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Abstract

The aim of this chapter is to investigate the relationship between financial literacy and numeracy. It turns out that numeracy and financial literacy are strongly correlated. In order to clarify this relationship, we review, in a first section, the general definition of numeracy and its most commonly used measures. We then try to enlighten the distinction that can be made between numeracy and financial literacy. In a second section, we focus on the relationship between numeracy and financial literacy using the main empirical studies performed. Since the analyses of their results show that numeracy is a key determinant of financial literacy, we highlight, in a third and final section, the key role that numeracy could have in education programs and consumer protection policies to improve financial decisions.

Keywords : Financial literacy ; Numeracy

JEL Codes : G4, G5, G53, D14

Introduction

Households are confronted with increasingly complex financial products and choices (Lusardi, 2015) such as student loans, retirement plans, housing loans, credit cards and so on. A growing literature examines to what extent households have adequate skills for making informed financial decisions since financial choices and trajectories are equally important for the individual citizen as well as for the society of which he is a member (Lusardi, 2012). Being financially literate is defined as a *life skill* and enables one to make the proper financial choice based on basic knowledge of financial concepts. Large empirical studies across the world find that financial literacy is unequally distributed among populations and that, overall, populations suffer from a lack of financial literacy skills (Lusardi & Mitchell, 2011a, 2008; van Rooij et al., 2011). In fact, this literature on financial choices raises one question: how is it possible to improve the financial decision-making of populations?

One way to reduce these inequalities is therefore to improve the financial knowledge of individuals through education (Lusardi & Mitchell, 2014). International organisations such as the OECD have promoted financial education programmes aimed at improving individuals' ability to make financial decisions. However, there is a real difficulty in improving the financial behaviour of households, as shown by the obstacles encountered by financial literacy education programmes implemented in recent years (Busom et al., 2017; Fernandes et al., 2014; Grohmann, 2018) . Indeed, these education programmes have assumed that the causal link between financial knowledge and decision-making seems to be self-evident, but this relationship appears to be more opaque (Fernandes et al., 2014). Skagerlund et al., (2018) question the lack of effect of financial education programmes on financial behaviour: individuals are still illiterate despite educational interventions. According to the authors, this result can be explained by the effect of a third variable which has been underestimated, as was also suggested by Fernandes et al., (2014) and this could be numeracy. Indeed, financial

decisions require the capacity to do, understand and use calculations, including complex ones. Numeracy can be broadly defined as "the ability to access, use, interpret and communicate mathematical information and ideas*"* (OECD, 2012). Numeracy can be defined as the ability to deal with basic numerical concepts, in particular with ratios, percentages or quantities (Cokely et al., 2012; Peters et al., 2006). Skagerlund et al., (2018) find that a central component of financial literacy can be related to numeracy and to the (emotional) attitude that an individual has towards numbers (what they call "mathematical anxiety"). Moreover, Fernandes et al., (2014) find that numeracy is correlated with financial literacy and with some financial behaviours. As Skagerlund et al., (2018) point out, a non-negligible portion of financial literacy can be explained by numeracy, by its own construction. Indeed, the most common measure of financial literacy is developed by Lusardi & Mitchell, (2014) and is based on numerical knowledge. A financial literacy score is created from the answers given to three questions. These questions evaluate knowledge of i) compound interest which is also called numeracy; ii) inflation; and iii) financial risk diversification. The first two questions in particular require the use of the skills of understanding numbers and even percentages. Thus, according to Fernandes et al., (2014) and Skagerlund et al., (2018), the field of study of financial literacy has not developed this concept in a theoretical way and there is a certain lack of measures that satisfy the psychometric properties (Knoll & Houts, 2012). In Skagerlund et al., (2018), "a theoretical framework is lacking" when discussing the concept of financial literacy.

The aim of this chapter is to investigate the relationship between financial literacy and numeracy. The chapter is divided into three main sections. The first reviews the general definition of numeracy and the most commonly used measures. This section tries to clarify the distinction that can be made between numeracy and financial literacy. The second section

focuses on the relationship between financial literacy and numeracy and hence makes reference to several empirical papers. The third section highlights the role of numeracy on education programmes and consumer protection policies in order to improve financial decisions.

I. Numeracy: definitions and measures

Numeracy is not a subset of mathematics but rather it measures the ability to apply mathematics to real-life situations and meets broad and specific definitions. As is the case for financial literacy, numeracy is then assessed by means of various measures but the results obtained are rather consistent. However, there is some confusion between the methods of measuring numeracy and financial literacy.

Numeracy is a relatively new term[1], used to designate mathematical literacy and including not only mathematical skills but all knowledge and skills required to effectively use numbers and manage the mathematical demands of diverse situations of everyday life. As noted by Christelis et al., (2010) numeracy should therefore be considered as a cognitive ability in line with the cognitive psychology and epidemiological literature which identifies four main domains of ability (orientation, memory, executive function and language) depending on both genetic endowment and environmental factors.

Numeracy is broadly defined as "the ability to access, use, interpret and communicate mathematical information and ideas" (OECD, 2012) or "the capacity to identify, to understand, and to engage in mathematics and to make well-founded judgements about the role that mathematics plays, as needed for the individual's current and future private life, occupational life, social life with peers and relatives, and life as a constructive, concerned,

[1] The first reference to numeracy was made by the UK Crowther Report (1959) which stated that 'numeracy' should "represent the mirror image of literacy". See Neill (2001).

and reflective citizen" (OECD Programme for International Student Assessment (PISA), definition of the term "mathematical literacy" instead of numeracy).

Numeracy can be divided into basic and higher levels. Reyna et al., (2009) consider that basic levels of numeracy are concerned with the "real number line, time, measurement, and estimation" whereas higher levels focus on "an understanding of ratio concepts, notably fractions, proportions, percentages, and probabilities". Cokely et al., (2012) use the term "statistical numeracy" to refer to this understanding of the operations of probabilistic and statistical computation, such as comparing and transforming probabilities and proportions. They point out that recent research in decision sciences has focused on these higher levels of numeracy which are important for informed and accurate risky decision-making and tend to concern highly educated samples. This subset of numeracy is in particular explored by Schwartz et al., (1997) and Lipkus et al., (2001) who give the following intuitive definition of numeracy: how facile people are with basic probability and mathematical concepts.

The more basic to the highest levels of numeracy have been evaluated in the literature among large and diverse samples using objectives measures. Some studies also used subjective measures, (e.g. "How good are you at working with percentages?") but while generally faster and less stressful for participants, they have questionable accuracy (Peters, 2012). Most objective measures are concentrated on probabilities, proportions and percentages.

Two of them have been used in more than 100 studies on topics such as medical decision-making, shared decision-making, trust, patient education, sexual behaviour, stock valuations, credit-card usage, graphical communication and insurance decisions, among many others (Lipkus & Peters, 2009). The first measure, by Schwartz et al., (1997) is based on three general questions aimed at assessing participants' basic familiarity with probability, ability to convert a percentage to a proportion (1% to 10 in 1,000) or vice versa (1 in 1,000 to 0.1%)

and to indicate how many times, out of 1,000 coin flips, a fair coin would be expected to land on heads.

As an extension, Lipkus et al., (2001)propose a numeracy test for highly educated samples based on 11 questions: a practice question, three general questions similar to those of Schwartz et al., (1997) and seven very closed questions phrased within the context of health risks. Two questions had multiple choice options while all others were open-ended. Concrete examples of general and health-related questions are: “Imagine that we rolled a fair, six-sided die 1,000 times. Out of 1,000 rolls, how many times do you think the die would come up even (2, 4, or 6)?”; “The chance of getting a viral infection is .0005. Out of 10,000 people, about how many of them are expected to get infected?”.

While the results indicated that this was a reliable and internally consistent measure of high-school and college educated individuals’ statistical numeracy, several concerns suggest that the Lipkus et al., (2001) test could be improved. Cokely et al., (2012) note in particular that it was not hard enough to adequately differentiate among the higher-performing, highly-educated individuals, the results showing in particular an extensive negative skew with scores approaching the measurement ceiling (e.g. most participants answered more than 80% of items correctly, in Cokely & Kelley, (2009) or Peters et al., (2006) for instance).

Building on both studies, Cokely et al., (2012) develop a new psychometrically sound statistical numeracy and risk literacy test designed for educated and high-ability samples. The Berlin Numeracy Test is based on the following four questions:

1. Out of 1,000 people in a small town, 500 are members of a choir. Out of these 500 members in the choir, 100 are men. Out of the 500 inhabitants that are not in the choir, 300 are men. What is the probability that a randomly drawn man is a member of the choir? Please indicate the probability in percent. ___25%___

2a. Imagine we are throwing a five-sided die 50 times. On average, out of these 50 throws how many times would this five-sided die show an odd number (1, 3 or 5)? __30__ out of 50 throws.

2b. Imagine we are throwing a loaded die (6 sides). The probability that the die shows a 6 is twice as high as the probability of each of the other numbers. On average, out of these 70 throws how many times would the die show the number 6? ___20___out of 70 throws.

3. In a forest, 20% of mushrooms are red, 50% brown and 30% white. A red mushroom is poisonous with a probability of 20%. A mushroom that is not red is poisonous with a probability of 5%. What is the probability that a poisonous mushroom in the forest is red? ___50%___

These questions can be used in three formats. The preferred format leveraged available computing technology and internet accessibility (e.g. online data collection and scoring; accessible via smart phones and other internet-ready devices). A participant's skill level is determined from answers to 2–3 questions in roughly half the time normally required for the Lipkus et al., (2001) numeracy test (less than three minutes).

The 2–3 questions asked to participants are adaptively selected based on participants' past success in answering previous questions. All questions have about a 50% probability of being answered correctly with subsequent questions adjusted on the basis of participants' prior answers. If an answer is correct/incorrect then a harder/easier question is automatically provided (see Figure 1 for test structure). This computer-adaptive format automatically scores and reports to researchers.

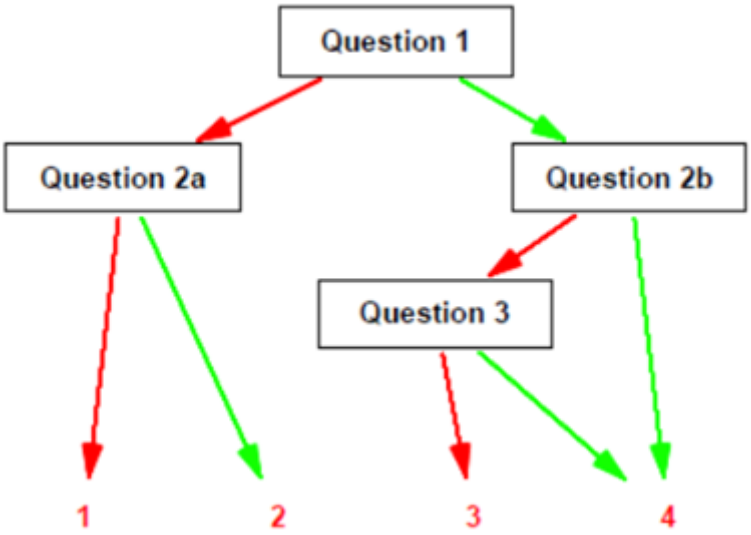

Figure 1 : Berlin Numeracy Test structure (Cokely et al., 2012)

The second possible, traditional (paper and pencil) format requires that participants answer all four questions from the Berlin Numeracy Test in sequence. Scoring involves totalling all correct answers (i.e. 0–4 points possible). This format may be useful when computerized testing is impractical, such as in group testing or when computer access is limited. A third format is available in cases where time is extremely limited: use only the first item of the test (question 1) as a means of estimating median splits. Those who answer the question correctly are estimated to belong to the top half of educated participants while all others are assigned to the bottom half.

The results obtained by Cokely et al., (2012) show that the Berlin Numeracy Test is the strongest predictor of comprehension of everyday risks (e.g. evaluating claims about products and treatments; interpreting forecasts), doubling the predictive power of other numeracy instruments and accounting for unique variance beyond other cognitive tests (e.g. cognitive reflection, working memory, intelligence).

Other measures of numeracy exist. Some are used to assess the impact of numeracy on financial decisions or literacy. For instance, the 2004 US Health and Retirement Study (HRS),

a survey covering people aged 50 and above, contained questions measuring numeracy that were first used by Lusardi & Mitchell, (2007a). Respondents were asked a first percentage calculation question and a second lottery division question. If they gave the correct answer to either the first or the second question, they were asked a third, compound interest question. The three questions were: 1) "If the chance of getting a disease is 10 percent, how many people out of 1,000 would be expected to get the disease?"; 2) "If 5 people all have the winning number in the lottery and the prize is 2 million dollars, how much will each of them get?"; 3) "Let's say you have 200 dollars in a savings account. The account earns 10 percent interest per year. How much would you have in the account at the end of two years?". These three questions and two additional questions were also asked in the English Longitudinal Study of Ageing (ELSA).[2]

Whatever test is used to measure numeracy, the results obtained are rather consistent. According to Lusardi, (2012), the review of studies and surveys that have been implemented in many countries shows, first, that the level of numeracy among the participants is very low and, second, that the lack of numeracy is particularly severe among some demographic groups.

The first finding is supported in particular by Lipkus et al., (2001) and Schwartz et al., (1997) and all the tests using their measures of numeracy. Lipkus et al., (2001) provided additional evidence that even among educated US community samples a sizeable proportion of individuals were likely to be statistically innumerate (e.g. 20% failed to correctly answer questions dealing with risk magnitude). Their results also indicated that domain framing (e.g. medical versus financial versus abstract gambles) did not necessary differentially affect test

[2] The two additional questions were: 4) "In a sale, a shop is selling all items at half price. Before the sale, the sofa costs $300. How much will it cost on the sale?"; 5) "A second-hand car dealer is selling a car for $6,000. This is two-thirds of what it cost new. How much did the car cost new?". See (Banks & Oldfield, 2007).

performance or comprehension. According to Cokely et al., (2012) this finding suggests that various domain-specific items (e.g. items framed in terms of financial or medical or gambling risks) can provide a reasonable basis for the assessment of general statistical numeracy skills that will have predictive power across diverse domains.

Their own results using the Berlin Numeracy Test (via the computer-adaptive format) among educated samples (current and former graduate or undergraduate) from 15 countries with diverse cultural samples show that the mean test score was 51.7% correct. This score indicates that on average the first test item of the Berlin Numeracy Test achieved the intended 50% discriminability.

Other measures used also support the finding of a low level of numeracy. For instance, show, Lusardi & Mitchell, (2007a) using the three questions of the 2004 US HRS on US respondents 51–56 years old, that while over 80% of them correctly answered the Percentage Calculation question, about half correctly answered the Lottery Division question and only 18% could correctly answer the Compound Interest question. Banks & Oldfield, (2007) show that UK respondents to these questions and the two additional questions asked in the ELSA also present a low level of numeracy: only 11% of them were able to answer all five questions correctly. These five questions were also asked of a sub-sample of US sub-prime mortgage borrowers and very similar findings were observed: only 13% of the sub-prime borrower group were able to answer all five questions correctly (Gerardi et al., 2010).

As discussed in Lusardi, (2012) the second important finding from this empirical literature is that as for financial literacy, the lack of numeracy is particularly severe among some demographic groups. In particular, numeracy was found to decline sharply with age in the 2004 HRS module on financial literacy and the results of the Survey of Health, Retirement and Ageing in Europe (SHARE), which surveys a representative sample of the population aged 50 and above in 11 countries, show that numeracy was low among the older population

in many European countries (Christelis et al., 2010). The countries with the highest level of numeracy were Germany, the Netherlands, Sweden and Switzerland, while the countries with the lowest level of numeracy were Italy and Spain, a finding consistent with the latest data from the PISA survey, which measures mathematical and numeracy skills among 15-year-old students.

Lusardi & Mitchell, (2007b, 2007a) and Christelis et al., (2010) also show that numeracy is especially lacking among those with low educational attainment while Lusardi et al., (2010) show significant heterogeneity in numeracy, even when examining a narrow age group in the population and when looking at those with similar levels of cognitive ability. Finally, there are also large differences among racial and ethnic groups, with African Americans and Hispanics displaying the lowest level of numeracy (Lusardi & Mitchell, 2007a, 2007b, 2011a). These results have potential consequences for both individuals and society since numeracy is important for many decisions in everyday life, in particular those involving ratios, percentages or probabilities, as well as health or financial ones.

However, the demarcation between measures of numeracy and financial literacy is not clear in the existing literature and is even regarded as inconsistent by Hung et al., (2011) or Almenberg & Widmark, (2012). Indeed, both concepts share important features and Hung et al., (2011) note that financial literacy involves skills, rather than just knowledge, that depend on the ability to work with numbers and, additionally, that some studies have explicitly included numeracy as a component of financial literacy tests (for instance, Lusardi & Mitchell, (2007a). Furthermore, Almenberg & Widmark, (2012) point out that different subsets of the questions used to measure financial literacy and largely based, according to Lusardi & Mitchell, (2007b, 2007a, 2011b), on those introduced in the US Health and Retirement Survey (2006) and in the Rand American Life Panel (2006), have been used in

many studies, varyingly labelled as measures of numeracy, cognitive ability or financial literacy.

However, numeracy represents a more basic skill set that can be applied to many areas outside finance, especially all decisions involving risk, while financial literacy also involves familiarity with financial concepts and products. Almenberg & Widmark, (2012) therefore consider there is some agreement on defining financial literacy as more knowledge-based whereas numeracy is more skills-based and directly related to cognitive abilities, in particular the ability to process numerical information and perform simple calculations.[3] According to this view, numeracy is considered distinct from financial literacy, instead treating it as a supporting construct, as suggested by Hung et al., (2011).

II. Numeracy and financial literacy in financial behaviour studies: empirical evidence

Analysis of the literature reveals that many empirical studies focus on either financial literacy or numeracy, yet few studies test the effect of both of these *abilities* on financial behaviour (Almenberg & Widmark, 2012).

On the one hand, the link between financial literacy and financial behaviour has been investigated by a large number of empirical studies across the world, and all agree on the fact that it leads to better management of personal finances but that it is unequally distributed among individuals. Differences in financial literacy have been found across subpopulations: the less educated, women, young adults and elders tend to be less financially educated and to struggle with financial concepts such as inflation, interest rates or risk diversification (Grohmann, 2018; Lusardi & Mitchell, 2014). Lusardi & Mitchell, (2011a) for example, show

[3] This literature identifies four main domains of ability (orientation, memory, executive function, and language) depending on both genetic endowment and environmental factors.

that American adults with some degree of financial literacy are more willing to plan for retirement (see also Ameriks et al., (2003); Arrondel et al., (2013); Bucher-Koenen et al., (2017)) are willing to increase their portfolio diversification (Abreu & Mendes, 2010). van Rooij et al., (2011) found positive relationships between financial knowledge, pension plans and household wealth. They show that financial literacy can increase households' wealth via two mechanisms: increasing their propensity to invest in equity markets and therefore to benefit from equity; and increasing their likelihood to have a retirement plan and therefore to have pension income during their retirement. Moreover, Huston, (2012) highlights a negative relationship between financial literacy and the cost of financial borrowing, whatever the channel used: credit cards or loans. Households with financial knowledge are more likely to have lower borrowing costs than other households.

On the other hand, it is well known that numeracy has a positive impact on financial choices and outcomes (Lusardi, 2012). Moreover, Ghazal et al., (2014) document that numeracy is a strong and positive predictor of financial behaviour and is linked to confidence and deliberation (cognitive awareness). Knowledge of interest rate calculation is positively correlated with having a retirement plan (Alessie et al., 2011; Lusardi & Mitchell, 2011a) with participating in private pension plans (Fornero & Monticone, 2011) and with owning stocks (Christelis et al., 2010; Lusardi & Mitchell, 2011a). Numeracy skills are necessary for effective financial decision-making throughout one's lifetime.

The correlation between numeracy, financial literacy and financial behaviour is widely documented (Lusardi, 2012) yet few empirical studies analyse the effect of both numeracy and financial literacy on financial behaviour. We try to select the most knowledgeable papers (see Table 1).

Study	Date	Financial Literacy measures	Numeracy measures	Financial Behaviours
Banks & Oldfield	2007	Knowledge about pensions	Banks & Oldfield (2007) ELSA	Retirement saving and investment portfolios
Banks, O'Dea & Oldfield	2011	Proxy instrument	Banks & Oldfield (2007) ELSA	Retirement savings
Almenberg & Widmark	2011	6 basic Financial literacy questions	Banks & Oldfield (2007)	Participation in the stock market
Gerardi, Goette & Meier	2013	2 basic Financial knowledge questions	Banks & Oldfield (2007)	Mortgage default
De Bassa Scheresberg	2013	3 basic financial literacy questions (Lusardi & Mitchell, 2011a)	Self-confidence measure	Savings and retirement plan
Darriet, Guille, Vergnaud & Shimizu	2020	3 basic financial literacy questions (Lusardi & Mitchell, 2014)	Specific measure (ratios)	Choice of bonds

Table 1: Selected papers that study the effect of both numeracy and financial literacy on financial behaviours

Banks & Oldfield, (2007) study the correlation between numeracy ability, financial knowledge of pension, other cognitive abilities such as memory and some measures of wealth and retirement saving outcomes. They find that numeracy ability and financial knowledge are positively correlated with planning for retirement and good investment portfolio behaviours, even when controlling for cognitive ability (executive function and memory) and socio-demographic variables such as level of education. In order to perform their analyses, they use the 2002 English Longitudinal Study of Ageing (ELSA) survey. The set of questions to

measure numeracy is detailed by Steel et al. (2003) and the procedure to implement it by Banks & Oldfield, (2007). For example, one of the first questions participants are required to answer is: “In a sale, a shop is selling all items at half price. Before the sale, a sofa costs £300. How much will it cost in the sale?”. Participants were classified into different groups depending on their numerical performance. The financial literacy data collected by Banks & Oldfield, (2007) is based on self-declarative questions relative to pension arrangements. For example, participants (who have benefited from employer pensions) are required to answer the following question: “What fraction will be added to your final pension for each year of service?”. Knowledge about defined benefit pensions and their indexation are collected. Then the results show that participants with higher numeracy have better financial knowledge regarding their own retirement plans. In line with these results, Banks et al., (2010) find a positive correlation between numeracy measured using the ELSA questionnaire and wealth and financial asset ownership. The authors assumed that the numeracy score derived from the ELSA data is a good proxy for the evaluation of financial literacy given the results of Banks & Oldfield, (2007) and since one measure of numeracy is focused on basic calculation (as is the case for some financial literacy questions from Lusardi & Mitchell, (2011a)).

Consequently, they find that it is difficult to analyse the effects of numeracy and (financial) literacy on financial life trajectories. They find that numeracy has an effect on wealth trajectories both pre- and post-retirement but not on distributions of expectations and net replacement rates of retirement. However, if these two results show some insight into the relationships between financial literacy and numeracy, the measurement of financial literacy is not precise (and makes not reference to developed by Lusardi & Mitchell, (2011a) which is widely used and thus does not allow comparisons).

Darriet et al., (2020) explore the relationship between numeracy, financial literacy and money illusion in a context of financial choices. Money illusion is considered as a bias that affects

financial decision-making (Akerlof and Shiller, 2010; Fehr & Tyran, 2001; Shafir et al., 1997) and can broadly be defined as a confusion between real and nominal values. The authors measure money illusion at the individual level from a series of choices between a pair of simple bonds whose returns are affected only by inflation (or deflation). Financial literacy is measured via three questions developed by Lusardi & Mitchell, (2014) whereas the authors create a specific measure of numeracy in relation to the financial task, which evaluates ability of participants to perform in ratios. Their results show that participants with financial literacy are less sensitive to money illusion while there is no evidence of an impact of numeracy. Contrary to these papers, Almenberg & Widmark, (2012) used standard measures of both abilities that have been employed widely in the literature. Financial literacy is measured through six questions aimed at measuring familiarity with financial concepts, largely based on questions designed by Lusardi & Mitchell, (2011a) (e.g. "Buying stock in a single company is usually safer than buying shares in a mutual fund. True or false?"). Numeracy is measured through the respondent's performance over six questions largely based on the original ELSA questions (e.g "If the probability of getting a disease is 10 per cent, how many people out of 1,000 would be expected to get the disease?"). Almenberg & Widmark, (2012) find that after controlling for other individual characteristics (such as attitude towards risks), both numeracy and financial literacy are positively correlated with participation in the stock market and only numeracy is positively correlated with homeownership (housing market). Furthermore, Gerardi et al., (2013) contact borrowers and study the effect of numerical ability on propensity to mortgage delinquency. They measure financial literacy using two questions designed by Lusardi & Mitchell, (2011a). Numerical ability is measured using five questions developed by Banks & Oldfield, (2007). They observe that there is a robust correlation between numerical ability and mortgagedefault is robust. They find that numerical ability impacts mortgage outcomes through the choice of mortgage contract. But individuals with

limited numerical ability default on their mortgage due to behaviour unrelated to the initial choice of their mortgage. They find that mortgage delinquency is specifically associated with numerical ability and not with financial literacy (called economic literacy by the authors) or with general IQ. However, the authors raise the issue of reverse causality and the possibility of an omitted variable. As they explained, this omitted variable could be financial literacy. Another empirical study analyses the effect of both numeracy and financial literacy on financial behaviour in young populations. Using the 2009 US National Financial Capability Study, de Bassa Scheresberg, (2013) examines the effect of financial education on financial behaviour. The study is based on a sample of more than 4,500 young adults aged 25-34, most of whom have are postgraduates. The author finds that more than 60% of the respondents have a very good financial literacy score, as they correctly answer the three questions (Lusardi & Mitchell, 2011a, 2008). Interestingly, they also measure self-confidence in financial knowledge and self-confidence in mathematics (e.g. participants are required to answer the following question on a scale from 1 to 7: "How strongly do you agree or disagree with the following statement? 'I am pretty good at math.'"). This study attests that respondents who score well in financial literacy or who are confident in their level of mathematics make better financial choices: they are more likely to have precautionary savings or to have a retirement plan in place and less likely to be in a high cost borrowing situation.

The correlation between numeracy, financial literacy and financial behaviour is well proven. However, as widely argued in the literature (Fernandes et al., 2014; Gerardi et al., 2013; Skagerlund et al., 2018) the issue of causality or reverse causality between numeracy and financial literacy or the existence of a third variable (Fernandes et al., 2014; Gerardi et al., 2013) remain unexplored avenues of investigation. What is more, only few studies used standard measures- of financial literacy and numeracy. As a baseline and in order to make

efficient comparisons financial literacy should be measured by questions largely based on the ones developped by Lusardi & Mitchell, (2011a; 2011b) while numeracy should be measured via the procedure described by Steel et al. (2003) and Banks & Oldfield, (2007) and present in the ELSA surveys. Independantly, the mesures of financial literacy could be improved to fullfill psychometric requirements.

III. How is it possible to improve numeracy and financial decisions?

Is improving numeracy an effective means of improving financial behaviour? To date, this question has rarely been addressed empirically as noted by Garcia-Retamero et al., (2019) in a recent survey. One exception is Cole et al., (2016) who find that personal finance courses have no effect on financial behaviour while mathematics training improves financial market participation, investment income and credit management. To identify these effects, they use changes in the educational policies of some American states that decided to introduce mandated personal finance courses or to reinforce mathematics teaching in high school as exogenous shocks.

These results at a highly aggregated level do not indicate what types of numeracy are important for financial decisions. One of the mechanisms suggested in the literature is the ability to perceive numbers accurately. In a lab experiment, Peters & Bjalkebring, (2015) have highlighted the importance of this psychophysical mechanism. They observe that participants with higher symbolic-number mapping abilities produced valuations that were closer to a risky gamble's expected value. Based on this observation, Sobkow et al., (2019) run a lab experiment where they compare the performance of participants randomly assigned to a Mental Number Line Training condition or an Arithmetic Training Active Control condition. Participants in the Mental Number Line Training developed a more precise mapping of numbers onto the mental number line but they do not perform better in financial decisions or

in the valuation of risky prospects. Overall, they observe that both groups improve their financial behaviour.

The finding that numeracy training provides only limited benefits for cognitive tasks other than those for which the subjects were trained may not be a surprise given similar mixed results observed for brain training in general. Using data collected by companies that sell "brain games" for improving cognition, Simons et al., (2016) find strong evidence of improved performance on the trained tasks, moderate evidence of improved performance on closely related tasks and little evidence of an effect on distantly related tasks or on everyday cognitive performance. Training limited to cognitive performance therefore seems to have low efficiency .

Rather than focusing on improving objective numeracy, a promising way forward seems to be to consider subjective numeracy, that is, one's confidence in being numerate. Indeed, Peters et al., (2019) show that beyond objective numeracy, low self-confidence is correlated with worse financial or health outcomes. Peters et al., (2017) supports its importance and shows that it can be another avenue for intervention. They use a value affirmation manipulation to enhance self-image and to change the perception of statistics classes that the students attended. The manipulation was effective in improving objective numeracy. The authors also observe an indirect effect via subjective and objective numeracy on financial outcomes, financial literacy and health behaviours.

Problems induced by low numeracy are not limited to the issue of financial behaviours (Windisch, 2016). Extensive literature has examined medical decisions, whether made by patients or by physicians. The paper authored by Schwartz et al., (1997) is one such seminal article. It showed the impact of low numeracy on medical decision-making, here the estimation of risk of death from breast cancer with and without mammography. It has been recognized that people who have problems understanding probability do not know how to use

medical statistical information to make a decision (see for instance Reyna et al., (2009) for a survey). Rather than identifying interventions to improve numeracy skills, the main approach in the medical domain has been to assist people in their processing of statistical information by presenting it in a way that makes it easier for people to process. This approach is particularly inspired by the work of Gigenrenzer (Gigerenzer & Hoffrage, 1995), who showed that people in general were much better at Bayesian reasoning if Bayesian inference problems were presented in the natural form of frequencies rather than the more abstract form of probabilities. Moreover, it has been observed that people with lower numeracy were the most sensitive to these framing effects (Peters, 2012). Many effective visual aids have been developed (see for instance Garcia-Retamero and Cokely, 2014). Lusardi et al., (2017) implement visual tools in order to improve financial literacy. Using the RAND American Life Panel, they exposed participants to different online education programmes with differing "material" supports: an informational brochure, a visual interactive tool, a written narrative and a video narrative. All these programmes deliver the same educational messsage related to risk diversification. After their exposure to one of the programmes, participants were asked about financial knowledge (risk-diversification). The authors found that the video support was the most effective programme for improving financial knowledge. It could be a promising avenue and development of such an aid would fit naturally into consumer protection mechanisms. This would involve identifying prototypical financial information that people generally find difficult to process and for which a way should be found to present it in a more natural way.

At the same time, another solution aimed at improving individuals' decision-making in investment choices, particularly with regard to pension schemes (United States), is the introduction of nudges (here, the default choice) as proposed by (Thaler & Benartzi, 2004). Nevertheless, despite the great success of this implementation, the nudge system does not

reduce the financial risk taken by households that are financially illiterate and have to cope with that risk (see Arrondel et al., (2013). Last but not least, financial illiteracy or lack of numeracy raises the issue of the protection of households in the financial sphere in terms of regulation. Recent consumer protection policies such as the MiFID II Directive (2014) in the euro area and the Dodd-Frank Act in the United States only partially consider this low level of household financial knowledge. Indeed, Mak & Braspenning, (2012) argue that the current regulation of the EU consumer credit market does not guarantee full consumer protection and they advocate that this regulation should give more protection to groups of consumers with low financial literacy and numeracy.

In conclusion, numeracy and financial literacy are strongly correlated, and empirical results show that numeracy is a key determinant of financial literacy and financial behaviours. Even if numeracy is a more general ability that affects decisions in many areas, it is likely that it is an important support for attaining financial knowledge. As suggested by Almenberg & Widmark, (2012) this raises the prospect that improving numeracy in the population may improve financial literacy as well. More research is needed to explore this indirect impact as well as the potential impact of other factors that could improve financial decisions, in particular education, emotion, ability to process information (Christelis et al., 2010) or confidence (Ghazal et al., 2014).

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