Subjective Financial Literacy and Retail Investors' Behavior

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Abstract

This paper investigates the relationship between *subjective* financial literacy, i.e. self-reported by investors, and trading behavior. In particular, we use the level of financial knowledge and experience reported in the MiFID tests by retail investors. Such tests are implemented in the EU from the so-called MiFID directive since November 2007. We show that subjective financial literacy helps explain cross-sectional variations in retail investors' behavior. Investors who report higher levels of financial literacy seem to invest *smarter*, even after controlling for gender, age, portfolio value, trading experience and education. They trade more and are less prone to the disposition effect. They tend to concentrate their portfolios on a small set of stocks and achieve diversification through investment funds holding. Their trading behaviors allow them to display higher gross and net returns as well as higher excess Sharpe ratios. Our findings are relevant for both policy making and understanding retail investors' behavior.

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1 Introduction

Lusardi and Mitchell (2014) define *financial literacy* as the ability to process economic information and make informed decisions about financial planning, wealth accumulation, debt and pensions. In order to assess such an ability, these authors have designed a set of questions built on the three following basics: numeracy and capacity to do calculations related to interest rates, understanding of inflation, and understanding of risk diversification.[1] Their set of questions is now recognized as a standard in the literature. It has been administered to populations of different ages in the US (Lusardi and Mitchell (2011a)) but also in other countries such as the Netherlands (Van Rooij et al. (2011)) and Japan (Sekita (2011)). The main empirical findings all converge at a widespread low level of financial literacy. Beyond the level of individuals' knowledge of financial concepts, several authors show that financial literacy is effectively related to different aspects of financial behavior. For example, Hilgert et al. (2003) document a strong correlation between financial literacy and day-to-day financial management skills. In the same vein, Lusardi and Mitchell (2007) find that individuals with low financial literacy are less likely to plan for retirement and therefore accumulate less wealth during their lifetime. As for Guiso and Jappelli (2008), they provide evidence that measures of financial literacy are strongly correlated with the degree of portfolio diversification. Finally, a bunch of papers highlight the positive relationship between financial literacy and stock market participation (a.o. Kimball and Shumway (2006), Christelis et al. (2010), Van Rooij et al. (2011)).

Most of the above papers refer to *objective* measures of financial literacy, i.e. based on a set of questions designed to assess how people deal with fundamental concepts at the root of saving and investment decisions. Such objective measures reveal individuals' *actual* knowledge, where the latter is based on correct answers. By contrast, *subjective* measures of financial literacy rely on questions asking people to indicate their self-assessed financial knowledge and expertise. Such subjective data may best capture psychological drivers affecting the individual's decision-making process. Their use remains however quite infrequent in the financial literature, despite the growing amount of papers relying on surveys to elicit investors' attributes (a.o. Glaser and Weber (2007), Graham et al. (2009), Merkle and Weber (2014)). The reluctance towards such data is mainly an a priori skepticism: Can we trust what people state? Can we use this information to understand how they behave? And for financial literacy in particular,

[1] For more details, see Lusardi and Mitchell (2008), Lusardi and Mitchell (2011a) and Lusardi and Mitchell (2011b).

respondents are expected to be rather confident about their financial knowledge and, overall, overestimate how much they actually know. According to the literature, the relationship between *objective* and *subjective* literacy may not be taken for granted (Lusardi and Mitchell (2014)). While some authors document a strong positive relationship between both measures (Dorn and Huberman (2005), Van Rooij et al. (2011)), others report only a weak relationship (Guiso and Jappelli (2008), Lusardi (2011) and Bucher-Koenen et al. (2012)). Xia et al. (2014) even use the difference between both measures as a proxy of overconfidence.

In this paper, we investigate the relationship between subjective financial literacy and actual trading behavior. For that purpose, we use subjective measures of financial literacy available in the so-called MiFID tests. The latter are implemented in the EU since the MiFID Directive[2] came into force in November 2007. This piece of European regulation was wide and far reaching; it covered all forms of intermediation/services or dealing activities and impacted all financial intermediaries, their clients (either professional or retail) and the majority of financial instruments. In a nutshell, MiFID has made compulsory for investment firms to collect specific information about their retail clients' needs and preferences. Accordingly, investment firms operating in the EU are obliged to submit tests to their clients in order to determine their level of knowledge and experience, their investment objectives as well as their financial capacity. Such tests should help offer investors suitable services. Specifically, *suitability* assessment is required before providing investment advice or portfolio management services while *appropriateness* assessment is required before providing execution and transmission of orders (what is called "execution only" in the industry) on complex financial instruments. Basically, the *Suitability* test aims at understanding the types of investments that will be suitable for the investor while the *Appropriateness* test should assess the investor's knowledge and experience in complex financial instruments so as to protect those who would not understand or be

[2]MiFID stands for Markets in Financial Instruments Directive. Formerly known as Investment Services Directive II, this directive was the second step in the harmonization of the European capital markets industry. It essentially aimed at adapting the first Investment Services Directive (ISD 1, issued in 1993) to the realities of the current market structure. On October 2011, the European Commission adopted a legislative proposal for the revision of MiFID. This revision took the form of a revised Directive (MiFID II) and a new Regulation (MiFIR). In a nutshell, MiFID II came into force in January 2018 and confirms the role of the MiFID tests by strengthening conduct rules such as an extended scope for the Appropriateness test and reinforced information to clients. For more details, see the European Commission website (`http://ec.europa.eu/internal_market/securities/isd/mifid2/index_en.htm`.)

aware of the potential implications and level of risk involved in a "complex" transaction (i.e. involving "complex" instruments such as derivatives).

Although the MiFID tests have now been implemented for several years, they have raised little interest so far, whether in academia or in the financial industry. MiFID deserves though a particular attention since it requires investment firms to gather survey data about their clients but without defining standard questionnaires.[3] MiFID mainly requires that suitability assessment covers three sets of items: investment objectives, financial capacity, experience and knowledge. As for appropriateness assessment, it has to be based on experience and knowledge only. Furthermore, MiFID does not impose the use of objective measures of financial literacy and most of the time investors are rather asked to self-assess their level of financial knowledge. This wide latitude for interpretation has led to a large diversity of questionnaires since each investment firm has developed its own tests for profiling its clients.[4]

As for academic research addressing this topic, it is still in its infancy. Marinelli and Mazzoli (2011) document the differences characterizing the MiFID tests across 14 Italian investment firms. These authors show that the questionnaires largely diverge in their structure and content. According to them, this huge heterogeneity may have side effects leading to inconsistent profiling.[5] Linciano and Soccorso (2012) also analyze the questionnaires used by several Italian intermediaries and confirm that they depend on the firm's business model. These authors point out a lack of appropriate training courses for the advisors who have to administer these MiFID tests to clients.[6] Furthermore, they report that the tests under scrutiny mainly require self-assessment from clients and include several ambiguous questions that are easy to misunderstand. More recently, Mazzoli and Marinelli (2014) have focused on risk profiling for

[3]The European regulator only provided guidelines and general rules for implementing the MiFID tests.

[4]Supervisory authorities have taken initiatives to both evaluate how well the questionnaires used in practice comply with MiFID requirements and improve the implementing guidelines (a.o. AMF (2010), FSA (2011), ESMA (2012), FSMA (2014)). The resulting evidence tends to reveal the poor quality of suitability tests, the poor quality of client profiling, and poor advisory services as a consequence.

[5]They show that the same investor could be characterized as 'cautious' or 'dynamic', depending on the test that is used.

[6] While in a few cases the staff has been specifically trained, the training was limited to refresher courses on the legal aspects, or generic training courses for advisers. Workshops on the design of questionnaires were rarely included in the training sessions, nor explicit references to the potential issues of cognitive and behavioural biases affecting the administration of questionnaires. According to Linciano and Soccorso (2012), this represents a major issue since building valid and reliable questionnaires requires specific multidisciplinary skills.

a sample of 1,149 suitable portfolios and conclude that information gathered in the tests are not sufficient to determine an investor's risk profile.[7]

In contrast with the aforementioned papers, we aim at finding whether the answers given by retail investors in the MiFID tests are informative and consistent with their trading behavior. Specifically, we focus on financial literacy since it is included in both tests and should help investment firms elicit the degree of their clients' knowledge and experience. As such, this paper is, to the best of our knowledge, the first paper investigating the informativeness of financial literacy in the MiFID tests. Guiso and Jappelli (2008) document that "eliciting financial literacy by simply asking people if they know finance is bound to lead to serious mistakes [...] To put it simply, using self-assessment to rank investors on the basis of their financial knowledge for regulatory purposes is confounded by investors' over- or underconfidence." Our aim is therefore to determine whether the investors' self-assessment of their financial literacy may be useful for characterizing investors' trading behavior and may be reliable for both regulators and investments firms.

Our research question is relevant because the extant literature is still scarce and the results are often mixed. Dorn and Huberman (2005) are some of the first authors to confront investors' portfolios and trading activity with their own statements. They highlight that the inclusion of subjective investor attributes offers several insights into investor behavior. Regarding the relationship between self-assessment of financial literacy and trading behavior, they find ambiguous evidence. On the one hand, they report that investors who perceive themselves as more knowledgeable about financial securities display a better diversified portfolio. On the other hand, those who perceive themselves as better informed about financial securities than the average investor churn over their portfolios more, which may be evidence of overconfidence. Graham et al. (2009) focus on the "competence effect" and its impact on financial behavior.[8] They find that investors who feel competent trade more often and have more internationally diversified portfolios. Finally, Allgood and Walstad (2013) investigate the relationship between credit card behavior and financial literacy by using objective and subjective measures of literacy. Their results suggest that financial literacy is significantly related to less costly practices

[7] In particular, they put forward variables that are directly related to both the risk-holding and risk-allocation decisions of the Italian households in their sample.

[8] The competence effect could be related to the self-perceived financial literacy we analyze since it is defined as the fact of feeling skillful or knowledgeable in an area. The authors suggest that the competence effect is particularly relevant to investors' behavior as investors are constantly required to make decisions based on subjective probabilities.

in credit card use. However, they find perceived financial literacy to be a stronger predictor than actual financial literacy. This study also shows that the combination of subjective and objective assessments of financial literacy provides a more comprehensive analysis of how financial literacy affects credit card behavior. We should stress that none of the above papers dealt with the relationship between subjective literacy and performance.

In this paper, we use a unique database from an important online Belgian brokerage house to investigate the behavior of 20,285 retail investors during the 2003-2012 period. This database includes usual information relative to investors' orders and trades, but also their answers to both MiFID tests. Those tests are conducted online and answers are self-reported decisions the investors make on their own. The advantage is that the answers are not affected by any conversation with a broker or a financial advisor. However, online tests - like online trading activities in general - have also a drawback: they make investors "do-it-yourselfers" in an information-rich environment, thereby bolstering their overconfidence due to an illusion of both knowledge and control (Barber and Odean (2001), Volpe et al. (2002)).

In a first step, we check the consistency between subjective financial literacy reported in the Suitability test (hereafter S-test) and the one reported in the Appropriateness test (hereafter A-test). Like for any survey, the fact that such tests force investors to self-assess their financial literacy and report a lot of individual perceptions may raise skepticism about the meaningfulness of answers. In a second step, we check the consistency between subjective financial literacy and trading behavior characterized along three different aspects: experience and familiarity with financial markets, diversification and performance.

Our main findings may be summarized as follows. Regarding the self-assessment of financial literacy, our results show an overall consistency across investors' answers: investors who report a high literacy in the A-test are much more likely to also report a high literacy in the S-test. As for the consistency between subjective financial literacy and actual behavior, we provide empirical evidence that subjective literacy helps explain cross-sectional variations in retail investors' behavior. Investors who report higher levels of financial literacy tend to invest *smarter*. Specifically, they trade more on both stocks and complex instruments and they are less exposed to the disposition effect, which is consistent with higher experience. Although investors with higher subjective literacy trade in a larger stock universe, they hold less diversified stock portfolios (but not riskier). In fact, they tend to concentrate their stock portfolios on a small set of securities and achieve global diversification through investment funds holding. Finally, investors with higher subjective financial literacy display higher both gross and net returns as

well as higher excess Sharpe ratios. All our results hold even when we control for gender, age, portfolio value, trading experience and education.

All in all, our findings support consistency between subjective literacy and actual trading behavior. Retail investors are overall consistent when reporting their financial literacy online. More importantly, this piece of information provided by the investors themselves could help better understand and characterize their actual trading behavior. Such results are relevant for both policy making and understanding retail investors' behavior. Subjective literacy reported in the MiFID tests is informative to characterize retail investors and hence deserve more attention in that perspective. This empirical evidence is meaningful for investment firms that are forced to administer the MiFID tests in the EU. Using subjective literacy could help those investment firms deliver the most suitable services to their retail clients. This paper could also provide insights for regulatory purposes, since we show that subjective financial literacy reported online does correlate with actual trading behavior. Generally speaking, our contribution to the literature appears even more relevant because the role of the MiFID tests has recently been confirmed in the European regulation.[9] It also opens new areas of research such as the role of opinions, perceptions and beliefs in the individuals' financial decision-making process.

The remainder of this paper is structured as follows. Section 2 describes our data and sample as well as the MiFID tests. We report our empirical work and the results in Section 3. Section 4 concludes.

2 Data and Sample

The data are provided by an online Belgian brokerage house and cover the period from January 2003 to March 2012. They refer to 20,285 retail investors and are made of two datasets. The first one contains information about the investors, that we classify into three categories. The first category includes socio-demographic data: year of birth and gender. The second category encompasses the answers to the A-test while the third category contains the answers to the S-test. The second dataset is made of detailed information about the investors' trading activity.

[9] With MiFID II that came into force in January 2018, the EU's regulation confirms the role of such tests by strengthening conduct rules such as an extended scope for the Appropriateness test and reinforced information to clients. For more details, see the European Commission website (`http://ec.europa.eu/internal_market/securities/isd/mifid2/index_en.htm`).

The online brokerage house provides their clients with an access to a large panel of financial instruments. The main traded securities are stocks, funds, options, warrants, and bonds. Only futures contracts cannot be directly traded on the common trading web platform of the broker.[10] The data include an ISIN code for each instrument, order size, price, type, executed quantity, trade price, time-stamps, explicit transaction costs as well as a code for the market where the trade was completed. Both datasets include an anonymized code identifying each investor, which allows us to select all information relative to a specific investor. For the purpose of our study, we use information about trading activity on stocks to build end-of-month portfolios for each investor in the sample. A third dataset including historical market data coming from Eurofidai and Bloomberg is then used to compute the market value of end-of-month stock portfolios.

2.1 Trading activity

Our sample contains 2,107,382 trades on stocks[11] executed by 20,285 investors across about 13,000 different stocks. 57% of the trades are purchases and 43% are sales on an aggregate basis. Individual investors execute about 235,000 trades in a typical year and about 20,000 trades in a typical month. Regarding socio-demographic data, the average investor is 48 years old[12] and we count only 10% of women in the sample. As for the level of education, 73% have a university degree, 20% hold a secondary/high school degree and 7% have no degree.

Tables 1 and 2 present descriptive statistics regarding trading activity. The average investor executes a total of 144 trades across all instruments. When focusing on stocks only, the average is 103 trades on 27 different stocks. With a sample period of 111 months, the average investor executes about 11 trades on stocks per year, which is similar to the trading activity reported in Kumar and Lee (2006).[13]

[10] As a result, we do not have data about the trading activity on futures contracts.

[11] We focus on stocks for which a valid ISIN code is available. For stocks traded in foreign currencies, we use exchange rates to convert monetary volumes into euros.

[12] Age is calculated in 2012 using the year of birth.

[13] Those figures are in line with other samples used in the literature on retail investors' trading activity. For example, Dhar and Zhu (2006) report an average of 60 trades on stocks per investor on a period from 1991 to 1995 (i.e. 12 trades per year per investor) and Barber and Odean (2000) find an average of 30 trades on stocks per investor over a 5-year period.

As for the other instruments, the average investor completes 26 trades on options or warrants, 12 trades on investment fund shares and less than 1 trade on bonds. The average trading experience is about 54 months (that is 4.5 years).[14] We observe a large dispersion in our sample. The number of total trades, the number of stock trades, the number of stocks traded and the trading experience are all positively skewed since the medians are substantially lower than the mean values. This positive skewness is even more striking for the number of trades on non-stock instruments. For example, only 25% of investors trade at least 2 options or 2 investment fund shares.

Table 1: Descriptive statistics for trading activity (1)

	Mean	Median	Q1	Q3
Number of total trades	144	54	19	144
Number of stock trades	103	40	15	102
Number of different stocks traded	27	16	7	34
Number of option trades	26.41	0	0	2
Number of fund trades	12.32	0	0	2
Number of bond trades	0.28	0	0	0
Trading experience (in months)	54	51	26	81

The table reports the cross-sectional mean, median, lower and upper quartiles for trade-based measures on a per investor basis over the sample period. 'Number of total trades' is the number of trades executed across all instruments. 'Number of stock trades' is the number of trades executed on stocks. 'Number of different stocks traded' is the number of different stocks traded during the whole trading period. 'Number of option trades' is the number of trades executed on both options and warrants. 'Number of fund trades' is the number of trades executed on investment fund shares. 'Number of bond trades' is the number of trades executed on bonds. 'Trading experience' is computed as the difference between the last trade date and the first trade date available in the sample. It is expressed in number of months.

Table 2 shows complementary statistics computed on binary variables. Regarding asset allocation, 34% of investors trade investment fund shares, 31% trade options or warrants, but only 8% trade bonds. These figures appear consistent both with the statistics reported in Table 1 and with papers dealing with other samples.[15]

[14]We compute the trading experience as the difference between the date of the last trade on stocks and the date of the first trade on stocks available in the sample. As in Glaser and Weber (2009), we exclude from our sample investors with less than 5 months of trading activity. This filter allows us to drop very short-lived investors.

[15]Boolell-Gunesh et al. (2012) report that about 12% of their French retail investors trade bonds and 25 % warrants. Korniotis and Kumar (2013) document that 22% of their sample investors hold mutual funds and 9%

Table 2: Descriptive statistics for trading activity (2)

	0	1
Bonds_trader	92%	8%
Funds_trader	66%	34%
Options_trader	69%	31%

The table reports statistics for trade-based measures built on binary variables. 'Bonds_trader', 'Funds_trader', 'Options_trader' are set to 1 when the investor made at least one trade on respectively bonds, investment fund shares and either options or warrants.

2.2 MiFID tests

MiFID came into force in 2007 across the EU member states. One of its objectives was to increase the level of protection of investment firms' clients. In addition to client categorization aiming at segregating retail investors from professional investors and eligible counterparts, MiFID requires investment firms to qualify their clients and the services requested through Suitability and Appropriateness tests. These two levels of qualification depend on the type of services provided to the investor.

The Suitability test (S-test) has to be submitted to investors before providing investment advice or portfolio management services. Assessment of suitability involves ensuring that the instruments and services offered meet the investor's objectives, financial capacity as well as his knowledge and experience in financial instruments. As mentioned earlier, the room for interpretation left by the regulator has generated a huge diversity of questionnaires used in the industry. In our case, the S-test under scrutiny is made of 11 questions. Among them, two questions directly deal with the level of knowledge of financial markets. For the purpose of our study, we only consider the answers to these two questions in the empirical part. Those are reported in Table 3, Panel B. Our sample is made of investors who asked for an access to an advice tool on stocks[16] and we have the S-test data for each of them.

trade at least once options. Koestner et al. (2017) find however a higher proportion of retail investors trading mutual funds in their sample (49%).

[16]During the sample period, the online brokerage house doesn't offer portfolio management services to its clients. It only provides a free access to an investment advice tool on stocks.

The Appropriateness test (A-test) has to be submitted to investors before providing execution and transmission of orders in complex financial instruments. Assessment of appropriateness mainly requires ensuring that the investor has the necessary experience and knowledge to understand the risks involved in complex financial instruments.[17] In practice, the brokerage house that provides us with data has implemented this test for an exhaustive list of instruments, including shares traded on a non-European market or on a European non-regulated market (such as Multilateral Trading Facilities under the MiFID typology). As a result, we have the answers to the A-test for all the retail investors of our sample so that it does not suffer from any selection bias. The A-test under scrutiny is made of 9 questions, among which one is about the general knowledge of financial markets. The answer to this specific question, which is provided in Panel A of Table 3, is considered in the empirical part.

[17] Unlike the S-test, the result of the A-test is not restrictive for investors. Based on the collected information, investment firms have only to provide recommendations about the appropriateness of financial instruments. Therefore an investor may choose, at his own risk, to go ahead with a transaction even if the involved instrument is flagged as inappropriate.

Table 3: Subjective financial literacy questions

Panel A: A-test question	Answers
What is your knowledge of financial markets?	
Level 0	I know a few things but I am interested by the financial markets
Level 1	I have sufficient experience to understand well the importance of a good diversification of risks
Level 2	I understand the functioning of the financial markets. I know that the fluctuations can be important and that the various sectors and categories of products have different characteristics relating to their revenue, growth and risk profile
Level 3	I consider myself as an experienced investor who manages any aspect of the financial markets
Panel B: S-test questions	**Answers**
What is your knowledge of the financial markets?	
Level 1	I know very little about it and I am not really interested in it
Level 2	I am not familiar with investments, but I am interested in it
Level 3	I have sufficient experience to acknowledge the importance of risk diversification
Level 4	I have a good knowledge of the financial markets. I am aware that the financial markets can strongly fluctuate, that sector and asset categories have different characteristics regarding revenue, growth and risk profile
Level 5	I consider myself as an experienced investor who thoroughly masters all the aspects of the financial markets
How do you estimate your level of knowledge and experience about risks and potential obligations inherent to shares, bonds, funds and structured products?	(*based upon the type of product in which you have the lowest experience*)
Level 0	No knowledge
Level 1	Average knowledge
Level 2	Good knowledge

The table reports the questions dealing with subjective financial literacy in the MiFID tests under scrutiny. Panel A refers to the single question about financial knowledge in the A-test. Panel B presents the two questions about financial knowledge and experience in the S-test.

We should stress that the answers to both MiFID tests are online decisions made by investors themselves, without intermediaries. They are therefore not affected by conversations with a broker or a financial advisor. In addition, both tests include subjective literacy assessment but, as shown in Table 3, they do not ask exactly the same questions and available answers differ. Investors are not necessarily forced to fill in both tests at the same time. One shortcoming of our data is that they report neither the date at which the investor filled in the tests nor their potential updates.

Statistics for subjective literacy are provided in Table 4. In Panel A, we observe a large heterogeneity among investors. Only 11% of investors consider themselves as experienced investors while 20% of them report a basic knowledge. The most frequently chosen level is the third on the scale, which states that the investor 'understands the functioning of the financial markets and knows that the fluctuations can be important and that the various sectors and categories of products have different characteristics relating to their revenue, growth and risk profile'.

In Panel B, the empirical frequencies regarding the 'knowledge of financial markets' seem to be somewhat consistent with those observed in Panel A despite the use of a different scale. 9% of investors view themselves as very experienced investors in the S-test but only 3% report that they know very little about financial markets. The first two levels represent about 17% of investors. Again, the most frequently selected level is the second last on the scale, which states that the investor 'has a good knowledge of the financial markets and is aware that the financial markets can strongly fluctuate, that sector and asset categories have different characteristics regarding revenue, growth and risk profile'. The second question in Panel B covers both the knowledge and experience about "complex" instruments.[18] 56% (30%) of investors consider they have an average (a good) knowledge and experience. Only a minority (14%) of investors report they have no knowledge and experience.

[18] As described in Table 3, investors are asked to answer this specific question based upon the type of product in which they have the lowest experience. The listed instruments are shares, bonds, funds and structured products.

Table 4: Statistics for questions about subjective financial literacy

Panel A: A-test question					
	0	1	2	3	
Knowledge of financial markets	20%	28%	41%	11%	
Panel B: S-test questions					
	1	2	3	4	5
Knowledge of financial markets	3%	14%	31%	43%	9%
	0	1	2		
Knowledge and experience about "complex" instruments	14%	56%	30%		

The table reports the empirical frequencies for subjective financial literacy in the MiFID tests. In Panel A, levels 0 to 3 refer to the answers to the question about financial knowledge in the A-test as reported in Table 3. In Panel B, levels 1 to 5 refer to the answers to the question about financial knowledge in the S-test as reported in Table 3. Levels 0 to 2 refer to the answers to the question about knowledge and experience about "complex" instruments in the S-test as reported in Table 3.

2.3 Stock portfolio data

As mentioned earlier, we use data on stock-related trading activity to build end-of-month portfolios for each investor. With these data at hand, we compute the monthly average number of stocks held in portfolio. Combining our data with historical market data, we also compute the monthly average portfolio value as well as the monthly average turnover as in Hoffmann et al. (2013).[19] Building on the literature, we assume that all trades executed in a given month take place on the last day of this month to finally compute both gross and net monthly returns.[20]

Table 5 reports descriptive statistics for the above-mentioned measures. From Panel A, we know that the average investor holds a six-stock portfolio while the median investor holds a four-stock portfolio. The average end-of-month portfolio value is about € 44,000 with a median value of about € 11,000. As for the turnover, the average investor churns 0.285 times

[19] Average of the absolute values of all purchases and sales in a particular month divided by the average of the portfolio values at the beginning and the end of this particular month.

[20] This assumption is used in Barber and Odean (2000), Barber and Odean (2001), Shu et al. (2004) and Glaser and Weber (2007). Barber and Odean (2000) show that this simplification does not bias the measurement of portfolio performance.

his portfolio each month (with a median of 0.1053). These figures are overall in line with other papers dealing with retail investors' portfolios (a.o. Barber and Odean (2001), Shu et al. (2004), Dorn and Huberman (2005), Kumar and Lee (2006), Glaser and Weber (2007), Goetzmann and Kumar (2008), Hoffmann et al. (2013)). Like the trade-based variables, all these portfolio-based variables are positively skewed since the means are substantially larger than the medians.

In Panel B, we report descriptive statistics for the average monthly gross and net return per investor, using both an arithmetic and a geometric average. Although the means of the arithmetic (gross and net) returns are quite large,[21] the median value is consistent with other empirical evidence (a.o. Glaser and Weber (2007)). The mean of the geometric gross returns is equal to 0.6% while the mean of the geometric net returns is not statistically different from zero. The average volatility of monthly gross returns is 28% while the median is 12%. These performance measures also display a positive skewness and reveal a large heterogeneity in our sample. This is consistent with Barber and Odean (2013) who point out that the aggregate performance of retail investors masks tremendous variations in behavior and in outcomes across individuals.

[21] Dorn and Huberman (2005) report quite similar figures, with a mean value of 2%.

Table 5: Descriptive statistics for end-of-month portfolio data

	Mean	Median	Q1	Q3
Panel A: Monthly stock portfolio				
Number of stocks	6	4	2	8
Portfolio value (€)	43,844	11,136	3,513	32,755
Turnover (%)	28.5	10.53	5.64	22
Panel B: Monthly trading performance				
Arithmetic gross return (%)	2.62	0.91	-0.32	3.13
Arithmetic net return (%)	1.64	0.48	-0.84	2.58
Geometric gross return (%)	0.6	0.38	-0.8	1.85
Geometric net return (%)	0	0	-1.3	1.44
Volatility (%)	27.87	12	8	22

The table reports the cross-sectional mean, median, lower and upper quartiles for portfolio-based measures on a per investor basis over the sample period. 'Number of stocks' is the monthly average number of stocks held in portfolio. 'Portfolio value' is the monthly average portfolio market value. 'Turnover' is the monthly average turnover. It is calculated as in Hoffmann et al. (2013), i.e. average of the absolute values of all purchases and sales in a particular month divided by the average of the portfolio values at the beginning and the end of this particular month. 'Arithmetic gross return' is the arithmetic average of monthly gross returns. 'Arithmetic net return' is the arithmetic average of monthly net returns. 'Geometric gross return' is the geometric average of monthly gross returns. 'Geometric net return' is the geometric average of monthly net returns. 'Volatility' is the standard deviation of monthly gross returns.

2.4 Measures of trading behavior and financial literacy

Some of the above variables will be used in the empirical part to characterize investors' trading behavior along three different aspects: experience and familiarity with financial markets, diversification and performance.

As measures of experience and familiarity with financial markets, we use the number of total trades across instruments, the number of stock trades and the monthly average turnover. Building on Goetzmann and Kumar (2008), we also consider whether investors trade options or warrants since these derivative securities create high entry barriers that individuals with low financial literacy may find difficult to overcome.[22] Moreover, we consider the retail investors' exposure to the Disposition Effect (DE hereafter), which refers to investors' reluctance to

[22] For example, Hsiao and Tsai (2018) provide evidence that individual investors with higher levels of knowledge are more likely to trade derivatives.

realize losses (i.e. they keep "losers") as well as their propensity to realize gains (i.e. they sell "winners"). This behavioral bias, which was first labelled by Shefrin and Statman (1984), is today well-documented and several papers show that investors' experience helps dampen it.[23] We apply the methodology of Odean (1998) to assess the DE at the individual level, i.e we measure this bias as the difference between the proportion of gains realized and the proportion of losses realized.

To assess diversification we use the number of different stocks traded during the whole period since it reveals how large an investor' stock investment universe is. In addition, we use the monthly average number of stocks held in portfolio. While Goetzmann and Kumar (2008) state that the number of stocks in a portfolio is a useful heuristic for identifying the degree of diversification, other authors report that this "crude" measure of diversification often overstates the actual level of diversification (a.o. Blume and Friend (1975)). Therefore, building on Dorn and Huberman (2005), we use the volatility of monthly returns as a complementary measure of risk diversification and we also consider whether investors trade investment funds. According to Guiso and Jappelli (2008), diversifying wealth through funds requires a good understanding of the diversification benefits as well as the risk properties of the assets pooled within the fund. As in Goetzmann and Kumar (2008) and Koestner et al. (2017), we finally add the monthly average Herfindahl-Hirschman Index (HHI hereafter). This index of diversification can be approximated by the sum of squared stock portfolio weights. HHI ranges then from 0 (for well-diversified portfolios) to 1 (for underdiversified portfolios including only one stock). However, for investors who hold monthly positions in investment funds, we adjust the index by replacing any position in funds by a portfolio of 50 equally-weighted securities as in Dorn and Huberman (2005) and Koestner et al. (2017). In that case, we refer to it as the modified HHI (M_HHI hereafter).

[23] Feng and Seasholes (2005) show that retail investors with higher trading experience display a lower DE. Dhar and Zhu (2006) provide evidence that the exposure to the DE is lower among investors who are older, have a higher professional status and larger income. Boolell-Gunesh et al. (2012) find that investors who trade derivatives, bonds, and hold multiple accounts to place orders are less exposed to the DE.

As performance measures, we first use the geometric average of both gross and net returns.[24] We also consider Sharpe ratios that are risk-adjusted measures.[25] In addition, to take into account the market performance, we compute excess Sharpe ratios, i.e. Sharpe ratios in excess of market Sharpe ratio. The latter is then measured as the monthly market portfolio return in excess of the risk-free rate compared to the volatility of monthly market portfolio returns.[26] For each investor, we end up then with six measures of performance that are his monthly average gross and net returns, Sharpe ratio and excess Sharpe ratio.

In the empirical part, we will relate the above measures that characterize investors' actual behavior with measures of subjective literacy. For the latter, we will directly use the questions from the MiFID tests presented in Table 3.

3 Empirical work

3.1 Consistency across investors' answers in both MiFID tests

Our motivation to assess the consistency across investors' answers for similar questions in both MiFID tests is threefold. First, both the S-test and the A-test force investors to self-assess their financial literacy, which may cast doubt about the meaningfulness of answers. Second, investors are not forced to fill in both tests at the same time because they depend on different services. Third, if both tests include literacy assessment, they do not ask exactly the same questions. The ordering of questions, the wording of questions or even the scales presented to investors could activate cognitive factors that affect the way they assess their knowledge (Bertrand and Mullainathan (2001)). These three phenomena could lead to some inconsistency across the answers provided by the same investor, an effect that Tversky and Kahneman (1981) name the "framing effect".[27]

[24] Given the high volatility of monthly returns over the sample period, the arithmetic average of monthly returns is not a representative measure of performance.

[25] Sharpe ratio measures the portfolio return in excess of the risk-free rate compared to the portfolio's riskiness as measured by the volatility of portfolio returns. In this paper, we use the monthly-equivalent 12-month Belgian T-bill rate as a proxy for the risk-free rate.

[26] As a benchmark for the market portfolio, we use the Eurostoxx 600 Index.

[27] Bruine de Bruin (2011) states that the framing effect may be due to variations in question wording, choice set, and presentation order.

For our purpose, we use contingency tables wherein unconditional and conditional empirical frequencies are reported. We focus on self-reported financial knowledge in both MiFID tests and provide the results in Table 6. Based on the χ^2 statistic,[28] we first strongly reject the null hypothesis of independence between the two measures of subjective financial literacy. Comparing unconditional to conditional frequencies, an investor who reports a high level of literacy in the A-test is much more likely to mention a high level of financial knowledge in the S-test. For example, while the unconditional empirical frequency for the investors who choose the highest level of literacy in the S-test is about 9%, the corresponding frequency increases to about 48% for the investors who also select the highest level of knowledge in the A-test.

Then, in order to assess the level of consistency between the two measures of subjective financial literacy, we use the Spearman's rank correlation. It exhibits a value of 54%, thereby confirming a high but not perfect consistency across answers. Such a perfect correlation should not be realistic because of the difference of scale, the difference of wording as well as the potential difference of timing between both tests.

Finally, the number of investors who provide totally inconsistent answers is substantially low. Only 66 (80) investors have selected the highest (lowest) level of knowledge in the A-test while they have chosen the lowest (highest) level of financial knowledge in the S-test, accounting for only 0.72% of investors in our sample.

[28] $\chi^2 = \sum_i \sum_j \frac{(n_{ij} - \frac{n_i n_j}{n})^2}{\frac{n_i n_j}{n}}$ where the degree of freedom is $(r-1)(c-1)$ with r the number of rows and c the number of columns.

Table 6: Subjective financial literacy in the A-test vs. in the S-test (1)

A-test		S-test					
		1	2	3	4	5	Total
0	(#)	166	1,847	1,172	797	80	4,062
	(%)	0.82	9.11	5.78	3.93	0.39	20.02
	(r%)	4.09	45.47	28.85	19.62	1.97	
	(c%)	28.92	64.81	18.85	9.04	4.39	
1	(#)	188	745	2,898	1,765	106	5,102
	(%)	0.93	3.67	14.29	8.70	0.52	28.11
	(r%)	3.30	13.07	50.82	30.95	1.86	
	(c%)	32.75	26.14	46.61	20.01	5.81	
2	(#)	154	234	1,952	5,379	547	8,266
	(%)	0.76	1.15	9.62	26.52	2.70	40.75
	(r%)	1.86	2.83	23.61	65.07	6.62	
	(c%)	26.83	8.21	31.40	60.98	30.01	
3	(#)	66	24	195	880	1,090	2,255
	(%)	0.33	0.12	0.96	4.34	5.37	11.12
	(r%)	2.93	1.06	8.65	39.02	48.34	
	(c%)	11.50	0.84	3.14	9.98	59.79	
Total	(#)	574	2,850	6,217	8,821	1,823	20,285
	(%)	2.83	14.05	30.65	43.49	8.99	100.00

Statistics	Value	P-value
χ^2	11,291	<.0001
Spearman's rank correlation	0.54	<.0001

This contingency table reports respectively, for each pair of answers, the empirical frequencies (#), the total percentages (%), the row percentages (r%) and the column percentages (c%). Answers for the A-test are positioned in rows while those for the S-test are in columns. For the question in the A-test, levels 0 to 3 refer to the answers to the question about financial knowledge in the A-test as reported in Table 3. For the question in the S-test, levels 1 to 5 refer to the answers to the question about financial knowledge in the S-test as reported in Table 3. The results for the Chi-Square test for the null hypothesis of independence are also provided as well as the Spearman's rank correlation.

As a robustness check, we replicate the same analysis with another combination of similar questions: the self-reported financial knowledge in the A-test and the self-reported knowledge and experience about "complex" instruments in the S-test. Our findings are still consistent and support overall consistency across investors' answers in both tests. Table 12 in appendix exhibits the results.

3.2 Consistency between subjective financial literacy and trading behavior

We now investigate the relationship between subjective financial literacy and trading behavior. For that purpose, we focus on two measures of subjective financial literacy that are the self-reported level of financial knowledge in the A-test and the self-reported level of knowledge and experience about "complex" instruments in the S-test.[29] The variables presented in Subsection 2.4 are used to characterize investors' trading behavior. We still distinguish measures of experience and familiarity with financial markets, diversification and performance.

3.2.1 Univariate analysis

In a preliminary step, we perform an analysis of variance (ANOVA hereafter) to investigate whether our measures characterizing trading behavior significantly vary across the different levels of subjective literacy. Table 7 reports the results for the levels of financial knowledge in the A-test while Table 8 provides the results for the levels of knowledge and experience about "complex" instruments in the S-test. In line with the consistency highlighted in Subsection 3.1, Tables 7 and 8 display similar findings.

All ANOVA results exhibit highly significant F-stat values, except for the monthly turnover. Our findings suggest a positive relationship between investors' experience and familiarity with financial markets and their subjective financial literacy. Specifically, investors who assess themselves as highly literate tend to display a higher trading activity on stocks and other instruments. Similarly, the proportion of option traders is higher among investors who choose the highest levels of financial literacy. Moreover, all categories of investors display a positive DE but the latter is lower for investors who report higher levels of financial literacy.

When focusing on diversification measures, the results suggest that investors who report a higher level of financial literacy tend to trade in a larger universe of stocks, to hold a higher number of stocks in portfolio, and to be more active on investment funds, which can be associated with a higher awareness of the diversification concept. In addition, the HHI is overall lower for investors who report higher levels of financial literacy, thereby suggesting they hold better diversified stock portfolios. When taking into account the monthly holding in

[29]The results for the self-reported financial knowledge in the S-test are qualitatively similar and are available upon request.

funds in the modified HHI, this finding is even more striking. However, the results also show higher levels of stock portfolio volatility for investors with higher literacy.

As for performance, investors who report a higher level of financial literacy display significantly higher gross and net returns. It is worth to point out that only investors who choose the highest level of subjective financial literacy earn on average positive net returns. The relationship still holds on a risk-adjusted basis since both gross and net Sharpe ratios increase along with levels of literacy. Moreover, investors who perceived themselves as highly literate tend to display positive gross excess Sharpe ratios. Nevertheless, when taking into account explicit transaction costs, only those who select the highest level of financial literacy in the A-test are able to perform as well as the market portfolio on a risk-adjusted basis.

Table 7: ANOVA results for subjective financial literacy in the A-test and trading behavior

		Financial knowledge				
		0	1	2	3	F-stat
Experience and familiarity	Number of total trades	74.11	110.27	168.77	272.22	167.02***
	Number of stock trades	60.34	86.62	118.83	171.20	84.66***
	Turnover (%)	29.17	27.60	27.38	33.82	0.93
	Option_trader (%)	13.98	20.69	37.45	63.76	792.00***
	DE	13.94	12.85	10.94	9.90	22.91***
Diversification	Number of different stocks traded	16.63	23.91	31.71	39.79	270.22***
	Number of stocks	4.41	5.64	6.91	7.30	127.97***
	Volatility (%)	24.78	27.49	28.83	30.83	5.33***
	Fund_trader (%)	21.07	29.12	40.78	47.93	249.71***
	HHI	0.55	0.48	0.45	0.48	113.84***
	M_HHI	0.51	0.44	0.39	0.41	175.80***
Performance	Gross return (%)	0.28	0.53	0.80	0.92	23.43***
	Net return (%)	-0.43	-0.06	0.18	0.22	24.42***
	Gross Sharpe-ratio (%)	-0.88	-0.93	0.10 (NS)	0.56	3.07**
	Net Sharpe-ratio (%)	-5.15	-4.55	-3.72	-3.09	3.99***
	Gross excess Sharpe-ratio (%)	-1.31	0.42 (NS)	2.35	3.77	24.17***
	Net excess Sharpe-ratio (%)	-5.58	-3.20	-1.47	0.11 (NS)	26.48***

The table reports the results for the analysis of variance (ANOVA) on the relationship between several variables characterizing trading behavior and subjective financial literacy in the A-test. For each variable under scrutiny, we report its mean for each level of literacy. Levels 0 to 3 refer to the available answers to the specific question about financial knowledge in the A-test as described in Table 3. 'Number of total trades' is the number of trades executed across all instruments. 'Number of stock trades' is the number of trades executed on stocks. 'Turnover' is the monthly average turnover, expressed in %. It is calculated as in Hoffmann et al. (2013), i.e. average of the absolute values of all purchases and sales in a particular month divided by the average of the portfolio values at the beginning and the end of this particular month. 'Option_trader' is the proportion of investors who made at least one trade on either options or warrants. 'DE' refers to the disposition effect computed at the individual level as the difference between the proportion of gains realized and the proportion of losses realized. 'Number of different stocks traded' is the number of different stocks traded during the whole trading period. 'Number of stocks' is the monthly average number of stocks held in portfolio. 'Volatility' is the standard deviation of the stock portfolio monthly gross returns. 'Fund_trader' is the proportion of investors who made at least one trade on investment funds. 'HHI' is the monthly average Herfindahl-Hirschman Index, which is computed as the sum of squared stock portfolio weights. 'M_HHI' is a modified version of the HHI for which any position in funds is replaced by a portfolio of 50 equally-weighted securities. 'Gross return' is the geometric average of monthly gross returns. 'Net return' is the geometric average of monthly net returns. 'Gross Sharpe-ratio' is a risk-adjusted measure of gross return. 'Net Sharpe-ratio' is a risk-adjusted measure of net return. 'Gross excess Sharpe-ratio' is the gross Sharpe ratio in excess of market Sharpe ratio. 'Net excess Sharpe-ratio' is the net Sharpe ratio in excess of market Sharpe ratio. The last column exhibits the F-stat values as well as their significance. *** indicates significance at 1%; ** indicates significance at 5%; * indicates significance at 10%. 'NS' in brackets indicates that the mean value is not statistically different from zero.

Table 8: ANOVA results for subjective financial literacy in the S-test and trading behavior

		Knowledge and experience about "complex" instruments			
		0	1	2	F-stat
Experience and familiarity	Number of total trades	80.21	119.05	224.11	210.72***
	Number of stock trades	61.39	91.99	146.49	105.51***
	Turnover (%)	31.53	27.06	29.79	1.04
	Option_trader (%)	15.64	24.31	50.74	905.81***
	DE	13.88	12.45	10.15	29.64***
Diversification	Number of different stocks traded	17.78	25.03	36.43	319.41***
	Number of stocks	4.62	5.87	7.23	130.74***
	Volatility (%)	23.22	27.72	30.36	12.05***
	Fund_trader (%)	22.44	31.13	45.84	301.77***
	HHI	0.54	0.48	0.46	84.37***
	M_HHI	0.50	0.43	0.39	147.32***
Performance	Gross return (%)	0.34	0.56	0.91	28.74***
	Net return (%)	-0.33	-0.07	0.28	26.99***
	Gross Sharpe-ratio (%)	-0.78	-0.76	0.67	6.06***
	Net Sharpe-ratio (%)	-5.05	-4.47	-3.18	6.12***
	Gross excess Sharpe-ratio (%)	-0.23 (NS)	0.70	2.91	17.53***
	Net excess Sharpe-ratio (%)	-4.5	-3.00	-0.93	17.73***

The table reports the results for the analysis of variance (ANOVA) on the relationship between several variables characterizing trading behavior and subjective financial literacy in the S-test. For each variable under scrutiny, we report its mean for each level of literacy. Levels 0 to 2 refer to the available answers to the specific question about knowledge and experience about "complex" instruments in the S-test as described in Table 3. 'Number of total trades' is the number of trades executed across all instruments. 'Number of stock trades' is the number of trades executed on stocks. 'Turnover' is the monthly average turnover, expressed in %. It is calculated as in Hoffmann et al. (2013), i.e. average of the absolute values of all purchases and sales in a particular month divided by the average of the portfolio values at the beginning and the end of this particular month. 'Option_trader' is the proportion of investors who made at least one trade on either options or warrants. 'DE' refers to the DE computed at the individual level as the difference between the proportion of gains realized and the proportion of losses realized. 'Number of different stocks traded' is the number of different stocks traded during the whole trading period. 'Number of stocks' is the monthly average number of stocks held in portfolio. 'Volatility' is the standard deviation of the stock portfolio monthly gross returns. 'Fund_trader' is the proportion of investors who made at least one trade on investment funds. 'HHI' is the monthly average Herfindahl-Hirschman Index, which is computed as the sum of squared stock portfolio weights. 'M_HHI' is a modified version of the HHI for which any position in funds is replaced by a portfolio of 50 equally-weighted securities. 'Gross return' is the geometric average of monthly gross returns. 'Net return' is the geometric average of monthly net returns. 'Gross Sharpe-ratio' is a risk-adjusted measure of gross return. 'Net Sharpe-ratio' is a risk-adjusted measure of net return. 'Gross excess Sharpe-ratio' is the gross Sharpe ratio in excess of market Sharpe ratio. 'Net excess Sharpe-ratio' is the net Sharpe ratio in excess of market Sharpe ratio. The last column exhibits the F-stat values as well as their significance. *** indicates significance at 1%; ** indicates significance at 5%; * indicates significance at 10%. 'NS' in brackets indicates that the mean value is not statistically different from zero.

3.2.2 Multivariate analysis

Trading behavior may differ across investors who report high and low levels of financial knowledge because subjective literacy correlates with other attributes that predict trading behavior. In the literature, gender, age and income are recognized as some of the major drivers of trading behavior (e.g. Barber and Odean (2001), Goetzmann and Kumar (2008), Hackethal et al. (2012), Graham et al. (2009), Hoffmann et al. (2013)). Furthermore, Lusardi and Mitchell (2014) report that financial knowledge significantly depends on the level of education.[30] In the same vein, several papers document that education is significantly related to financial behavior (a.o. Haliassos and Bertaut (1995) and Campbell (2006)). However, controlling for the level of education does not decrease the impact of financial literacy but it can even enhance it as shown in Lusardi and Mitchell (2011a) and Van Rooij et al. (2011). Lusardi and Mitchell (2014) conclude therefore that general knowledge and financial knowledge both contribute to explain financial behavior.

In order to assess whether different trading behaviors can be related to differences in subjective financial literacy, we estimate cross-sectional regressions wherein the dependent variables are our measures characterizing trading behavior (see Subsection 2.4) and the set of explanatory variables includes several dummies based on subjective literacy[31] as well as control variables such as age, gender, income (that we proxy by the natural logarithm of the monthly average portfolio value) and the level of education. We also control for trading experience, i.e. the number of months during which an investor actively trade within the sample period.

Tables 9, 10 and 11 report the results for the regressions including three dummies for the three highest levels of subjective literacy in the A-test.[32] For continuous dependent variables, parameters are estimated thanks to OLS regressions while Logit models are used for binary dependent variables.[33]

[30] Lusardi and Mitchell (2007) and Lusardi and Mitchell (2011b) bring evidence that individuals without a college education are less likely to know basic financial literacy concepts.

[31] For each MiFID question, we include N-1 dummies and consider the lowest level as the category of reference.

[32] Tables 13, 14 and 15 in appendix report the results for the regressions including two dummies for the two highest levels of knowledge and experience in "complex" instruments in the S-test. The results are qualitatively similar.

[33] Building on Glaser and Weber (2007), we use the natural logarithm of the number of total trades across instruments, the number of stock trades, the turnover, the number of different stocks traded, the average number of stocks held in portfolio, the volatility, the HHI and Modified HHI since these variables are positively skewed. The authors state that this methodology allows to avoid problems of normality, nonlinearity and heteroscedas-

In Table 9, we focus on measures of experience and familiarity with financial markets. The results show that investors who perceive themselves as highly literate display a higher trading activity (whatever the instruments), churn over their portfolios more, and are also more likely to invest in options or warrants. This suggests an obvious higher level of experience and familiarity with financial markets. In addition, those investors tend to be less exposed to the DE, which is again consistent with a higher level of experience (Feng and Seasholes (2005), Dhar and Zhu (2006) and Boolell-Gunesh et al. (2012)).

Table 10 provides the results for our measures of diversification. Regression (1) brings evidence that investors who perceive themselves as highly literate trade in a larger stock universe while Regressions (2) and (3) suggest that those investors hold less diversified *stock* portfolios. However, Regression (4) shows that they do not hold riskier portfolios in terms of volatility. Furthermore, their higher tendency to invest in investment funds enables them to hold better diversified *global* portfolios. Hence, investors who report higher levels of financial literacy hold portfolios for which the modified HHI is lower. Taken all together, these findings suggest therefore that investors who report higher levels of financial literacy concentrate their stock portfolios on a small set of securities and achieve global diversification through investment funds holding.

The dependent variables are performance measures in Table 11. The results show that investors who report a higher level of financial literacy tend to display higher gross and net returns. However, this relationship does not hold anymore when focusing on Sharpe ratios. Regressions (5) and (6) suggest nevertheless that investors who perceive themselves as highly literate exhibit higher excess Sharpe ratios.

In Tables 9, 10 and 11, the results for our control variables are overall in line with the extant literature. They bring evidence that masculinity is positively related to trading activity while this attribute is negatively related to performance (Barber and Odean (2001)). As documented in Barber and Odean (2001) and Dorn and Huberman (2005), older investors tend to churn over their portfolios less and are less likely to invest in options and warrants. In addition, older investors are less exposed to the DE, are more prone to hold better diversified portfolios (as in Dorn and Huberman (2005) and Goetzmann and Kumar (2008)), and earn higher returns (as shown in Barber and Odean (2001)). As for the impact of income on trading behavior,

ticity in cross-sectional regressions. For the turnover, we compute the natural logarithm of (1+turnover) as in Glaser and Weber (2009) since a very low proportion of investors display an average turnover of 0. These investors typically build their portfolios during their first month of trading and do not change it afterwards.

our results show that investors who hold larger portfolios display a higher trading activity (as highlighted in Glaser (2003), Vissing-Jorgensen (2003) and Abreu and Mendes (2012)), are less exposed to the DE, hold better diversified portfolios (as shown in Dorn and Huberman (2005), Guiso and Jappelli (2008) and Goetzmann and Kumar (2008)), and also earn higher returns. Only our results about education are mixed. We find that investors with a university degree tend to churn over their portfolios less, exhibit a lower DE, hold more diversified portfolios but do not earn higher returns.

Table 9: Results for subjective financial literacy in the A-test & experience and familiarity with markets

	(1)	(2)	(3)	(4)	(5)
	Ln(total_trades)	Ln(stock_trades)	Ln(1+turnover)	O_trader	DE
Intercept	0.03	-0.60***	2.53***	-3.51***	30.76***
Gender	0.09***	0.06***	0.10***	0.03	-1.43**
Age	0.01	-0.01	-0.01***	-0.01***	-0.17***
Level of education 1	0.18***	0.17***	0.11***	0.08	-0.28
Level of education 2	-0.01	-0.04	-0.13***	0.08	-1.68**
Ln(PF value)	0.29***	0.36***	0.05***	0.16***	-0.81***
Trading experience	0.02***	0.02***	-0.01***	0.01***	0.01
Financial markets knowledge 1	0.06***	-0.01	-0.01	0.27***	0.21
Financial markets knowledge 2	0.23***	0.04**	0.04*	0.98***	-1.07**
Financial markets knowledge 3	0.55***	0.14***	0.21***	2.04***	-2.19***
Adjusted R^2	44.26%	54.21%	2.73%	-	1.81%
Pseudo R^2	-	-	-	12.76%	-
N	20,285	20,285	20,285	20,285	20,285

The table reports the regression results for the relationship between our measures of experience and familiarity with financial markets and subjective financial literacy in the A-test. The dependent variables of Regressions (1) to (5) are the natural logarithm of the total number of trades across instruments, the natural logarithm of the number of stock trades, the natural logarithm of (1+turnover), a binary variable set to 1 when the investor traded at least once options or warrants, and the investor's DE measured as the difference between the proportion of gains realized and the proportion of losses realized. In the set of explanatory variables, 'Gender' is a dummy set to 1 for males, 'Age' is the investor's age in 2012, 'Level of education 1' is a dummy set to 1 for investors with a secondary/high school degree, 'Level of education 2' is a dummy set to 1 for investors with a university degree, 'Ln(PF value)' is the natural logarithm of the average monthly portfolio value (as a proxy of wealth) and 'Trading experience' is defined as the difference between the date of the last trade and the date of the first trade on stocks. The last three variables 'Financial markets knowledge 1', 'Financial markets knowledge 2', 'Financial markets knowledge 3' are dummies used respectively for the levels 1, 2 and 3 in the question about financial knowledge in the A-test as reported in Table 3. *** indicates significance at 1%; ** indicates significance at 5%; * indicates significance at 10%. 'N' gives the number of observations used in each model.

Table 10: Results for subjective financial literacy in the A-test & Diversification

	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(n_stocks)	Ln(n_stocks_PF)	Ln(HHI)	Ln(volatility)	F_trader	Ln(M_HHI)
Intercept	-0.93***	-1.26***	1.18***	2.21***	-3.08***	0.81***
Gender	-0.01	-0.04***	0.06***	0.02	-0.05	0.04**
Age	0.01***	0.01***	-0.01***	-0.01***	0.01***	-0.01***
Level of education 1	0.11***	0.06***	-0.01*	-0.03	-0.01	-0.01
Level of education 2	0.01	0.07***	-0.08***	-0.17***	0.32***	-0.11***
Ln(PF value)	0.28***	0.29***	-0.20***	0.07***	0.11***	-0.16***
Trading experience	0.01***	0.01***	-0.01***	0.01***	0.01***	0.01***
Financial markets knowledge 1	0.05***	-0.02	-0.02	-0.01	0.23***	-0.10***
Financial markets knowledge 2	0.10***	-0.02*	-0.02	-0.04**	0.64***	-0.19***
Financial markets knowledge 3	0.14***	-0.1***	0.07***	-0.02	0.89***	-0.13***
Adjusted R^2	57.39%	52.23%	33.54%	5.74%	-	15.96%
Pseudo R^2	-	-	-		5.16%	-
N	20,285	20,285	20,285	20,285	20,285	20,285

The table reports the regression results for the relationship between our measures of diversification and subjective financial literacy in the A-test. The dependent variables of Regressions (1) to (6) are the natural logarithm of the number of different stocks traded during the sample period, the natural logarithm of the average number of stocks held in portfolio, the natural logarithm of the monthly average Herfindahl-Hirschman Index (computed as the sum of squared stock portfolio weights), the natural logarithm of the volatility of monthly portfolio returns, a binary variable set to 1 for investors who traded at least once investment fund shares, and the natural logarithm of the average modified Herfindahl-Hirschman Index (for which any position in funds is replaced by a portfolio of 50 equally-weighted securities). In the set of explanatory variables, 'Gender' is a dummy set to 1 for males, 'Age' is the investor's age in 2012, 'Level of education 1' is a dummy set to 1 for investors with a secondary/high school degree, 'Level of education 2' is a dummy set to 1 for investors with a university degree, 'Ln(PF value)' is the natural logarithm of the average monthly portfolio value (as a proxy of wealth) and 'Trading experience' is defined as the difference between the date of the last trade and the date of the first trade on stocks. The last three variables 'Financial markets knowledge 1', 'Financial markets knowledge 2', 'Financial markets knowledge 3' are dummies used respectively for the levels 1, 2 and 3 in the question about financial knowledge in the A-test as reported in Table 3. *** indicates significance at 1%; ** indicates significance at 5%; * indicates significance at 10%. 'N' gives the number of observations used in each model.

Table 11: Results for subjective financial literacy in the A-test & performance

	(1)	(2)	(3)	(4)	(5)	(6)
	Gross return	Net return	Gross Sharpe-Ratio	Net Sharpe-Ratio	Gross E-Sharpe-Ratio	Net E-Sharpe-Ratio
Intercept	-1.53***	-2.65***	-0.09***	-0.16***	-0.10***	-0.17***
Gender	-0.28***	-0.39***	-0.01*	-0.02***	-0.03***	-0.03***
Age	0.02***	0.02***	0.01***	0.01***	0.01***	0.01***
Level of education 1	-0.17	-0.29**	-0.01	-0.02*	-0.02*	-0.02**
Level of education 2	-0.11	-0.10	0.01	-0.01	-0.01	-0.01
Ln(PF value)	0.11***	0.13***	0.01***	0.01***	0.01***	0.01***
Trading experience	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***
Financial markets knowledge 1	0.12	0.17*	-0.01	-0.01	0.01	0.01
Financial markets knowledge 2	0.29***	0.27***	-0.01	-0.01	0.02***	0.01**
Financial markets knowledge 3	0.41***	0.29**	-0.01	-0.01	0.03***	0.02***
Adjusted R^2	1.92%	2.69%	0.71%	1.56%	1.82%	2.92%
Pseudo R^2	-	-	-	-	-	-
N	20,285	20,285	20,285	20,285	20,285	20,285

The table reports the regression results for the relationship between our measures of performance and subjective financial literacy in the A-test. The dependent variables of Regressions (1) to (6) are the geometric average of monthly gross returns, the geometric average of monthly net returns, the gross Sharpe ratio, the net Sharpe ratio, the gross excess Sharpe ratio, and the net excess Sharpe ratio. In the set of explanatory variables, 'Gender' is a dummy set to 1 for males, 'Age' is the investor's age in 2012, 'Level of education 1' is a dummy set to 1 for investors with a secondary/high school degree, 'Level of education 2' is a dummy set to 1 for investors with a university degree, 'Ln(PF value)' is the natural logarithm of the average monthly portfolio value (as a proxy of wealth) and 'Trading experience' is defined as the difference between the date of the last trade and the date of the first trade on stocks. The last three variables 'Financial markets knowledge 1', 'Financial markets knowledge 2', 'Financial markets knowledge 3' are dummies used respectively for the levels 1, 2 and 3 in the question about financial knowledge in the A-test as reported in Table 3. *** indicates significance at 1%; ** indicates significance at 5%; * indicates significance at 10%. 'N' gives the number of observations used in each model.

3.2.3 Discussion on subjective financial literacy and overconfidence

The literature often associates a high level of trading with overconfidence, i.e. people overtrade because they overestimate their actual skills and knowledge. The latter is usually considered as an investment mistake since it leads to poor net performance due to transaction costs. This view has been well summarized in Koestner et al. (2017) who define overtrading as one of the three investment mistakes the most cited in the literature and for which the significant negative effect on performance is well-documented. From that perspective, our results that show that investors who perceive themselves as highly literate tend to trade more looks totally consistent with overconfidence. However, the fact that those investors also display better performances, even after controlling for transaction costs and on a risk-adjusted basis, is much more surprising. To the best of our knowledge, this paper is the first to bring such empirical evidence. Dorn and Huberman (2005) and Graham et al. (2009) also find that investors with high subjective literacy tend to trade more. Nevertheless, these authors do not investigate the relationship between subjective financial literacy and trading performance. In this paper, we show that the higher trading activity of investors with higher levels of subjective financial literacy does turn into better performance.

The above new finding is consistent with a few papers that document a positive relationship between active trading and performance. For example, Shu et al. (2004) provide evidence that active trading is not necessarily detrimental to performance. These authors find a U-shape relationship between turnover and performance, suggesting that investors who trade the least/most earn higher returns than investors who exhibit an average trading activity. Such results are not consistent with the overconfidence hypothesis.

Distinguishing "smart" from "dumb" investors, Korniotis and Kumar (2013) provide consistent empirical evidence with our findings. In particular, these authors show that while both categories of investors display portfolio distortions, the underlying reasons differ: overtrading by "dumb" investors reflects behavioral biases, although the high trading activity of the "smart" ones reveals superior information. Korniotis and Kumar (2013) explain this finding by the strategy adopted by the"smart" investors. The latter combine both stock portfolio concentration and active trading to generate positive abnormal returns. The authors suggest that portfolio concentration eases "smart" investors' attention, information gathering as well as processing, which enables them to be better informed on a small set of stocks and trade more actively with profits. The investors who report higher levels of financial literacy in our sample seem to adopt a similar investment strategy since we find that those investors

invest in investment funds and concentrate their stock portfolios on a small number of securities. This could enable them to benefit from risk diversification through funds and ease their information-gathering process to trade more actively on this small set of stocks.

4 Conclusion

Using survey data available in the MiFID tests, we investigate the relationship between subjective financial literacy and actual trading behavior. For that purpose, we analyse a sample of 20,285 retail investors who traded online during the 2003-2012 period and characterize their trading behaviors along three different aspects: experience and familiarity with financial markets, diversification and performance.

Regarding subjective financial literacy itself, our results provide evidence of overall consistency across investors' answers: investors who report a high literacy in one MiFID test are much more likely to do so in the other one. Retail investors are then consistent when self-reporting their financial literacy online. More importantly, we show that this piece of information provided by the investors themselves is helpful to characterize their actual trading behavior. Investors who report higher levels of financial literacy tend to invest *smarter*. Specifically, they trade more on both stocks and complex instruments, and they are less exposed to the disposition effect, which is consistent with higher experience. In addition, they tend to concentrate their stock portfolios on a small set of securities and achieve global diversification through investment funds holding. Finally, investors with a higher subjective financial literacy display higher both gross and net returns as well as higher excess Sharpe ratios. All these results hold even when we control for gender, age, portfolio value, trading experience, and education.

Our findings are not consistent with overconfidence because the higher trading activity of investors with higher levels of subjective financial literacy in our sample does result in better performance. This new empirical evidence is consistent with the strategy adopted by the "smart" investors in Korniotis and Kumar (2013). Those investors invest in investment funds and concentrate their stock portfolios on a small number of securities. This behavior could enable them to benefit from risk diversification through funds and ease their information-gathering process to trade more actively on this small set of stocks with profits.

This paper brings relevant insights for both policy making and understanding retail investors' behavior. Since subjective literacy reported in the MiFID tests is informative to

characterize retail investors, it should deserve more attention in that perspective. Using subjective literacy could help investment firms provide the most suitable services to their retail clients. Generally speaking, this paper also opens new areas of research such as the role of opinions, perceptions and beliefs in the individuals' financial decision-making process.

5 Appendix

Table 12: Subjective financial literacy in the A-test vs. in the S-test (2)

A-test		S-test			
		0	1	2	Total
0	(#)	1,480	2,260	322	4,062
	(%)	7.30	11.14	1.59	20.02
	(r%)	36.44	55.64	7.93	
	(c%)	50.79	19.99	5.31	
1	(#)	858	4,146	698	5,702
	(%)	4.23	20.44	3.44	28.11
	(r%)	15.05	72.71	12.24	
	(c%)	29.44	36.67	11.51	
2	(#)	473	4,526	3,267	8,266
	(%)	2.33	22.31	16.11	40.75
	(r%)	5.72	54.75	38.52	
	(c%)	16.23	40.03	53.88	
3	(#)	103	375	1,777	2,255
	(%)	0.51	1.85	8.76	11.12
	(r%)	4.57	16.63	78.80	
	(c%)	3.53	3.32	29.30	
Total	(#)	2,914	11,307	6,064	20,285
	(%)	14.37	55.74	29.89	100.00

Statistic	Value	P-value
χ^2	6,185	<.0001
Spearman's rank correlation	0.49	<.0001

This contingency table reports respectively, for each pair of answers, the empirical frequencies (#), the total percentages (%), the row percentages (r%) and the column percentages (c%). Answers for the A-test are positioned in rows while those for the S-test are in columns. For the question in the A-test, levels 0 to 3 refer to the answers to the question about financial knowledge in the A-test as reported in Table 3. For the question in the S-test, levels 0 to 2 refer to the answers to the question about knowledge and experience about "complex" instruments in the S-test as reported in Table 3. The results for the Chi-Square test for the null hypothesis of independence are also provided as well as the results for the Spearman's rank correlation.

Table 13: Results for subjective literacy in the S-test & experience and familiarity with markets

	(1)	(2)	(3)	(4)	(5)
	Ln(total_trades)	Ln(stock_trades)	Ln(1+turnover)	O_trader	DE
Intercept	-0.03	-0.59***	2.52***	-3.81***	31.08***
Gender	0.10***	0.07***	0.10***	0.04	-1.43**
Age	0.01	-0.01	-0.01***	-0.01***	-0.17***
Level of education 1	0.26***	0.18***	0.12***	0.43***	-0.49
Level of education 2	0.09***	-0.02	-0.12***	0.48***	-1.93***
Ln(PF value)	0.30***	0.35***	0.05***	0.16***	-0.81***
Trading experience	0.02***	0.02***	-0.01***	0.01***	0.01
"Complex" instruments knowledge 1	0.03	-0.05**	-0.01	0.35***	-0.25
"Complex" instruments knowledge 2	0.31***	0.03	0.09***	1.36***	-1.90***
Adjusted R^2	43.88%	54.18%	2.52%	-	1.81%
Pseudo R^2	-	-	-	11.37%	-
N	20,285	20,285	20,285	20,285	20,285

The table reports the regression results for the relationship between our measures of experience and familiarity with financial markets and subjective financial literacy in the S-test. The dependent variables of Regressions (1) to (5) are the natural logarithm of the total number of trades across instruments, the natural logarithm of the number of stock trades, the natural logarithm of (1+turnover), a binary variable set to 1 when the investor traded at least once options or warrants, and the investor's DE measured as the difference between the proportion of gains realized and the proportion of losses realized. In the set of explanatory variables, 'Gender' is a dummy set to 1 for males, 'Age' is the investor's age in 2012, 'Level of education 1' is a dummy set to 1 for investors with a secondary/high school degree, 'Level of education 2' is a dummy set to 1 for investors with a university degree, 'Ln(PF value)' is the natural logarithm of the average monthly portfolio value (as a proxy of wealth) and 'Trading experience' is defined as the difference between the date of the last trade and the date of the first trade on stocks. The last two variables '"Complex" instruments knowledge 1', '"Complex" instruments knowledge 2' are dummies used respectively for the levels 1 and 2 in the question about knowledge and experience in complex instruments in the S-test as reported in Table 3. *** indicates significance at 1%; ** indicates significance at 5%; * indicates significance at 10%. 'N' gives the number of observations used in each model.

Table 14: Results for subjective financial literacy in the S-test & diversification

	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(n_stocks)	Ln(n_stocks_PF)	Ln(HHI)	Ln(volatility)	F_trader	Ln(M_HHI)
Intercept	-0.95***	-1.24***	1.18***	2.23***	-3.32	0.87***
Gender	-0.01	-0.04***	0.05***	0.02	-0.04	0.04*
Age	0.01***	0.01***	-0.01***	-0.01***	0.01***	-0.01***
Level of education 1	0.14***	0.05***	-0.04**	-0.04	0.21***	-0.07***
Level of education 2	0.05***	0.06***	-0.09***	-0.18***	0.57***	-0.19***
Ln(PF value)	0.28***	0.29***	0.20***	0.07***	0.11***	-0.15***
Trading experience	0.01***	0.01***	-0.01***	0.01***	0.01***	0.01***
"Complex" instruments knowledge 1	0.01	-0.04***	0.01	-0.03	0.28***	-0.07***
"Complex" instruments knowledge 2	0.07***	-0.08***	0.05***	-0.05**	0.76***	-0.12***
Adjusted R^2	57.33%	52.23%	33.46%	5.74%	-	15.62%
Pseudo R^2	-	-	-		4.99%	-
N	20,285	20,285	20,285	20,285	20,285	20,285

The table reports the regression results for the relationship between our measures of diversification and subjective financial literacy in the S-test. The dependent variables of Regressions (1) to (6) are the natural logarithm of the number of different stocks traded during the sample period, the natural logarithm of the average number of stocks held in portfolio, the natural logarithm of the monthly average Herfindahl-Hirschman Index (computed as the sum of squared stock portfolio weights), the natural logarithm of the volatility of monthly portfolio returns, a binary variable set to 1 for investors who traded at least once investment fund shares, and the natural logarithm of the average modified Herfindahl-Hirschman Index (for which any position in funds is replaced by a portfolio of 50 equally-weighted securities). In the set of explanatory variables, 'Gender' is a dummy set to 1 for males, 'Age' is the investor's age in 2012, 'Level of education 1' is a dummy set to 1 for investors with a secondary/high school degree, 'Level of education 2' is a dummy set to 1 for investors with a university degree, 'Ln(PF value)' is the natural logarithm of the average monthly portfolio value (as a proxy of wealth) and 'Trading experience' is defined as the difference between the date of the last trade and the date of the first trade on stocks. The last two variables '"Complex" instruments knowledge 1', '"Complex" instruments knowledge 2' are dummies used respectively for the levels 1 and 2 in the question about knowledge and experience in complex instruments in the S-test as reported in Table 3. *** indicates significance at 1%; ** indicates significance at 5%; * indicates significance at 10%. 'N' gives the number of observations used in each model.

Table 15: Results for subjective financial literacy in the S-test & performance

	(1)	(2)	(3)	(4)	(5)	(6)
	Gross return	Net return	Gross Sharpe-Ratio	Net Sharpe-Ratio	Gross E-Sharpe-Ratio	Net E-Sharpe-Ratio
Intercept	-1.59***	-2.7***	-0.08***	-0.15***	-0.09***	-0.17***
Gender	-0.28***	-0.38***	-0.01*	-0.02***	-0.03***	-0.03***
Age	0.02***	0.01***	0.01***	0.01***	0.01***	0.01***
Level of education 1	-0.07	-0.19	-0.01	-0.02**	-0.01	-0.02**
Level of education 2	-0.01	0.01	-0.01	-0.01	0.01	0.01
Ln(PF value)	0.11***	0.13***	0.01***	0.01***	0.01***	0.01***
Trading experience	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***
"Complex" instruments knowledge 1	0.04	0.01	-0.01	-0.01	-0.01	-0.01
"Complex" instruments knowledge 2	0.28***	0.19**	-0.01	-0.01	0.01	-0.01
Adjusted R^2	1.91%	2.68%	0.72%	1.57%	1.77%	2.89%
Pseudo R^2	-	-	-	-	-	-
N	20,285	20,285	20,285	20,285	20,285	20,285

The table reports the regression results for the relationship between our measures of performance and subjective financial literacy in the S-test. The dependent variables of Regressions (1) to (6) are the geometric average of monthly gross returns, the geometric average of monthly net returns, the gross Sharpe ratio, the net Sharpe ratio, the gross excess Sharpe ratio, and the net excess Sharpe ratio. In the set of explanatory variables, 'Gender' is a dummy set to 1 for males, 'Age' is the investor's age in 2012, 'Level of education 1' is a dummy set to 1 for investors with a secondary/high school degree, 'Level of education 2' is a dummy set to 1 for investors with a university degree, 'Ln(PF value)' is the natural logarithm of the average monthly portfolio value (as a proxy of wealth) and 'Trading experience' is defined as the difference between the date of the last trade and the date of the first trade on stocks. The last two variables '"Complex" instruments knowledge 1', '"Complex" instruments knowledge 2' are dummies used respectively for the levels 1 and 2 in the question about knowledge and experience in complex instruments in the S-test as reported in Table 3. *** indicates significance at 1%; ** indicates significance at 5%; * indicates significance at 10%. 'N' gives the number of observations used in each model.

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