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Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
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JEL Classification: G53, C81, D91

Keywords: financial knowledge, Gender Gap, financial decision making, confidence, Measurement error, latent class model, finite mixture model

Tabea Bucher-Koenen - tabea.bucher-koenen@zew.de
ZEW - Leibniz Center for European Economic Research

Rob Alessie - r.j.m.alessie@rug.nl
University of Groningen and Netspar

Annamaria Lusardi - alusardi@gwu.edu
The George Washington University, NBER, and Netspar and CEPR

Maarten Van Rooij - m.c.j.van.rooij@dnb.nl
De Nederlandsche Bank and Netspar

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Fearless Woman: Financial Literacy and Stock Market Participation

Tabea Bucher-Koenen
University of Mannheim, ZEW and Netspar
Rob Alessie
University of Groningen and Netspar
Annamaria Lusardi
The George Washington University, CEPR, NBER and Netspar
and
Maarten van Rooij*
De Nederlandsche Bank and Netspar

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* Tabea Bucher-Koenen, ZEW-Leibniz Center for European Economic Research, L7, 1, 68161 Mannheim, Germany (tabea.bucher-koenen@zew.de); Rob J.M. Alessie, School of Economics and Business, University of Groningen, P.O. Box 800, 9700 AV, Groningen (R.J.M.Alessie@rug.nl); Annamaria Lusardi, George Washington University, Duquès Hall, Suite 450E, Washington D.C. (Annamaria.Lusardi@gwu.edu); Maarten C.J. van Rooij, Economics & Research Division, De Nederlandsche Bank, P.O. Box 98, 1000 AB, Amsterdam (M.C.J.van.Rooij@dnb.nl).
The authors wish to thank Martin Brown, Joao Cocco, Helmut Farbmacher, Adriaan Kalwij, Marc Kramer, Pierre-Carl Michaud, Federica Teppa, Nathanael Vellekoop, and Joachim Winter for helpful feedback and Audrey Brown for editorial assistance. They are also grateful to seminar participants in Amsterdam, Frankfurt, Jena, Giessen, Groningen, Mannheim, Maastricht, Montreal, Munich, Utrecht, and Sterling, and the participants at the Annual Meeting of the Neuroeconomic Society in Bonn, the EIB meetings in Paris, the Annual Conference of the European Economic Association in Toulouse, the Cintia conference in Turin, the Netspar Pension Workshop in Amsterdam, the Netspar Conference on Advances in Household Finance in Modena, the Annual Meeting of the International Association of Applied Econometrics in Milan, the Women in Finance Conference at Columbia University in New York, the Household Finance Workshop in Sheffield, the SAFE Household Finance Workshop in Frankfurt, and the DIW Workshop on Gender and Financial Literacy in Berlin for useful comments. Financial support from the European Investment Bank Institute is gratefully acknowledged. The findings, interpretations, and conclusions presented in this article are entirely those of the authors and should not be attributed in any manner to the European Investment Bank or its Institute or to the De Nederlandsche Bank.

1. Introduction

Three facts motivate the work in this paper. First, there is a pronounced gender difference in financial inclusion. Worldwide, only 47% of women versus 55% of men have access to an account at a formal financial institution. Women are also significantly less likely to have access to formal credit, both in high-income and developing economies (see World Bank 2013). Even before the onset of the COVID-19 crisis, women were found to be more financially fragile than men and to lack buffer stocks of savings (Hasler and Lusardi 2019). Moreover, women own fewer assets and are less likely to have pensions and to invest in risky, high-yield assets (see, e.g., Almenberg and Dreber 2015, and Lusardi and Mitchell 2008). The cost of these differences is staggering. Regarding non-participation in the stock market, for instance, price-adjusted historical returns show that savings invested in risk-free assets versus stocks result in large differences in wealth holdings over a long period of time.[1]

Second, there is a universal gender gap in financial literacy. Notably, in the majority of countries, women tend to disproportionately indicate they "do not know" the answer to financial literacy questions. This is true across cultures and measures of financial knowledge as well as across socio-demographic characteristics. It is also true in other financial knowledge domains such as debt literacy and pension literacy (see, e.g., Bucher-Koenen et al. 2017, Klapper and Lusardi 2020, OECD 2013). At the same time, financial literacy has been shown to be a crucial determinant of financial decision making, including stock market participation, portfolio choice, retirement planning, wealth accumulation, and debt management (see Lusardi and Mitchell 2014 for a review).

The third fact, which motivates the title of this paper, is related to *Fearless Girl*—a bronze statue of a girl that was placed in front of the *Charging Bull* on Wall Street in New York City on March 7, 2017 (one day before International Women's Day). The intent was to raise awareness and encourage women's leadership. Its symbolic placement sparked a debate about women's roles, particularly in financial professions, and pointed to the importance of confidence, especially in the fields of finance and investing. A fearless girl will become a fearless woman.

[1] Bovenberg et al. (2007) show that, compared to an optimal strategy, not participating in the stock market for retirement and other savings yields a welfare loss of 12 percent.

We take these observations to the data and consider whether and the extent to which confidence contributes to the persistent gender gap in financial literacy and financial behavior. Inspired in part by the interest generated by *Fearless Girl*, we examine the role of confidence in explaining the gender gap in stock market participation. The central questions we address can be summarized as follows: *Are women financially literate yet lacking confidence in their knowledge?* and *Is it lack of confidence or lack of financial knowledge that is responsible for the gender difference in stock market participation?* These questions are of paramount importance, particularly now that women play a greater role in saving and investing, including making decisions regarding retirement savings and stock market participation.

To investigate these questions, we use data from the De Nederlandsche Bank (DNB) Household Survey (DHS), which is a panel study of the Dutch central bank and is representative of the Dutch-speaking population in the Netherlands. We designed two survey modules, which were fielded to panel participants, using the Big Three financial literacy questions, which measure knowledge about basic but fundamental financial concepts: interest compounding, inflation, and risk diversification.[2] These questions were asked in each module, and we altered the survey design as follows: In the first module we used the standard setup, which includes a "do not know" option among the possible answers to the financial literacy questions. In the second module, asked about six weeks after the first, we took away the "do not know" option, thus forcing respondents to choose an answer from a set of options. Additionally, we asked respondents how confident they were in their answer. Based on these data, we develop and estimate a latent class model (LCM) to predict "true" financial literacy. The objective of the LCM is to create a measure of financial knowledge that is not confounded by differences in answering behavior related to confidence. The model helps us assess how much of the financial literacy gender gap is due to differences in knowledge versus confidence. For each concept (interest compounding, inflation, and risk diversification), our model predicts the probability that the respondent knows the answer, conditional on the structure of responses to the financial literacy questions in the two modules, information on confidence, and background variables. Thus, in contrast to the financial literacy measures often used in the literature, in which the number of correct answers is simply added up, we develop a more rigorous measure that takes into consideration the entire structure of the answers to the financial literacy questions. Using

[2] These questions were developed by Annamaria Lusardi and Olivia Mitchell and are the questions most commonly used to measure financial literacy in surveys around the world (see Lusardi and Mitchell 2011a, 2011b, and 2014).

this new measure, we assess the impact of financial literacy on stock market participation, an important outcome which is quite consequential for wealth accumulation and financial wellbeing.

The contributions of this paper are as follows: First, we provide a novel perspective on financial literacy measurement and show how we can better use the Big Three financial literacy questions in empirical research. Good measurement forms the basis of rigorous research and is essential to making progress in a field. The literature on financial literacy has grown rapidly in the past decade, and most empirical work includes measures of financial literacy.[3] The Big Three financial literacy questions have been added to national surveys around the world and have become a standard measure of financial literacy, but few studies have examined the quality of their measurement and the best way to use the information they provide. Second, we extend the growing literature on gender differences in financial decision making. This is relevant given that women are increasingly important participants in financial markets. Third, we provide a methodological contribution to the literature on financial literacy.

Our results show a pronounced gender gap in financial literacy, confirming previous findings: women are less likely to answer the financial literacy questions correctly and more likely to choose the "do not know" option. However, taking away the "do not know" response option substantially reduces the gender gap. Applying our novel estimation strategy, we can decompose the gender gap into a gap in "true" knowledge and a gap in confidence. We find less of a gender gap in our measure of true financial literacy than in the measure that has been standard in the research to date. Specifically, we find that about two-thirds of the financial literacy gender gap is explained by lower financial knowledge and the remaining one-third is due to lower confidence. In other words, women have lower financial literacy than men, but they know more than they think they know. Moreover, we find that both factors—knowledge and confidence—are important for understanding gender differences in stock market participation, so it is important to have information on both.

We also show that the way in which financial literacy is measured matters for our observed financial outcome, i.e., stock market participation. We recognize that many researchers do not have access to the type of data we were able to collect. However, we also show that including the number of "do not know" responses to financial literacy questions in addition to the number

[3] Financial literacy now has its own JEL classification code: G53.

of correct answers in empirical regressions that assess the impact of financial literacy on behavior can partially account for differences in confidence.

Finally, our findings can provide insights for policy and for educational programs designed to improve financial decision making. First, according to our estimates, the majority of the financial literacy gender gap is a knowledge gap. Thus, boosting women's financial knowledge is important to the promotion of financial market participation. Second, we do find a gender gap in confidence, and this matters for financial decisions, as symbolized by the *Fearless Girl* statue. Thus, our results indicate that financial education programs specifically tailored to women that boost both knowledge and confidence might be more effective than one-size-fits-all programs.

The paper is organized as follows: In the next section we provide a literature review. In Section 3, we describe the data and report descriptive results on financial literacy using information from two modules of the DHS data. In Section 4, we describe our econometric strategy for measuring financial literacy when there are heterogeneous differences in confidence across gender. We explore the relationship between measures of financial literacy and financial behavior in Section 5 and the role of confidence in Section 6. In section 7, we discuss instrumental variables estimates and how we can make use of the "do not know" answers. We provide conclusions in Section 8.

2. Literature overview

We provide below a review of the literature that is related to our work and that includes gender differences not only in financial knowledge but also in financial behavior and measurement issues as well.

2.1 Gender differences in income and financial outcomes

Gender differences have been widely studied in economics. Most of the research on gender equality focuses on gender differences in income (see e.g. Blau and Kahn 2017 and Goldin et al. 2017) and labor force participation (see, e.g., Goldin and Mitchell 2017). While the gender wage gap has been declining over time, a substantial gap still exists in many countries. Among the reasons cited to explain this gap are gender differences in education, wages, occupational segregation, part-time work, and taxation (see, e.g., Goldin and Katz 2016, Goldin et al. 2017, Eckstein et al. 2019); medical progress and fertility choices (Albanesi and Olivetti 2016); and

selection into family-friendly career paths (Adda et al. 2017). However, even after accounting for many contributing factors, some of the gender gap remains unexplained.

The gender gap in income is directly related to gender gaps in other income-dependent domains. Dynan et al. (2004), for example, show a strong relationship between lifetime income and saving rates in the US. Moreover, in many countries pension income is linked to contributions made during the working life; thus, gender gaps in income and labor force participation directly affect pension income. With pension reforms shifting from defined benefit to defined contribution plans and from state pensions to occupational contracts and private savings, the link between labor market status and retirement income will become even more pronounced, potentially widening the gender gap in retirement income.

Women, on average, are found to hold lower amounts of wealth (e.g., Lusardi and Mitchell 2008, Neelakantan and Chang 2010). They also invest more conservatively; i.e., they are less likely to own stocks and more likely to invest in fixed-income securities (see Almenberg and Dreber 2015; Sundén and Surette 1998). And, of relevance given the current crisis driven by the COVID-19 pandemic, women are found to be more financially fragile; i.e., they are less confident about their capacity to handle a financial shock (Hasler and Lusardi 2019).

Another strand of literature examines the relationship between gender and access to formal financial services, mostly in developing countries. Access to formal financial services, such as credit and savings vehicles, is crucial for entrepreneurship and firm growth (Aterido et al. 2013). Klapper and Parker (2010) survey the gender gap in credit access and find that compared to men, women are less likely to get access to formal financial institutions, are charged higher interest rates, and raise less venture capital (Brush et al. 2004). Asiedu et al. (2013) study access to financing in 90 developing countries and find that compared to male-owned firms, female-owned firms are more financially constrained.

Moreover, there is increasing evidence of differential treatments by financial institutions. Alesina et al. (2013) provide evidence that female entrepreneurs are charged higher interest rates. Brock and de Haas (2019) show discriminatory behavior by loan officers against female borrowers. Additionally, there is evidence that women get lower quality financial advice both in field experiments (see, e.g., Bhattacharya et al. 2020) and in real-world data from advisor protocols (Bucher-Koenen et al. 2020). Moreover, Niessen-Ruenzi and Ruenzi (2018) find

evidence of a gender bias in the mutual fund industry, with higher inflows going into male managed funds.

2.2 Gender and financial literacy

One potential determinant of the gender difference in economic outcomes, including those mentioned above, is the gender difference in financial literacy. We follow Lusardi and Mitchell (2014) and define financial literacy as *"people's ability to process economic information and make informed decisions about financial planning, wealth accumulation, debt, and pensions"* (p. 6). Thus, in line with this strand of the literature, we look at financial literacy as the knowledge needed to make an informed financial decision.

There is a wide literature documenting consistently lower financial literacy among women than men (see Bucher-Koenen et al. 2017 for a survey). This gender difference is documented in both developed and developing countries (Klapper and Lusardi 2020). It is particularly striking that financial literacy levels seem to be low even among young women who are well educated and have strong labor market attachment. For example, even women from an elite American college show a considerable lack of financial knowledge (Mahdavi and Horton 2014).

Differences in financial literacy matter. Almenberg and Dreber (2015) show that differences in financial literacy can explain some of the gender gap in stock market participation. Similarly, Bannier and Neubert (2016) show that financial literacy and risk tolerance both matter for the gender gap in investments and that the correlation between sophisticated investments and self-assessed financial literacy is stronger for women than for men. Beckmann and Menkhoff (2008) examine female fund managers and conclude that financial expertise reduces the gender difference in financial behavior but differences do not completely disappear, even among experts.[4]

While the evidence of persistent gender differences in knowledge and behavior is compelling, its origins are hard to explain. There is little evidence so far on what contributes to the gender gaps mentioned above, particularly on what might explain the gender differences in financial literacy. Fonseca et al. (2012) and Hsu (2016) suggest that within households, men specialize more often in financial decision making than women, but gender differences are also found among singles and teen-agers (see Lusardi and Mitchell 2014; Bucher-Koenen et al. 2017,

[4] Allgood and Walstad (2015) as well as Bannier and Schwartz (2018) show that both actual and perceived financial literacy are related to financial behaviors.

Driva et al. 2016). Giuliano (2017) provides a survey on the role that history plays in gender norms and observed gender differences today. She argues that gender roles emerge as a response to specific historic circumstances and are highly persistent even after circumstances change. Strong transmission channels from parents to children cause long-term persistence of gender roles in society. Thus, if women were not responsible for financial decision making historically, it might take a long time for them to become decision makers today – even if circumstances have changed.

Filipiak and Walle (2015) compare financial literacy of individuals who live in matrilineal with those who live in patriarchal environments in India and find no gender differences in the matrilineal cultural environment. They show that a sizable portion of the financial literacy differences between women living in matrilineal and patriarchal societies remains unexplained and suggest nurture as a potential reason for those differences.

2.3 Measurement of financial literacy

Few studies have focused on the measurement of financial literacy to explain gender differences in knowledge and behavior. For example, there is evidence that women and girls are more likely to skip questions in multiple choice settings (Baldiga 2014, Riener and Wagner 2017). Reasons put forward for such behavior are related to avoidance of high-stakes and competitive settings (Niederle and Vesterlund 2007 and 2010), risk aversion (Croson and Gneezy 2009), and confidence in male specific tasks and willingness to contribute to tasks that are outside the gender-specific domain (Baldiga Coffman 2014). These arguments can be relevant for the measurement of financial literacy as well.

There is ample evidence that women are less confident than men in many situations, particularly those that are considered male domains (see, e.g., Beyer 1990, Deaux and Farris 1977, Prince 1993). In the context of financial knowledge, Chen and Volpe (2002) find that female college students are less confident and enthusiastic about financial topics. Webster and Ellis (1996) provide evidence that even among financial experts, women show lower self-confidence in financial analyses than men. Girls are also less confident with respect to their math abilities, even if there is no difference in test performance (Weinhardt 2017). Since many of the financial literacy test items involve math, this could contribute to the measured financial literacy gender gap.

3. Data and descriptive evidence

We focus hereafter on three questions related to gender differences in financial literacy. The first is whether the observed financial literacy gender gap is affected by the way in which financial literacy is measured. Specifically, how does answering behavior change if the "do not know" response option is taken away? The second question is whether selection of the "do not know" response can be traced to confidence. Are women less confident in their responses to specific financial literacy questions compared to men? The third and most important question is whether the way in which financial literacy is measured affects the assessment of its impact on behavior. Specifically, how important is it to disentangle knowledge from confidence?

3.1 The data

We use data from the DHS, which is a panel study of the Dutch central bank that is collected by CentERdata and is representative of the Dutch speaking population in the Netherlands. [5] The central bank of the Netherlands is one of the few central banks that have been collecting financial literacy data for many years now; similar data have increasingly been collected in other countries around the world, including the United States.[6] We merge DHS data with data from two survey modules we designed and that are collected from CentERpanel respondents. The objective of the two modules is to understand what drives the gender gap in financial literacy, particularly what drives the gender difference in the "do not know" responses. In the first module, we ask the Big Three financial literacy questions in the traditional way; i.e., respondents have the option (as part of the multiple-choice answers) to select "do not know." Six weeks later, in the second module, we ask these respondents the same financial literacy questions, but this time without the "do not know" option. To the second module, we also add a follow-up question that asks how confident respondents are about their answers. The resulting new sets of data allow us to dissect the answers to the financial literacy questions and examine the drivers of women's "do not know" responses.

As mentioned, we ask the Big Three financial literacy questions to the same respondents twice (see appendix A.1 for the exact wording of the questions). Alessie et al. (2011) and Angrisani et al. (2020) compare answers to the financial literacy questions over time and show a very high

[5] The CentERpanel is an online household panel run by CentERdata, a survey agency at Tilburg University. Participants without internet access are provided with equipment that enables them to participate. For more information, see www.centerdata.nl. The panel participants answer surveys regularly. Once a year they respond to the DHS survey.

[6] The US Board of Governors of the Federal Reserve System's Survey of Consumer Finances added the Big Three financial literacy questions to its questionnaire in 2016; these questions have also been added to the Bundesbank and the Bank of Italy surveys, among others.

stability of answers within respondents. However, unlike our study, these studies asked the exact same questions twice. Our design is as follows: When we asked the financial literacy questions in May 2012 (May module), respondents faced the standard list of response options, which includes "do not know".[7] When respondents were asked the same questions for the second time about six weeks later, at the end of June/beginning of July 2012 (July module), the "do not know" options were not included (July module). Respondents were then required to rate their level of confidence in their answer on a scale from 1 (not confident at all) to 7 (completely confident) after each question.

Our sample includes all panel members who are household heads and their partners. Respondents are age 18 and older. For our main analysis, we restrict the sample to respondents who participated in both the May and July modules (balanced panel). Because we allowed both the household head and their partner to participate, we have two individual observations for a number of households (and in the regression analysis we compute standard errors which are clustered at the household level). We drop respondents who did not complete the financial literacy modules (30 respondents; 1.35% of the initial raw sample).[8] Our final sample contains 1,532 respondents: 861 (56.2%) are men and 671 (43.8%) are women. Further socio-demographic characteristics of the sample are provided in the summary statistics in appendix table A.1.

Because we work with a balanced panel, we consider both attrition and learning, though neither is likely to affect our findings.

To test for attrition between the modules, we look at the three financial literacy questions and the number of correct answers in the May questionnaire and partition the sample into those who participated in the May module only (N=221) and those who participated in both modules (N=1,532). We do not find a systematic difference in the average financial literacy of those groups. Thus, respondents did not systematically drop out after the May module because they were uncomfortable answering the financial literacy questions. The same is true for attrition

[7] Note that there is also the option "to refuse to answer," which is chosen by a very small fraction of respondents and is therefore irrelevant.

[8] Twenty respondents had at least one missing answer in the first financial literacy survey and 10 respondents had at least one missing answer in the second financial literacy survey. Thus, despite taking away the "do not know" option, the missing rate did not increase.

based on gender. Men and women both dropped out after the May module with equal probability (see appendix table A.2, panel A).

Because the same group of respondents was asked the same questions twice, there could be concern about learning effects. We can test for learning by comparing the refresher sample (N=445) with the group that participated in both modules (N=1,532). The respondents in the refresher sample participated only in the July module and thus saw only the questions without the "do not know" option. So if we find a higher probability of answering correctly among panel participants than among those in the refresher sample, we can attribute the difference to panel participants having seen the questions before. The results of this exercise are shown in table A.2, panel B, in the appendix. There are no significant differences in the responses of those two groups. We also split the sample by gender and do not find learning effects for men or women. Thus, we are confident that learning effects are not confounding our results.

3.2 Comparing answers across modules

In table 1, we present the answers to the three financial literacy questions for both the May and July modules separately for men and women.[9]

[Table 1 - about here]

In the May module, when we look at the question assessing understanding of compound interest (the "interest question"),[10] which is the simplest question, we find that men are more likely to answer correctly than women (91.9% vs. 84.4%, see table 1, panel A). The gender gap for this question is 7.5 percentage points. Women are more often incorrect, but they also report a higher number of "do not know" (DK for short) answers. While 6.7% of the women reply "do not know" to this question, only 2.8% of the men pick the "do not know" option. In the July module, we ask the same question, this time without the DK option. The number of correct answers increases to 94.7% for men and 91.2% for women. The number of incorrect answers also increases. However, overall the gender difference shrinks by half, to 3.5 percentage points.[11]

[9] The statistics presented in this paper are not weighted. We also used sampling weights but found only very small differences.

[10] This question is very simple; it measures basic knowledge of the workings of interest rates and the capacity to do calculations in the context of interest rates.

[11] As mentioned earlier, the number of refusals is very small: less than 0.5% for each of the questions (see Table 1). Therefore, we lump this category together with the "do not know" responses because in both cases respondents display a reluctance to answer the question.

When we look at the responses to this question in July for those who chose "do not know" in May (see table 2), we find that the majority are able to provide the correct answer. Around 70% of both men and women who responded "do not know" to this simple question in the May module are, in fact, able to correctly answer the question in the July module. [12]

[Table 2 - about here]

The question measuring respondents' knowledge of the workings of inflation (the "inflation question") appears to be somewhat more difficult for the respondents in our sample. The number of correct answers is lower than for the previous question, and the gender gap is larger at more than 9 percentage points (see table 1, panel B). Two-thirds of the gender gap is again driven by the DKs, although the number of incorrect answers is somewhat higher among women. When forced to answer, i.e., when the "do not know" option is taken away, the gender gap diminishes from 9 to 6 percentage points. This is again because those who responded "do not know" to this question in the May module are, in fact, often able to provide the correct answer when forced to make a choice.[13] Nevertheless, within the DK group, men more often provided a correct answer when forced to make a choice than women (67% for men versus 62% for women; see table 2, panel B).

The third question assesses knowledge of the workings of risk diversification (the "risk diversification" question). For this question, the proportion of DK answers is much higher for both men and women, but especially for women. More than half of the women indicate that they do not know the answer to this question (54.7%) compared to 30.1% of the men (see table 1, panel C). The gender gap for this question is as high as 27.5 percentage points. Strikingly, when responding in the July module, in which a choice is forced, the gap shrinks to 9 percentage points. The majority of both women and men who chose DK in the May module are able to answer this question correctly in the July module.[14] Yet the proportion of correct answers is higher for men than for women (72.6% versus 67.7%; see table 2, panel C).

Panel D of table 1 shows the number of correct answers. The probability of answering all three questions correctly increases from 58.1% to 74.9% for men and from 29.4% to 60.1% for

[12] Random answering is rejected at the 0.1% significance level.
[13] Random answering is rejected at the 0.1% significance level.
[14] Random answering is rejected at the 0.1% significance level.

women between the May and the July modules. The financial literacy gender gap shrinks by about half from 29 to 15 percentage points.

To summarize, we confirm a gender gap in financial literacy. This is due in part to women more often stating they do not know the answer—when given the option to do so—to the financial literacy questions. When respondents are forced to answer, the gender gap decreases substantially (but does not disappear). The "do not know" answers may signal lack of certainty along with a high likelihood of being correct. Indeed, conditional on responding "do not know" in the May module, both men and women are likely to give a correct answer in the July module for each of the three questions. In the next section, we turn to an examination of the role of confidence.

3.3 Confidence in knowledge

As mentioned earlier, in the July module, respondents were asked to rank their confidence in their answers to the financial literacy questions on a scale from 1 (not confident) to 7 (completely confident). Average scores for all three questions for men and women are in table 3. Overall, we confirm that women are significantly less confident in their answers than men. Among men, a large fraction are very confident in their answers (ratings of 6 or 7), but this is not true for women, who report much lower levels of confidence. Comparing the ratings for the three questions reveals that respondents are fairly confident in their answers to the interest and inflation questions, which are simpler questions. Confidence ratings for the more difficult risk question are lower.

[Table 3 - about here]

We turn next to evaluate the confidence levels from the July module, conditional on the respondent's answers to the same questions in the May module. What we find is that conditional on giving a correct answer in the May module, women are significantly less confident than men in their answers in the July module for all three questions. Thus, even when they pick the correct answer, women are not confident in their knowledge. Conditional on answering DK in the May module, women are less confident in their answers in the July module compared to men for the risk diversification question. The effect is not statistically significant for the first two questions (potentially due to the much lower number of DK responses), but it is statistically significant for the risk diversification question. Further, respondents who selected a DK answer in the May

module are, on average, much less confident compared to those who choose an answer, whether correct or incorrect, in the May module.[15]

In summary, the financial literacy scores in the May module reflect both knowledge and confidence. The measure resulting from the July module, in which respondents were forced to pick an answer, is not confounded by confidence. At the same time, the July measure is likely to contain measurement error and to be upward biased due to respondents simply guessing the correct answer. Thus, taking away the DK option does not necessarily lead to a better measure of financial literacy or provide a superior way to measure financial knowledge. In the next section, we use information from both survey modules and develop a latent class model (LCM) in order to estimate a measure of "true" financial literacy.

4. Modeling "true" financial literacy

To get a measure of "true" financial literacy, we estimate each respondent's probability of truly knowing the answer to a specific financial literacy question depending on the structure of their responses to the financial literacy and the confidence questions in the two survey modules. For this purpose, we set up a latent class model.[16]

The descriptive statistics reported above show that respondents, particularly women, are often uncertain about their answers to the financial literacy questions. Respondents seem to pick the "do not know" option when they are not confident in their knowledge, even if they may actually know the correct answer. This leads to systematic bias with respect to gender in the measurement of financial literacy. On the other hand, some respondents seem to pick an answer randomly. Thus, answers may be correct simply because of random guessing. Therefore, just counting the number of correct answers, as it is usually done in the literature (including our own previous work), creates noisy financial literacy measures.

The central contribution of the LCM is to disentangle "true" knowledge, confidence, and guessing in order to calculate a financial literacy index with minimal measurement error. For this purpose, we derive a measure of "true" financial knowledge based upon the structure of the

[15] We also ran regressions with "do not know" responses as the dependent variables and confidence levels (as well as the socio-demographic variables of gender, age, income, education, and marital status) as explanatory variables. We find a significant negative relationship between higher confidence levels and "do not know" responses. The relationship is particularly strong for the risk diversification question. Results are available upon request.

[16] Also known as finite mixture model (Aitkin and Rubin 1985; Cameron and Trivedi 2005).

two survey modules, using respondents' confidence in their answers to correct for guessing. Based on this information, we predict the probability that a respondent truly knows the correct answer, thus taking a value between 0 and 1 for each of the questions. Our new financial literacy index is the sum of these probabilities for the individual financial literacy questions. As in the standard measure, these probabilities have the value of one if a respondent knows the correct answer for certain or zero if the respondent does not know the correct answer. However, for some respondents, these probabilities take values between zero and one; this is particularly the case for respondents who responded with "do not know" in the May survey and would have received a zero weight in the standard financial literacy index but do, in fact, know the answer with some degree of confidence. Providing a good measure of financial literacy has implications for assessing its impact on financial behavior, as we will show in the next section.

First, we define for each of our three financial literacy questions the following latent variable for "true" knowledge:

$\tilde{y}_{ik} = 1$ if respondent *i* truly knows the correct answer to financial literacy question k (k=1,2,3),

$\tilde{y}_{ik} = 0$ otherwise.

We do not observe $\tilde{y}_{ik}$, but we do observe some proxies for this variable: let y_{ik}^m be the individual's *i* answer to literacy question *k* in May (superindex *m*). Notice that y_{ik}^m can take on the following three values: 0 (incorrect answer), 1 (correct answer), 2 (do not know/refusal). Since the July module does not allow for a "do not know" option, the variable y_{ik}^j (the answer to question *k* in July) can only take on the values 0 and 1. As previously noted, instead of the "do not know" option, the July module has a follow-up question to each financial literacy question that measures the level of confidence in the response on a Likert scale (from 1 to 7). The variable $conf_{ik}^j$ represents the answer to this question. Our goal is to use the information embodied in a vector of background characteristics x_i and in the variables y_{ik}^m, y_{ik}^j, and $conf_{ik}^j$ to predict the probability that a respondent truly knows the answer to financial literacy question *k*. In other words, for each respondent in our sample and for each of our three financial literacy questions, we want to compute the following conditional probability:

$$P(\tilde{y}_{ik} = 1 | y_{ik}^m, y_{ik}^j, x_i, conf_{ik}^j);\ k = 1,2,3. \qquad (1)$$

Second, we construct a summary measure of financial literacy by adding up the probabilities of having true knowledge for the three individual financial literacy questions:

$$finlit_i = \sum_{k=1}^{3} P(\tilde{y}_{ik} = 1 | y_{ik}^m, y_{ik}^j, x_i, conf_{ik}^j). \quad (2)$$

In the next subsection, we present a latent class model that can be used to predict the probability (see equation 1) that the respondent truly knows the answer to financial literacy question k ($k = 1,2,3$).

4.1 The latent class model

We define a random variable, g_{ik}, that summarizes the answers we observe in the May and July modules into all possible combinations of answers: $g_{ik} = 3 \cdot y_{ik}^j + y_{ik}^m$. In other words, the variable can take on six different values (from 0 to 5) depending on the combination of answers given in the modules. For example, $g_{ik} = 0$ if respondent *i* answers question *k* incorrectly in both modules, and $g_{ik} = 4$ if the respondent answers correctly in both modules. The log-likelihood of our LCM is based on the conditional multinomial density of g_{ik} : $P(g_{ik} = g | x_i, conf_{ik}^j)$. This conditional probability can be written as a weighted average of two multinomial probabilities $P(g_{ik} = g | \tilde{y}_{ik} = 1, x_i, conf_{ik}^j)$, i.e., the probability of observing answer pattern $g_{ik} = g$ given true knowledge ($\tilde{y}_{ik} = 1$), and $P(g_{ik} = g | \tilde{y}_{ik} = 0, x_i, conf_{ik}^j)$, i.e., the probability of observing answer pattern g_{ik} given a lack of true knowledge ($\tilde{y}_{ik} = 0$), where the probabilities for having or not having true knowledge, i.e. $P(\tilde{y}_{ik} = 1 | x_i, conf_{ik}^j)$ and $P(\tilde{y}_{ik} = 0 | x_i, conf_{ik}^j)$, serve as weights:

$$\begin{aligned} &P(g_{ik} = g | x_i, conf_{ik}^j) = P(g_{ik} = g, \tilde{y}_{ik} = 1 | x_i, conf_{ik}^j) + P(g_{ik} = g, \tilde{y}_{ik} = 0 | x_i, conf_{ik}^j) = \\ &P(g_{ik} = g | \tilde{y}_{ik} = 1, x_i, conf_{ik}^j) P(\tilde{y}_{ik} = 1 | x_i, conf_{ik}^j) + \\ &P(g_{ik} = g | \tilde{y}_{ik} = 0, x_i, conf_{ik}^j) P(\tilde{y}_{ik} = 0 | x_i, conf_{ik}^j) = \\ &\alpha_g^1(x_i, conf_{ik}^j) P(\tilde{y}_i = 1 | x_i, conf_{ik}^j) + \alpha_g^0(x_i, conf_{ik}^j) P(\tilde{y}_i = 0 | x_i, conf_{ik}^j) \end{aligned} \quad (3)$$

where the conditional multinomial probabilities are defined as

$$\alpha_g^1(x_i, conf_{ik}^j) = P(g_{ik} = g | \tilde{y}_{ik} = 1, x_i, conf_{ik}^j)$$

$$\alpha_g^0(x_i, conf_{ik}^j) = P(g_{ik} = g | \tilde{y}_{ik} = 0, x_i, conf_{ik}^j).$$

We assume that, conditional on background characteristics, x_i true knowledge is independent of confidence. This means

$$P\left(\tilde{y}_{ik} = 1 \middle| x_i, conf_{ik}^{j}\right) = P(\tilde{y}_{ik} = 1 | x_i). \quad (4)$$

In other words, only the answers g_{ik} are influenced by confidence, but whether a respondent truly knows the correct answer or not is independent of confidence. In addition, we assume that the probability in equation (4) can be modeled by means of a probit specification, so that the conditional probability that respondent *i* truly knows the answer to literacy question *k* is equal to

$$P(\tilde{y}_{ik} = 1 | x_i) = \Phi(x_i' \beta_k), \quad (5)$$

where $\Phi(.)$ denotes the cumulative distribution function of the standard normal distribution. We also assume that $\alpha_g^1\left(x_i, conf_{ik}^{j}\right) = \alpha_g^1\left(conf_{ik}^{j}\right)$ and $\alpha_g^0\left(x_i, conf_{ik}^{j}\right) = \alpha_g^0\left(conf_{ik}^{j}\right)$; thus, the observed answer pattern depends on true knowledge and confidence but not on any additional background characteristics. These two probabilities are modeled by using a multinomial logit specification ($I\left(conf_{ik}^{j} = l\right) = 1$ if $conf_{ik}^{j} = l$ and $I\left(conf_{ik}^{j} = l\right) = 0$ otherwise):[17]

$$\alpha_g^1\left(conf_{ik}^{j}; \gamma_k^1\right) = \frac{\exp\left(\sum_{l=1}^{7} \gamma_{kgl}^1 I(conf_{ik}^{j} = l)\right)}{\sum_{h=0}^{5} \exp\left(\sum_{l=1}^{7} \gamma_{khl}^1 I(conf_{ik}^{j} = l)\right)} \quad (6a)$$

$$\alpha_g^0\left(conf_{ik}^{j}; \gamma_k^0\right) = \frac{\exp\left(\sum_{l=1}^{7} \gamma_{kgl}^0 I(conf_{ik}^{j} = l)\right)}{\sum_{h=0}^{5} \exp\left(\sum_{l=1}^{7} \gamma_{khl}^0 I(conf_{ik}^{j} = l)\right)} \quad (6b)$$

Where $\gamma_k^1 = (\gamma_{k01}^1, \ldots, \gamma_{k07}^1, \ldots, \gamma_{k51}^1, \ldots, \gamma_{k57}^1)'$ and $\gamma_k^0 = (\gamma_{k01}^0, \ldots, \gamma_{k07}^0, \ldots, \gamma_{k51}^0, \ldots, \gamma_{k57}^0)'$. Assumptions (4), (5), and (6) imply that the density described in (3) can be rewritten as follows:

$$P\left(g_{ik} = g \middle| x_i, conf_{ik}^{j}\right) = \alpha_g^1\left(conf_{ik}^{j}; \gamma_k^1\right)\Phi(x_i' \beta_k) + \alpha_g^0\left(conf_{ik}^{j}; \gamma_k^0\right)\Phi(-x_i' \beta_k). \quad (7)$$

We base the log-likelihood function on the density function (7). Notice that there is an identification problem: the parameter vector $(\gamma_k^{1\prime}, \gamma_k^{0\prime}, \beta_k')'$ is observationally equivalent with

[17] We assume without loss of generality that $\gamma_{k4l}^1 = 0,\ l = 1, \ldots, 7$ (i.e., for the "$\tilde{y}_{ik} = 1$ multinomial logit model," the reference group consists of individuals who give a correct answer in both surveys, i.e., for which $y_{ik}^m = y_{ik}^j = 1$, i.e., $g = 1 \cdot 3 + 1 = 4$) and $\gamma_{k0l}^0 = 0, l = 1, \ldots, 7$ (for the "$\tilde{y}_{ik} = 0$ multinomial logit model," the reference group consists of individuals who give an incorrect answer in both surveys, i.e., for which $y_i^m = y_i^j = 0$, i.e. $g = 0 \cdot 3 + 0 = 0$).

$(\gamma_k^{0\prime}, \gamma_k^{1\prime}, -\beta_k{}')'$ in the sense that they both result in the same probability distribution of observable data.[18] We address this identification problem by making the following assumptions:

$$\alpha_0^1(conf_{ik}^j; \gamma_k^1) = P\left(g_{ik} = 0 \middle| \tilde{y}_{ik} = 1, conf_{ik}^j\right) = P\left(y_{ik}^m = 0, y_{ik}^j = 0 \middle| \tilde{y}_{ik} = 1, conf_{ik}^j\right) = 0 \quad (8a)$$

$$\alpha_1^1(conf_{ik}^j; \gamma_k^1) = P\left(g_{ik} = 1 \middle| \tilde{y}_{ik} = 1, conf_{ik}^j\right) = P\left(y_{ik}^m = 1, y_{ik}^j = 0 \middle| \tilde{y}_{ik} = 1, conf_{ik}^j\right) = 0 \quad (8b)$$

$$\alpha_2^1(conf_{ik}^j; \gamma_k^1) = P\left(g_{ik} = 2 \middle| \tilde{y}_{ik} = 1, conf_{ik}^j\right) = P\left(y_{ik}^m = 2, y_{ik}^j = 0 \middle| \tilde{y}_{ik} = 1, conf_{ik}^j\right) = 0 \quad (8c)$$

$$\alpha_3^1(conf_{ik}^j; \gamma_k^1) = P\left(g_{ik} = 3 \middle| \tilde{y}_{ik} = 1, conf_{ik}^j\right) = P\left(y_{ik}^m = 0, y_{ik}^j = 1 \middle| \tilde{y}_{ik} = 1, conf_{ik}^j\right) = 0 \quad (8d)$$

$$\alpha_4^0(conf_{ik}^j; \gamma_k^0) = P\left(g_{ik} = 4 \middle| \tilde{y}_{ik} = 0, conf_{ik}^j\right) = P\left(y_{ik}^m = 1, y_{ik}^j = 1 \middle| \tilde{y}_{ik} = 0, conf_{ik}^j\right) = 0 \quad (8e)$$

Intuitively, these assumptions can be explained in the following way: First, regardless of the confidence level, if a respondent truly knows the answer to a financial literacy question, he/she will not pick a wrong answer twice (see equation 8a). Second, conditional on true knowledge, respondents will answer consistently in both modules, i.e., they will not answer correctly in May and incorrectly in July or vice versa (see equation 8b and 8d). Moreover, we exclude the possibility that individuals with true knowledge would pick a "do not know" response in May and answer incorrectly in July (see equation 8c). Thus, given true knowledge, the only possible answer patterns are to provide the correct answer twice or "do not know" in May and the correct answer in July. In other words, respondents who are truly knowledgeable do not randomly pick an answer or make mistakes.

The assumption in equation (8e) refers to the structure we impose conditional on the lack of knowledge. Here we impose that given that the respondent does not know the answer, the probability of guessing the correct answer twice (in May and July) is zero.[19] The estimation results of the LCM (see equation 7) are presented in appendix A.4.

4.2 A summary estimate for respondent's financial literacy based on the LCM

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[18] Notice that according to equation (6a) $\alpha_0^1\left(conf_{ik}^j; \gamma_k^1\right) = \frac{\exp\left(\sum_{l=1}^{7} \gamma_{k0l}^1 I(conf_{ik}^j = l)\right)}{\sum_{h=0}^{5} \exp\left(\sum_{l=1}^{7} \gamma_{khl}^1 I(conf_{ik}^j = l)\right)}$. Since the reference group consists of individuals for which $g_{ik} = 4$, we can impose the condition $P\left(g_{ik} = 0 \middle| \tilde{y}_i = 1, conf_{ik}^j\right) = 0$ (see equation 8a) a priori by assigning the parameters γ_{k0l}^1 $(l = 1, \ldots, 7)$ a very small value. In the empirical application, we impose the following restriction: $\gamma_{\mathrm{0kl}}^1 = -22$. Assumptions mentioned in equations (8b),…,(8e) are imposed in an analogous way.

[19] For an intuitive explanation of this assumption, recall that all respondents have the opportunity to choose the "do not know" option in the May module. Our assumption implies that individuals with low confidence who do not know the answer ($\tilde{y}_{ik} = 0$) will choose the "do not know" option when it is available rather than randomly choosing an answer. Individuals with high confidence who do not know the correct answer ($\tilde{y}_{ik} = 0$) will not randomly pick an answer either.

Once we have estimated the parameters, we can compute for each financial literacy question the probability $P\left(\tilde{y}_{ik}=1\middle|g_{ik}=g,x_i,conf_{ik}^{j}\right)$ (see equation 1) as follows (Vermunt 2010):

$$P\left(\tilde{y}_{ik}=1\middle|g_{ik}=g,x_i,conf_{ik}^{j}\right)$$
$$=\frac{P\left(g_{ik}=g\middle|\tilde{y}_{ik}=1,x_i,conf_{ik}^{j}\right)P(\tilde{y}_{ik}=1|x_i)}{P\left(g_{ik}=g\middle|\tilde{y}_{ik}=1,x_i,conf_{ik}^{j}\right)P(\tilde{y}_{ik}=1|x_i)+P\left(g_{ik}=g\middle|\tilde{y}_{ik}=0,x_i,conf_{ik}^{j}\right)P(\tilde{y}_{ik}=0|x_i)}$$
$$=\frac{\alpha_g^1\left(conf_{ik}^{j};\gamma_k^1\right)\Phi(x_i'\beta_k)}{\alpha_g^1\left(conf_{ik}^{j};\gamma_k^1\right)\Phi(x_i'\beta_k)+\alpha_g^0\left(conf_{ik}^{j};\gamma_k^0\right)\Phi(-x_i'\beta_k)} \quad (9)$$

Note that this probability can be thought of as the posterior probability of having true knowledge (our latent variable), which results after updating the prior probability using additional information from the two surveys (Bayes' rule).

Thus, for each respondent, we predict the probability of truly knowing the correct answer to a given financial literacy question. This probability depends on the responses given in the May and July modules (i.e. $g_{ik}=g$) and on the respondent's reported level of confidence in the July module. The higher the estimated posterior probability, the more knowledge the individual has. Notice that the posterior distribution of $\tilde{y}_{ik}$ is degenerate if the following conditions are met:

$$P\left(\tilde{y}_{ik}=1\middle|g_{ik}=g,x_i,conf_{ik}^{j}\right)=1 \text{ if } \alpha_g^0\left(conf_{ik}^{j};\gamma_k^0\right)=0$$
$$P\left(\tilde{y}_{ik}=1\middle|g_{ik}=g,x_i,conf_{ik}^{j}\right)=0 \text{ if } \alpha_g^1\left(conf_{ik}^{j};\gamma_k^1\right)=0$$

Due to the assumptions (see equations 8a to 8e) presented in the previous subsection, the posterior distribution of $\tilde{y}_{ik}$ is degenerate in many cases: that is, $\tilde{y}_{ik}=0$ with certainty if (a) respondents answer inconsistently over time (once correctly, once incorrectly), (b) answer incorrectly two times, or (c) pick the "do not know" answer in the May module and an incorrect answer in the July module. The respondent truly knows the correct answer ($\tilde{y}_{ik}=1$) with certainty if he/she answers the literacy questions correctly two times (irrespective of the confidence level). For respondents who provide a "do not know" answer in the May module and a correct answer in the July module, the LCM is used to predict the probability of true knowledge, $P\left(\tilde{y}_{ik}=1\middle|g_{ik}=5,x_i,conf_{ik}^{j}\right)$, which could take on a value between 0 and 1 (see equation 9 and table A.4 in the appendix). In section 6, we will argue that it is only these respondents who are "underconfident" because they likely have knowledge ($P\left(\tilde{y}_{ik}=1\middle|g_{ik}=5,x_i,conf_{ik}^{j}\right)>0$) yet have selected the "do not know" response option.

Figure A.1 in the appendix displays the distribution of our estimated (posterior) probabilities of true knowledge for each of the three questions. The probability of truly knowing the answer to the interest question is 0 for 12.4% of respondents and 1 for 87.6%; we do not observe probabilities between 0 and 1. The probability of truly knowing the answer to the inflation question is 0 for 13.1% of the sample and 1 for 85.2% of the sample; 1.7% of respondents have values in between. The probability of truly knowing the answer to the risk diversification question is 0 for 28.9% of respondents and 1 for 44.4%; 26.7% are assigned probabilities between 0 and 1. These are reasonable findings considering that the first two questions are rather simple and intuitive while the third question is, by design, more difficult.

We compute a measure of respondents' level of financial literacy by summing up the estimated probabilities for each question (see equations 2 and 9). Unlike current financial literacy indicators, which simply sum up the number of correct answers (giving a value of 1 to the correct answers and 0 to the incorrect answers or "do not know" responses), this new measure recognizes that respondents who select the "do not know" option may actually know the answer. Moreover, using consistency in answering behavior over time, our measure is able to filter out respondents without knowledge who simply guess and so are more likely to provide a correct answer once in a single survey than to provide a correct answer in both surveys. In the next section, we will compare the overall financial literacy measures for individual respondents based on the observed total number of correct answers in the May and July modules and the results from the LCM. We will then use our new measure of financial literacy to estimate the relationship between stock market participation and financial literacy and compare it with estimates using traditional measures of financial literacy.

5. Estimation results

5.1 Comparing measures of financial literacy

We present our measures of financial literacy in table 4. The comparison of panel A for the May measure and panel B for the July measure was discussed extensively in Section 3.

[Table 4 –about here]

In panel C, we present our measure of true financial literacy based upon the LCM described in the previous section (see equation 2). Since the standard way of measuring financial literacy includes the DK option, we compare the May measure to the LCM results. The average probability of a correct answer to the interest question is slightly lower in the LCM (87.6%)

than in the May survey module (88.6%), which indicates that for the interest question, there is some (correct) guessing even when the DK option is available. The pattern is reversed for the other two questions. According to the LCM, the average probability that respondents truly know the answer to the inflation question is 86.3%, while only 85.8% of respondents correctly answered this question in the May module. The average probability that respondents truly know the answer to the risk diversification question is 64%, while only about half of respondents gave a correct answer to this question in the May module. The average value of true financial literacy is 2.38, which is slightly above the May measure of 2.24.

We also display the gender gap in financial literacy based on the May module and the LCM. When considering true knowledge, the gender gap is smaller for all three financial literacy questions. Specifically, while the gender gap indicated by correct answers to the standard interest (inflation / risk) question is 7.5 (9.2 / 27.5) percentage points, the estimated difference in true knowledge is 5.7 (8.8 / 13.8) percentage points, respectively. Thus, when interpreting gender differences in financial literacy based on responses to the standard set of questions, which include the DK option, one has to bear in mind that women are more likely to select the "do not know" option, making their financial literacy levels appear lower than men's.

To further investigate the financial literacy measures, we run ordinary least squares regressions to show the relationship between the different financial literacy measures and gender. Table 5, panel A, shows the results. The financial literacy gender gap excluding controls is 0.44 for the May measure and 0.28 for the LCM. Thus, the gender gap in true knowledge predicted by the latent class model is smaller than the gender gap that is identified based on responses to the standard questions. In other words, more than one-third (0.44-0.28/0.44=0.36) of the financial literacy gender gap identified in the May module can be attributed to differences in response behavior and to confidence.

[Table 5 –about here]

Next, we include background variables to explain the variation in the financial literacy measures (table 5 panel B); specifically, we control for education, marital status, income, and age. The R^2 of the regressions is 0.164 for the May measure and 0.152 for the LCM measure. For all measures of literacy, we still find that women score worse than men. However, not surprisingly, the gender difference becomes smaller when including socio-demographic variables; for example, women on average have lower education and income. All other controls show the

usual patterns reported in the literature.[20] However, our main findings are similar to the univariate estimates: around 38% of the gender difference can be explained by differences in confidence rather than differences in knowledge.

We performed an extensive set of robustness checks. Specifically, we estimate the LCM using different specifications: alternative sets of financial literacy questions, added measures of interest in finance, and restricted the sample to financial respondents, i.e., those responsible for making financial decisions in the households. Overall, our results are robust to these different specifications (see appendix A.6 for further details).

5.2 Financial literacy and stock market participation

It is important to measure financial literacy correctly because many studies have shown that financial literacy can be linked to financial behavior (see Lusardi and Mitchell 2014 for a review). We focus next on stock market participation, given our interest in initiatives such as *Fearless Girl*, and because of the importance of investment and portfolio choice, in particular now that individuals are more in charge of their retirement savings. We assess whether and the extent to which the measures of financial literacy we have developed lead to different findings regarding the effect of financial literacy on stock market participation. Traditional measures of financial literacy have shown that higher financial knowledge increases stock market participation (see Lusardi and Mitchell 2014 for a review and Van Rooij et al. 2011 for evidence on Dutch data). However, the evidence in this paper shows that those measures reflect both true knowledge and confidence. Therefore, the estimates found in previous studies reflect a mix of both.

Below, we investigate what the use of different financial literacy measures say about the relationship between financial literacy and stock market participation. The objective is to check how our different measures of financial literacy perform in these estimations and what we can learn about the potential bias plaguing these estimates. First, we run a regression using the standard measure of financial literacy (May measure) and thereafter we compare the results with regressions based on the LCM financial literacy measure. In discussing the results, we focus on the financial literacy coefficient estimate as well as the gender coefficient estimate, as both are likely to be impacted, as explained below.

[20] Full regression results are available upon request.

Following the example of previous studies, we define a dummy for stock market participation that equals 1 if the respondent holds investments in stocks and/or mutual funds and 0 otherwise. As reported in table 6, there is a strong negative correlation between gender and stock market participation: 33.9% of men in our sample own stocks versus 20.3% of women (table 6, column 1). If we control for the usual background characteristics and the traditional financial literacy measure (the May measure), we find a strong positive relationship between financial literacy and stock market participation.[21] While the gender effect becomes much smaller than in column 1, it is still significant (column 2). Compared to men, women have a 4.61 percentage point lower chance of owning stocks after controlling for a set of background variables, including income, education, etc. Moreover, a one standard deviation higher level of financial literacy results in a 9.01 percentage point higher probability of owning stocks (comparable to the effect found in the literature). This is a sizeable effect, but note that this coefficient estimate reflects both confidence and knowledge.

[Table 6 – Stock market participation - about here]

Next, we run a regression using the financial literacy measure from the July module, which should be unconfounded by confidence (column 3). While still significant, the financial literacy effect reduces to a 5.49 percentage point higher likelihood of investing in the stock market for a one standard deviation higher level of literacy. Note that the female coefficient estimate becomes more negative compared to the estimate in column 2, because it is now likely to pick up part of the confidence effect; being less confident, women are less likely to invest in stocks. The July measure for financial literacy is affected by measurement error due to guessing since respondents are forced to pick an answer. As a result, the financial literacy coefficient may be biased toward zero. Indeed, once we use the predicted measure of true financial literacy, the financial literacy coefficient is somewhat higher (column 4). We estimate a 6.72 percentage point higher likelihood of investing in the stock market for a one standard deviation higher level of true financial literacy, and a smaller effect of being female. In other words, both the estimates for the effect of financial literacy and the effect of gender are impacted by the financial literacy measures used in the estimation.

Note that measurement error in financial literacy may not be the only problem biasing the estimation results for the effect of financial literacy on stock market behavior. The regression

[21] The financial literacy variables are standardized so that they have mean 0 and variance 1, which facilitates the comparison of the regression results across specifications.

estimates could also be biased due to omitted variables (e.g., ability) and reverse causality (e.g., knowledge may increase due to investing in the stock market). Therefore, in many studies researchers also report results from instrumental variables (IV) regressions (see, e.g., Van Rooij et al. 2011). We discuss the use of IV estimation in section 7.

6. Confidence

An additional question we investigate is whether we can get an estimate of the degree of confidence and whether confidence matters for financial decisions. More specifically, we are interested in the role of underconfidence. By *underconfidence*, we mean that respondents can be financially literate, i.e., they may know the answers to the financial literacy questions even though they respond by selecting the "do not know" option. Thus, we assume that underconfidence is present only among those who respond to questions in the May module with "do not know" ($y_{ik}^{m} = 2$) and answer the July questions correctly ($y_{ik}^{j} = 1$), i.e. $g_{ik} = 5$. Those respondents are underconfident if they truly know the correct answer to question *k* and respond with "do not know" nevertheless. The probability of this event might be positive and equal to $P(\tilde{y}_{ik} = 1 | g_{ik} = 5, x_i, conf_{ik}^{j})$.

People who responded with "do not know" in May but an incorrect answer in July ($y_{ik}^{j} = 0$) cannot be underconfident according to our LCM model because we have assumed that

$$P(g_{ik} = 2 | \tilde{y}_{ik} = 1, conf_{ik}^{j}) = P(y_{ik}^{m} = 2, y_{ik}^{j} = 0 | \tilde{y}_{ik} = 1, conf_{ik}^{j}) = 0$$

(see assumptions in Section 4.1). Consequently, those respondents (a) cannot be financially knowledgeable, i.e., $P(\tilde{y}_{ik} = 0 | g_{ik} = 2, x_i, conf_{ik}^{j}) = 1$ and (b) cannot be underconfident.

According to our definition, those who do not choose a "do not know" response in May do not face the problem of underconfidence, i.e., the underconfidence measure is equal to zero for those respondents. Thus, the underconfidence measure relates to the probability of true knowledge conditional on a "do not know" response in May and a correct answer in July.

As before, we compute an overall measure of underconfidence for our respondents by summing up the estimated probabilities for the individual questions

$$\text{Und\_conf} = \sum_{k=1}^{3} P(\tilde{y}_{ik} = 1 | g_{ik} = 5, x_i, conf_{ik}^{j}) \cdot I(g_{ik} = 5)$$

where $I(.)$ denotes an indicator function that is 1 if $g_{ik} = 5$ and 0 otherwise (as before *k* is an index for question *k*, *k*=1,2,3).[22]

In table 7, we show the mean probability of being underconfident for women and men. According to our measures, there are more underconfident women than men for all questions. The fraction of underconfident women and men is higher for the more difficult questions, i.e., the risk diversification question. Overall, average underconfidence is equal to 0.187 for men and 0.365 for women. When we run regressions on underconfidence (see table 5, column 4), the gender difference in underconfidence is between 0.178 and 0.154.

[Table 7 –about here]

In the next step, we include underconfidence as an additional explanatory variable in the stock market regression (see table 8, column 2); for ease of comparison we also report the results from the regression of financial literacy on stock market participation using true financial literacy (column 1) and the May measure of financial literacy (column 3). All variables are standardized so that their point estimates can be compared. Controlling for true financial literacy and consistent with the idea behind the *Fearless Girl* initiative, stock market participation is lower for underconfident respondents. Interestingly, when including underconfidence as an additional control variable, its estimated effect has about the same order of magnitude as the effect of true financial literacy and the financial literacy estimate is almost unaffected (see the estimates in table 8, columns 1 and 2). According to Hayashi (2000), in case of an omitted variable, the difference in the estimated coefficients of a variable of interest (in our case financial literacy) and the omitted variable (here underconfidence) is low if either the coefficient of the omitted variable is small or if the correlation between the variable of interest and the omitted variable is low (see section 3.9 in Hayashi 2000). The estimated coefficient of underconfidence is not small. However, underconfidence is almost uncorrelated with true financial literacy estimated from the LCM (correlation coefficient of -0.0085).

[Table 8 – Stock market participation and underconfidence - about here]

Turning to the gender effect, the estimate becomes almost 30% smaller in column 2 compared to column 1. The reason for this is that underconfidence and gender are highly correlated. In a

[22] We used a more restrictive definition of underconfidence by imposing that respondents report confidence levels below the threshold level 6. This reduces the share of underconfident respondents slightly, but does not change our conclusions.

regression of underconfidence on gender, financial literacy and various control variables, gender turns out to be the most important explanatory variable.[23] Comparing the size of the gender effect between columns 2 and 3 reveals that the gender effect, when controlling for true financial literacy and underconfidence, has about the same order of magnitude as the gender effect in the regression when controlling for the May financial literacy measure (column 3). In summary, the regression results show that it is important to control for both financial literacy and confidence when explaining stock market participation.

The finding that both financial knowledge and underconfidence in financial knowledge matter for financial behavior has important consequences not only for measuring financial literacy but also for financial education interventions, as discussed in the next sections.

7. IV estimation and making use of the "do not know" answers

Researchers have often used instrumental variables estimation when assessing the effect of financial literacy on financial decisions. This is necessary not only due to measurement error but also because of potentially omitted variables, such as ability. There can also be the problem of reverse causality. Financial literacy can itself be endogenous and dependent on wealth, including stock market wealth (see Lusardi, Michaud, and Mitchell 2017). In order to address these concerns, we have re-estimated all of our models, considered in table 6, using the Generalized Method of Moments (GMM). The details are reported in appendix A.5, which also described the instruments we have used in previous work. The GMM estimate of the literacy coefficient is statistically significant at the 5% level and relatively similar across specifications (around 0.20). This is a comforting result and differences between literacy measures become less important when good instruments are available. However, one big challenge of this literature is to find good instruments. The central outcome of our exercise is that finding strong instruments is easier for more accurate measures of financial literacy. The predictive value of the instruments is lowest for the July measure, which translates into a less precise GMM estimate for the financial literacy coefficient and a higher standard error.[24] Thus, while instrumenting financial literacy can address some of the problems noted in this paper, it is notoriously difficult to find good instruments. Our paper provides an additional explanation for why instruments are hard to find and how we can better address the measurement error problem.

[23] These additional regressions are available upon request.

[24] We interpret this as a sign that the July measure contains considerable measurement error, which makes it difficult to find valid instruments.

As should be clear by now, properly measuring financial literacy is difficult. Hereafter, we propose a simple way to proxy for confidence when having two measurements of financial literacy (as we do) is not feasible. We have documented that "do not know" responses and underconfidence are highly correlated. Accordingly, in table 8, column 4, we regress stock market participation on the May measure of financial literacy (which is the measure commonly available in most surveys) and the number of "do not know" responses to the three financial literacy questions. The point estimate of the May financial literacy measure is now rather close to the point estimate when using true financial literacy in the regression (compare column 1 with column 4). Moreover, the point estimate of the female dummy is similar to the point estimate in column 2, where we accounted for underconfidence. Thus, controlling for the number of "do not know" responses can fix the problem caused by not controlling for underconfidence explicitly. However, note that the number of "do not know" responses is an imperfect proxy for underconfidence, i.e., the point estimate is biased toward zero and insignificant in the regression reported in column 4. Thus, while using this proxy does not provide a good estimate of underconfidence, it does help to get a better estimate of the effect of financial literacy.[25]

Based on these findings, contrary to what has been done so far in most studies, we recommend taking advantage of the "do not know" responses in financial literacy surveys and using that information when investigating the relationship between financial literacy and financial decision making; i.e., use information on both the correct answers and the "do not know" answers in the empirical work.

8. Discussion and conclusion

The central result of our paper is that when it comes to financial literacy, women know less than men, but they know more than they think they know. When measured using the standard Big Three financial literacy questions, which have been used extensively in the literature, more than one-third of the gender gap in financial knowledge can be attributed to differences in confidence and the remainder to true knowledge differences. Crucially, the analysis of stock

[25] Note that, as an alternative short cut, we also estimated a model using the July measure and an aggregate measure of confidence (on a scale from 1 to 7), as implemented in the July survey. It turns out that the coefficient of the July measure is downward biased because of measurement error due to guessing, even if we control for confidence. Results are available upon request.

market participation shows that both financial literacy and confidence matter for financial decision making and that it is important to distinguish these two effects.

In our methodological framework, we provide a way to estimate both true knowledge and confidence. We find that differences in response behavior have a direct impact on the measurement of financial literacy and thereby on how results have to be interpreted. In our setting, this applies to several dimensions: the observed gender difference in financial literacy, the effect of gender on stock market participation, and the effects of financial literacy and underconfidence, respectively, on stock market participation.

Disentangling the effects of confidence and knowledge matters greatly for policy. First and foremost, our paper shows that there is a substantial gender gap in financial knowledge even after correcting for differences in confidence. Thus, financial education programs are necessary, and programs targeted to women may provide a way to close the knowledge gap (see Driva et al. 2016, and Bottazzi and Lusardi, 2020). [26]

Second, boosting knowledge might not be enough to close the financial literacy gender gap if differences in confidence persist between women and men. Filippin and Paccagnella (2012) develop a theoretical model and show that confidence plays an important role in the accumulation of human capital. Small initial differences in confidence, such as those related to gender, can result in large differences in human capital accumulation. The same argument applies to the accumulation of financial literacy and wealth. Small initial differences in confidence might lead to large differences in accumulated financial literacy and financial well-being. Particularly in the context of long-term financial decisions such as investment, retirement savings plans, private saving, and wealth accumulation, lower levels of confidence can be detrimental to women. And the effect may be exacerbated because women, on average, have a substantially longer life expectancy than men.

From this point of view, it seems crucial to support individuals not only in acquiring financial knowledge but also in instilling confidence in their knowledge. An interesting example in this context is the paper by Jha and Shayo (2020) who study a stock market trading experiment. They show that gathering experience while trading stocks with modest stakes (of about $50) for about four weeks increases women's financial literacy, confidence, and subsequent stock

[26] For recent evidence on the effectiveness of financial education, see Frisancho (2020), Lührmann et al. (2018), and Kaiser et al. (2020).

market participation. Thus, closing the gender gap in stock market participation involves both building knowledge and confidence. The statue of the *Fearless Girl* symbolizes this idea very clearly and getting this right matters tremendously; the hope is that a fearless girl will grow into a fearless woman. More research is needed to know what can be done to make women not only more knowledgeable but also more fearless when it comes to finance. This might be an important step in lowering the documented gender inequality in financial literacy, wealth accumulation, and financial inclusion, including access to formal credit and high-quality financial advice.

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Figures and Tables

Table 1: Answers to the financial literacy questions in the two modules

	May module			July module		
A. Interest question:						
	Men	Women	All	Men	Women	All
More than 102 euro	91.9	84.4	88.6	94.7	91.2	93.2
Exactly 102 euro	3.0	4.0	3.5	3.7	6.0	4.7
Less than 102 euro	2.0	3.9	2.8	1.6	2.8	2.2
Do not know	2.8	6.7	4.5	-	-	-
Refuse	0.4	1.0	0.7	-	-	-
Total	100	100	100	100	100	100
B. Inflation question:						
	Men	Women	All	Men	Women	All
More	2.1	2.4	2.2	2.2	2.7	2.4
Exactly the same	3.3	5.4	4.2	4.1	9.8	6.6
Less	89.8	80.6	85.8	93.7	87.5	91.0
Do not know	4.7	10.7	7.3	-	-	-
Refuse	0.2	0.9	0.5	-	-	-
Total	100	100	100	100	100	100
C. Risk Diversification question:						
	Men	Women	All	Men	Women	All
Incorrect ‘right’	7.6	9.7	8.5	17.7	27.0	21.7
Correct ‘false’	61.9	34.4	49.9	82.4	73.0	78.3
Do not know	30.1	54.7	40.9	-	-	-
Refuse	0.5	1.2	0.8	-	-	-
Total	100	100	100	100	100	100
D. No. of correct answers:						
	Men	Women	All	Men	Women	All
0	3.6	6.6	4.9	0.5	0.8	0.6
1	7.3	16.8	11.5	3.3	6.9	4.8
2	31.0	47.2	38.1	21.4	32.3	26.2
3	58.1	29.4	45.5	74.9	60.1	68.4

Note: Data from the DNB Household Panel. Surveys on financial literacy were fielded in May and July 2012. In the July module, the “do not know” option was not offered. We report percentages of total number of respondents. Number of observations: Men: 861, Women: 671, Total: 1,532.

Table 2: Answers in the July module conditional on answers in the May module

	Men			Women		
May module	incorrect	correct	do not know	incorrect	correct	do not know
July module						
A. Interest question:						
Incorrect	23.3	3.5	29.6	28.3	5.0	30.8
Correct	76.7	96.5	70.4	71.7	95.0	69.2
Total	100	100	100	100	100	100
B. Inflation question:						
Incorrect	41.3	2.7	33.3	30.8	7.0	38.5
Correct	58.7	97.3	66.7	69.2	93.0	61.5
Total	100	100	100	100	100	100
C. Risk Diversification question:						
Incorrect	38.5	10.3	27.4	47.7	12.6	32.3
Correct	61.5	89.7	72.6	52.3	87.4	67.7
Total	100	100	100	100	100	100

Note: Data from the DNB Household Panel. Surveys on financial literacy were fielded in May and July 2012. In the July module, the "do not know" option was not offered. We report the percentage of correct and incorrect answers given in the July module depending on the responses given in the May module for each of the financial literacy questions. Number of observations: Men: 861, Women: 671, Total: 1,532.

Table 3: Confidence in financial literacy

	ALL			MEN			WOMEN		
	N	mean	sd	N	mean	sd	N	mean	sd
Interest									
Overall confidence	1532	6.34	1.35	861	6.52	1.24	671	6.11	1.44
Cond. on incorrect	96	5.45	1.74	43	5.47	1.86	53	5.43	1.66
Cond. on correct	1357	6.52	1.15	791	6.64	1.11	566	6.35	1.19
Cond. on "do not know"	79	4.39	1.88	27	4.81	1.62	52	4.17	1.98
Inflation									
Overall confidence	1532	5.97	1.58	861	6.34	1.36	671	5.49	1.72
Cond. on incorrect	98	4.87	1.91	46	4.96	1.99	52	4.79	1.86
Cond. on correct	1314	6.25	1.34	773	6.53	1.15	541	5.84	1.49
Cond. on "do not know"	120	3.83	1.69	42	4.33	1.56	78	3.56	1.70
Risk diversification									
Overall confidence	1532	4.82	1.73	861	5.33	1.60	671	4.15	1.66
Cond. on incorrect	130	4.85	1.48	65	5.34	1.31	65	4.35	1.48
Cond. on correct	764	5.55	1.47	533	5.84	1.35	231	4.90	1.53
Cond. on "do not know"	638	3.93	1.64	263	4.31	1.63	375	3.66	1.60

Note: Data from the DNB Household Panel. Respondents report confidence levels on a Likert scale from 1 to 7 after each question in the July module. We report the overall confidence levels for each question and confidence conditional on the answers given in the May module for each of the financial literacy questions. Number of observations: Men: 861, Women: 671, Total: 1,532.

Table 4: Share of correct answers and average number of correct answers for alternative financial literacy measures

	Men	Women	Gender Difference (Men-Women)	Total
Panel A: May measure				
Interest	91.9	84.4	7.5	88.6
Inflation	89.8	80.6	9.2	85.8
Risk	61.9	34.4	27.5	49.9
Financial literacy measure	2.44	1.99	0.45	2.24
Panel B: July measure				
Interest	94.7	91.2	3.5	93.2
Inflation	93.7	87.5	6.2	91
Risk	82.4	73	9.4	78.3
Financial literacy measure	2.71	2.52	0.19	2.62
Panel C: "true" financial literacy				
Interest	90.1	84.4	5.7	87.6
Inflation	90.2	81.3	8.8	86.3
Risk	69.9	56.0	13.8	63.8
Financial literacy measure	2.50	2.22	0.28	2.38

Note: In panels A and B, financial literacy refers to the observed percentage of respondents who answered a specific question correctly. The financial literacy measure refers to the sum of the correctly answered questions. In panel C, the probabilities of giving a correct answer are estimated from our latent class model. The gender difference is the difference between the averages of men and women. Number of observations: Men: 861, Women: 671, Total: 1,532.

Table 5: OLS regression financial literacy

	(1)	(2)	(3)	(4)
VARIABLES	May	July	True Financial Literacy	Underconfidence
Panel A: Only controlling for gender				
Female	-0.442***	-0.190***	-0.284***	0.178***
	(0.0386)	(0.0291)	(0.0352)	(0.0249)
R-squared	0.068	0.024	0.036	0.033
Adjusted R^2	0.067	0.024	0.035	0.032
Panel B: Controlling for marital status, age, education, income				
Female	-0.361***	-0.147***	-0.225***	0.154***
	(0.0394)	(0.0301)	(0.0362)	(0.0258)
R-squared	0.164	0.103	0.152	0.0538
Adjusted R^2	0.156	0.094	0.143	0.044

Note: Results from OLS regressions in which the dependent variable is the number of correctly answered financial literacy questions in the May module (column 1), in the July module (column 2), and estimated from the latent class model (column 3). In column 4 the dependent variable is a measure for underconfidence. In panel A, we include only gender as an explanatory variable. In panel B we add controls for marital status, age, education and income. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Number of observations: 1,532. The full regressions are available upon request.

Table 6: OLS regression stock market participation

VARIABLES	(1)	(2) May	(3) July	(4) True Financial Literacy
Financial literacy		0.0901***	0.0549***	0.0672***
		(0.0105)	(0.0097)	(0.0101)
Female	-0.136***	-0.0461**	-0.0715***	-0.0646***
	(0.0207)	(0.0212)	(0.0213)	(0.0213)
Constant	0.339***	0.143*	0.101	0.112
	(0.0161)	(0.0753)	(0.0731)	(0.0741)
Controls	-	x	x	x
Observations	1,532	1,532	1,532	1,532
R-squared	0.023	0.147	0.126	0.132
Adjusted R^2	0.0221	0.137	0.117	0.122

Note: Results from OLS regressions in which the dependent variable is a dummy for stock market participation. In column (1) we control only for gender. In columns (2) to (4) we add financial literacy measures and controls for marital status, age, education, and income. The financial literacy measures in models (2), (3), and (4) differ; we normalize them by subtracting the mean and dividing them by the standard deviation. We use the number of correct answers to the three financial literacy questions in May (column 2), in July (column 3), and estimated from the latent class model (column 4). Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Number of observations: 1,532.

Table 7: The share of underconfident respondents and the average underconfidence score by gender

	Underconfidence		
	Men	Women	Total
Interest question	0.015	0.042	0.027
Inflation question	0.028	0.064	0.044
Risk question	0.144	0.259	0.194
Underconfidence score	0.187	0.365	0.265

The probabilities of being underconfident is estimated from the LCM; the measure is defined according to $\sum_{k=1}^{3} P(\tilde{y}_{ik} = 1 | g_{ik} = 5, x_i, conf_{ik}^{j}) \cdot I(g_{ik} = 5)$. Number of observations: 1,532.

Table 8: Explaining stock market participation

	(1)	(2)	(3)	(4)
VARIABLES	True Financial Literacy		May	
"True" Financial Literacy	0.0672***	0.0707***		
	(0.0101)	(0.0100)		
Underconfidence		-0.0621***		
		(0.00940)		
Financial Literacy (May)			0.0901***	0.0666***
			(0.0105)	(0.0187)
DK (May)				-0.0279
				(0.0170)
Female	-0.0646***	-0.0440**	-0.0461**	-0.0443**
	(0.0213)	(0.0212)	(0.0212)	(0.0213)
Observations	1,532	1,532	1,532	1,532
R-squared	0.132	0.150	0.147	0.148
Adjusted R^2	0.122	0.140	0.137	0.138

Note: Results from OLS regressions in which the dependent variable is a dummy for stock market participation. Additional controls for marital status, age, education, and income are included. The financial literacy measures and underconfidence measure in columns (1) and (2) are based on the latent class model. The financial literacy measures and the DK measure in columns (3) and (4) are based on the May module. We normalize the financial literacy measures, underconfidence, and the DK variable by subtracting the mean and dividing them by the standard deviation. Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. Number of observations: 1,532.

APPENDIX

A.1 Financial literacy questions

1. Set Up May Module (2012):

1. **Interest question:** *Suppose you had €100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow? More than €102* / Exactly €102 / Less than €102 / Do not know/ Refuse to answer*

2. **Inflation question:** *Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account? More than today / Exactly the same / Less than today* / Do not know / Refuse to answer*

3. **Risk question:** *Please tell me whether this statement is true or false. "Buying a single company's stock usually provides a safer return than a stock mutual fund." True / False* / Do not know / Refuse to answer*

** indicates the correct answer.*

2. Set Up July Module (2012):

Questions 1 to 3 without the "do not know" and "refuse to answer" options

After each question – **Confidence question**: *On a scale from 1 to 7, how confident are you in this answer? 1—not confident at all ... 7—completely confident*

A.2 Summary statistics

Table A.1: Sample statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
How much of high school education devoted to economics? (ref: not applicable, hardly at all)					
little, some, a lot	1,532	0.727	0.446	0	1
Don't know/refuse	1,532	0.038	0.191	0	1
Economics in high school exam? 1=yes	1,532	0.416	0.493	0	1
Female	1,532	0.438	0.496	0	1
Marital status (ref. group: single)					
married, no child	1,532	0.495	0.500	0	1
married, child	1,532	0.255	0.436	0	1
single parent, other	1,532	0.043	0.203	0	1
Age_class (ref. group: <=35)					
36-50	1,532	0.249	0.432	0	1
51-65	1,532	0.401	0.490	0	1
65 and older	1,532	0.299	0.458	0	1
Education level (ref. primary education)					
Preparatory intermediate vocational	1,532	0.277	0.448	0	1
Intermediate vocational	1,532	0.157	0.364	0	1
Secondary pre-university	1,532	0.125	0.330	0	1
Higher vocational	1,532	0.258	0.438	0	1
University	1,532	0.138	0.345	0	1
Monthly net household income in Euros (ref. <1902)					
1902<x~2600	1,532	0.250	0.433	0	1
2600<x~3471	1,532	0.245	0.430	0	1
x>3471	1,532	0.247	0.431	0	1
refuse/dk	1,532	0.011	0.105	0	1

A.3 Attrition and learning effects

Table A.2: Test for sample attrition and learning effects

Panel A: Regression of gender and financial literacy in the May module on participation

	(1) Gender	(2) Interest	(3) Inflation	(4) Risk	(5) Financial Literacy	(6) Financial Literacy
	All	All	All	All	All	All
Participation in May only	0.05	0.01	-0.03	-0.02	-0.04	-0.05
	(0.031)	(0.023)	(0.029)	(0.037)	(0.064)	(0.058)
Constant	0.44***	0.89***	0.86***	0.50***	2.24***	2.25***
	(0.010)	(0.009)	(0.010)	(0.013)	(0.023)	(0.322)
Controls	-	-	-	-	-	X
Observations	1,753	1,753	1,753	1,753	1,753	1,753
R-squared	0.001	0.000	0.001	0.000	0.000	0.152

Panel B: Regression of financial literacy in the July module on first or second time of participation

	(1) Interest	(2) Inflation	(3) Risk	(4) Financial Literacy	(5) Financial Literacy	(6) Financial Literacy
	All	All	All	All	Men	Women
Participation in July only	0.01	0.01	-0.02	0.00	-0.00	0.04
	(0.013)	(0.015)	(0.023)	(0.031)	(0.041)	(0.049)
Constant	0.93***	0.91***	0.78***	2.62***	2.71***	2.52***
	(0.007)	(0.008)	(0.011)	(0.017)	(0.019)	(0.025)
Observations	1,977	1,977	1,977	1,977	1075	902
R-squared	0.001	0.000	0.000	0.000	0.000	0.001

Note: Results are based on OLS regressions. We use the number of correct answers to the three financial literacy questions in the May module (panel A) and the July module (panel B). Controls refer to marital status, age, education, and income. *All* refers to men and women. Standard errors are clustered at the household level and displayed in parentheses: * p<0.1, ** p<0.05, *** p<0.01.

A.4 Results of the latent class model

In tables A.3 and A.4, we show the parameters estimated from the latent class model (LCM). Table A.3 shows the parameter estimates of the probit equation explaining true knowledge for each of the three financial literacy questions. This means that in columns (k=1), (k=2), and (k=3) we show the parameters for truly knowing the correct answer to the interest, inflation, and risk diversifications questions, respectively (cf. equation 5). The parameters refer to the x variables. The patterns observed with respect to the socio-demographic variables are as expected. Men and those with high income and high education have a higher likelihood of knowing the correct responses to each of the questions compared to women and individuals with lower income and education.

The left panel of Table A.4 contains the estimates of the parameters γ_{kgl}^{1} of the multinomial logit model explaining the probability $P(g_{ik} = g|\tilde{y}_{ik} = 1, conf_{ik}^{j})$ (see equation (6a)). Again, the index k refers to the parameters for the three different financial literacy questions. The index $g(= 3 \cdot y^{j} + y^{m})$ can take on six different values (from 0 to 5) depending on the combination of answers given in the modules. The dummy variables $I\left(conf_{ik}^{j} = l\right), \mathrm{l} = 1, \ldots, 7$ refer to the different confidence levels l. The right panel of Table A.4 reports the estimates of the parameters γ_{kgl}^{0} of the multinomial logit model explaining the probability $P(g_{ik} = g|\tilde{y}_{ik} = 0, conf_{ik}^{j})$ (see equation (6b)). In many cases we restricted a γ parameter to be equal to -22 in order to impose the restrictions (8a)-(8e) that some probabilities are equal to 0 (see also footnote 19).

The parameters γ_{kgl}^{1} and γ_{kgl}^{0} are used to predict the probability of observing a specific combination of answers given confidence and (latent) true knowledge according to equation (10). We show the predicted probabilities in Table A.5 for ease of interpretation, where g is the observed answering pattern for answers in May, y^{m}, and July, y^{j}. $\alpha_{kg}^{1}(conf_{ik}^{j})$ is the probability of observing $g=0,\ldots,5$ given confidence level $conf_{ik}^{j}$ and $\tilde{y}_{ik} = 1$; and $\alpha_{kg}^{0}(conf_{ik}^{j})$ is the probability of observing $g=0,\ldots5$ given confidence level $conf_{ik}^{j}$ and $\tilde{y}_{ik} = 0$. n refers to the number of observations in the respective cells, i.e., the number of respondents with a specific confidence level for each of the three questions. For example, looking into the first panel on the interest question, the line g=0 (y_{i1}^{m}=0; y_{i1}^{j}=0) shows 0.000 for $\alpha_{10}^{1}(1)$. This means that the probability of observing two incorrect answers given true knowledge and confidence level 1 is 0. In the same line $\alpha_{10}^{0}(1)$=0.308. Thus, the probability of giving two incorrect answers given no true knowledge and confidence level 1 is 0.308. In this way all probabilities can be interpreted. The probabilities over g from 0 to 5 add up to 1 for each question and each confidence level. Comparing probabilities of observing two correct answers (g=4) over confidence levels shows an increasing pattern in particular for the risk question. The pattern is not so stable for the lower confidence levels of the interest and the inflation questions because of a low number of observations in these cells. However, it is present for higher levels on the confidence scale.

Table A.3: Estimation results latent class model—parameter estimates of the probit equation explaining true knowledge (see equation (5) of the paper)

	(k=1)	(k=2)	(k=3)
VARIABLES	Interest	Inflation	Risk Diversification
Female	-0.218**	-0.349***	-0.339***
	(0.0904)	(0.0940)	(0.0906)
How much of high school education devoted to economics? (ref: not applicable, hardly at all)			
Little, some, a lot	0.0253	0.112	0.0651
	(0.112)	(0.113)	(0.104)
Refuse/DK	-0.140	-0.486**	-0.535**
	(0.212)	(0.198)	(0.228)
Economics in high school exam? 1=yes	0.258**	0.216**	0.0756
	(0.104)	(0.104)	(0.0877)
Marital status (ref. Single)			
Married, no child	-0.103	-0.170	-0.299**
	(0.128)	(0.128)	(0.118)
Married, child	-0.324**	-0.0664	-0.489***
	(0.151)	(0.149)	(0.138)
Single parent, other	-0.571***	-0.201	-0.597***
	(0.204)	(0.219)	(0.215)
Age (ref. <=35)			
36-50	0.0577	0.315	0.564***
	(0.226)	(0.198)	(0.190)
51-65	0.0154	0.600***	0.376**
	(0.220)	(0.199)	(0.185)
>65	0.0211	0.717***	0.0537
	(0.231)	(0.217)	(0.193)
Education level (ref. primary education)			
Preparatory intermediate vocational	0.363**	0.107	-0.294
	(0.178)	(0.187)	(0.194)
Intermediate vocational	0.553***	0.0503	-0.307
	(0.200)	(0.205)	(0.209)
Secondary pre-university	1.040***	0.718***	-0.130
	(0.229)	(0.231)	(0.212)
Higher vocational	0.679***	0.568***	-0.0440
	(0.190)	(0.204)	(0.198)
University	1.017***	0.906***	0.383*
	(0.231)	(0.291)	(0.222)
Monthly net household income in Euros (ref. first quartile)			
1902<x<=2600	0.431***	0.178	0.102
	(0.123)	(0.123)	(0.121)
2600<x<=3471	0.257**	0.227*	0.358***
	(0.129)	(0.133)	(0.131)
x>3471	0.522***	0.441***	0.464***
	(0.146)	(0.162)	(0.139)
Refuse/dk	0.468	-0.157	0.305
	(0.413)	(0.355)	(0.387)
Constant	0.442	0.208	0.348
	(0.298)	(0.289)	(0.289)
Observations	1,532	1,532	1,532
Log likelihood	-864.2	-980.6	-1890
No. estimated parameters	55	55	55

Table A.4: Estimation results latent class model—parameter vectors γ_k^0 and γ_k^1 of the multinomial logit models (see equations (6a) and (6b) of the paper)

	$\alpha_g^1(conf_{ik}^j;\gamma_k^1) = P(g_{ik} = g\|\tilde{y}_{ik} = 1, conf_{ik}^j = 1)$			$\alpha_g^0(conf_{ik}^j;\gamma_k^0) = P(g_{ik} = g\|\tilde{y}_{ik} = 0, conf_{ik}^j = 1)$		
	(k=1)	(k=2)	(k=3)	(k=1)	(k=2)	(k=3)
VARIABLES	Interest	Inflation	Risk diversification	Interest	Inflation	Risk diversification
	g=0: incorrect in May, incorrect in July			*g=0: incorrect in May, incorrect in July*		
$conf_{ik}^j = 1$	-22	-22	-22	REFERENCE GROUP		
	(0)	(0)	(0)			
$conf_{ik}^j = 2$	-22	-22	-22			
	(0)	(0)	(0)			
$conf_{ik}^j = 3$	-22	-22	-22			
	(0)	(0)	(0)			
$conf_{ik}^j = 4$	-22	-22	-22			
	(0)	(0)	(0)			
$conf_{ik}^j = 5$	-22	-22	-22			
	(0)	(0)	(0)			
$conf_{ik}^j = 6$	-22	-22	-22			
	(0)	(0)	(0)			
$conf_{ik}^j = 7$	-22	-22	-22			
	(0)	(0)	(0)			
	g=1: correct in May, incorrect in July			*g=1: correct in May, incorrect in July*		
$conf_{ik}^j = 1$	-22	-22	-22	-0.693	-16.68	1.946*
	(0)	(0)	(0)	(0.866)	(2,958)	(1.069)
$conf_{ik}^j = 2$	-22	-22	-22	16.45	-0.223	-4.34e-05
	(0)	(0)	(0)	(2,155)	(0.671)	(1.000)
$conf_{ik}^j = 3$	-22	-22	-22	-0.406	1.792*	0.405
	(0)	(0)	(0)	(0.913)	(1.080)	(0.645)
$conf_{ik}^j = 4$	-22	-22	-22	0.539	0.442	0.288
	(0)	(0)	(0)	(0.476)	(0.427)	(0.382)
$conf_{ik}^j = 5$	-22	-22	-22	0.693	0.629	0.154
	(0)	(0)	(0)	(0.866)	(0.438)	(0.278)
$conf_{ik}^j = 6$	-22	-22	-22	1.386*	1.946*	0.642
	(0)	(0)	(0)	(0.791)	(1.069)	(0.391)
$conf_{ik}^j = 7$	-22	-22	-22	1.273***	0.368	0.693
	(0)	(0)	(0)	(0.428)	(0.434)	(0.707)
	g=2: DK in May, incorrect in July			*g=2: DK in May, incorrect in July*		
$conf_{ik}^j = 1$	-22	-22	-22	0.405	0.916	3.091***
	(0)	(0)	(0)	(0.645)	(0.837)	(1.023)
$conf_{ik}^j = 2$	-22	-22	-22	16.04	-2.64e-05	2.565***
	(0)	(0)	(0)	(2,155)	(0.632)	(0.734)
$conf_{ik}^j = 3$	-22	-22	-22	-0.406	1.792*	1.792***
	(0)	(0)	(0)	(0.913)	(1.080)	(0.540)
$conf_{ik}^j = 4$	-22	-22	-22	0.357	0.693*	1.749***
	(0)	(0)	(0)	(0.493)	(0.408)	(0.313)
$conf_{ik}^j = 5$	-22	-22	-22	1.22e-05	-4.94e-06	0.256
	(0)	(0)	(0)	(1.000)	(0.500)	(0.272)
$conf_{ik}^j = 6$	-22	-22	-22	6.12e-05	-2.61e-05	0.182
	(0)	(0)	(0)	(1.000)	(1.414)	(0.428)

$conf_{ik}^{j} = 7$	-22	-22	-22	-16.67	-2.197**	1.099*
	(0)	(0)	(0)	(1,578)	(1.054)	(0.667)

Table A.4 continued

	g=3: incorrect in May, correct in July			*g=3: incorrect in May, correct in July*		
$conf_{ik}^{j} = 1$	-22	-22	-22	-1.386	0.916	1.099
	(0)	(0)	(0)	(1.118)	(0.837)	(1.155)
$conf_{ik}^{j} = 2$	-22	-22	-22	16.45	-0.223	0.405
	(0)	(0)	(0)	(2,155)	(0.671)	(0.913)
$conf_{ik}^{j} = 3$	-22	-22	-22	-1.099	1.609	0.405
	(0)	(0)	(0)	(1.155)	(1.095)	(0.645)
$conf_{ik}^{j} = 4$	-22	-22	-22	0.133	-0.405	0.460
	(0)	(0)	(0)	(0.518)	(0.527)	(0.369)
$conf_{ik}^{j} = 5$	-22	-22	-22	1.504*	0.405	-0.405
	(0)	(0)	(0)	(0.782)	(0.456)	(0.323)
$conf_{ik}^{j} = 6$	-22	-22	-22	2.251***	2.485**	-0.223
	(0)	(0)	(0)	(0.743)	(1.041)	(0.474)
$conf_{ik}^{j} = 7$	-22	-22	-22	1.455***	0.747*	1.846***
	(0)	(0)	(0)	(0.420)	(0.405)	(0.621)
	g=4: correct in May, correct in July			*g=4: correct in May, correct in July*		
$conf_{ik}^{j} = 1$	REFERENCE GROUP			-22	-22	-22
				(0)	(0)	(0)
$conf_{ik}^{j} = 2$				-22	-22	-22
				(0)	(0)	(0)
$conf_{ik}^{j} = 3$				-22	-22	-22
				(0)	(0)	(0)
$conf_{ik}^{j} = 4$				-22	-22	-22
				(0)	(0)	(0)
$conf_{ik}^{j} = 5$				-22	-22	-22
				(0)	(0)	(0)
$conf_{ik}^{j} = 6$				-22	-22	-22
				(0)	(0)	(0)
$conf_{ik}^{j} = 7$				-22	-22	-22
				(0)	(0)	(0)
	g=5: DK in May, correct in July			*g=5: DK in May, correct in July*		
$conf_{ik}^{j} = 1$	-1.946***	-1.032**	1.052***	-14.89	-3.101	2.281*
	(0.617)	(0.511)	(0.354)	(1,517)	(32.85)	(1.189)
$conf_{ik}^{j} = 2$	-1.504*	-0.0953	1.069***	-0.187	-15.57	0.449
	(0.782)	(0.437)	(0.347)	(3,664)	(1,495)	(1.830)
$conf_{ik}^{j} = 3$	-0.540	-1.386***	0.748**	-14.64	-14.04	0.523
	(0.476)	(0.423)	(0.301)	(1,626)	(2,059)	(1.035)
$conf_{ik}^{j} = 4$	-1.099***	-0.959***	0.321*	-15.52	-15.65	0.781
	(0.348)	(0.245)	(0.180)	(972.3)	(1,079)	(0.595)
$conf_{ik}^{j} = 5$	-1.653***	-2.100***	-1.096***	-14.68	-15.75	0.364
	(0.364)	(0.306)	(0.278)	(4,828)	(1,305)	(0.398)
$conf_{ik}^{j} = 6$	-2.859***	-3.683***	-2.131***	-13.82	-0.554	1.162***
	(0.343)	(1.109)	(0.476)	(2,512)	(7.873)	(0.429)
$conf_{ik}^{j} = 7$	-19.15	-6.308***	-17.38	0.693	-0.0644	2.457***
	(800.9)	(2.031)	(633.5)	(0.463)	(0.591)	(0.602)

Table A.5: Estimation results latent class model—predicted probabilities

Interest question

			$conf_{i1}^{j}=1$			$conf_{i1}^{j}=2$			$conf_{i1}^{j}=3$			$conf_{i1}^{j}=4$			$conf_{i1}^{j}=5$			$conf_{i1}^{j}=6$			$conf_{i1}^{j}=7$	
g	y^j	y^m	n_1	$\alpha_{1g}^{1}(1)$	$\alpha_{1g}^{0}(1)$	n_2	$\alpha_{1g}^{1}(2)$	$\alpha_{1g}^{0}(2)$	n_3	$\alpha_{1g}^{1}(3)$	$\alpha_{1g}^{0}(3)$	n_4	$\alpha_{1g}^{1}(4)$	$\alpha_{1g}^{0}(4)$	n_5	$\alpha_{1g}^{1}(5)$	$\alpha_{1g}^{0}(5)$	n_6	$\alpha_{1g}^{1}(6)$	$\alpha_{1g}^{0}(6)$	n_7	$\alpha_{1g}^{1}(7)$	$\alpha_{1g}^{0}(7)$
0	0	0	37	0.000	0.308	19	0.000	0.000	27	0.000	0.375	81	0.000	0.189	73	0.000	0.118	197	0.000	0.065	1098	0.000	0.092
1	0	1	37	0.000	0.154	19	0.000	0.375	27	0.000	0.250	81	0.000	0.324	73	0.000	0.235	197	0.000	0.258	1098	0.000	0.329
2	0	9	37	0.000	0.462	19	0.000	0.250	27	0.000	0.250	81	0.000	0.270	73	0.000	0.118	197	0.000	0.065	1098	0.000	0.000
3	1	0	37	0.000	0.077	19	0.000	0.375	27	0.000	0.125	81	0.000	0.216	73	0.000	0.529	197	0.000	0.613	1098	0.000	0.395
4	1	1	37	0.875	0.000	19	0.818	0.000	27	0.632	0.000	81	0.750	0.000	73	0.839	0.000	197	0.946	0.000	1098	1.000	0.000
5	1	9	37	0.125	0.000	19	0.182	0.000	27	0.368	0.000	81	0.250	0.000	73	0.161	0.000	197	0.054	0.000	1098	0.000	0.184

Inflation question

			$conf_{i2}^{j}=1$			$conf_{i2}^{j}=2$			$conf_{i2}^{j}=3$			$conf_{i2}^{j}=4$			$conf_{i2}^{j}=5$			$conf_{i2}^{j}=6$			$conf_{i2}^{j}=7$	
g	y^j	y^m	n_1	$\alpha_{2g}^{1}(1)$	$\alpha_{2g}^{0}(1)$	n_2	$\alpha_{2g}^{1}(g,2)$	$\alpha_{2g}^{0}(2)$	n_3	$\alpha_{2g}^{1}(3)$	$\alpha_{2g}^{0}(3)$	n_4	$\alpha_{2g}^{1}(4)$	$\alpha_{2g}^{0}(4)$	n_5	$\alpha_{2g}^{1}(5)$	$\alpha_{2g}^{0}(5)$	n_6	$\alpha_{2g}^{1}(6)$	$\alpha_{2g}^{0}(6)$	n_7	$\alpha_{2g}^{1}(7)$	$\alpha_{2g}^{0}(7)$
0	0	0	46	0.000	0.165	39	0.000	0.278	53	0.000	0.056	130	0.000	0.191	153	0.000	0.186	202	0.000	0.046	909	0.00	0.18
1	0	1	46	0.000	0.000	39	0.000	0.222	53	0.000	0.333	130	0.000	0.298	153	0.000	0.349	202	0.000	0.324	909	0.00	0.26
2	0	9	46	0.000	0.414	39	0.000	0.278	53	0.000	0.333	130	0.000	0.383	153	0.000	0.186	202	0.000	0.046	909	0.00	0.02
3	1	0	46	0.000	0.414	39	0.000	0.222	53	0.000	0.278	130	0.000	0.128	153	0.000	0.279	202	0.000	0.556	909	0.00	0.38
4	1	1	46	0.737	0.000	39	0.524	0.000	53	0.800	0.000	130	0.723	0.000	153	0.891	0.000	202	0.975	0.000	909	1.00	0.00
5	1	9	46	0.263	0.007	39	0.476	0.000	53	0.200	0.000	130	0.277	0.000	153	0.109	0.000	202	0.025	0.027	909	0.00	0.17

Diversification question

			$conf_{i3}^{j}=1$			$conf_{i3}^{j}=2$			$conf_{i3}^{j}=3$			$conf_{i3}^{j}=4$			$conf_{i3}^{j}=5$			$conf_{i3}^{j}=6$			$conf_{i3}^{j}=7$	
g	y^j	y^m	n_1	$\alpha_{3g}^{1}(1)$	$\alpha_{3g}^{0}(1)$	n_2	$\alpha_{3g}^{1}(2)$	$\alpha_{3g}^{0}(2)$	n_3	$\alpha_{3g}^{1}(3)$	$\alpha_{3g}^{0}(3)$	n_4	$\alpha_{3g}^{1}(4)$	$\alpha_{3g}^{0}(4)$	n_5	$\alpha_{3g}^{1}(5)$	$\alpha_{3g}^{0}(5)$	n_6	$\alpha_{3g}^{1}(6)$	$\alpha_{3g}^{0}(6)$	n_7	$\alpha_{3g}^{1}(7)$	$\alpha_{3g}^{0}(7)$
0	0	0	93	0.000	0.023	87	0.00	0.06	109	0.000	0.086	342	0.000	0.084	319	0.000	0.180	251	0.000	0.124	331	0.00	0.04
1	0	1	93	0.000	0.164	87	0.00	0.06	109	0.000	0.128	342	0.000	0.113	319	0.000	0.210	251	0.000	0.235	331	0.00	0.08
2	0	9	93	0.000	0.514	87	0.00	0.72	109	0.000	0.513	342	0.000	0.485	319	0.000	0.232	251	0.000	0.148	331	0.00	0.12
3	1	0	93	0.000	0.070	87	0.00	0.08	109	0.000	0.128	342	0.000	0.134	319	0.000	0.120	251	0.000	0.099	331	0.00	0.26
4	1	1	93	0.259	0.000	87	0.26	0.00	109	0.321	0.000	342	0.420	0.000	319	0.750	0.000	251	0.894	0.000	331	1.00	0.00
5	1	9	93	0.741	0.229	87	0.74	0.09	109	0.679	0.144	342	0.580	0.184	319	0.250	0.259	251	0.106	0.395	331	0.00	0.49

Note: This presents predictions of the following probabilities: $\alpha_{kg}^{1}\left(conf_{ik}^{j}\right)=\alpha_{g}^{1}\left(conf_{ik}^{j};\gamma_{k}^{1}\right)=P\left(g_{ik}=g\middle|\tilde{y}_{ik}=1,conf_{ik}^{j}\right)$ and $\alpha_{kg}^{0}\left(conf_{ik}^{j}\right)=\alpha_{g}^{1}\left(conf_{ik}^{j};\gamma_{k}^{1}\right)=P\left(g_{ik}=g\middle|\tilde{y}_{ik}=1,conf_{ik}^{j}\right)$, see equations (6a) and (6b) of the paper). Th estimates of the parameter vectors γ_{k}^{0} and γ_{k}^{1} are presented in Table A.4.

Figure A.1 Distribution of "true" knowledge for the Big Three financial literacy questions and the financial literacy summary measure

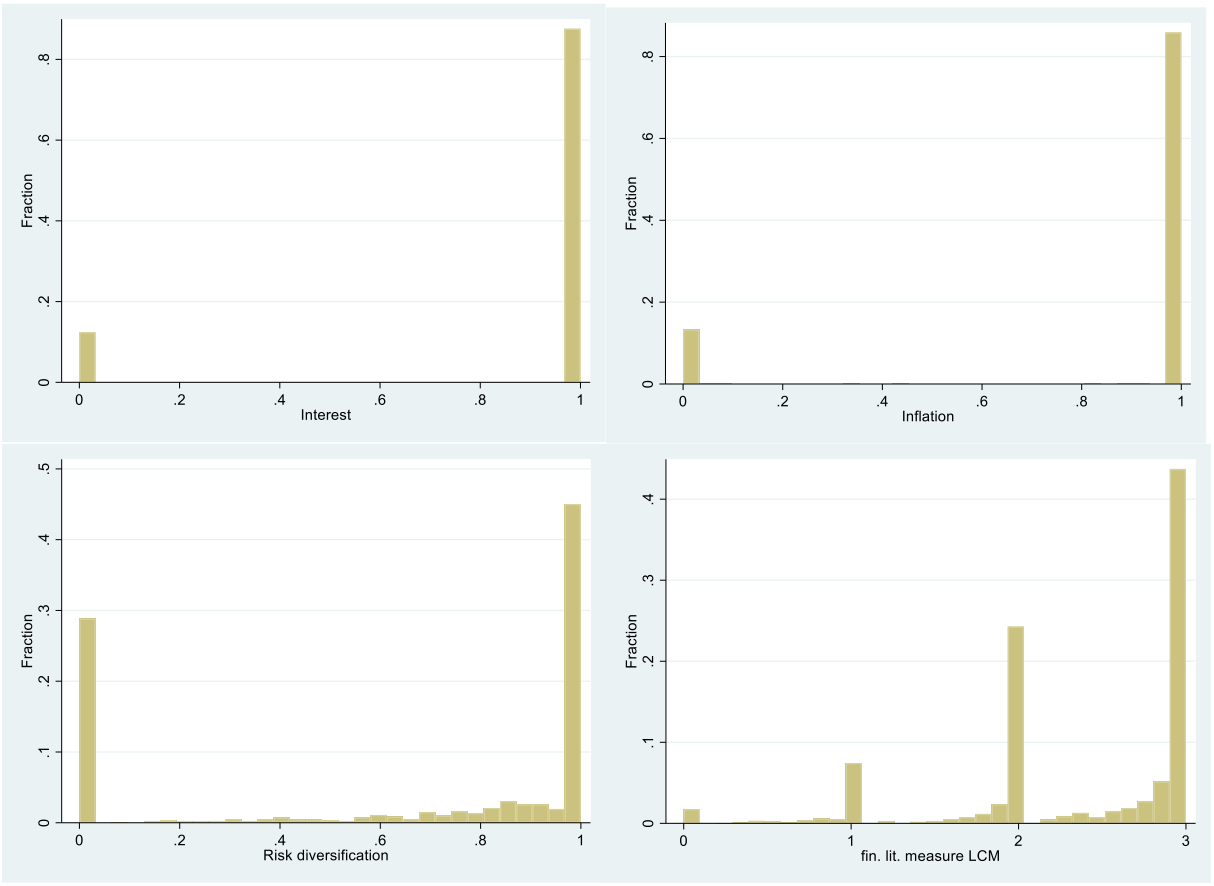

Table A.6: Explaining stock market participation—OLS results (N = 1,532)

VARIABLES	(1)	(2) May	(3) July	(4) True financial literacy
Financial literacy		0.0901***	0.0549***	0.0672***
		(0.0105)	(0.00970)	(0.0101)
female	-0.136***	-0.0461**	-0.0715***	-0.0646***
	(0.0207)	(0.0212)	(0.0213)	(0.0213)
Marital status (ref. Single)				
married, no child		-0.0943***	-0.0896***	-0.0839***
		(0.0320)	(0.0326)	(0.0324)
married, child		-0.123***	-0.119***	-0.110***
		(0.0371)	(0.0375)	(0.0373)
single parent, other		-0.132**	-0.133**	-0.124**
		(0.0548)	(0.0557)	(0.0556)
Age (ref. <=35)				
36-50		0.139***	0.149***	0.140***
		(0.0475)	(0.0473)	(0.0472)
51-65		0.202***	0.207***	0.203***
		(0.0465)	(0.0460)	(0.0460)
>65		0.201***	0.209***	0.207***
		(0.0496)	(0.0490)	(0.0491)
Education level (ref. primary education)				
Preparatory intermediate vocational		-0.0872*	-0.0623	-0.0647
		(0.0510)	(0.0516)	(0.0519)
Intermediate vocational		-0.0237	-0.0108	-0.00916
		(0.0555)	(0.0564)	(0.0566)
Secondary pre-university		-0.0659	-0.0338	-0.0464
		(0.0589)	(0.0595)	(0.0599)
Higher vocational		-0.00615	0.0166	0.00994
		(0.0557)	(0.0567)	(0.0569)
University		0.141**	0.174***	0.163***
		(0.0618)	(0.0621)	(0.0624)
Monthly net household income in Euros (ref. first quartile)				
1902<x<=2600		0.0470	0.0682**	0.0590*
		(0.0305)	(0.0311)	(0.0309)
2600<x<=3471		0.0958***	0.122***	0.110***
		(0.0352)	(0.0351)	(0.0352)
x>3471		0.183***	0.214***	0.198***
		(0.0381)	(0.0385)	(0.0385)
Refuse/DK		0.198**	0.198*	0.192*
		(0.0950)	(0.103)	(0.0997)
Constant	0.339***	0.143*	0.101	0.112
	(0.0161)	(0.0753)	(0.0731)	(0.0741)
Observations	1,532	1,532	1,532	1,532
R-squared	0.023	0.147	0.126	0.132
Adjusted R^2	0.0221	0.137	0.117	0.122

Note: Results from OLS regressions in which the dependent variable is a dummy for stock market participation. In column (1) we control only for gender. The financial literacy measures in models (2), (3), and (4) differ. Specifically, we use the number of correct answers to the three financial literacy questions in the May module (column 2), in the July module (column 3), and estimated from the latent class model (column 4). Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1 .

A.5 Instrumental variables regressions

Here we report the results of regressions that are similar to those presented in the text but based on GMM, using high school financial education as instruments for financial literacy. The instruments we use are similar to those used in Van Rooij et al. (2012) and are based upon information on exposure to economic education when young. In the Dutch Household Panel, respondents are asked how much attention has been paid to economics during their high school education. Moreover, respondents report whether and the extent to which economics was part of their final high school exam.

We measure exposure to education before entering the job market using the responses to the questions "How much of your education in high school was devoted to economic subjects?" with the following answer categories: "a lot," "some," "little," "hardly at all," "not applicable, I did not complete high school," "do not know," or "refuse to answer." We distinguish three groups. The first group consists of respondents who did not get economics in high school; i.e., those who answer "hardly at all" or "not applicable." This is the reference group in our empirical analysis. The second group is a dummy variable for respondents who were exposed to economics during high school; i.e., those who answered "a lot," "some," and "little." The third group consists of those who answered with do not know or refuse to answer (very few respondents refused to answer this question). The instruments have high predictive power for financial literacy, as shown in table A.7; the *F*-values of the first stage regression are mostly above 10 (bottom of table A.8 (cf. columns 2, 4, and 6).

Unless respondents indicate they did not complete high school, they are asked this follow-up question: "Did you have at least one economics subject in your final examination year?" with the response options "yes," "no," "not applicable, I didn't do a final exam," "do not know," or "refuse to answer." We create an additional instrument dummy variable that takes the value 1 for those respondents who answer "yes" and the value 0 otherwise. When we include this variable in the instrument set, we obtain *F*-values in excess of or very close to 10 (which, in the literature, is the recommended threshold to avoid weak instrument problems; see Staiger and Stock 1997) for the other measures (see columns 1, 3, and 5 of table 7). One may argue, however, that the third dummy is not a valid instrument, as for some students, the economic subject in their final exam may have been a choice variable and, thus, is likely to be correlated with interest in financial matters (interest in financial matters is an omitted variable in our regression) which in turn may affect financial decision making. Therefore, we present the results including and excluding this variable in the set of instruments.

Table A.8 presents the GMM results for stock market participation. The Hansen J test results indicate that the over-identifying restrictions cannot be rejected in any of the specifications. The GMM C tests (see Hayashi 2000) show mixed results for stock market participation. Using the extended set of instruments, the test suggests that financial literacy is endogenous to stock market participation; while using the smaller set of instruments we cannot reject that financial literacy is an exogenous variable. The latter result is consistent with previous findings (Van Rooij et al. 2011).

Table A.7: First stage regression

VARIABLES	(1) May	(2) July	(3) True Knowledge
Female	-0.351***	-0.141***	-0.218***
	(0.0395)	(0.0299)	(0.0360)
How much of high school education devoted to economics? (ref: not applicable, hardly at all)			
Little, some, a lot	0.104*	0.0566	0.0561
	(0.0568)	(0.0442)	(0.0495)
Refuse/dk	-0.265**	-0.229**	-0.386***
	(0.125)	(0.0999)	(0.107)
Economics in high school exam? 1=yes	0.186***	0.101***	0.107***
	(0.0464)	(0.0322)	(0.0399)
Marital status (ref. Single)			
Married, no child	-0.0316	-0.0930**	-0.156***
	(0.0669)	(0.0436)	(0.0529)
Married, child	-0.0757	-0.128**	-0.228***
	(0.0740)	(0.0511)	(0.0625)
Single parent, other	-0.243*	-0.283***	-0.375***
	(0.132)	(0.106)	(0.114)
Age (ref. <=35)			
36-50	0.227**	0.162**	0.262***
	(0.106)	(0.0733)	(0.0851)
51-65	0.240**	0.197***	0.254***
	(0.106)	(0.0736)	(0.0837)
>65	0.212*	0.131	0.165*
	(0.112)	(0.0796)	(0.0893)
Education level (ref. primary education)			
Preparatory intermediate vocational	0.207	0.00365	0.0381
	(0.130)	(0.116)	(0.120)
Intermediate vocational	0.148	0.0780	0.0611
	(0.135)	(0.119)	(0.125)
Secondary pre-university	0.399***	0.190	0.329***
	(0.135)	(0.121)	(0.124)
Higher vocational	0.349***	0.216*	0.290**
	(0.131)	(0.118)	(0.122)
University	0.559***	0.349***	0.477***
	(0.136)	(0.121)	(0.126)
Monthly net household income in Euros (ref. first quartile)			
1902<x<=2600	0.251***	0.0667	0.170***
	(0.0701)	(0.0502)	(0.0591)
2600<x<=3471	0.322***	0.110**	0.235***
	(0.0757)	(0.0524)	(0.0633)
x>3471	0.410***	0.157***	0.334***
	(0.0781)	(0.0565)	(0.0661)
Refuse/DK	0.0721	0.0760	0.161
	(0.219)	(0.147)	(0.171)
Constant	1.542***	2.320***	1.951***
	(0.172)	(0.133)	(0.146)
Observations	1,532	1,532	1,532
R-squared	0.189	0.121	0.172
Adjusted R^2	0.179	0.110	0.161

Table A.8: Explaining stock market participation—GMM results

	May		July		Prob "True knowledge"	
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Financial literacy	0.192***	0.166**	0.222***	0.185*	0.204***	0.168**
	(0.0671)	(0.0815)	(0.0842)	(0.0947)	(0.0751)	(0.0800)
Female	-0.00335	-0.0142	-0.0310	-0.0399	-0.0235	-0.0341
	(0.0369)	(0.0415)	(0.0308)	(0.0321)	(0.0325)	(0.0331)
Marital status (ref. Single)						
Married, no child	-0.090***	-0.091***	-0.0627*	-0.0681*	-0.0555	-0.0621*
	(0.0328)	(0.0324)	(0.0364)	(0.0363)	(0.0365)	(0.0364)
Married, child	-0.115***	-0.115***	-0.087**	-0.092**	-0.0724*	-0.0806*
	(0.0379)	(0.0374)	(0.0416)	(0.0412)	(0.0421)	(0.0420)
Single parent, other	-0.0998*	-0.106*	-0.0511	-0.0681	-0.0547	-0.0712
	(0.0601)	(0.0601)	(0.0739)	(0.0740)	(0.0695)	(0.0689)
Age (ref. <=35)						
36-50	0.111**	0.118**	0.106*	0.115**	0.0942	0.105*
	(0.0545)	(0.0549)	(0.0576)	(0.0569)	(0.0576)	(0.0569)
51-65	0.176***	0.183***	0.161***	0.170***	0.163***	0.172***
	(0.0523)	(0.0524)	(0.0563)	(0.0557)	(0.0540)	(0.0532)
>65	0.181***	0.186***	0.183***	0.188***	0.185***	0.189***
	(0.0545)	(0.0539)	(0.0558)	(0.0542)	(0.0537)	(0.0524)
Education level (ref. primary education)						
Preparatory intermediate vocational	-0.119**	-0.110*	-0.0699	-0.0664	-0.0760	-0.0714
	(0.0563)	(0.0577)	(0.0587)	(0.0559)	(0.0559)	(0.0542)
Intermediate vocational	-0.0530	-0.0459	-0.0432	-0.0355	-0.0278	-0.0227
	(0.0593)	(0.0600)	(0.0656)	(0.0635)	(0.0608)	(0.0592)
Secondary pre-university	-0.128*	-0.112	-0.103	-0.0862	-0.120	-0.0993
	(0.0716)	(0.0770)	(0.0741)	(0.0745)	(0.0735)	(0.0741)
Higher vocational	-0.0615	-0.0466	-0.0562	-0.0389	-0.0534	-0.0360
	(0.0669)	(0.0716)	(0.0729)	(0.0736)	(0.0693)	(0.0696)
University	0.0622	0.0826	0.0652	0.0905	0.0657	0.0913
	(0.0812)	(0.0885)	(0.0880)	(0.0912)	(0.0846)	(0.0859)
Monthly net household income in Euros (ref. first quartile)						
1902<x<=2600	0.0145	0.0216	0.0485	0.0518	0.0287	0.0354
	(0.0364)	(0.0382)	(0.0346)	(0.0337)	(0.0356)	(0.0352)
2600<x<=3471	0.0540	0.0632	0.0888**	0.0938**	0.0672	0.0760*
	(0.0442)	(0.0467)	(0.0405)	(0.0399)	(0.0428)	(0.0425)
x>3471	0.130**	0.143**	0.166***	0.176***	0.134***	0.150***
	(0.0508)	(0.0558)	(0.0474)	(0.0479)	(0.0518)	(0.0530)
Refuse/DK	0.190**	0.192**	0.179*	0.185*	0.167*	0.173*
	(0.0869)	(0.0881)	(0.0998)	(0.0992)	(0.0908)	(0.0923)
Constant	0.220**	0.200**	0.170*	0.155*	0.180**	0.163*
	(0.0933)	(0.0985)	(0.0875)	(0.0867)	(0.0873)	(0.0864)
Observations	1,532	1,532	1,532	1,532	1,532	1,532
R-squared	0.104	0.123	0.002	0.051	0.054	0.089
F stat first stage	14.19	11.12	9.189	7.694	11.26	12.18
p-value Hansen overid test	0.551	0.335	0.670	0.576	0.606	0.840
p-value GMM C exogeneity test	0.111	0.332	0.0255	0.121	0.0480	0.171

A.6 Robustness checks

In order to establish the robustness of the latent class model and the results derived from it, we conducted a series of robustness checks. We summarize the most important ones here. Detailed results are available upon request.

Reduced set of financial literacy questions: We also ran the LCM based on the interest and inflation questions only. The results are similar but less strong than the results based on all three questions. Overall about 10-12% of the gender difference measured in those two questions is explained by confidence. The reason for the smaller effect is that the interest and inflation questions have fewer respondents who answer with "do not know" and, thus, the LCM adds less information. In other words, the two questions are less influenced by confidence. In the stock market participation regressions, the financial literacy coefficients based on the interest and inflation questions are slightly smaller compared to our baseline results, but still highly significant. The estimated coefficients in the GMM models are in the same order of magnitude as before, however, the first stage F-statistic is low, indicating a weak instrument problem.

Extended set of financial literacy questions: In our survey, we have an additional financial literacy question—on bond pricing—that is not normally used in the literature.[27] We reran the model including this additional question and again our results overall are similar to our original results. Confidence accounts for about 34-35% of the measured gender difference. Overall, there is a slightly higher fraction of underconfident men and women because of the addition of a comparably difficult question to the literacy measure. There is also a larger gender difference in financial literacy when including this measure. The relationship with stock market participation is qualitatively and quantitatively similar in the OLS regressions. The effects become somewhat smaller in the GMM, but are still highly significant, and the first stage F-stats are also high.

Interest in financial matters: One reason why women are less likely to answer the financial literacy questions correctly and opt instead for a "do not know" response could be less interest in financial matters. In our module, we asked "How would you rate your interest in financial matters?" with responses given on a Likert scale from 1 (very little) to 7 (a lot).[28] We include interest in financial matters among the control variables of the LCM (X variables). Thus, the weighting function, i.e., the probit, includes interest in financial matters. The LCM shows that financial interest is especially relevant for knowledge about interest compounding but less so for the inflation and risk diversification questions. Our estimated financial literacy gender gap is qualitatively unaffected by including this additional control variable. Around 35% of the gender gap is explained by confidence. Underconfidence is also unaffected.

Financial respondents: In our data set, we know which respondents are the financially responsible person in their household (financial respondent). We restricted our analysis to the financial respondents only, which reduced our sample size from 1,532 to 1,266 observations. Again the results do not change dramatically. However, we note that overall the gender differences become stronger when we use the sample of financial respondents only.

[27] Stocks are normally riskier than bonds. True/False/DK/refuse to answer. This question is also included in the extended financial literacy measure in Van Rooij et al. (2011).

[28] Women have a mean score of 4.06 and men of 4.69 on this scale, indicating a lower interest in financial matters among women. The difference is highly significant.