	4.04
Financial knowledge score (FK)	6.93
All correct answers	27.26
All correct answers Big Three	46.63

Percentage proportions and average values are computed over the period 2020–2023 using sample weights

FF) that classifies individuals reporting that they could probably not or certainly not come up with 2,000 Euro as financially fragile. From Table 1, we notice that, over the whole survey period, 26.89 percent of the respondents are financially fragile. Panel (a) of Fig. 1 shows the proportion of financially fragile individuals across Italian regions. It can be noted that financial fragility is more widespread in southern regions and islands.

3.2.2 Financial Knowledge

We focus on six questions designed to assess an individual's knowledge of basic financial concepts, widely considered essential for financial decision-making, available in all four survey waves. These questions relate to simple interest rates, inflation, risk diversification, mortgages, compound interest rates, and risk-return relationship. All the questions are in a multiple-choice format, with only one correct answer, and offer the "Don't Know" option. These financial knowledge questions are largely comparable to the Big Three and the Big Five questions proposed by Lusardi and Mitchell (Lusardi and Mitchell 2008; Lusardi 2011) and to those proposed in the harmonised

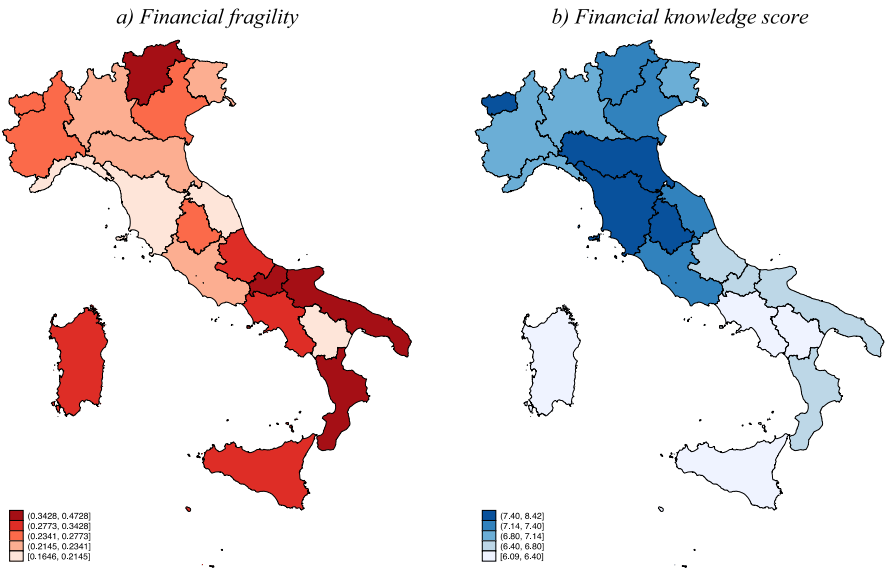

Fig. 1 Financial fragility and financial knowledge at the regional level. Notes: Average values are computed over the period 2020–2023 using sample weights. Source: Authors' elaboration

questionnaire defined by the OECD International Network on Financial Education (OECD 2023).[2]

For each financial knowledge question, we define a dummy variable that indicates whether the respondent provided the correct answer. Then, following van Rooij et al. (2011), we perform an exploratory factor analysis on the tetrachoric correlation matrix estimated for these six binary variables on the pooled sample using the iterated principal factor method. This analysis shows that all six knowledge items load into a single latent factor, which describes a respondent's level of financial knowledge. We use the predicted scores of this factor to construct a continuous index of financial knowledge (*Financial knowledge score, FK*), which we then normalise to vary between 0 and 10 to ease interpretation. Details on the factor analysis are reported in Supplementary Appendix B. As in Fornero and Monticone (2011), we also identify individuals with high financial knowledge through a dummy variable equal to one when the respondent provides correct answers to all six financial knowledge questions (*All correct*).

From Table 1, we notice that, over the four waves of the survey, the average number of correct answers to the six knowledge questions is 4, and the average financial knowledge score is equal to 6.93. Moreover, the percentage of individuals who answered all six questions correctly equals 27.26, while 46.63% of the respondents answered all the Big Three questions (i.e., those related to simple interest rates, inflation, and risk diversification) correctly. Similar results are obtained in other surveys (Klapper and Lusardi 2020; Bottazzi and Oggero 2023). As an example, the OECD (2023) highlights that financial knowledge in Italy is relatively low compared to other European

[2] The exact wording of the six financial knowledge questions is reported in Supplementary Appendix A.

Table 2 Ability to cope with unexpected expenses by financial knowledge

Number of correct answers	Obs	Able to come up with € 2000 within a month?				Financially Fragile (%)
		Certainly (%)	Probably (%)	Probably not (%)	Certainly not (%)	
0	786	17.89	25.53	21.86	34.72	56.58
1	1159	21.91	32.89	24.05	21.16	45.21
2	1316	20.98	36.64	20.65	21.74	42.38
3	1740	28.61	33.63	18.35	19.40	37.75
4	2333	37.66	34.93	15.35	12.06	27.41
5	3450	50.22	31.73	10.52	7.52	18.04
6	4042	57.20	29.40	8.59	4.81	13.40
Total	14,827	41.09	32.02	14.23	12.66	26.89

Percentage proportions are computed over the period 2020–2023 using sample weights

countries, with only 39% of Italians reaching the minimum target score of five correct answers out of seven financial knowledge questions. In line with previous empirical evidence (e.g., Sconti 2024), Panel b) of Fig. 1 displays higher average financial knowledge scores in Northern and Central Italy, whereas southern regions and islands exhibit significantly lower financial competencies.

Analysing individuals' ability to cope with an unexpected expense by the number of correct answers (Table 2), we notice that among respondents who have the highest level of financial knowledge, 57.20% declare that they would certainly be able to come up with € 2,000 within a month, while only 4.81% would certainly not be able to cope with this unexpected expense. These percentages stand at 17.89 and 34.72% among those with the lowest level of financial knowledge, respectively. Accordingly, the incidence of financial fragility decreases with the number of correct answers: among respondents who correctly answer all the financial knowledge questions, only 13.40% are financially fragile, while the percentage rises to 56.58% for those who do not correctly answer any of the financial knowledge questions. These descriptive findings are consistent with the robust evidence across countries highlighting the lower incidence of financial difficulties among more financially knowledgeable individuals (Estrada-Mejia et al. 2023; Vaahtoniemi et al. 2023; Bucher-Koenen et al. 2024).

3.2.3 Individual Characteristics

We account for a large set of control variables to capture the impact of other relevant factors on financial fragility. First, we control for individual socio-demographic characteristics, namely age (included as a second-order polynomial), gender, education, and occupational status. We then account for the respondent's household composition using binary indicators for the presence of children (aged between 0 and 14 years) and of elderly persons (aged 70 years and over) and control for the financial situation of the household through dummies for homeownership status, disposable income, and positive saving in the pre-pandemic period. Following Clark et al. (2021) and Bottazzi

and Oggero (2023), we include a binary variable identifying individuals who have experienced a decrease in their household disposable income since the onset of the COVID-19 crisis, to investigate how pandemic-induced shocks on incomes affected the ability to cope with unexpected expenses. We also include a composite index of financial resilience in the period before the outbreak of the COVID-19 pandemic (*Pre-pandemic financial resilience*), exploiting retrospective information provided in the first wave of the survey. Specifically, this indicator is based on five binary variables indicating that, before the outbreak of the COVID-19 pandemic, the respondent had emergency savings that could cover expenses for at least 3 months in case of loss of earnings, was able to save money, was not in arrears on debt repayments, bills, and taxes, tracked expenditures and had saving plans. In line with Lusardi et al. (2021) and Clark and Michell (2022), this variable aims to capture the ability to respond to financial shocks that could negatively affect their financial well-being. Finally, we include region fixed effects and survey round dummies to account for differences in the likelihood of financial fragility over time and across regions. Table A1 in the Appendix provides complete definitions and summary statistics for all the explanatory variables considered in the analysis. Table C1 in Supplementary Appendix C reports instead the incidence of financial fragility by economic and demographic characteristics. From this Table, we notice that the most financially fragile are young people, women and unemployed, those with a lower level of education and with at least one child, one elderly or disabled person in their household. Furthermore, individuals with lower income, having suffered a pandemic-induced income shock, and having a lower-than-average pre-pandemic resilience display a higher likelihood of being financially fragile.

4 Econometric Methods

In this study, we assess the impact of financial knowledge on individuals' financial fragility during the COVID-19 crisis, controlling for a large set of socio-demographic characteristics. Formally, based on the binary financial fragility indicator FF_{it}, we define the following static panel probit model:

$$FF_{it} = 1(\boldsymbol{x}_{it}'\boldsymbol{\beta} + \gamma FK_{it} + c_{i1} + u_{it1} > 0) \tag{1}$$

with $i = 1, \ldots, N$ and $t = 1, \ldots, T_i$ and where $1(\cdot)$ is an indicator function, $\boldsymbol{x}_{it}$ is a vector of strictly exogenous regressors (that can include time dummies), FK_{it} is the financial knowledge score, c_{i1} is time-constant unobserved heterogeneity, and u_{it1} is a standard normal idiosyncratic error, capturing unobserved time-varying factors, independent of the regressors conditional on c_{i1}.

To address the potential endogeneity arising from the correlation between financial knowledge and time-varying unobservables (i.e., *idiosyncratic endogeneity*), we extend model (1) to allow u_{it1} to be correlated with FK_{it} and specify a linear model for FK_{it} as:

$$FK_{it} = \boldsymbol{z}_{it}'\boldsymbol{\alpha} + c_{i2} + u_{it2} \tag{2}$$

with $z_{it} = (x'_{it}, z_{it2}')'$, where z_{it2} includes strictly exogenous regressors excluded from (1), c_{i2} is time-constant heterogeneity and u_{it2} is a normal idiosyncratic error term independent of z_{it} and c_{i2}.

Following Papke and Wooldridge (2008) and Lin and Wooldridge (2019), we also address the potential endogeneity arising from omitted variable bias due to nonzero correlation between unobserved heterogeneity and explanatory variables (i.e., *heterogeneity endogeneity*). To this aim, we use the Mundlak-Chamberlain correlated random effects (CRE) approach (Mundlak 1978; Chamberlain 1980) and model time-constant unobserved effects as linear functions of all the exogenous variables. As in Wooldridge (2019) and Bates et al. (2024), we account for panel unbalancedness by allowing unobserved heterogeneity to be a function of the number of times an individual appears in the dataset. Formally, we adopt a CRE approach for unbalanced panels (CREU) and model unobserved heterogeneity as:

$$c_{i1} = \psi_1 + \boldsymbol{T}'_i\theta_1 + \overline{z}'_i\boldsymbol{\xi}_1 + a_{i1} \tag{3}$$

$$c_{i2} = \psi_2 + \boldsymbol{T}'_i\theta_2 + \overline{z}'_i\boldsymbol{\xi}_2 + a_{i2} \tag{4}$$

where a_{i1} and a_{i2} are unobserved effects, independent of $z_i = (z_{i1}, \ldots, z_{iT})$ and normally distributed, $\boldsymbol{T}_i$ are binary indicators for the number of time observations, and $\overline{z}_i = T_i^{-1}\sum_{t=1}^{T_i} z_{it}$ is the vector of individual time means of time-varying exogenous regressors, including those omitted from (1) to allow instruments to be systematically correlated with time-constant omitted factors.[3] Upon substitution, we obtain the following two-equation system, which defines a recursive CREU probit model with one continuous endogenous explanatory variable:

$$\begin{aligned} FF_{it} &= 1\big(x'_{it}\boldsymbol{\beta} + \gamma FK_{it} + \psi_1 + \boldsymbol{T}'_i\boldsymbol{\theta}_1 + \overline{z}'_i\boldsymbol{\xi}_1 + a_{i1} + u_{it1} > 0\big) \\ &\equiv 1(x'_{it}\boldsymbol{\beta}_a + \gamma_a FK_{it} + \psi_{a1} + \boldsymbol{T}'_i\theta_{a1} + \overline{z}'_i\boldsymbol{\xi}_{a1} + v_{it1} > 0) \end{aligned} \tag{5}$$

$$FK_{it} = z'_{it}\boldsymbol{\alpha} + \psi_2 + \boldsymbol{T}'_i\boldsymbol{\theta}_2 + \overline{z}'_i\boldsymbol{\xi}_2 + a_{i2} + u_{it2} \tag{6}$$

where the composite errors $v_{it1} = (a_{i1} + u_{it1})/(1 + \sigma^2_{a_1})^{1/2}$ and $v_{it2} = a_{i2} + u_{it2}$, conditional on z_i, follow a bivariate normal distribution, with zero means, variances equal to 1 and $\sigma^2_{v_2}$, respectively, and covariance $\rho\sigma_{v_2}$. In Eq. (5), subscript a denotes the scaling of the parameters by $(1 + \sigma^2_{a_1})^{1/2}$.[4] Note that if $\rho = 0$, FK_{it} is exogenous and

[3] Following Albarran et al. (2019), we consider, as a simplifying assumption, that the variance of the individual time-constant effects is constant across subsets of individuals with the same number of time observations. In the present application, given the limited number of possible sequences of observations for each individual, this assumption should not be problematic. As discussed in Wooldridge (2019), this assumption can be relaxed by allowing the variance of the individual effects to be a function of $\boldsymbol{T}_i$. It is also worth remarking that Eqs. (3) and (4) can be further extended to include interactions between indicators for the number of time-observations, covariate time averages, and covariates themselves (i.e., $\boldsymbol{T}_i \otimes \overline{z}_i$ and $\boldsymbol{T}_i \otimes z_i$) to more fully account for the unbalancedness of the panel (see Bates et al. (2024)).

[4] As pointed out in Bates et al. (2024), these scaled coefficients are identified for all $T_i \geq 2$, provided there is some time variation in all exogenous regressors and no perfect collinearity.

consistent parameter estimates can be obtained by estimating each equation separately; conversely, when $\rho \neq 0$, FK_{it} is endogenous and cross-equation error correlation must be taken into account for consistency.

Equations (5) and (6) can be estimated jointly using pooled or full maximum likelihood estimation (MLE) methods. Pooled methods, despite being inefficient compared to full MLE, are robust to any distributional misspecification other than the conditional mean and allow for unrestricted dependence over time (Lin and Wooldridge 2019). In nonlinear panel data models, pooled MLE represents a convenient and computationally simple estimation approach, which only requires adjusting standard errors to account for serial correlation (Wooldridge 2010).[5]

To assess the effects of explanatory variables, we compute average marginal effects (AMEs), which measure the *ceteris paribus* effects of changes in regressors on the probability of being financially fragile, averaged across both unobservables and observables. As shown in Papke and Wooldridge (2008), the AMEs on the probability that $FF_{it} = 1$ depend on the scaled coefficients in (5) and are identified under no assumption on serial dependence. Specifically, the AME of the continuous financial knowledge score FK_{it} can be estimated as:

$$\widehat{AME}_{FK} = \widehat{\gamma}\left[\frac{1}{N}\sum_{i=1}^{N}\frac{1}{T_i}\sum_{t=1}^{T_i}\phi\left(\boldsymbol{x}_{it}'\widehat{\boldsymbol{\beta}} + \widehat{\gamma}FK_{it} + \widehat{\psi}_1 + \boldsymbol{T}_i'\widehat{\boldsymbol{\theta}}_1 + \overline{\boldsymbol{z}}_i'\widehat{\boldsymbol{\xi}}_1\right)\right] \tag{7}$$

where $\widehat{\boldsymbol{\beta}}_a$, $\widehat{\gamma}_a$, $\widehat{\psi}_{a1}$, $\widehat{\theta}_{a1}$, and $\widehat{\boldsymbol{\xi}}_{a1}$ are the estimated scaled parameters and $\phi(\cdot)$ is the standard normal probability function. The AMEs of the other continuous regressors are defined similarly; for binary regressors, the AMEs are obtained as average differences in the probability that $FK_{it} = 1$ when the binary regressor changes from 0 to 1.

5 Empirical Results

Table 3 presents the main empirical findings on the determinants of individuals' financial fragility in terms of AMEs estimated from static endogenous CREU probit models.[6]

[5] Papke and Wooldridge (2008) and Bates et al. (2024) propose a control function (CF) estimation approach, consisting of a two-step procedure: (i) estimate the reduced form for FK_{it} and obtain the residuals $\widehat{v}_{it2}$; (ii) estimate a pooled probit of FF_{it} on $\boldsymbol{x}_{it}$, FK_{it}, $\boldsymbol{T}_i$, $\overline{\boldsymbol{z}}_i$, and $\widehat{v}_{it2}$. Estimation of second-stage scaled parameters can be carried out by pooled or full MLE; clustered bootstrap methods can be applied to obtain valid standard errors. A cluster-robust Wald test for the significance of the coefficient on the reduced form residuals $\widehat{v}_{it2}$ can be used to test the exogeneity of FK_{it}. Lin and Wooldridge (2019) suggest adding the time mean of the continuous endogenous regressor ($\overline{FK}_i$) in the second-stage regression to allow unobserved heterogeneity to be correlated with all the explanatory variables. This leads to a cleaner test of the null hypothesis of idiosyncratic exogeneity.

[6] As sample stratification in the survey is based on exogenous variables, we follow Kim et al. (2021) and posit that sampling probabilities are uncorrelated with models' error terms. Therefore, all regression models control for stratification variables and are estimated without sampling weights for improved efficiency (Wooldridge 1999). As advised by Solon et al. (2015), we have also carried out estimations using sampling weights. Our main findings remain unchanged (see Table C8 in Supplementary Appendix C), indicating

Table 3 The determinants of financial fragility during the pandemic

Model	Endogenous CREU probit		Endogenous CREU probit	
Dependent variable	FF	FK	FF	FK
	(1)	(2)	(3)	(4)
Financial knowledge score (FK)	− 0.0505***		− 0.0395***	
	(0.0050)		(0.0060)	
Age	0.0018***	0.0284***	0.0009**	0.0304***
	(0.0004)	(0.0039)	(0.0004)	(0.0039)
Female	− 0.0204**	− 0.6559***	− 0.0132	− 0.6528***
	(0.0089)	(0.0813)	(0.0090)	(0.0809)
Upper secondary education	0.0109	0.7293***	0.0081	0.7046***
	(0.0125)	(0.1164)	(0.0120)	(0.1158)
Tertiary education	− 0.0003	0.9394***	0.0034	0.8775***
	(0.0139)	(0.1197)	(0.0132)	(0.1191)
Self-employed	− 0.0400***	0.0613	− 0.0330***	0.0211
	(0.0127)	(0.1359)	(0.0127)	(0.1351)
Employee	− 0.0214*	− 0.1380	− 0.0146	− 0.1629
	(0.0110)	(0.1099)	(0.0109)	(0.1098)
Retired	− 0.0241	0.2122	− 0.0247	0.1805
	(0.0164)	(0.1541)	(0.0160)	(0.1533)
Young children	0.0124	− 0.2934***	0.0115	− 0.2739***
	(0.0088)	(0.0793)	(0.0086)	(0.0789)
Elderly/Disabled persons	0.0203**	− 0.0253	0.0199**	− 0.0227
	(0.0086)	(0.0725)	(0.0085)	(0.0722)
Homeowner without mortgage	− 0.0830***	0.0941	− 0.0675***	0.0146
	(0.0088)	(0.0681)	(0.0079)	(0.0680)
Income: 1060–1549 euro	− 0.0107	0.2039**	− 0.0140	0.2060**
	(0.0128)	(0.0931)	(0.0134)	(0.0931)
Income: 1550–2454 euro	− 0.0426***	0.2775***	− 0.0509***	0.2796***
	(0.0147)	(0.1024)	(0.0154)	(0.1025)
Income: > 2455 euro	− 0.0692***	0.3396***	− 0.0794***	0.3441***
	(0.0185)	(0.1141)	(0.0194)	(0.1141)
Income shock	0.0315***	− 0.0162	0.0348***	− 0.0163
	(0.0081)	(0.0522)	(0.0084)	(0.0522)
Wave 2	− 0.0516***	0.0056	− 0.0539***	− 0.0051
	(0.0067)	(0.0986)	(0.0068)	(0.1002)
Wave 3	− 0.0521***	0.0016	− 0.0550***	− 0.0014
	(0.0071)	(0.0440)	(0.0073)	(0.0440)
Wave 4	− 0.0632***	0.2085***	− 0.0699***	0.2079***
	(0.0084)	(0.0449)	(0.0085)	(0.0449)

Table 3 (continued)

Model	Endogenous CREU probit		Endogenous CREU probit	
Dependent variable	FF	FK	FF	FK
	(1)	(2)	(3)	(4)
Pre-pandemic financial resilience			− 0.0223***	0.0889***
			(0.0019)	(0.0126)
Average math score		0.0593*		0.0494
		(0.0359)		(0.0378)
Internet use		0.1773***		0.1686***
		(0.0127)		(0.0127)
Peer uninformed decision-making		− 0.7062*		− 0.6589*
		(0.3605)		(0.3609)
Region fixed effects	Yes	Yes	Yes	Yes
Wald test of exogeneity ($\rho = 0$)	58.21 [0.0000]		27.05 [0.0000]	
Amemiya-Lee-Newey overid. test	0.117 [0.9431]		0.106 [0.9483]	
Weak-instrument F test	190.03 [0.0000]		168.02 [0.0000]	
Observations	14,827		14,827	

The Table reports average marginal effects on the probability of being financially fragile and on the level of financial knowledge, estimated from endogenous CREU probit models. Standard errors, clustered at the individual level, are reported in parentheses. The p-values of the Wald test of exogeneity, the Amemiya-Lee-Newey overidentification test, and the F test for weak instruments are reported in square brackets
***, ** and * denote significance at the 1, 5 and 10% levels, respectively

Before discussing the effects of the explanatory variables, we illustrate our identification strategy and assess its validity. We rely on previous literature to identify the excluded instruments z_{it2}. First, following Grohmann et al. (2018) and Klapper and Lusardi (2020), we consider the level of numeracy of primary school children as an exogenous instrument for adults' financial competencies. Specifically, we use the average math score in the OECD-PISA test of second and fifth-grade students at the provincial level (*Average math score*) as a proxy for children's numeracy. The choice of this instrument is based on the idea that adults' financial knowledge is higher in provinces where numeracy scores in primary schools are higher, since mathematical ability is a precondition for financial literacy, whereas numeracy of children does not directly impact financial fragility. Second, we exploit information on respondents' use of the Internet as an instrument for their financial knowledge. As pointed out by previous literature (Fornero and Monticone 2011; Bavafa et al. 2019; Lo Prete 2022; Cucinelli and Soana 2023), the use of the Internet and other information and communication technologies might facilitate respondents' acquisition of knowledge and information and thus increase their financial literacy; at the same time, we can argue that it only indirectly affects fragility through its impact on financial knowledge. We thus construct a continuous index of Internet use (*Internet use*) based on the predicted

Footnote 6 continued
that endogenous sampling is not a concern in our analysis and suggesting that the models are correctly specified.

scores of the first factor obtained from a factor analysis on the tetrachoric correlation matrix estimated on four binary variables indicating that the respondent uses the Internet to buy goods and services, access digital government services, pay bills, and work remotely. Third, we assume that an individual's level of financial knowledge is lower when uninformed financial decision-making is more widespread among their peers. As argued by Klapper et al. (2013) and Rink et al. (2021), direct and indirect exposure to financial information and the use of different information sources significantly affects individuals' financial competencies, but we can safely assume that they do not directly impact their ability to cope with unexpected expenses. To this aim, we construct a "leave-out" instrument (*Peer uninformed decision-making*) as the proportion of other individuals, in the same local demographic group (by province and age class) as the respondent, making financial decisions without consulting any information source or using informal sources, such as non-specialized media, friends, relatives and colleagues, and non-specialized online resources.

The results of the tests presented in the bottom part of Table 3 indicate that the overidentifying restrictions are valid and the three additional instruments are not weak, providing support to our identification strategy. Moreover, the results of the exogeneity tests point out that financial knowledge is endogenous, suggesting that an endogenous probit model should be preferred to consistently estimate the causal effect of financial knowledge on financial fragility.

The estimates presented in Table 3 support the initial predictions that financial knowledge plays a significant role in reducing the likelihood of experiencing financial fragility. Columns (1) and (2) report the AMEs of our baseline model and demonstrate that a one-unit increase in the financial knowledge score (FK) reduces the probability of financial fragility by 5.05 percentage points, suggesting that financial knowledge significantly contributes to improved individuals' financial resilience. It is worth remarking that by accounting for the correlation between financial knowledge and time-varying unobservables, we avoid downwardly biased estimates of its impact on financial fragility. Specifically, as reported in Table C2 in Supplementary Appendix C, the AME of FK_{it} estimated employing a standard (exogenous) CREU probit model, despite being statistically significant at the 1% level, reduces to 1.74 percentage points. This severe downward bias can be explained by the negative correlation between the financial knowledge score and the error term in the financial fragility equation, which is not modelled in the standard CREU probit.

Concerning the other covariates, our results also reveal that the age of the respondent is positively associated with financial fragility, indicating that older individuals are more susceptible to this phenomenon (Bottazzi and Oggero 2023). Analogously, the presence of elderly or disabled members in the household and having experienced a decrease in income since the onset of the COVID-19 pandemic significantly increases the probability of being financially fragile. In contrast, being employed or self-employed, being a homeowner without a mortgage, and having a higher income are associated with a lower likelihood of financial fragility. It is interesting to note that the variable *Female* exerts a negative and statistically significant (at the 5% level) effect both on the probability of being fragile and on the level of financial knowledge. Our findings thus highlight the existence of a significant gender gap in financial knowledge against women, confirming the robust empirical evidence provided by previous

research across countries (see, e.g., Lusardi and Mitchell 2011; Klapper and Lusardi 2020; Aristei and Gallo 2022). At the same time, when the endogeneity of financial knowledge is taken into account, we find that women responsible for their household financial choices have a lower probability of being financially fragile than men. Furthermore, we find that education is positively associated with financial knowledge, but it does not have a significant impact on financial fragility. This result highlights that financial knowledge exerts a separate significant effect on the ability to cope with unexpected expenses, while financial fragility is not affected by formal educational attainment. In line with previous literature (e.g., Lusardi and Mitchell 2014, 2023), the results reported in column (2) of Table 3 also indicate that financial knowledge significantly increases with individuals' age and income, while respondents living in households with children aged between 0 and 14 years display significantly lower levels of financial knowledge. Consistently with our identification strategy, individuals with a higher index of Internet use and living in provinces where numeracy in primary schools is higher are more financially knowledgeable, whereas financial knowledge reduces when uninformed financial decision-making is more widespread among the respondent's peers.

Columns (3) and (4) of Table 3 present the results of the extended model controlling for pre-pandemic financial resilience. Coherently with Clark and Mitchell (2022), we find that greater pre-pandemic resilience is associated with a lower probability of financial fragility, suggesting that individuals who had precautionary savings and adopted sound financial behaviours before the outbreak of the COVID-19 crisis are able to better cope with unexpected income needs. It is also worth noticing that, controlling for pre-pandemic financial resilience, the impact of financial knowledge on fragility remains negative and highly significant and only slightly reduces compared to the baseline model. The effects of the other independent variables remain substantially unchanged in the extended model, while, as in Clark and Mitchell (2022), differences in financial fragility between women and men are no longer significant. This latter evidence suggests that the gender gap in fragility highlighted in the baseline model is mainly driven by differences in financial conditions and attitudes before the pandemic.

6 Robustness Checks and Additional Analyses

6.1 Robustness

We present several additional analyses to assess the robustness of our main empirical findings on the role of financial knowledge on financial fragility.

First, we assess the robustness of our main empirical findings to the estimation approach. Following Papke and Wooldridge (2008), we re-estimate the recursive endogenous CRE probit using a two-step control function method. The results (column (1) of Panel A in Table 4) are in line with those obtained with pooled MLE methods (column (3) of Table 3) and confirm the significant role of financial knowledge in alleviating financial fragility. We also consider the CF approach proposed by Lin and Wooldridge (2019) and add the time average of the endogenous regressor

Table 4 Robustness: estimation approach and panel unbalancedness

Panel A: Alternative estimation approaches

Model	Endogenous CREU probit	Endogenous CREU probit	Endogenous CREU probit	Endogenous CREU linear model	Endogenous CREU linear model	Endogenous CREU linear model
Dependent variable	FF	FF	FF	FF	FF	FF
Estimation approach	CF	CF-LW	RE-FIML	StdIV-LPM	GenIV-LPM	AugIV-LPM
	(1)	(2)	(3)	(4)	(5)	(6)
Financial knowledge score (FK)	− 0.0418***	− 0.0300***	− 0.0422***	− 0.0475***	− 0.0311***	− 0.0373***
	(0.0091)	(0.0099)	(0.0063)	(0.0075)	(0.0073)	(0.0057)
Other control variables	Yes	Yes	Yes	Yes	Yes	Yes
$\overline{FK}_i$	No	Yes	No	No	No	No
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Wald test of exogeneity ($\rho = 0$)	[0.0001]	[0.0004]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Amemiya-Lee-Newey overid. test	[0.8690]	[0.8855]	[0.6918]	[0.7693]	[0.2555]	[0.3045]
C test of external instruments' exogeneity						[0.5669]
Weak-instrument F test	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Observations	14,827	14,827	14,827	14,827	14,827	14,827

Table 4 (continued)

Panel B: Panel structure and alternative approaches to handle panel unbalancedness

Model	Endogenous CREU probit	Endogenous CREU probit	Endogenous CREU probit	Endogenous CREU probit
Dependent variable	FF	FF	FF	FF
Panel structure	$T_i \geq 3$	Balanced sample	CREU1	CREU2
	(1)	(2)	(3)	(4)
Financial knowledge score (FK)	− 0.0334*** (0.0070)	− 0.0296*** (0.0080)	− 0.0381*** (0.0062)	− 0.0385*** (0.0065)
Other control variables	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Wald test of exogeneity ($\rho = 0$)	[0.0057]	[0.0283]	[0.0003]	[0.0005]
Amemiya-Lee-Newey overid. test	[0.9647]	[0.9610]	[0.9378]	[0.9081]
Weak-instrument F test	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Observations	13,227	10,308	14,827	14,827

Notes: the Table reports average marginal effects estimated from endogenous CREU probit and linear models. All the models include the same control variables included in the extended specification controlling for pre-pandemic financial resilience. Control function estimates (columns 1 and 2 of Panel A) also allow the variance of the individual effects to be a function of $\boldsymbol{T}_i$. IV-LPM estimates in column (5) of Panel A use heteroskedasticity-based constructed instruments only, while those reported in columns (6) of Panel A exploit both generated instruments and external instruments (see Lewbel 2012). Complete results are available upon request. Panel B reports marginal effects estimated on the sample of individuals observed in at least three waves of the survey (i.e., $T_i \geq 3$) (column (1)), on the balanced sample of individuals observed in all the four waves (column (2)), and on the whole unbalanced sample adding interactions between time-observations indicators, covariates and their individual time means (columns (3) and (4)). Standard errors, clustered at the individual level, are reported in parentheses; cluster-bootstrap (500 replications) standard errors are reported for two-step control function estimates. The p-values of the Wald test of exogeneity, the Amemiya-Lee-Newey overidentification test, the C test for the exogeneity of external instruments, and the F test for weak instruments are reported in square brackets

***, ** and * denote significance at the 1, 5 and 10% levels, respectively

to the second-stage regression. This renders FK_{it} strictly exogenous in the estimating equation, allowing to separate the two sources of endogeneity and leading to a cleaner test of idiosyncratic exogeneity. From the results presented in column (2) of Table 4, we first notice that the null hypothesis of exogeneity is still clearly rejected, suggesting that the idiosyncratic endogeneity of FK_{it} must be properly accounted for to consistently estimate the effect of financial knowledge. The results also indicate that, even when unobserved heterogeneity is allowed to be correlated with all the explanatory variables, the AME of FK_{it} remains negative and statistically significant at the 1% level and is only slightly lower in absolute terms than that obtained in the baseline model. Column (3) of Panel A in Table 4 presents the results from a full MLE approach: when we consider a random-effects CREU endogenous probit model, the estimated AME of financial knowledge is very similar to that estimated from the pooled model.

Furthermore, we specify a CREU linear probability model (LPM) for the likelihood of being financially fragile and adopt a standard instrumental variable approach to deal with the potential endogeneity of financial knowledge (column (4) of Panel A in Table 4). This approach represents the linear analogous to the combined CREU/CF approach for probit models with continuous endogenous regressors and is equivalent to an instrumental variable fixed-effects estimator. We find that the AME of FK_{it} estimated from this linear estimation approach is equal to -4.75 percentage points and statistically significant at the 1% level, making it only slightly larger in magnitude than that obtained from the endogenous CRE probit. Within the linear modelling approach, we also consider the heteroskedasticity-based identification approach proposed by Lewbel (2012). This method consists of constructing valid instruments by exploiting heteroskedasticity in the errors in the first-stage regression and can be useful if no external instruments are available and for testing the validity of external instruments. Columns (5) and (6) of Panel A in Table 4 report the results from this estimation approach when only constructed instruments and when both constructed and external instruments are used, respectively. Our main empirical findings are largely confirmed when identification is based solely on heteroskedasticity-based instruments: the AME of financial knowledge remains significant at the 1% level and is only slightly lower than that obtained from the endogenous CRE probit. Finally, when the constructed instruments are used along with the three external instruments discussed in Sect. 5, the beneficial role of financial knowledge in reducing financial fragility is again confirmed. This robustness check provides further support to our main identification strategy: the C test fails to reject the null hypothesis of external instruments' exogeneity, confirming the validity of the additional instrumental variables considered.

Second, we assess the robustness of our results to the structure of the panel data. We first drop 800 respondents observed in only two periods (i.e., with $T_i = 2$) and re-estimate the endogenous CREU probit model on the subsample of 3,605 individuals with at least three observations over time (i.e., with $T_i \geq 3$). The results presented in column (1) of Panel B in Table 4 confirm the evidence obtained in the whole sample: the AME of FK_{it} is equal to -3.34 percentage points and is still significant at the 1% level, providing further support to the beneficial role of financial knowledge in alleviating financial fragility. Following Wooldridge (2019), we then focus

on the balanced panel sample and estimate the endogenous probit model on the subsample of 2577 individuals observed in all four survey waves (i.e., with $T_i = 4$, $\forall i$), using standard CRE methods. The results are reported in column (2) of Panel B in Table 4 in the Appendix and are largely consistent with those obtained on the unbalanced sample using the CREU approach. Following Bates et al. (2024), we also consider additional specifications to handle the unbalancedness of the panel, obtained by extending the CREU approach to include interactions between time-observation indicators and covariate time averages (CREU1) and also between time-observation indicators and the covariates themselves (CREU2). Columns (3) and (4) of Panel B in Table 4 show that the inclusion of these additional interactions does not affect our main findings, yielding estimates of the AME of financial knowledge (-3.81 and -3.85 percentage points, respectively) that are very close to the value obtained in the CREU model.

Third, we consider alternative measures of financial knowledge and define two additional factor scores (scaled to vary between 0 and 10) based on the Big Three questions and on the six questions used in our main analysis plus an additional question related to supplementary pension plans. Columns (1) and (2) of Panel A in Table 5 report the AMEs of these two factor scores on the probability of being financially fragile estimated. The empirical results confirm that the estimated effect of financial knowledge is not affected by the score composition and remains unchanged compared to our main results. We also measure financial knowledge by simply counting the number of correct answers instead of using factor scores. The AMEs (see columns (3), (4), and (5) of Panel A in Table 5) remain negative and statistically significant at the 1% level regardless of the index considered. In particular, coherently with Bottazzi and Oggero (2023), we find that a unit increase in the number of correct answers to the Big Three questions reduces the probability of financial fragility by about 13.08 percentage points.

We also assess the effect on financial fragility of having a high level of financial knowledge. To this aim, we define a binary indicator equal to one when an individual correctly answers all the financial knowledge questions ($Allcorrect_{it}$) and define a bivariate CREU probit model, obtained by replacing Eq. (6) with:

$$Allcorrect_{it} = 1[\boldsymbol{z}_{it}'\boldsymbol{\alpha} + \psi_2 + \boldsymbol{T}_i'\theta_2 + \overline{\boldsymbol{z}}_i'\boldsymbol{\xi}_2 + a_{i2} + v_{it2} > 0] \tag{8}$$

where the composite errors v_{it1} and v_{it2} are assumed to follow a bivariate standard normal distribution, with arbitrary correlation ρ. The results, reported in Panel B of Table 5, show that highly knowledgeable individuals have a significantly lower probability of being financially fragile. Those who answer correctly to all the Big Three questions are 31.02 percentage points less likely to be unable to cope with an unexpected expense, while those who answer correctly to all the six and seven financial knowledge questions have a 28.37 and 27.02 percentage points lower probability of financial fragility. This evidence provides further support for the beneficial role of financial competencies on the ability to withstand unexpected economic shocks.

Fourth, we analyse the robustness of our results to the definition of the dependent variable. As in Wiersma et al. (2020), we consider an ordered indicator of financial fragility instead of a binary one and estimate an endogenous CREU ordered probit.

Table 5 Robustness: definition of financial knowledge

Panel A: Alternative definition of financial knowledge

Model	Endogenous CREU probit	Endogenous CREU probit	Endogenous CREU probit	Endogenous CREU probit	Endogenous CREU probit
Dependent variable	FF	FF	FF	FF	FF
Financial knowledge questions	Big3	7Q	Big3	6Q	7Q
	(1)	(2)	(3)	(4)	(5)
Financial knowledge score (FK)	− 0.0384***	− 0.0377***			
	(0.0060)	(0.0062)			
Number of correct answers			− 0.1308***	− 0.0647***	− 0.0549***
			(0.0205)	(0.0106)	(0.0091)
Other control variables	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes
Wald test of exogeneity ($\rho = 0$)	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Amemiya-Lee-Newey overid. test	[0.9434]	[0.9228]	[0.9036]	[0.9411]	[0.8992]
Weak-instrument F test	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Observations	14,827	14,827	14,827	14,827	14,827

Panel B: High financial knowledge

Model	Bivariate CREU probit	Bivariate CREU probit	Bivariate CREU probit
Dependent variable	FF	FF	FF
Financial knowledge questions	Big3	6Q	7Q
	(1)	(2)	(3)
All correct	− 0.3102***	− 0.2837***	− 0.2702***
	(0.0303)	(0.0288)	(0.0295)
Other control variables	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes
Wald test of exogeneity ($\rho = 0$)	[0.0000]	[0.0000]	[0.0000]
Amemiya-Lee-Newey overid. test	[0.9160]	[0.8378]	[0.8299]
Weak-instrument F test	[0.0000]	[0.0000]	[0.0000]
Observations	14,827	14,827	14,827

The Table reports average marginal effects on the probability of being financially fragile estimated from endogenous CREU probit models and bivariate CREU probit. All the models include the same control variables included in the extended specification controlling for pre-pandemic financial resilience. Complete results are available upon request. Standard errors, clustered at the individual level, are reported in parentheses. The p-values of the Wald test of exogeneity, the Amemiya-Lee-Newey overidentification test, and the F test for weak instruments are reported in square brackets

***, ** and * denote significance at the 1, 5 and 10% levels, respectively

This analysis allows us to assess the impact of financial knowledge on each of the ordered alternatives related to respondents' ability to cope with an unexpected shock. The results, presented in Table C3 in Supplementary Appendix C, confirm the findings obtained from probit regressions. In particular, the estimated AMEs show that financial knowledge increases by about 4.8 percentage points the probability of being certainly able to come up with € 2000 within a month. Conversely, financial knowledge significantly reduces the likelihood of being probably able and of being probably and certainly unable to cope with an unexpected expense by about 1.0, 1.4 and 2.4 percentage points, respectively.

Finally, Table C4 in Supplementary Appendix C reports a disaggregated analysis of the impact of the different components of the pre-pandemic financial resilience index on financial fragility. Column (1) shows the AMEs of the overall financial resilience score computed by assigning equal weight to each of the components. In line with the results of our baseline model, we find that a one-unit increase in the financial resilience score reduces the probability of financial fragility by 2.1 percentage points, while a one-unit increase in the financial knowledge score reduces the probability of financial fragility by 3.89 percentage points. From column (2), it is possible to assess the impact of the different components of the pre-pandemic financial resilience score. The results indicate that three of the five components of the score exert a negative and statistically significant impact on financial fragility. Specifically, respondents who, before the pandemic, had an emergency fund to cover expenses for at least 3 months in case of loss of earnings, were able to save money, and were not in arrears on debt repayments, bills, and taxes, display a significantly lower probability of being financially fragile during the pandemic. Conversely, respondents' aptitudes to track expenditures and to define saving objectives before the outbreak of the COVID-19 crisis do not significantly impact their financial fragility. Again, the effect of financial knowledge score on fragility remains negative and statistically significant at the 1% level.

6.2 Heterogeneity in the Effect of Financial Knowledge

In Table 6, we assess the extent to which the impact of financial knowledge on financial fragility varies across different subgroups of the population. To this aim, we consider two extended specifications: first, we extend the baseline model by adding a single interaction term between the FK score and each binary indicator reflecting group membership; second, we consider a fully interacted model, allowing subgroup indicators to interact with all the explanatory variables of the baseline specification. The findings show that financial knowledge consistently plays a significant role in mitigating financial fragility across different demographics and economic backgrounds.

Focusing on gender, the results presented in Panel A of the Table confirm that financial knowledge exerts a sheltering effect against financial fragility, with both women and men benefiting from increased financial knowledge. However, coherently with the findings of Hasler et al. (2018) and Kass-Hanna et al. (2022), we provide evidence of a significant differential effect, suggesting that the impact of financial literacy is more pronounced for female respondents. Specifically, a one-unit increase

Table 6 Heterogeneity in the effect of financial knowledge

Model	Endogenous CREU probit Single interaction			Endogenous CREU probit Fully interacted		
Dependent variable	FF			FF		
	(1)			(2)		
Panel A: Gender						
	Female	Male	*Diff*	Female	Male	*Diff*
Financial knowledge score (FK)	− 0.0424***	− 0.0355***	− 0.0069***	− 0.0414***	− 0.0345***	− 0.0069***
	(0.0066)	(0.0060)	(0.0019)	(0.0069)	(0.0061)	(0.0023)
Panel B: Education						
	Less than upper secondary	Upper secondary and above	*Diff*	Less than upper secondary	Upper secondary and above	*Diff*
Financial knowledge score (FK)	− 0.0420***	− 0.0367***	− 0.0053*	− 0.0402***	− 0.0373***	− 0.0029
	(0.0073)	(0.0062)	(0.0027)	(0.0074)	(0.0062)	(0.0032)
Panel C: Area of residence						
	South/Islands	North/Centre	*Diff*	South/Islands	North/Centre	*Diff*
Financial knowledge score (FK)	− 0.0401***	− 0.0370***	− 0.0031	− 0.0393***	− 0.0367***	− 0.0026
	(0.0068)	(0.0060)	(0.0020)	(0.0072)	(0.0062)	(0.0024)
Panel D: Household monthly disposable income						
	< 1550 euro	≥ 1550 euro	*Diff*	< 1550 euro	≥ 1550 euro	*Diff*
Financial knowledge score (FK)	− 0.0493***	− 0.0312***	− 0.0180***	− 0.0500***	− 0.0314***	− 0.0186***
	(0.0076)	(0.0056)	(0.0029)	(0.0077)	(0.0056)	(0.0029)

Table 6 (continued)

Model	Endogenous CREU probit Single interaction			Endogenous CREU probit Fully interacted		
Dependent variable	FF			FF		
	(1)			(2)		
Panel E: Experienced a pandemic-induced income shock						
	Yes	No	*Diff*	Yes	No	*Diff*
Financial knowledge score (FK)	− 0.0462***	− 0.0329***	− 0.0133***	− 0.0485***	− 0.0329***	− 0.0156***
	(0.0074)	(0.0056)	(0.0023)	(0.0072)	(0.0055)	(0.0026)
Panel F: Pre-pandemic financial resilience						
	Below avg	Above avg	*Diff*	Below avg	Above avg	*Diff*
Financial knowledge score (FK)	− 0.0472***	− 0.0297***	− 0.0175***	− 0.0475***	− 0.0299***	− 0.0176***
	(0.0072)	(0.0072)	(0.0027)	(0.0075)	(0.0056)	(0.0028)

The Table reports average marginal effects obtained from endogenous CREU probit models. All the models include the same control variables included in the extended specification controlling for pre-pandemic financial resilience and relevant interaction terms. Complete results are available upon request. Standard errors, clustered at the individual level, are reported in parentheses

***, ** and * denote significance at the 1, 5 and 10% levels, respectively

in the financial knowledge score reduces the likelihood of being financially fragile by 0.69 percentage points more for women than for men.

Panel B shows that educational attainment further affects the relationship between financial knowledge and fragility. Individuals who have completed at least upper secondary education gain greater benefits from financial knowledge compared to those with lower educational attainment; however, this difference seems to be less pronounced in the fully interacted model. In contrast, there are no significant differences observed in the impact of financial literacy on fragility between respondents living in Southern Italy and those living in the northern and central regions (Panel C).

One of the most relevant findings relates to income levels. The results shown in Panel D reveal a significantly stronger effect of financial knowledge among respondents with lower monthly household disposable incomes. This evidence demonstrates that financial literacy is particularly important for the resilience of low-income individuals, consistent with the findings of Angrisani et al. (2023). Furthermore, experiencing a pandemic-induced income shock magnifies the importance of financial knowledge: individuals who were more adversely affected by the COVID-19 crisis exhibit a more pronounced impact of financial knowledge in alleviating financial fragility (Panel E). Finally, pre-pandemic financial resilience also interacts with financial knowledge, indicating that individuals with below-average pre-pandemic resilience experience a more substantial reduction in fragility as their financial literacy increases than those with above-average resilience (Panel F).

Overall, the results presented in Table 6 emphasise the importance of accounting for the moderating effect of demographic and economic factors when evaluating the impact of financial knowledge on fragility. They also suggest that financial education initiatives should be tailored to leverage the diverse effects of financial knowledge across demographic groups, thereby enhancing overall financial stability and resilience in the face of adverse economic shocks.

7 The Dynamics of Financial Fragility

Thus far, we have focused exclusively on static models of financial fragility. However, if the probability of being financially fragile is persistent over time, then omitted dynamics can potentially drive the results. In this respect, previous studies have provided evidence of the persistence of financial difficulties over time (Giarda 2013; Brown et al. 2014; French 2023; Loschiavo et al. 2024). We thus extend model (1) to account for the dynamics of financial fragility and specify the following dynamic probit model:

$$FF_{it} = 1(\alpha FF_{it-1} + \boldsymbol{x}'_{it}\boldsymbol{\beta} + \gamma FK_{it} + c_{i1} + u_{it1} > 0) \tag{9}$$

where FF_{it-1} is the lagged financial fragility status and α is the state dependence parameter. A positive and statistically significant estimate of α identifies persistence in the probability of being financially fragile, which may be due to true or spurious state dependence (Heckman 1981). True state dependence arises when past fragility has a genuine causal effect on financial difficulties at time t; spurious state dependence

occurs instead when the intertemporal relationship is determined by time-invariant unobserved heterogeneity. To identify and consistently estimate true state dependence, it is thus necessary to account for unobserved effects that are correlated over time, as well as for the endogeneity of the initial conditions. Here, we follow the approach to the initial conditions problem proposed by Wooldridge (2005) and model the distribution of the unobserved effects c_{i1} conditional on the initial value of the dependent variable and exogenous regressors. Formally:

$$c_{i1} = \psi_1 + \psi_2 FF_{i1} + \boldsymbol{T}_i'\theta_1 + \overline{\boldsymbol{z}}_i'\boldsymbol{\xi}_1 + \boldsymbol{z}_{i1}'\boldsymbol{\xi}_{11} + a_{i1} \tag{10}$$

where FF_{i1} is the initial financial fragility condition, $\overline{\boldsymbol{z}}_i$ represents the within-unit averages of time-variant regressors (based on all periods), and where we include the initial values of the explanatory variables $\boldsymbol{z}_{i1}$ to avoid biased estimation of state dependence in short panels (see Rabe-Hesketh and Skrondal 2013). Plugging (10) into (9), we obtain the following dynamic CREU probit model with endogenous initial conditions:

$$FF_{it} = 1\left(\alpha FF_{it-1} + \boldsymbol{x}_{it}'\boldsymbol{\beta} + \gamma FK_{it} + \psi_1 + \psi_2 FF_{i1} + \boldsymbol{T}_i'\theta_1 + \overline{\boldsymbol{z}}_i'\boldsymbol{\xi}_1 + \boldsymbol{z}_{i1}'\boldsymbol{\xi}_{11} + a_{i1} + u_{it1} > 0\right) \tag{11}$$

To account for the potential endogeneity of financial knowledge, we consider the linear reduced form Eq. (6) for FK_{it} and assume that the composite errors in (11) and (6) have, conditional on $\boldsymbol{z}_i$, a zero mean bivariate normal distribution, with variances respectively equal to 1 and $\sigma^2_{v_2}$, and covariance $\rho\sigma_{v_2}$. Following Giles and Murtazashvili (2013), we adopt a control function estimation approach consisting of a two-step procedure: (i) estimate the reduced form (6) for FK_{it} using pooled OLS and obtain the residuals $\widehat{v}_{it2}$; (ii) estimate a random-effects probit of FF_{it} on $FF_{it-1}, \boldsymbol{x}_{it}, FK_{it}$, $FF_{i1}, \boldsymbol{T}_i, \overline{\boldsymbol{z}}_i, \boldsymbol{z}_{i1}, \widehat{v}_{it2}, \overline{\widehat{v}}_{i2}$, and $\widehat{v}_{i12}$, using clustered bootstrap methods to obtain valid standard errors.

To identify the parameters of the dynamic model in (11) and neatly disentangle the effect of the lagged dependent variable and that of the initial conditions, we focus on the unbalanced panel of individuals observed in at least three time periods (i.e., with $T_i \geq 3$), two of which are consecutive.[7] It is also worth remarking that Wooldridge's approach and its extensions allow attrition to depend on initial conditions in an arbitrary way, reducing problems associated with the use of unbalanced panels.

As in the static model, the AMEs of regressors on the probability that $FF_{it} = 1$ can be computed based on the scaled parameters estimated from the second-stage random effects probit regression (using a clustered bootstrap for valid inference). The magnitude of genuine state dependence and the effect of initial conditions can be measured as the average differences in the probability of being financially fragile at

[7] Including individuals observed in only two consecutive periods (i.e., with $T_i = 2$) would pose an additional difficulty in discriminating between the effect of lagged and initial values of the dependent variable. For these 459 individuals, the lagged dependent variable is, in fact, the same as the initial value ($FF_{it-1} = FF_{i1}$,) and the associated coefficient captures the sum of the two effects (Raymond et al. 2015). Thus, by focusing on individuals with $T_i \geq 3$, we identify genuine state dependence more clearly, without significantly reducing the size of the estimation sample for the dynamic model.

time t when the lagged financial fragility indicator (FF_{it-1}) and the initial fragility status (FF_{i1}) change from 0 to 1, respectively.

Table 7 reports the AMEs estimated from the dynamic endogenous CREU probit model, not including (column (1)) and including (column (2)) the pre-pandemic financial resilience score. First, we stress that financial fragility is characterized by a significant degree of persistence over time. In line with the findings of Mussida and Sciulli (2024), we provide strong evidence of genuine state dependence in financial fragility. Controlling for observed and unobserved firm-level heterogeneity and endogenous initial conditions, the AMEs of FF_{it-1} are statistically significant in both the specifications and indicate that being financially fragile in the previous period increases the probability of being currently fragile by about 3.2 and 3.0 percentage points, respectively. Furthermore, we find that initial fragility status significantly affects the probability of being fragile at time t, confirming the importance of handling the endogeneity of initial conditions to properly identify state dependence (Grotti and Cutuli 2020). The AMEs of FF_{i1} indicate that being fragile in the initial period significantly increases the current risk of fragility by about 22.5 and 19.8 percentage points in the two specifications, respectively. Interestingly, initial conditions are particularly important for the subsequent dynamics of financial fragility and represent the factor most associated with financial fragility at any t. In this latter respect, as argued by Ayllón (2015) and Mussida and Sciulli (2022), we can shed light on the evolution of the trapping effect associated with financial fragility by comparing estimates of lagged and initial values. As the estimated AME of initial fragility is higher than that of lagged fragility in both models, our results suggest that the intensity of the trapping effect tends to increase over time.

Focusing on the impact of financial knowledge, the dynamic model largely confirms the evidence obtained in the static analysis. The results reported in the bottom part of Table 7 suggest that our identification strategy is valid even in the dynamic model and confirm that financial knowledge is an endogenous determinant of financial fragility. The effect of financial knowledge is statistically significant at the 1% level in both the specifications and the estimated AMEs of FK_{it} (equal to -6.05 and -2.91 percentage points, respectively) are very similar to that estimated from the static CREU model.[8] Thus, even after taking into account state dependence in financial fragility, respondents' financial knowledge remains a significant determinant of their ability to cope with unexpected expenses.

Figure 2 presents the predicted probability of being financially fragile (based on the specification controlling for pre-pandemic financial resilience) by level of financial knowledge, disaggregated by initial fragility status. From the Figure, we notice that, as financial knowledge increases, the likelihood of financial fragility at time t for those who were not fragile in the initial period tends towards zero, reducing from 0.322 to 0.017 when FK_{it} passes from 0 to 10. Financial knowledge also significantly reduces the financial fragility of individuals who were fragile in the initial period. The

[8] It should be noted that when the idiosyncratic endogeneity of financial knowledge is not taken into account, we again obtain downwardly biased estimates of its impact on financial fragility. As reported in Table C5 in Supplementary Appendix C, when we consider a dynamic exogenous CREU probit, the AME of FK_{it} remains statistically significant at the 1% level but reduces to 1.12 and 1.03 percentage points in the two specifications, respectively.

Table 7 The determinants of financial fragility during the pandemic: dynamic model

Model	Dynamic endogenous CREU probit	Dynamic endogenous CREU probit
Dependent variable	FF	FF
	(1)	(2)
Financial fragility at time $t-1$ (FF_{t-1})	0.0321*** (0.0048)	0.0298*** (0.0047)
Financial fragility at time 1 (FF_1)	0.2250*** (0.0177)	0.1983*** (0.0154)
Financial knowledge score (FK)	− 0.0605*** (0.0102)	− 0.0291*** (0.0086)
Age	0.0014** (0.0006)	0.0002 (0.0005)
Female	− 0.0272** (0.0121)	− 0.0056 (0.0105)
Upper secondary education	0.0113 (0.0176)	− 0.0072 (0.0150)
Tertiary education	0.0177 (0.0160)	− 0.0028 (0.0142)
Self-employed	− 0.0301 (0.0186)	− 0.0288* (0.0165)
Employee	− 0.0205 (0.0153)	− 0.0123 (0.0127)
Retired	− 0.0036 (0.0200)	− 0.0067 (0.0176)
Young children	− 0.0011 (0.0114)	0.0068 (0.0098)
Elderly/Disabled persons	− 0.0114 (0.0108)	− 0.0106 (0.0095)
Homeowner without mortgage	− 0.0561*** (0.0101)	− 0.0504*** (0.0090)
Income: 1060–1549 euro	− 0.0201 (0.0155)	− 0.0284*** (0.0145)
Income: 1550–2454 euro	− 0.0519*** (0.0164)	− 0.0626*** (0.0152)
Income: > 2455 euro	− 0.0684*** (0.0207)	− 0.0818*** (0.0189)
Income shock	0.0210** (0.0105)	0.0215** (0.0099)
Wave 3	− 0.0042 (0.0060)	− 0.0058 (0.0056)
Wave 4	− 0.0174** (0.0082)	− 0.0249*** (0.0077)
Pre-pandemic financial resilience		− 0.0132*** (0.0014)
Region fixed effects	Yes	Yes
Variance $\sigma^2_{a_{i1}}$	0.9129*** (0.0712)	0.8868*** (0.0705)
Wald test of exogeneity	60.05 [0.0000]	10.34 [0.0013]
Amemiya-Lee-Newey overid. test	0.400 [0.8200]	0.506 [0.7766]
Weak-instrument F test	172.19 [0.0000]	155.31 [0.0000]
Observations	9175	9175

The Table reports average marginal effects on the probability of being financially fragile estimated from dynamic endogenous CREU probit models on the unbalanced panel of individuals observed in at least three time periods, two of which are consecutive. Panel-bootstrapped standard errors (500 replications) are reported in parentheses. The p-values of the Wald test of exogeneity, the Amemiya-Lee-Newey overidentification test, and the F test for weak instruments are reported in square brackets

***, ** and * denote significance at the 1, 5 and 10% levels, respectively

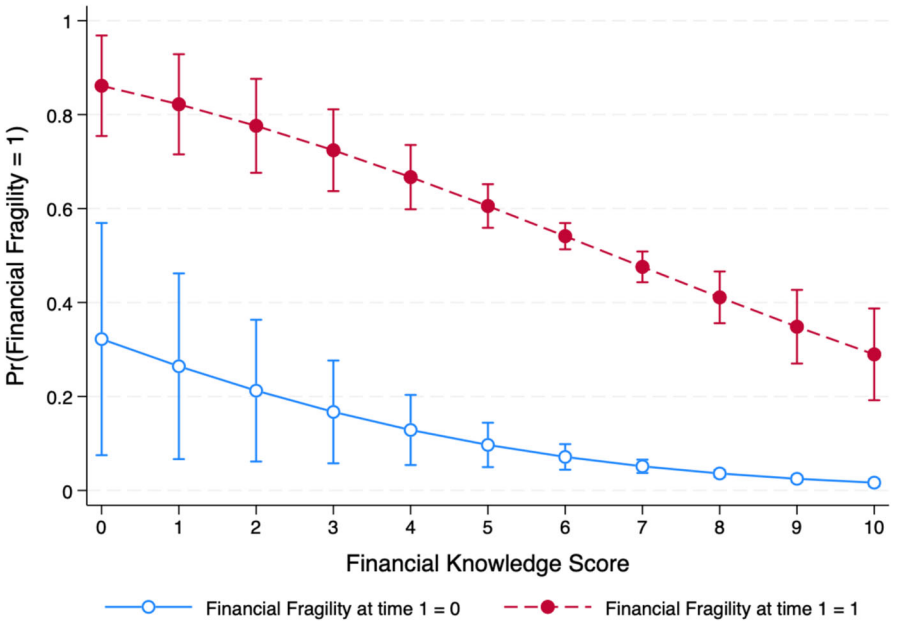

Fig. 2 Predicted probabilities of being financially fragile by financial knowledge and over initial fragility status. Notes: Predicted probabilities are estimated from the dynamic endogenous CREU probit controlling for pre-pandemic financial resilience. Source: Authors' elaboration

probability of financial fragility at time t for initially fragile individuals reduces from 0.861 to 0.290 as FK_{it} increases from 0 to 10, and the gap in predicted probabilities between the two groups, despite remaining statistically significant, tends to shrink with financial knowledge. This evidence suggests that financial literacy might also contribute to reducing the trapping effect of fragility.

Concerning the other control variables, the results from the dynamic model align with those presented in Table 3. Specifically, respondents with a higher income and homeowners without a mortgage are significantly less likely to be financially fragile. Furthermore, individuals who have experienced a pandemic-induced drop in income have a significantly higher probability of being unable to cope with unexpected expenses. When we extended the model to control for pre-pandemic financial resilience (column (2) of Table 7), we find that gender differences in financial fragility are no longer significant. At the same time, respondents who had emergency savings, were not in arrears on debt, and engaged in sound financial behaviours before the outbreak of the COVID-19 crisis, are significantly less likely to be financially fragile during the pandemic.

As in Pigini et al. (2016), we assess the accuracy of the dynamic probit compared to that of the static model. In Figure C1 in Supplementary Appendix C, we present the Receiver Operating Characteristic (ROC) curve for both dynamic and static models estimated on the unbalanced panel of individuals with $T_i \geq 3$, together with the corresponding area under the curve (AUROC). The results from the ROC analysis provide strong support to the prediction accuracy of both models: the values of the AUROC are equal to 0.8793 and 0.8326 for the dynamic and the static endogenous CREU probit models, respectively, and are both significantly higher than 0.5 (i.e., the value of the AUROC for a completely uninformative model). Moreover, the difference between the AUROCs is statistically significant (the Wald Chi-squared test statistic is 136.42 and the p-value is 0.0000), indicating that dynamic endogenous CREU probit has a higher predictive power and describes financial fragility more accurately than its static counterpart.

We further evaluate the robustness of the results to the time dimension of the panel. To this end, as in Raymond et al. (2010) and Aristei and Angori (2022), we re-estimate the dynamic model on the balanced sample of individuals observed in all four survey waves. The results (Table C6 in Supplementary Appendix C) largely confirm the evidence obtained from the whole sample and support the presence of genuine state dependence and the relevance of initial fragility status on the probability of being fragile at time t. The AME of financial knowledge on fragility slightly decreases but remains significant at the 1% level, in line with the evidence obtained for the static model (see column (1) of Panel B in Table 4).[9]

Finally, to assess the extent to which persistency in financial knowledge affects our main results, we extend the dynamic model to include the lagged value of financial knowledge FK_{it-1}. The results (Table C7 in Supplementary Appendix C) are largely consistent with those presented in Table 7. In particular, the AMEs of financial knowledge at time t remain almost unchanged, whereas the AMEs of FK_{it-1} are not statistically significant in both empirical specifications. This evidence further confirms that our main findings are not driven by potentially omitted dynamics in the relationship between financial knowledge and financial fragility.

8 Conclusions

Exploiting novel longitudinal data on financial knowledge and competencies of Italian adults over the period 2020–2023, our study provides robust empirical evidence on the relevance of financial knowledge in reducing individuals' financial fragility during the pandemic. Specifically, we show that more financially knowledgeable individuals are less likely to face difficulties in coping with unexpected expenses and are better protected against the income shocks associated with the COVID-19 crisis. Our main

[9] Table C6 in Supplementary Appendix C presents findings on an unbalanced panel that also includes individuals with only two consecutive time observations. To properly discriminate between the effect of the lagged dependent variable and that of the initial conditions, we follow Raymond et al. (2015) and include in Eq. (10) different initial values with different coefficients for individuals with $T_i \geq 3$ and for those observed over just two consecutive periods. The results (columns 3 and 4 of Table C6) confirm the presence of genuine state dependence and the relevance of initial conditions. Furthermore, the findings regarding the impact of financial knowledge remain substantially unchanged.

findings also suggest that the effect of financial knowledge varies with individual characteristics and is particularly beneficial in reducing the fragility of more vulnerable groups of the population. Extending our model to account for the dynamics of financial fragility, we show that financial fragility tends to persist over time due to genuine state dependence and unobserved heterogeneity and determines a significant trapping effect. Nonetheless, even after accounting for state dependence and endogenous initial conditions, financial knowledge remains a significant determinant of individuals' ability to cope with unexpected expenses, and its impact is particularly beneficial in reducing the difficulties of those who were financially fragile in the initial period.

In line with previous cross-sectional evidence for Italy (e.g., Sconti 2024; Bottazzi and Oggero 2023), our findings stress that policy interventions aimed at improving individuals' financial knowledge and skills might contribute to improving their ability to cope with unexpected expenses and improve financial well-being. These initiatives might be even more effective when targeted to more vulnerable subgroups of the population, who have lower levels of initial financial resilience, are more exposed to income shocks, and still lag behind in terms of financial knowledge. Furthermore, the evidence obtained suggests that financial education programmes could also help to reduce the trapping effect of previous fragility status and alleviate future financial difficulties.

Although limited to the Italian context, our findings align with previous studies conducted in countries characterised by diverse socioeconomic conditions and varying levels of financial literacy. Indeed, financial knowledge has been shown to exert a positive influence on financial well-being both in countries with low levels of financial literacy (Estrada-Mejia et al. 2023; Beckmann and Kiesl-Reiter 2023) and in countries where financial competencies are comparably higher (Vaahtoniemi 2023; Bucher-Koenen et al. 2024). These considerations further underscore the importance of promoting and disseminating financial knowledge to enhance financial well-being and inclusion. Nevertheless, the availability of internationally comparable data could improve the generalizability of the results across different national contexts. Future research would also benefit from longitudinal data spanning extended periods to examine the long-term effects of financial knowledge on financial fragility and assess the effectiveness of financial education programmes and policy interventions in the post-pandemic period. Additional research efforts should also be directed towards identifying and disentangling the main mechanisms through which financial knowledge might strengthen individuals' capacity to cope with unexpected shocks and contribute to reducing the persistence of financial fragility over time.

Appendix

See Table 8.

Table 8 Variable definitions and descriptive statistics

Variable	Definition	Mean
a) Dependent variable		
Financial fragility (FF)	Equals 1 if the respondent replies "I could probably not come up with €2,000" or "I am certain I could not come up with €2,000" to the question "If an unexpected expense arose, how confident are you that you could come up with €2,000 within a month?"; 0 otherwise	0.2689
b) Explanatory variables		
Financial knowledge score (FK)	Index (normalized to vary between 0 and 10) based on the predicted scores of the first factor obtained from a factor analysis on six binary variables indicating the correct answer to each of the six financial knowledge questions (related to simple interest rates, inflation, risk diversification, mortgages, compound interest rates, and risk-return relationship)	6.9313
Number of correct answers	Number of correct answers to the six financial knowledge questions	4.0364
All correct	Equals 1 if the respondent answers correctly all the six financial knowledge questions; 0 otherwise	0.2726
Age	Age of the respondent (in years)	54.408
Female	Equals 1 if the respondent is a woman; 0 otherwise	0.3424
Upper secondary education	Equals 1 if the respondent has an upper secondary education; 0 otherwise	0.3578
Tertiary education	Equals 1 if the respondent has a tertiary education; 0 otherwise	0.1856
Self-employed	Equals 1 if the respondent is self-employed; 0 otherwise	0.1660
Employee	Equals 1 if the respondent is an employee; 0 otherwise	0.5432
Retired	Equals 1 if the respondent is retired; 0 otherwise	0.2553
Young children	Equals 1 if any child aged between 0 and 14 years lives in the respondent's household; 0 otherwise	0.1804
Elderly/disabled persons	Equals 1 if any elderly (aged 70 years and over) or disabled person lives in the respondent's household; 0 otherwise	0.2278
Homeowner without mortgage	Equals 1 if the respondent is a homeowner without a mortgage; 0 otherwise	0.6100

Table 8 (continued)

Variable	Definition	Mean
Income: 1060–1549 euro	Equals 1 if the respondent's net monthly household disposable income is between 1060 and 1549 euro; 0 otherwise	0.3073
Income: 1550–2454 euro	Equals 1 if the respondent's net monthly household disposable income is between 1550 and 2454 euro; 0 otherwise	0.3155
Income: > 2454 euro	Equals 1 if the respondent's net monthly household disposable income is above 2454 euro; 0 otherwise	0.2469
Income shock	Equals 1 if the respondent experienced a decrease in household disposable income since the onset of the COVID-19 pandemic; 0 otherwise	0.4104
Pre-pandemic financial resilience	Index (normalized to vary between 0 and 10) based on the predicted scores of the first factor obtained from a factor analysis on five binary variables indicating that, before the COVID-19 pandemic, the respondent had an emergency fund that could cover expenses for at least 3 months in case of loss of earnings; was able to save money; was not in arrears on debt repayments, bills, and taxes; tracked expenditures; and had saving plans	6.2175
Average math score	Primary school students' average math score in the OECD-PISA test at the provincial level. Source: INVALSI, PISA tests in different years	56.259
Internet use	Index (normalized to vary between 0 and 10) based on the predicted scores of the first factor obtained from a factor analysis on four binary variables indicating that the respondent used the Internet to buy goods and services; access digital government services; pay bills; and work remotely	6.3172
Peer uninformed decision-making	Leave-out proportion of individuals in the same province and age class of the respondent who make financial decisions without consulting any information source or using informal sources of information (such as non-specialized media, friends, relatives and colleagues, and non-specialized online resources)	0.4700

Average values are computed over the period 2020–2023 using sample weights

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40797-025-00324-7.

Funding Open access funding provided by Università degli Studi di Perugia within the CRUI-CARE Agreement.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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