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Increasing Financial Literacy through Simulations: The Case of the CFA Society Italy Fund Management Challenge

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Abstract

The need to develop household personal finance literacy is an increasingly important issue in many countries, especially in the wake of the latest financial crisis. The literature broadly demonstrates that most individuals do not have an adequate level of financial literacy. A number of initiatives aimed at different groups (usually defined by gender, age, work status and income) have been developed. The present paper is part of a strand of literature that focuses on the financial literacy of university students, and in particular, the potential benefits of their participation in investment simulations, in terms of improved skills and knowledge. It analyzes an innovative online portfolio management competition for graduate students, the Fund Management Challenge, which is promoted by the CFA Society Italy. The results demonstrate how this Challenge, and investment simulations in general, set with specific rules to mitigate opportunistic behaviors, can help to improve participants' financial literacy levels. In addition to this, the use of quality indicators encourages students to learn and helps mentors and educators to better allocate resources to those in need of assistance. The study represents an original analysis of the Challenge. If further analysis supports this preliminary evidence, the Challenge could become a reference point for future investment simulations targeting university students.

Keywords: Financial Literacy; Financial Knowledge; Investment Simulations; Financial Initiatives.
JEL Codes: G02; G10.

1 Introduction

The need to develop household literacy in the field of personal finance is an increasingly important issue in many countries, especially in the wake of the latest financial crisis. Research shows that low financial literacy levels in households can have negative effects at

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both the macro level (for example financial system instability) and the micro level (such as low asset diversification, low purchasing insurance, Miller *et al.*, 2009) and difficulties in accessing appropriate financial services and products (Anderloni *et al.*, 2008).

Current literature on the subject sustains that there is a link between an inadequate level of financial literacy and a households' financial over-indebtedness, which in turn could lead to higher risk of default (Jappelli *et al.*, 2013). Following the Organisation for Economic Co-operation and Development (OECD) recommendations, governments, academia, industry and civil society organizations in several leading economies have developed and promoted initiatives aimed at increasing financial education among households, in order to mitigate these risks (Iwanicz-Drozdowska *et al.*, 2010).

Initiatives have been developed and promoted to target a variety of audiences, usually defined by gender, age, work status and income, but with little definition of measurement of literacy levels and impact on participants' ability to make proper financial decisions. Although many of these initiatives teach the fundamentals of rational investment, decisions in the real world are based on cognitive and emotional biases, such as sentiment and mood. For example, the same person may take a different decision, depending on how the problem is presented, a phenomenon known as «the framing effect» (Fowler, 1995; Lusardi and Mitchell, 2009; Schmeiser and Seligman, 2013). In addition, biases may lead to a choice that deviates from the optimal theoretical decision. Although there is no single solution to reduce or remove such biases from the decision-making process, it has been noted that training based on continuous feedback and followed by periodic nudging can help people to overcome their biases, and improve their ability to make rational decisions as investors and in their daily lives (Cadotte, 1995).

The present paper is part of a strand of literature focusing on university students, and specifically on the role that trading and asset management simulations play in increasing participants' financial literacy and reducing behavioral biases. In particular, it analyzes a portfolio management simulation with rules that incorporate major academic findings to reduce participants' opportunistic behaviors and increase their financial education. This paper presents diverse definitions of financial literacy, summarises major international initiatives dedicated to improving financial literacy among university students, and shows the positive effect that simulations can have in reaching this objective.

This study has two objectives. Firstly, it considers whether financial simulations with set rules to prevent potential opportunistic behavior can be seen as an effective teaching method complementary to traditional university courses. Secondly, it illustrates how simulations with independent and objective evaluation can increase students' learning speed and understanding of financial markets, and stimulate their desire to deepen their financial knowledge.

This paper is innovative in several respects. It confirms that continuous feedback and evaluation during financial simulations improve financial behavior and promote skills development, leading to an increase of participants' financial literacy. Furthermore, it showcases the application of a proprietary indicator that measures literacy based on participants' actual behavior, as opposed to survey results, as is usually the case in financial literacy studies.

This paper is also unique in that it uses a database provided exclusively for this paper, of the trades and evaluations of 16 graduate student teams, from leading Italian universities, participating in a simulation over the period of five months.

The paper is structured as follows: section two summarizes the discussion regarding the meaning of financial literacy, and describes the active role of simulations in increasing students' financial literacy. Section three describes the methodologies adopted and the data used in the study. Section four analyzes the empirical results. Finally, section five provides final remarks and concludes the paper.

2 Literature Review

There are three main strands in financial literature, which are relevant to this paper: the debate regarding the meaning of financial literacy and the definition of financial knowledge and financial education; major initiatives for university students and, in particular those in Italy, and the role of trading simulations in assessing and increasing financial literacy.

2.1 Definition of Financial Literacy and Financial Knowledge

Despite the growing number of international financial literacy initiatives, including courses, websites, mobile apps, and communication campaigns that have arisen since the 2007-08 financial crisis, there is no agreement on a single definition of «financial literacy». Huston (2010) and Robb (2012) show that the terms «financial knowledge» and «financial literacy» are often used interchangeably despite their different meanings. The former can be defined as understanding basic key financial terms and concepts (Bowen, 2002), while in one of its first iterations, the latter was defined as «the ability to make informed judgments and to take effective decisions regarding the use and management of money» (Noctor *et al.*, 1992).

Over the years several other definitions have been proposed by academics, as well as national and international organizations, all with a tendency to broaden the definition of «financial literacy» to include the capacity to take *good* financial decisions (*inter alia* Huston, 2010 and Remund, 2010). For example, The Jump$tart Coalition (2007) defined it as «the ability to use knowledge and skills to manage one's financial resources effectively for lifetime financial security». The OECD (2005) called it «the combination of consumers'/investors' understanding of financial products and concepts and their ability and confidence to appreciate financial risks and opportunities, to make informed choices, to know where to go for help, and to take other effective actions to improve their financial well-being». For a more detailed and complete literature review on this topic see Frączek (2014) and Nicolini *et al.* (2014).

For the purposes of this paper, we accept the definition proposed by Hung *et al.* (2009), which elaborates on the language proposed by the Jump$tart Coalition in 2007, to become the «knowledge of basic economic and financial concepts, as well as the ability to use that knowledge and other financial skills to manage financial resources effectively for a lifetime of financial well-being». For Hung *et al.* (2009) each individual level of financial literacy is a combination of: *i*) financial knowledge (and its

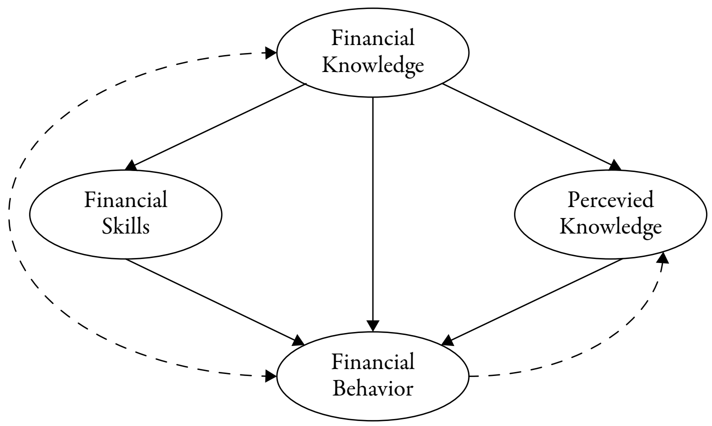

Figure 1: Conceptual Model of Financial Literacy.

Source: Hung *et al.* (2009).

perception); *ii*) financial skills and *iii*) financial behavior, and how these three factors influence each other (see Fig. 1).

Although there is no standardised methodology to measure financial literacy levels (Huston, 2010 and Robb, 2012), most of the studies to date conclude that households lack the knowledge and skills to make basic financial decisions; this is also true in leading economies[1].

In a recent study conducted in Germany, Italy, Japan, the Netherlands, New Zealand, Russia, Sweden, and the United States, more than half[2] of interviewees were unable to correctly answer three simple questions about compounded interest rates, the effect of inflation on the value of money, and the benefits of portfolio diversification (Lusardi and Mitchell, 2011). In particular, the study shows lower levels of financial literacy based on age, gender, employment status, and level of education, and concludes that young and old, women, the unemployed and those who had not completed high-school are the most affected. Xu and Zia (2012) demonstrate the level of individual financial literacy as a function of the life-cycle with an inverted-U shape distribution, showing financial knowledge and skills that are modest in the young adult phase, which then grow in the maturity phase to peak before declining in the aging phase.

2.2 International Initiatives Dedicated to University Students

Participation in financial education initiatives is usually reserved for individuals who have less financial knowledge, (in general terms, women and the less well-off), those who need to practice corrective financial decisions (for example near-retirees), and young people who are finishing their studies or newly-employed.

[1] For studies on US households financial literacy see Lusardi and Mitchell (2007), Lusardi *et al.* (2010), Lusardi (2008), for the Netherlands: van Rooij *et al.* (2011), for Italy: Monticone (2010), for Sweden: Calvert *et al.* (2009) and for Australia: Worthington (2006). For an international comparative analysis, see among others Atkinson and Messy (2012), Jappelli (2010), and Kempson (2009).

[2] With the exception of Germany, where 53% of those surveyed identified the right answers.

For the sake of this study, a survey of major initiatives focused on assessing and increasing university students' financial literacy was conducted. This field of research has mainly developed in the United States, where university students have been found to have a low level of financial knowledge (Volpe *et al.*, 1996; Volpe and Chen, 1998), and a higher level of indebtedness as a consequence of higher university fees (Reed, 2008). U.S. studies agree that socio-demographic factors, such as gender, education and previous work experience, are primary determinants of the level of students' financial literacy. On average, women appear to be less financially educated than men, while students of economics or those with previous work experience are more financially literate compared to their peers, regardless of gender (*inter alia* Chen and Volpe, 2002). In fact, only one third of interviewees understand the effects of inflation, the benefits of portfolio diversification, and are able to calculate compounded interest rates (Lusardi *et al.*, 2010). According to the same study, family (also known as «parental influence») also plays an important role in youth financial education. Lusardi *et al.* (2010) show that university students from families that invest in stocks or retirement savings plans have a higher level of financial knowledge. That said, more recent studies show that despite the growing number of private and public initiatives dedicated to the financial education of young adults in the United States, that have sprung-up in the aftermath of the financial crisis, levels of financial education remain insufficient (Money matters on campus, 2014).

Comparatively, studies in Australia have shown improvements over time. In their study conducted in 2003, Beal and Delpachitra (2003) conclude that the level of financial literacy of university students surveyed is not high (specifically, the weighted average score for decision-making skills is 47%), while results from Bird (2008) were more encouraging, as they highlight just a small number of areas that still needed to be reinforced. In South Africa, Shambare and Rugimbana (2012) note a moderate level of financial literacy among a sample of more than 200 students, and indicate a need to strengthen basic financial knowledge even among students that scored in the highest percentile.

In the United Kingdom, Marriott *et al.* (2010), surveying a sample of first year students from different faculties of economics, show a critical lack of knowledge in every financial area measured by the study. In Romania, research conducted by Oanea and Dornea in 2012 on a sample of 200 graduate students in finance, shows on average a good level of knowledge. The authors concluded that approximately half of students show a high level of financial literacy. A study in Hungary involving more than 1,700 university students (Luksander *et al.*, 2014) confirms low levels of financial literacy among undergraduate students. Students were more prone to answer theoretical questions correctly than practical ones. Finally, in Portugal, a survey conducted in 2012 on more than 600 university students from different institutions (Rodrigues *et al.*, 2012), confirmed that financial literacy is strongly correlated to socio-demographic factors including gender, age, course of study and «parental influence».

Among numerous recent studies measuring the financial literacy of university students in Italy, it is worth mentioning two by Bongini *et al.* (2012; 2013) for their research methodology applied in the domain of financial literacy testing. The first study is based on a 39-question survey submitted to 400 first year students of economics. Using Rasch models, the authors were able to indirectly measure respondents' ability (including the level of numeracy), attitudes and personal traits, as well as the relative importance of these aspects. Controlling for these non-measurable factors, the authors show students in general have a high level of numeracy, yet display limited knowledge of more sophisticated financial issues. Choice of study major is a critical factor in defining which students need to strengthen their financial knowledge. For instance, marketing students have less financial knowledge than peers studying finance. Finally, women without previous work experience or a checking account are also more likely to have a lower level of financial literacy than their peers. In the second study, the authors confirm the results of their previous research regarding the influence of socio-economic variables on the level of financial literacy, and demonstrate that individual attitudes, which influence the choice of study major, affect students' levels of financial literacy. The authors conclude that individuals' financial behavior is influenced by personal attitudes more than by their level of information or their knowledge.

In another research study on financial literacy, Milioli *et al.* (2011) surveyed more than one thousand students enrolled in three different faculties (economics, medicine and arts) at the same university in their first and third years of study. Answers to survey questions were scored on whether a good level of literacy and/or good financial attitude was demonstrated. Despite the fact that most students correctly answered more than half of the questions, the average score recorded was not high, suggesting that financial attitudes are not related to financial literacy. Furthermore, financial literacy is higher among third year students, regardless of their field of study, indicating the influence of age and experience. The study notes an element of adverse selection by which students needing greater financial literacy are less likely to take part in financial education courses. Finally, Tagliavini and Ronchini (2011), analyse a sample of three different sub-groups (high-school and undergraduate students, and adults) and conclude that despite the average university student's lack of adequate financial knowledge, this group is better financially educated than adults or high-school students[3].

In examining the international studies conducted to date, it appears there is no general consensus on a methodology to measure or methods to increase financial literacy. With regard to the former, the majority of studies resort to surveys that usually cover a wide range of topics (e.g. retirement savings, credit cards, inflation, etc.), leaving the academic community wondering whether superior methodologies could be adopted. To address these concerns, some alternative methods such as the psychometric index promoted by Knoll and Houts (2012) have been proposed as a possible starting point for a more systematic approach to measuring financial literacy. As for the latter, likely due to lower implementation costs, an increasing number of financial education initiatives make use of investment simulations. The following paragraph looks at the pros and cons of simulations for measuring financial literacy.

[3] Though, consistent with neurofinance research, adults are usually wiser when it comes to managing money and investing (Sapra and Zak, 2010).

2.3 The Role of Trading Simulations in Increasing Financial Literacy

A simulation can be defined as a teaching method based on probable situations (Cilchot, 2001). Compared to traditional learning methodologies, simulations bridge the gap between theoretical concepts and real-life decision making (Kumar and Lightner, 2007), and help participants learn from the empirical results of different strategies (Tiwari *et al.*, 2014). Simulations are also known to be effective in increasing participants' financial literacy, as they stimulate learning through active participation. In fact, several studies have measured the close relationship between the use of simulations and improved learning. Furthermore, the active role of instructor(s) (Glynn *et al.*, 2005) is critical to the latter. Before the simulation begins, instructors should carefully define the rules of the challenge based on the learning objectives. Throughout and after the simulation, students should be encouraged to discuss the strategies applied and share lessons learned with other participants. Instructors should provide constructive feedback to facilitate participants learning throughout the process. Indeed, Cadotte (1995) shows how the type and amount of feedback provided to students and the quality of the students' debriefing directly influences their learning experience, and Tiwari *et al.* (2014) confirm that debriefing sessions focused on learning outcomes are an important component of simulations. The critical role of the instructor is confirmed in several other studies (*inter alia* Knotts and Keys, 1997), which state that the instructor's active participation in the simulation determines its effectiveness as a teaching method.

The use of financial market simulations is widespread across business faculties (Faria, 2001; Ebner and Holzinger, 2007), and many business schools have introduced simulations as part of their curricula (Abodor and Daneshfar, 2006). Alonzi *et al.* (2000) analyse feedback from students that participated in futures trading simulations and find that the experiential learning component and joyful experience increases participants' knowledge of the subject matter. Levkin (2005) finds a positive relationship between increased trading skills among finance students and their academic performance. Ascioglu and Kugle (2005) also confirm the importance of participants' enjoyment in simulations. King and Jennings (2004) further show that learning through trading simulations has higher learning retention rates than traditional chalk-and-talk pedagogy. Results from a study performed by Moffit *et al.* (2010), comparing participants' scores before and after an online trading stock market simulation, show a significant improvement in students' learning. The authors concluded that stock market simulations are an effective tool to increase students' financial knowledge, and that further studies in this field would be worthwhile.

Despite the majority of studies concluding that there are strong positive benefits to students participating in financial simulations (*inter alia* De Freitas, 2006), some researchers remain doubtful. Camerer and Hogarth (1999) argue that learning is a long process, while simulations last for a short amount of time, making them an ineffective tool for financial education. Kubinska *et al.* (2012) as well as Markiewicz and Weber (2013), provide evidence that individuals remain vulnerable to behavioral biases (such as the disposition effect) even when participating in a simulation (playing with chips as opposed to real money).

Martelli (2013) argues that simulation rules strongly influence participants' behavior throughout. Analysing a trading simulation for university students in which participants enroll for free, are rewarded based on their final performance ranking, and do not lose anything if they rank poorly, Martelli illustrates how asymmetric payoffs related to their final performance encourage participants to adopt «make-or-break» behaviors, such as taking extreme and unrealistic bets by concentrating their exposure into a limited number of risky instruments as the simulation nears its end[4]. In real life such behavior is curtailed, as investors risk reputational damage, financial or job loss if they perform poorly. Consequently, Martelli recommends corrective measures that should be included in simulation rules to mitigate participants' behaviors (such as overtrading and home bias). Participants should be penalised for poor performance. This may be achieved by requiring participants to incur a (small) up-front cost to participate in the simulation. Also, participants should not be able to assess the performance gap between their portfolio return and other participants' returns during the competition. To this end, Martelli suggests that participants' portfolio performance be ranked in descending order and that the ranking (not the performance) be distributed to the participants (i.e. relative ranking). However, each participant should receive his/her portfolio performance. This way, participants see the ranking, but not the performance gap, and are able to verify that their portfolio performance is accurate. These remedial measures serve to reduce and eventually eliminate opportunistic behaviors, encouraging participants to behave as they would in real life, thus enhancing their learning experience. In summary, the absolute ranking (where both the teams' position and performance returns are disclosed) might incentivise teams to adopt unrealistic strategies. In contrast, the relative ranking (where only the position or rank of the team relative to the others is disclosed) provides a lesser incentive to adopt unrealistic strategies[5].

3 Data and Methodology

3.1 Brief Description of the Challenge

One example of a simulation which has adopted best practices that include Martelli's recommendations, is the CFA Society Italy Fund Management Challenge (hereinafter

[4] The situation is similar to holding a call option without having paid any premium, as participants have nothing to lose for performing poorly, but can win a prize if they perform well.

[5] A simple example could help to clarify this concept. Let us assume a competition with weekly portfolio turnover and prizes for the top three performers, with decreasing amounts. Suppose the third ranked team (team C) is taking the final weekly investment decision before the end of the game. In order to outdo the number two ranked team (team B) and/or the number one ranked team (team A), team C has two alternatives: 1) continue to invest following its strategy, or 2) bet on the most volatile (i.e. highest risk, highest return) instrument, which increases both the chances of receiving a higher prize and the risk of going down the ranking. Evidence shows that team C is more inclined to opt for strategy 1 if the team does not know the performance return of the other teams (relative ranking) while is more likely to choose strategy 2 if the teams' actual performance returns are disclosed (absolute ranking). The different behavior is due to the different perceptions and emotions in the two situations. Consistent with the Prospect Theory, in uncertain situations individuals are generally risk averse in the gain domain, as the hope for a profit (even a small one) encourages the participants to take decisions that are consistent with their investment strategies. On the contrary in all situations that are perceived certain, for example when participants can measure the effective distance between the other teams (absolute ranking), investors are more prone to adopt opportunistic behaviors. This is particularly true when the gap between the followers and the leaders is wide, or the reward between two different positions in the ranking is notably different.

FMC)[6]. The FMC is an innovative online portfolio management competition for graduate students. Launched in 2011, the FMC has run every year from January to May. The FMC aims to educate graduate students to apply the principles of sound investment in real-life situations and to learn from the experience of senior financial professionals.

Student teams begin[7] by submitting an investment portfolio, which they will trade over the five month period. Supervised by one or two faculty members, each student team, using a professional platform (FactSet[8]), picks five long and five short stocks from the EuroStoxx50, as though they were trading the actual stocks, and provides a short description of the investment rationale (investment case) for each stock in their portfolio. A nominal fee is applied to each virtual transaction to make the conditions of the competition more realistic. Each team may rebalance its portfolio at predetermined dates (rebalancing dates), maintaining the five long and five short stock structure and providing a short description of the investment case for each new buy/sell decision.

Student teams are encouraged to correctly apply fundamental analysis in the investment case, but their final investment decisions may deviate from the fundamental evidence and be based, for instance, on quantitative or technical analysis.

Groups comprised of three independent graders[9] access the student teams' portfolios every rebalancing date, review the investment rationale, and provide feedback as necessary. The graders, following a predetermined evaluation template that covers the main critical financial analysis and portfolio management areas, evaluate the logic and consistency of the investment rationale rather than its merit. The grading is anonymous and graders are rotated every week to smooth out grading biases.

To further improve the learning experience, penalties reflecting teams' financial knowledge and their ability to improve their financial learning, and ranging in varying degrees from reprimands (non-performance penalties) to performance cuts (performance penalties), may be applied. Also relative portfolio return rankings (as opposed to absolute rankings) are disclosed to student teams in order to minimise unrealistic participant behavior[10].

At the end of the competition, members of the three teams with the best absolute performance (including dividends) net of transaction costs and penalties are awarded

[6] CFA Society Italy (CFASI) is a local association of Italian investment professionals. Affiliated to CFA Institute, CFASI promotes the highest ethical and professional standards within the Italian investment industry and encourages professional development through the CFA Program and the CIPM Program. CFA Institute is a global, non-profit member organisation of financial analysts, portfolio managers, and other investment professionals. The CFA designation is given to investment professionals who have successfully completed the requirements set by the CFA Institute. «CFA charterholders» are those individuals who have earned the right to use the CFA designation granted by the CFA Institute. These people have satisfied certain requirements, including completion of the CFA Program and the required years of acceptable work experience. Once granted the right to use the designation, individuals must remit annually to CFA Institute a completed Professional Conduct Statement, which renews the commitment to abide by the requirements of the Code and Standards and the CFA Institute Professional Conduct Program, and pay applicable CFA Institute membership dues on an annual basis (CFA Institute, 2010).

[7] Before the start of the competition, students are informed about the critical aspects examined during the grading and provided with study materials as well as access to mentors.

[8] FactSet is a leading provider of financial information and analytics - See more at: www.factset.com.

[9] Graders are CFA Society Italy members, who volunteer in the Fund Management Challenge. They are CFA Charterholders with extensive experience in equity portfolio management and valuation.

[10] See section 2.3 above.

scholarships that can be converted to a cash prize[11]. Winners have increasingly chosen the former, signaling that financially educated individuals are more willing to invest in their financial wellbeing.

Since its inception, the FMC organizing committee has sought to improve the quality of the competition and its educational content, mainly through technology and process innovation. In the 2014 edition it pioneered a proprietary quality index (FMC QI), which is described later in this paper (see Section 3.3).

3.2 Data

The present study analyses the weekly investment decisions of all the sixteen participating university student teams in the 2014 edition of the FMC, over a period of five months.

3.2.1 The Dataset

The dataset used is from the evaluation and performance databases. The former comprises all the investment rationale of all 16 participating university student teams in the 2014 edition and the graders' evaluations. The database has 2800 records, includes 630 trading decisions and 650 net evaluations[12]. The latter regards information including stock tickers, closing prices, dividends, corporate actions, portfolio weights, and other data for the portfolio performance calculation. The performance database is integrated in the FactSet Research Management System database. The data in both databases was collected from inception on January 17, 2014 to the end of the competition on May 23, 2014, and at each of the 16 portfolio rebalancing dates. The two databases store all the relevant information regarding student teams' portfolios and the graders' evaluation[13], with a frequency of 7.8 days[14].

In this paper we will use the information in the evaluation database to calculate the FMC QI, and the performance results of the Factset Research Mangement System to analyse the correlation between the FMC QI and the performance rankings.

3.2.2 Team Characteristics

All participants were graduate students, mainly from Economics faculties, independently selected by university faculty member(s). At the competition inception, 86% were between 22 and 24 years of age with a median of 23 (see Fig. 2). The majority of the

[11] The net cash prize is lower than the monetary value of the scholarship due to tax and other deductions.
[12] Net evaluations are defined as the total number of evaluations minus the number of evaluations that are «in line».
[13] Information such as: stock name, type of trade, stock price, evaluation of the investment recommendations, etc.
[14] Around the Easter break and other national holidays the rebalancing frequency, decreases resulting in an average frequency of 7.8 days.

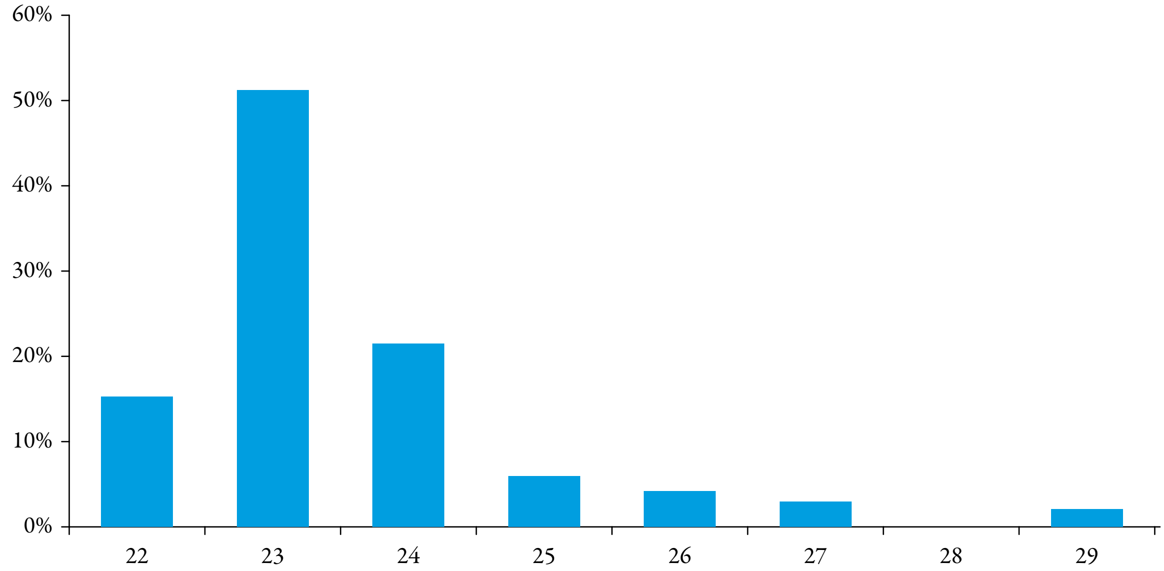

Figure 2: FMC student age distribution.

Source: Authors' elaboration.

Table 1: Team statistics

Geographic Location	Faculty	# Faculty supervisor(s)	# Students	Gender ratio (F:M)	Age (min-max)
Center	Economics	2	5	1:4	23
Center	Economics	1	3	1:2	23-25
Center	Economics	1	4	1:3	22-24
North	Other	2	5	1:4	22-29
North	Economics	2	5	1:4	23-24
North	Economics	1	5	3:2	23-25
North	Economics	1	4	1:3	22-23
North	Economics	2	5	0:5	23-24
North	Economics	2	5	2:3	23-25
North	Economics	1	5	1:4	23-25
North	Other	1	4	1:3	23
North	Economics	1	5	1:4	22-24
North	Economics	1	4	1:3	22-24
South & Islands	Economics	1	4	2:2	22-26
South & Islands	Economics	1	4	0:4	23-27
South & Islands	Economics	1	5	2:3	22-27
		21	72	19:53	22-29

Source: Authors' elaboration.

participating universities were located in Northern Italy, the most industrialised part of the country (see Tab. 1).

3.3 The FMC Evaluation Process and the FMC Quality Index

This paragraph illustrates the FMC evaluation process and the steps followed to calculate the FMC Quality Index: *i*) teams' investment rationale evaluation, *ii*) grading storage, *iii*) transformation of qualitative assessments into quantitative scores, and *iv*) calculation and normalisation of the team's scores. Table 2 provides an example of a simplified competition.

Table 2: Example of competition – Panel 1

Number of:	
Rebalancing dates (T)	4
Teams (I)	4
Stocks (Z)	4
Evaluation criteria (J)	7

Teams' investment case and graders' evaluations are for illustrative purposes

Panel 1 ($t = 1$)	Team $i = 1$		Team $i = 2$		Team $i = 3$		Team $i = I = 4$		Reference to Table	Reference to Section 3.3
	Stock z = 1	New Long	Stock z = 2	New Long	Stock z = 3	New Long	Stock z = 4	New Long		
Investment Case	Bank Z1 is undervalued: its P/E is 8x vs 12x sector average.		Z2 FY15 EPS growth (+19%) will outpace consensus as expect the WTI price to hit our estimated \$70 vs \$55 cons amid lower drilling activity in North America.		Z3 is a pure-player in the liquified gas industry that will greatly benefit from company specific trends.		We expect Z4 new flagship phone to be released in 1Q vs 2Q consensus. Valuation seems not to reflect it as the stock trades 10% below its peers (13x) on our above cons estimates (1.15 FY15 EPS vs 1.05).			
Grading	P/E is not an evaluation metric for banks. Please review the study materials and contact your mentor.		The investment case is not supported by fundamental data and valuation. Please review the study materials and contact your mentor.		The investment case is consistent, but lacks the valuation argument. Please review the study materials and contact your mentor.					
	Below Avg	On Watch	Below Avg	On Watch	Below Avg	On Watch	Above Avg	None	(T1)	(2)*
	$f(\cdot)$		$f(\cdot)$		$f(\cdot)$		$f(\cdot)$			
Evaluation Buckets (1)	Low	−1	Low	−1	Low	−1	Low	1		
	Medium	0	Medium	0	Medium	0	Medium	0	(T2)	(3)
	High	0	High	0	High	0	High	0		
			g(·) = normalized inverted bucket frequency							(5)
Severity Vector (2)			Low	1.00						
			Medium	-					(T3)	(6)
			High	-						
Evaluation Score (1)' x(2)	−1.00		−1.00		−1.00		1.00		(T4)	
Normalized Evaluation Score (FMC QI)	0		0		0		100		(T5)	(7)

* Graders' evaluations in (T1) are stored as a set of zeros and ones in the tensor (2).

Step 1 – Teams' investment rationale evaluation

On each rebalancing date, student teams' investment rationales are graded by a group of independent financial professionals (graders) using a two dimensional grading system. Following a predetermined evaluation template, each team's investment rationale is ranked using the first grading dimension: a three level scale (below average, inline, above average) that evaluates teams' investment rationale relative to graders expected teams' average financial. If the investment case is below average and the team is requested to review it, the graders apply the second grading dimension, which is a seven level

Table 2: (*follows*) Example of competition – Panel 2

Teams' investment case and graders' evaluations are for illustrative purposes

Panel 2 ($t = 2$)	Team $i = 1$	Team $i = 2$	Team $i = 3$	Team $i = I = 4$	Reference to Table	Reference to Section 3.3
	Stock $z = 1$ | Long	Stock $z = 2$ | Long	Stock $z = 3$ | Long	Stock $z = 4$ | Long		
Investment Case	Bank Z1 is undervalued: its EV/EBITDA is $5x$ vs $7x$ sector average.	We expect Z2 EPS growth (+19%) to outpace consensus as we expect the price of the WTI to hit \$70 vs \$55 cons.amid lower drilling activity in NA. Z1 trades at $8x$ on our estimates vs $12x$ cons average.	Z3, a pure-player in the liquified gas industry, will greatly benefit from an above consensus ramp-up in the new Singapore liquifying facility. Valuation-wise, the stock is undervalued as the P/E declines from this year to next year.	We expect Z4 new flagship phone to be released in 1Q vs 2Q. Valuation seems not to reflect it as the stock trades 10% below its peers(13x) on our above cons estimates (1.15 FY15 EPS vs 1.05).		
Grading	EV/EBITDA is not a valuation metric for banks. Please, review the study materials and contact your mentor.		The valuation argument is not supported: growth companies last year P/E is always lower than current one. Please, review the study materials and contact your mentor.		(T1)	(2)*
	Below Avg | Yellow card	Infine | None	Below Avg | Yellow card	Infine | None		
	$f(\cdot)$	$f(\cdot)$	$f(\cdot)$	$f(\cdot)$		
Evaluation Buckets (1)	Low −1 Medium −1 High 0	Low −1 Medium 0 High 0	Low −1 Medium −1 High 0	Low 1 Medium 0 High 0	(T2)	(3)
		$g(\cdot)$ = normalized inverted bucket frequency				(5)
Severity Vector (2)		Low 1.00 Medium 0.50 High -			(T3)	(6)
Evaluation Score (1)' x (2)	−1.00	−0.50	−1.00	0.50	(T4)	
Normalized Evaluation Score (FMC QI)	0	33	0	100	(T5)	(7)

* Graders' evaluations in (T1) are stored as a set of zeros and ones in the tensor (2).

review penalty system[15]. The graders usually[16] start from the lowest non-performance penalty (reprimand) and adjust the penalty upward or downward, depending on the team's receptiveness to feedback and their investment rationale evaluations in subsequent weeks. The progressive penalty system allows students adequate time to study and apply the principles of fundamental analysis. As a result, the majority of teams

[15] None, On Watch, Yellow Card, Red Card –0.10%, Red Card –0.20%, Red Card –0.40%, Red Card –0.80%.

[16] When the investment rationale is well below average, the graders may begin with a higher non-performance penalty/reprimand.

Table 2: (*follows*) Example of competition – Panel 3

Teams' investment case and graders' evaluations are for illustrative purposes

		Team $i = 1$	Team $i = 2$	Team $i = 3$	Team $i = I = 4$	Reference to Table	Reference to Section 3.3
Panel 3 ($t = 3$)	Investment Case	Stock $z = 1$ | Long Bank Z1 is undervalued: its EV/EBITDA is 5x vs 7x sector average.	Stock $z = 2$ | Long (+19%) to outpace consensus as we expect the price of the WTI to hit \$70 vs \$55 cons.amid lower drilling activity in NA. Z1 trades at 8x on our estimates vs 12x cons average.	Stock $z = 3$ | Long Z3, a pure-player in the liquified gas industry, will greatly benefit from an above consensus ramp-up in the new Singapore liquifying facility. Valuation-wise, the stock is undervalued as its P/E trades 2 std below its 10 year average despite good fundamentals.	Stock $z = 4$ | Long We expect Z4 new flagship phone to be released in 1Q vs 2Q. Valuation seems not to reflect it as the stock trades 10% below its peers (13x) on our above cons estimates (1.15 FY15 EPS vs 1.05).		
	Grading	The stock is overvalued. Please review the study materials and contact your mentor if you have questions. Below Avg | Red card	Infine | None	Infine | None	Infine | None	(T1)	(2)*
		$f(\cdot)$	$f(\cdot)$	$f(\cdot)$	$f(\cdot)$		
	Evaluation Buckets (1)	Low −1 Medium −1 High −1	Low −1 Medium 0 High 0	Low −1 Medium −1 High 0	Low 1 Medium 0 High 0	(T2)	(3)
			$g(\cdot)$ = normalized inverted bucket frequency				(5)
	Severity Vector (2)		Low 0.25 Medium 0.25 High 0.50			(T3)	(6)
	Evaluation Score (1)' x (2)	−1.00	−0.25	−0.50	0.25	(T4)	
	Normalized Evaluation Score (FMC QI)	0	60	40	100	(T5)	(7)

* Graders' evaluations in (T1) are stored as a set of zeros and ones in the tensor (2).

finish the competition with nil or very minimal performance curtailments (0.10% on average)[17]. The two dimensional grading system reflects the financial knowledge of the teams' investment rationale which is often weak among teams who maintain insufficient levels of financial literacy and those who do not adopt the graders' suggestions to improve their financial knowledge.

[17] Performance curtailments are usually applied to investment rationales that do not materially improve after two or more weeks.

Table 2: (*follows*) Example of competition – Panel 4

Teams' investment case and graders' evaluations are for illustrative purposes

Panel 4 ($t = 4$)	Team $i = 1$	Team $i = 2$	Team $i = 3$	Team $i = I = 4$	Reference to Table	Reference to Section 3.3
	Stock $z = 1$ – Long	Stock $z = 2$ – Long	Stock $z = 3$ – Long	Stock $z = 4$ – Long		
Investment Case	Buy bank Z1 trades at discount on a P/BV-ROE basis: although its P/BV is $2x$ vs $1.5x$ sector, its ROE is 23% vs 12% sector.	We expect Z2 EPS growth (+19%) to outpace consensus as we expect the price of the WTI to hit \$70 vs \$55 cons.amid lower drilling activity in NA. Z1 trades at $8x$ on our estimates vs $12x$ cons average.	Z3, a pure-player in the liquified gas industry, will greatly benefit from an above consensus ramp-up in the new Singapore liquifying facility. Valuation-wise, the stock is undervalued as its P/E trades 2 std below its 10 year average despite good fundamentals.	We expect Z4 new flagship phone to be released in 1Q vs 2Q. Valuation seems not to reflect it as the stock trades 10% below its peers($13x$) on our above cons estimates (1.15 FY15 EPS vs 1.05).		
Grading	Infine – None	Infine – None	Infine – None	Infine – None	(T1)	(2)*
	$f(\cdot)$	$f(\cdot)$	$f(\cdot)$	$f(\cdot)$		
Evaluation Buckets (1)	Low −1 Medium −1 High −1	Low −1 Medium 0 High 0	Low −1 Medium −1 High 0	Low 1 Medium 0 High 0	(T2)	(3)
		$g(\cdot)$ = normalized inverted bucket frequency				(5)
Severity Vector (2)		Low 0.25 Medium 0.25 High 0.50			(T3)	(6)
Evaluation Score (1)' x(2)	−1.00	−0.25	−0.50	0.25	(T4)	
Normalized Evaluation Score (FMC QI)	0	60	40	100	(T5)	(7)

* Graders' evaluations in (T1) are stored as a set of zeros and ones in the tensor (2).

Source: Authors' elaboration.

The example presented in Table 2 assumes four teams ($I = 4$) that begin by selecting one instrument from a four stock investment universe ($Z = 4$) and hold the selected stock throughout the four rebalancing dates ($T = 4$). Each Panel shows the FMC evaluation process and the FMC Quality Index calculation at each rebalancing date. At the beginning of this competition (Panel 1 – Investment Case), each team selects a stock, defines the action type (long or short), and provides a short investment case, explaining the rationale behind their decision. Graders evaluate each team's investment case (Panel 1, 2, 3, 4 – Grading) by using the two-dimension grading system[18].

[18] Throughout the example, while the first dimension of the two-dimension grading system is unchanged (above

If necessary, graders comment and/or provide suggestions to improve the investment rationale. The dialog between teams and graders continues in the following panels.

In Panel 1, Team 1's investment case applies a wrong metric to evaluate a bank. Graders detect the gap and assign the «Below Average» – «On Watch» penalty, meaning that the team's investment case will be reevaluated the following rebalancing date. In Panel 2, Team 1 amends the investment case but fails to apply the correct evaluation metric and the graders increase the penalty to «Below Average» – «Yellow Card» In Panel 3, Team 1's investment case provides the right metric (P/BV) and characterises the bank as undervalued. However, based on the information provided in the investment case, the bank is overvalued. This is an even deeper gap that the graders flag with the «Below Average» – «Red Card» penalty. Finally, in Panel 4, Team 1 provides a consistent and correct investment case and the graders do not assign any penalty.

Step 2 – Grading storage

As the grading is completed, the information is stored in a database whose dimension varies depending on the number of participating teams ($I \in \mathbb{N}^+$), rebalancing dates ($T \in \mathbb{N}^+$), evaluation criteria ($J \in \mathbb{N}^+$) and instruments in the investable universe ($Z \in \mathbb{N}^+$).

Using algebra notation[19], we define the vector $[1; n]$ as:

$$[1; n] \equiv \{1, 2, ..., n - 1, n\} \tag{1}$$

For each team $i \in [1; I]$ and instrument $z \in [1; Z]$, at each rebalancing date $\bar{t} \in [1; T]$, the graders' evaluations $j \in [1; J]$ are stored as a set of zeros and ones in the tensor:

$$\begin{aligned} \boldsymbol{E}_{\bar{t}} : \{1, 2, \dots, i, \dots I\} \times \{1, 2, \dots, j, \dots J\} \times \{1, 2, \dots, z, \dots Z\} \times \\ \times \{1, 2, \dots, t, \dots \bar{t}\} \mapsto e_{ijzt} \in \{0,1\} \end{aligned} \tag{2}$$

where 0 means the graders did not apply the j-th evaluation criterium for team i, instrument z at time t; 1 means the graders did apply the the j-th evaluation criterium for team i, instrument z at time t.

On each rebalancing date $\bar{t} \in [1; 4]$, the grading evaluations (T1) shown in Table 2 are stored in the tensor (2) as a collection of zeros and ones. For every rebalancing date rebalancing date $\bar{t} \in [1; T]$, the tensor has dimension $I \times J \times Z \times \bar{t}$ and stores the graders' evaluations from the beginning of the competition, $t = 1$, up to the latest rebalancing date $\bar{t}$. For example, in Table 2 - Panel 1, the tensor dimension is $4 \times 7 \times 4 \times 1$. Each element in the tensor stores the graders' j-th evaluation criterium for team i, instrument z at the rebalancing date $\bar{t}$. At the inception ($\bar{t} = 1$), without loss of approximation, the tensor can be represented as a three-dimension object (Fig. 3).

average, inline, below average), the second dimension is cut to 4 levels (none, on watch, yellow card, red card), hence J equals 7 (3 levels for the first dimension and 4 for the second one).

[19] The generalised versions of all equations in this paragraph can be found in the appendix with reference number (AX), where X is the number of the equation in the text.

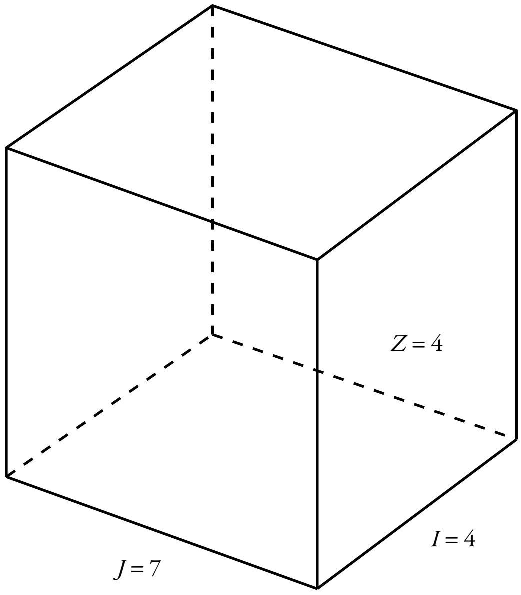

Figure 3: Geometric representation of tensor (1) at $\bar{t} = 1$.

Source: Authors' elaboration.

Table 3: Graders' evaluation as stored in the tensor (1) for Team 1 at $t = 1$

	$j = 1$	$j = 2$	$j = 3$	$j = 4$	$j = 5$	$j = 6$	$j = 7$
$i = 1, t = 1$	AA	IL	BA	NN	OW	YC	RC
Stock $z = 1$	0	0	1	0	1	0	0
Stock $z = 2$	0	0	0	0	0	0	0
Stock $z = 3$	0	0	0	0	0	0	0
Stock $z = 4$	0	0	0	0	0	0	0

Source: Authors' elaboration.

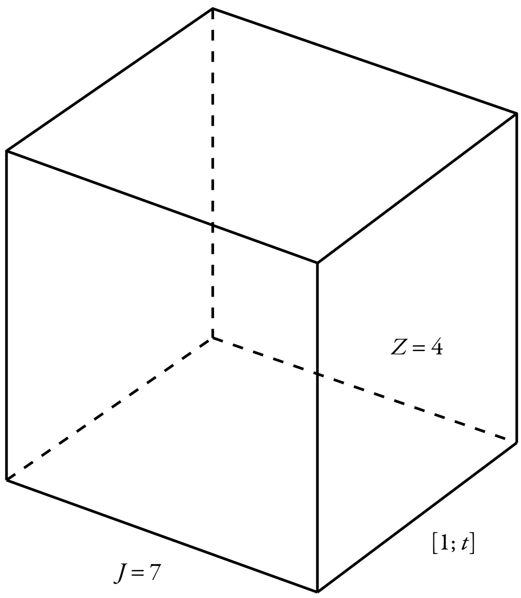

Figure 4: Geometric representation of tensor (1) for Team i.

Source: Authors' elaboration.

Table 4: Graders' evaluation for Team 1 at $t = 1$ (a) and $t = 2$ (b) as stored in the tensor (1)

(a)

	$j = 1$	$j = 2$	$j = 3$	$j = 4$	$j = 5$	$j = 6$	$j = 7$
$i = 1, t = 1$	AA	IL	BA	NN	OW	YC	RC
Stock $z = 1$	0	0	1	0	1	0	0
Stock $z = 2$	0	0	0	0	0	0	0
Stock $z = 3$	0	0	0	0	0	0	0
Stock $z = 4$	0	0	0	0	0	0	0

(b)

	$j = 1$	$j = 2$	$j = 3$	$j = 4$	$j = 5$	$j = 6$	$j = 7$
$j = 1, t = 2$	AA	IL	BA	NN	OW	YC	RC
Stock $z = 1$	0	0	1	0	0	1	0
Stock $z = 2$	0	0	0	0	0	0	0
Stock $z = 3$	0	0	0	0	0	0	0
Stock $z = 4$	0	0	0	0	0	0	0

Source: Authors' elaboration.

For each t, team grading is stored in a matrix as a set of zeroes and ones as showed in Table 3 for Team 1 at $t = 1$.

At the rebalancing date $\bar{t} = 2$, tensor (2) contains the graders evaluations in Panel 1 and 2, hence it becomes a tensor of order four. If we limit our analysis to the information in the tensor for Team 1, the subset is stored in a tensor of order three that contains the graders' evaluations for two rebalancing dates. The former is the grading at the rebalancing date $t = 1$ and the latter the grading at the following rebalancing date ($\bar{t} = t = 2$) (see Fig. 4 and Tab. 4).

In Table 3 and 4, the zeros and ones are the factors e_{ijzt} in (2).

Step 3 – Transformation of qualitative assessments into quantitative scores

On every rebalancing date $\bar{t}$, a proprietary algorithm applies the function $f(\cdot)$ to transform the tensor $\boldsymbol{E}_{\bar{t}}$ into the evaluation buckets $\boldsymbol{EB}_{\bar{t}}$:

(3)
$$\boldsymbol{E}_{\bar{t}} \xrightarrow{f(E_{\bar{t}})} \boldsymbol{EB}_{\bar{t}}$$

Where:

(4)
$$\boldsymbol{EB}_{\bar{t}}\colon \{1, 2, ..., i, ... I\} \times \{1, 2, 3\} \mapsto eb(\bar{t})_{ik} \in \mathbb{R}$$

$f(\cdot)$ transforms the graders' evaluations into scores, collapse the two dimensional grading system into three buckets (low, middle, high penalty), adjust each team grading for the portfolio turnover, and for each bucket, sum up the number of adjusted scores for each team.

In Table 2, for every $\bar{t}$[20]:

a) Transforms the entries in the tensor (2) into scores as follows: it assigns +1 to «Above Average» ($j = 1$), −1 to the «On Watch» ($j = 5$), «Yellow Card» ($j = 6$) and «Red Card» ($j = 7$) if the graders applied the penalty and/or the positive mention, 0 otherwise (T1). Figure 3 – step a) shows this transformation for Team 1 in Panel 1. The tensor element $e_{1511} = 1$, which refers to the «Yellow Card» penalty is transformed into −1, and $e_{1311} = 1$, refers to the «Below average» penalty, into 0.

b) Maps, if applicable, above average and on watch, yellow card and red card scores from previous Step a) in the low, middle and high evaluation buckets respectively, discards the rest of the information. Figure 3 – step b), shows this step for Team 1 in Panel 1: $e_{1511} = 1$ that was transformed to −1 in step a) is now mapped into the low evaluation bucket $eb(1)_{11} = -1$, and

c) For any rebalancing date $\bar{t} > 1$, sums up the scores in the low, middle, and high evaluation buckets for each team i from the beginning of the competition ($t = 1$) up to the latest rebalancing date $\bar{t}$. For $\bar{t} \in [1; T]$, each column i in $\boldsymbol{EB}_{\bar{t}}$ is a vector (3×1) that aggregates the entire grading history for team i into the three evaluation buckets, from the beginning of the competition up to $\bar{t}$, as transformed by $f(\cdot)$ (Figure 3 – step c)).

Using another function, $g(\cdot)$:

(5)
$$\boldsymbol{EB}_{\bar{t}} \xrightarrow{g(EB_{\bar{t}})} \boldsymbol{sw}_{\bar{t}}$$

where:

(6)
$$\boldsymbol{sw}_{\bar{t}}\colon \{1, 2, 3\} \mapsto sw(\bar{t})_k \in \mathbb{R}^+$$

[20] In the FMC, $f(\cdot)$ is more complex. In particular, $f(\cdot)$ adjusts each team's grading penalties for portfolio turnover. In table 2 teams have the same turnover ($1x$) making this adjustment unnecessary.

the average grading severity weights, $sw(\bar{t})_k$, for the low, middle and high evaluation buckets, are estimated from the evaluation buckets $\boldsymbol{EB}_{\bar{t}}$[21]. is a vector (3 × 1) whose elements are the grading severity weights.

In Table 2, for each rebalancing date $\bar{t}$, $g(\cdot)$[22] transforms the scores in the low, middle and high evaluation buckets from $f(\cdot)$ into the severity weights (5). The steps for Panel 2 are illustrated in Figure 3:

d) Sums the scores in the low, middle and high evaluation buckets for all teams up to the latest rebalancing date. For instance, in Panel 2, this transformation results in this vector [–2, –2, 0]´, that is obtained by adding horizontally the four vectors in Panel 2 (T2),

e) Calculates the relative bucket weights dividing the vector calculated in step d) by the sum of the elements in d) itself: $\frac{[-2,-2,0]}{-4} = [0.5, 0.5, 0]$,

f) Calculates the reciprocal of each bucket weight in e), resulting in [2, 2, 0]´,

g) Rescales the reciprocals in f) such that their sum equals 1, resulting in the severity vector [0.5, 0.5, 0]´ in Panel 2 (T3)[23] (Fig. 5).

Using algebra notation $g(\cdot)$ is defined as:

$$r\left(\frac{\boldsymbol{sumbf}_{\bar{t}}}{Tsumbf_{\bar{t}}} \cdot \;\hat{}\;(-1), 0, 1\right)$$

where:

– $\boldsymbol{sumbf}_{\bar{t}} \equiv (\boldsymbol{EB}_{\bar{t}} \cdot \mathbf{1})$ is a vector (3x1) with the sum of the scores in the low, middle and high evaluation buckets at the rebalancing date $\bar{t}$,

– $Tsumbf_{\bar{t}} \equiv \mathbf{1}' \, \boldsymbol{EB}_{\bar{t}} \mathbf{1}$ is a scalar equal to the sum of the scores in $\boldsymbol{sumbf}_{\bar{t}}$,

– $r(v, 1)$ is the rescaling function defined in g) above, and

– $\cdot\hat{}(-1)$ is the element-wise division operator such that $[a, b, c] \cdot \hat{}\,(-1) \equiv \left[\frac{1}{a}, \frac{1}{b}, \frac{1}{c}\right]$.

The objective of the function $g(\cdot)$ is to assign grading marks to the evaluation buckets that are proportional to the scores calculated in step d). For instance, in Table 2 – Panel 3 ($\bar{t}$ = 3), as the sum of the scores in the high evaluation bucket is higher (–1) than the low and medium buckets, the high evaluation bucket gets the higher severity weight (0.50%). Once again, the severity weights are a function of the entire grading history up to the latest rebalancing date.

Step 4 – Calculation and normalisation of the team's scores

To calculate each team evaluation score, each team's adjusted evaluation vector is multiplied by the severity vector ($\boldsymbol{EB}_{\bar{t}} \cdot \boldsymbol{sw}_{\bar{t}}$). Using the normalisation function $h(\cdot)$, the team evaluation scores are normalised on a scale of 0 to 100, where 100 is the highest score, and 0 is the lowest score:

[21] It should be noted that the grading severity weights are the same for all the teams.

[22] In the FMC, $g(\cdot)$ is different but has a similar objective.

[23] Although step e) and f) are redundant in this example, this is not usually the case (for an example, see Panel 3).

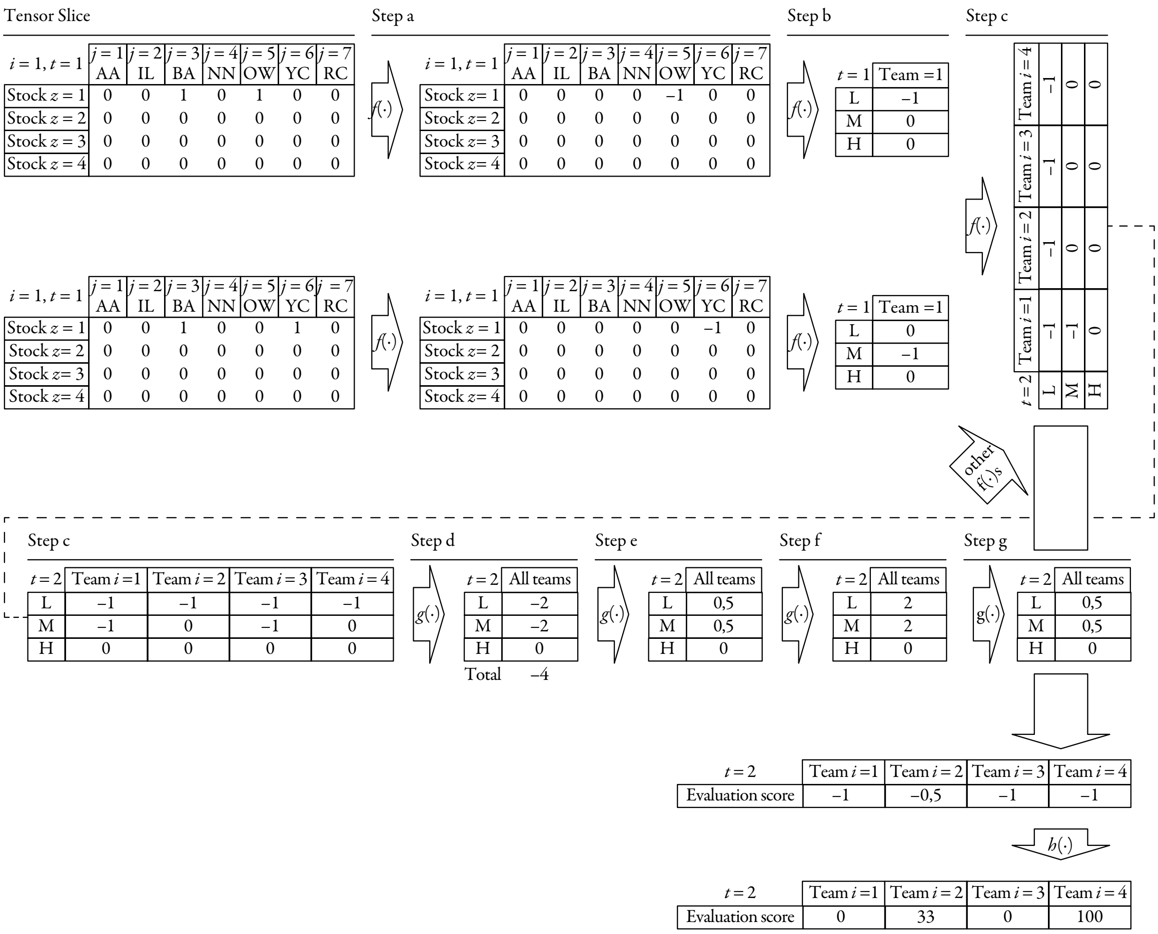

Figure 5: Transformation of qualitative assessments into quantitative scores: an example.

Source: Authors' elaboration.

$$\boldsymbol{EQI}_{\bar{t}} = h(\boldsymbol{EB}_{\bar{t}} \cdot \ \boldsymbol{sw}_{\bar{t}}, 0, 100) = \begin{bmatrix} eqi_1 \\ \dots \\ eqi_i \\ \dots \\ eqi_I \end{bmatrix}$$

For the rebalancing date $\bar{t}$, the stack of normalised evaluation scores for each team i in (7) is defined as the FMC Quality Index ($\boldsymbol{EQI}_{\bar{t}}$).

The ranked FMC QI ($\boldsymbol{REQI}_{\bar{t}}$) is defined as the vector in which the elements in (7) are ranked from the highest to the lowest:

$$\boldsymbol{REQI}_{\bar{t}} = \begin{bmatrix} 100 \\ \dots \\ reqi_r \\ \dots \\ 0 \end{bmatrix} \tag{8}$$

In the example (Table 2), to calculate the teams' evaluation scores in (T4) the evaluation buckets/vectors in (T2) for all Teams i, are transposed and multiplied by the severity vector in (T3). The evaluation scores are then normalised on a scale of 0 to 100 (T5). For instance, in Table 2 – Panel 2, Team 4 evaluation score results from the product of vector (T2) and (T3) ($[1, 0, 0] \cdot [0.5, 0.5, 0]'$), that being the highest score in Panel 2 (T4), is normalised to 100 (T5). In Panel 2, Team 1 and 3 receive the same grading evaluations and thus have the same team evaluation scores (−1). Having the lowest evaluation scores, they are normalised to 0. In Panel 2, Team 2, who get fewer and less severe grading penalties than team 1 and 3, but whose graders' evaluations are not as good as at Team 4, has an a normalised evaluation score (33) between Team 4's and Team 1 and 3's normalised evaluation scores. At the next rebalancing date (Panel 3), new information from the graders is incorporated in the tensor (2) allowing the FMC QI to provide a more granular ranking. In practical applications, due to the higher number of instruments (Z) and the higher number of evaluation criteria (J), the FMC QI provides a granular representation of teams' financial knowledge from $\bar{t} = 1$.

It is possible to note that, by construction, the FMC QI and the ranked FMC QI are relative indexes. The team normalised score and ranking are affected by the results of the grading of each team vis-a-vis the other teams. As the graders evaluate the ability of the teams in applying portfolio management and financial analysis techniques, and the FMC QI is a function of the graders' evaluation, the ranked FMC QI ranks the teams by their relative financial knowledge. For example, if the financial knowledge of a team's investment rationale does not change significantly throughout the competition, while that of the other teams diminishes, the former will experience an increased normalised score and its ranking according to the FMC QI might rise.

4 Empirical Results

4.1 Descriptive Statistics

Figure 3 shows the distribution of (8) at the end of the competition that is skewed to the right. Two teams, U15 and U16, explain the majority of the skewedness. Also, U15 and U16 explain most of the difference between Q1 and Q2 averages.

Table 2 shows the statistical distribution of the FMC QI, including and excluding U15 and U16. The distribution excluding U15 and U16 is provided for illustrative purposes. In fact, as U15 and U16 comprise a sizable chunk of the graders' adjusted qualitative assessments, the FMC QI grading severity weightings would have been different, as would the FMC QI, had U15 and U16 not participated in the competition (Fig. 6, Tab. 5).

4.2 Discussion

To evaluate the FMC QI, we have calculated the quality index $\boldsymbol{EQI}_{\bar{t}}$ in (7) at the 4th, 8th, 12th and 16th rebalancing date ($\bar{t} \in [4, 8, 12, 16]$).

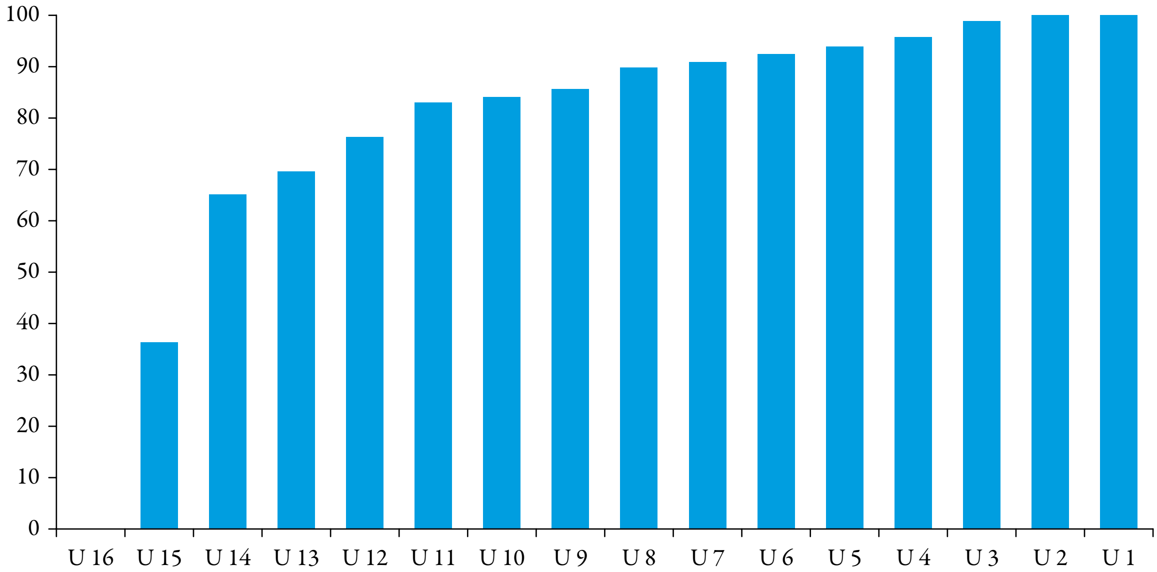

Figure 6: FMC QI distribution – End of the competition.

Source: Authors' elaboration.

Table 5: FMC QI – Descriptive Statistics and Interquartile mean – End of the competition

Descriptive Statistics U1-U16		Descriptive Statistics U1-U14		Interquartile mean U1-U16	
Mean/Median	82.5/89.9	Mean/Median	90.6/91.9	Q1	52.70
Skew	−2.75	Skew	−0.37	Q2	84.88
St. dev.	24.26	St. dev.	7.30	Q3	94.02
Range	100.00	Range	20.51	Q4	98.54

Source: Authors' elaboration.

Before analysing the panel data it is worthwhile mentioning that the participating teams were not aware of their relative FMC QI ranking. Furthermore, teams were not incentivised to react to non-performance penalties. As a result, the team response to non-performance penalties was more a function of each team's propensity to risk a performance penalty at a later date (penalty aversion), than a direct effect of the non-performance penalties. Penalty aversion is usually higher among teams with greater risk aversion and higher portfolio return.

Figure 3 shows each team's relative financial knowledge as measured using the FMC QI. With some noticeable exceptions, the time-series for each team shows limited movement within a narrow range: as learning is a long process, variations of teams' FMC QI should not differ substantially from one month to the next. Furthermore, the majority of teams started and finished the competition with a quality index greater than 60, indicating that they had a good relative level of financial knowledge at the start, and were responsive to the graders' suggestions throughout the competition.

As the competition progresses from $t = 4$ to $t = 16$, we note that the cross-sectional dispersion increases. This may be explained by certain teams' relative (i.e. compared to other participating teams) inability to cope with the graders' stricter evaluation criteria, which become more exacting during the competition. Another reason for the increased cross-sectional volatility is that each team's motivation is partly a function of their portfolio performance ranking and its weekly changes. At the beginning of the competition motivation is high. However, during the competition underperforming teams may display increasing levels of frustration and/or investment fatigue, while outperforming teams may become overconfident and less attentive to graders' suggestions.

In particular, teams that are persistently at the bottom of the portfolio performance ranking may experience increasing frustration, spend more time complaining among themselves and less time analysing stocks. Frustration may lead to irrational behaviors and vicious cycles[24]. For instance, increased portfolio turnover, a common reaction, reduces the time available for investment analysis, resulting in weak investment rationale and higher penalties. These vicious cycles may reduce students' motivation, which is key to productive learning (Prensky, 2003). The FMC QI detects these patterns and can be used for the effective and timely allocation of mentoring resources to struggling teams.

Focusing on teams in the first quartile at the end of the competition ($t = 16$), we observe two teams (red square and blue star) that exhibit a steep downward-sloping trajectory. The blue cross team remains at the bottom of the chart, while the gray circle team exhibits an upward-sloping trajectory.

The anecdotal evidence from the competition suggests that falling trajectories are the result of frustration from underperformance in the case of the blue star team, and overconfidence in the team's fundamental analytical skills in the case of the red square team. The team that remains at the bottom of the ranking suffers from both wide gaps in its fundamental analysis and its reluctancy to follow suggestions[25]. On the contrary, the team with the upward sloping trajectory demonstrates the benefits of greater attention paid to the FMC committee suggestions, coupled with a higher penalty aversion, perhaps due to better performance.

A different representation of the FMC QI is presented in Figure 4. The FMC QI is ranked from 1 to 16, where 1 is the team with the highest FMC QI and 16 is the team with the lowest FMC QI.

As in Figure 4, Figure 5 shows that, with some exceptions, the time-series of each student team, as measured by the FMC QI, is fairly persistent. The maximum range variation for the teams (difference between the maximum and the minimum ranking for each team) varies between 0 and 6. The average maximum range of variation is 2.4, and the standard deviation of the maximum range of variation is 1.58.

This persistence reflects different levels of financial knowledge and motivation among student teams. Furthermore, as the FMC QI comprises the time-series of each student teams' penalties, this persistence should increases as the time-series lengthens (Fig. 7 e 8).

Student teams' portfolio *performance* quartiles at the end of the competition are shown on the right of Figure 4. In order to assess whether teams' portfolio performance and

[24] See footnote 8 for an example.

[25] For the first three editions, including the edition from which the FMC QI is calculated in this paper, there were no incentives to follow graders' suggestions, except for infrequent performance curtailments and the theoretical possibility of being disqualified. Therefore, some outperforming teams were tempted to forgo the graders' suggestions, hoping to make up for the performance curtailment with better portfolio performance. It appears that the lowest quality team, which was actually performing quite well in the first half of the competition, ceded to that ephemeral temptation.

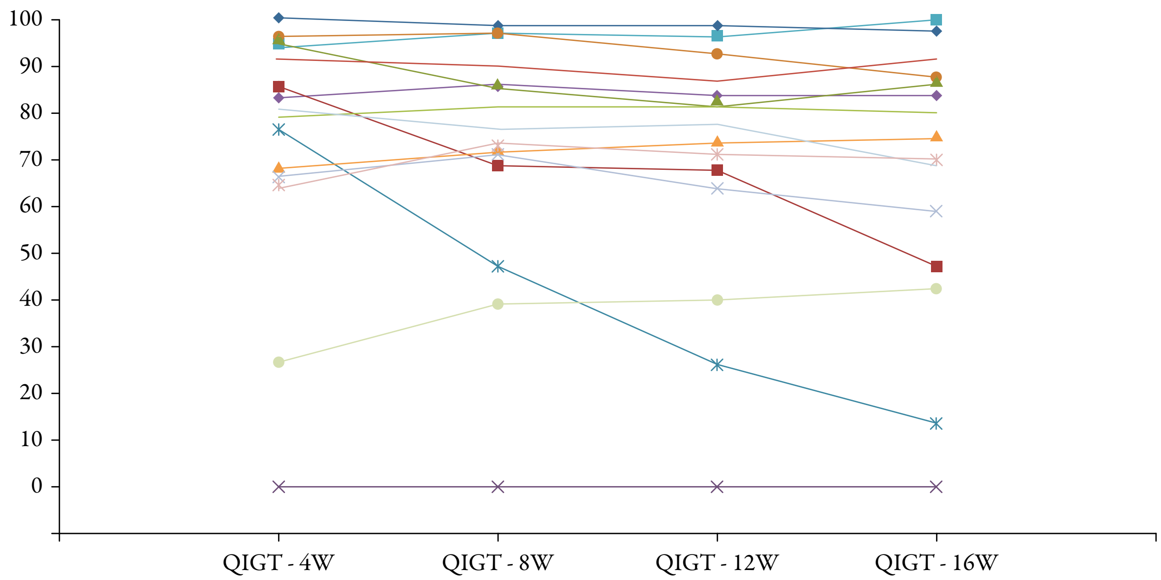

Figure 7: FMC Quality Index.

Source: Authors' elaboration.

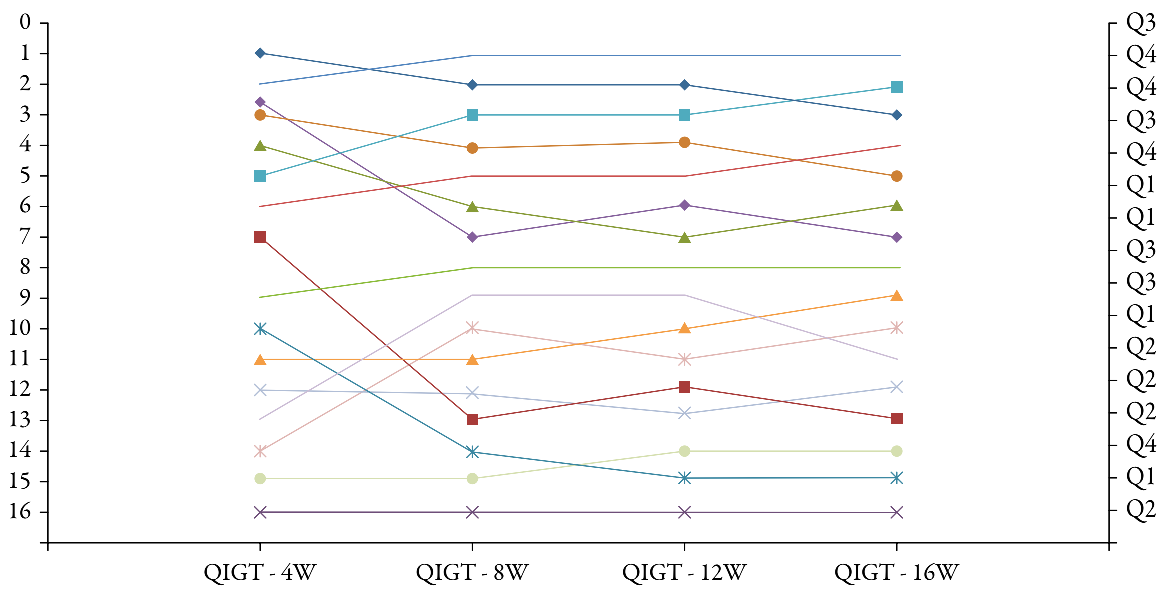

Figure 8: Quality Index Ranking and Performance Quartiles.

Source: Authors' elaboration.

ranked FMC QI are correlated, we have calculated the Spearman's rank order correlation coefficient and the Kendall's tau. Contrary to Figure 4, the two indicators are calculated using the portfolio performance ranking, as opposed to the quartiles[26].

The results in Table 3 shows that the FMC QI and the portfolio performance ranking are correlated, though the statistical tests cannot exclude the null hypothesis that the two rankings are not correlated at the 10% level (Tab. 6).

[26] The portfolio performance rankings are not disclosed to protect the anonymity of the participating teams.

Table 6: Spearman Rank Order and Kendall tau Correlation – Ungrouped Data

Pair	Kendall tau	Spearman Rho
Performance; FMC QI	0.25	0.4147
p-value	(0.1949)	(0.1102)

Source: Authors' elaboration using Python.

5 Conclusions

Empirical evidence in the literature is inconclusive with regards to the effectiveness of financial education initiatives, including simulations. Lusardi (2004) supports these initiatives, while Benartzi and Thaler (2007) remain doubtful.

To investigate the effectiveness of financial education initiatives, we analysed the CFA Society Italy Fund Management Challenge (FMC), a financial learning simulation, aimed at graduate students from 16 Italian universities.

The FMC aims to teach graduate students to apply the principles of sound investment in real-life situations, and to learn from the experience of senior financial professionals.

Student teams apply financial theory throughout the competition. The rules of the simulation are set to mitigate possible opportunistic behaviors, while requiring investment rationale for each financial decision provides a basis for feedback from external and independent financial professionals.

Although it is not possible at this stage to clearly distinguish between direct effects of the simulation (e.g. the impact of graders' feedback) and indirect effects (i.e. all actions and behaviors, including attending financial courses and reading financial news, that might increase students' financial knowledge), preliminary evidence demonstrates that the Challenge encourages participants' financial learning, and the FMC Quality Index confirms that teams are responsive to graders' suggestions. Unfortunately, not all students appear to take advantage of the benefits of the simulation. Some teams are indifferent to the feedback and penalties received. In particular, underperforming teams, which persistently remain at the bottom of the portfolio performance ranking, may experience increased frustration leading to irrational behaviors and vicious cycles. These patterns may reduce students' motivation, a key to productive learning. The FMC QI provides a tool to detect these patterns and effectively allocate resources to mentor struggling teams.

Despite encouraging preliminary results, the simulation and the FMC Quality Index are not exempt from criticism for their reliance on a small population of students, and the lack of a qualitative survey (including personal experience), along with financial factors that are directly inferable from behaviour manifested during the simulation. Future development of the FMC might include a greater number of teams in the simulation, surveys to measure initial and final levels of financial literacy, disclosure of the FMC Quality Index to participating teams throughout the competition, and rewarding teams that improve their financial knowledge by following graders' suggestions.

Within the academic debate on the effectiveness of financial education initiatives, the results of this study are consistent with Carlin and Robinson (2012), who affirm that financial literacy can be taught, but not without some noteworthy limitations. As Gentner, Lowenstein, and Thompson (2003) show, individuals have difficulties extrapolating and applying underlying principles from previous situations to new conditions; even good students can make bad financial decisions.

As confirmed by our study, the key to an effective educational simulation is timely support and mentoring to help mitigate detrimental behaviour throughout the learning process. That said, as inappropriate behaviors can reappear over time, financial literacy requires a commitment to sustained life-long learning.

Appendix

The algebraic explanation of the FMC Quality Index

$I \in \mathbb{N}^+$ is defined as the number of participating teams, $T \in \mathbb{N}^+$ as the number of rebalancing dates, $J \in \mathbb{N}^+$ as the total number of evaluation criteria in the first and the second grading dimension, $Z \in \mathbb{N}^+$ is the number of instruments in the investable universe and $[1; n]$ as:

$$[1; n] \equiv \{1, 2, ..., n-1, n\} \tag{A1}$$

$E_{\bar{t}}$, the evaluation tensor at the rebalancing date $\bar{t} \in [1; T]$, is defined as:

$$\boldsymbol{E}_{\bar{t}}: \{1, 2, ..., i, ... I\} \times \{1, 2, ..., j, ... J\} \times \{1, 2, ..., z, ... Z\} \times \{1, 2, ..., t, ... \bar{t}\} \mapsto e_{ijzt} \in \{0, 1\} \tag{A2}$$

The evaluation tensor $E_{\bar{t}}$ contains all the J ($j \in [1; J]$) evaluation criteria for the Z investable instruments ($z \in [1; Z]$) for all the I student teams ($i \in [1; I]$) for the dates $t \in [1; \bar{t}]$ (i.e. from the start of the competition to the latest rebalancing date $\bar{t}$).

In order to calculate the quality index at the rebalancing date $\bar{t}$, the evaluation tensor $E_{\bar{t}}$ is collapsed into the «bucketed evaluation matrix» $\boldsymbol{EB}_{\bar{t}}$ using a non-linear transformation $f(\cdot)$. The non-linear transformation: *a*) aggregates the evaluation for each team i into three evaluation buckets, and *b*) adjusts the evaluation for the turnover:

$$\boldsymbol{E}_{\bar{t}} \xrightarrow{f(E_{\bar{t}})} \boldsymbol{EB}_{\bar{t}} \tag{A3}$$

Where:

$$\boldsymbol{EB}_{\bar{t}}: \{1, 2, ..., i, ... I\} \times \{1, 2, 3\} \mapsto eb(\bar{t})_{ik} \in \mathbb{R} \tag{A4}$$

$eb^{\bar{t}}_{ik}$ is the k-th evaluation bucket ($k \in [1; 3]$) for team at the rebalancing date $\bar{t}$.

Each evaluation bucket is multiplied by the severity vector $\boldsymbol{sw}_{\bar{t}}$, which is a non-linear transformation $g(\cdot)$ of $\boldsymbol{EB}_{\bar{t}}$:

$$\boldsymbol{EB}_{\bar{t}} \xrightarrow{g(EB_{\bar{t}})} \boldsymbol{sw}_{\bar{t}} \tag{A5}$$

where:

(A6) $$\boldsymbol{sw}_{\bar{t}}: \{1, 2, 3\} \mapsto sw(\bar{t})_k \in \mathbb{R}^+$$

and $sw(\bar{t})_k$ is the k-th severity weight ($k \in [1; 3]$) that applies to the evaluation bucket k at the rebalancing date $\bar{t}$.

(A6.2) $$h(\boldsymbol{v}, v_{min}, v_{max})$$

is defined as a transformation of vector $\boldsymbol{v}$: $\{1, 2, ..., i, ... I\} \mapsto v_i \in \mathbb{R}$, such that $h(\max(\boldsymbol{v})) = v_{max}$, $h(\min(\boldsymbol{v})) = v_{min}$ and the other elements are proportionally rescaled between v_{min} and v_{max}.

The FMC QI vector for the participating teams at the rebalancing date $\bar{t}$ is defined as:

(A7) $$\boldsymbol{EQI}_{\bar{t}} = h(\boldsymbol{EB}_{\bar{t}} \cdot \ \boldsymbol{sw}_{\bar{t}}, 0, 100) = \begin{bmatrix} eqi_1 \\ \dots \\ eqi_i \\ \dots \\ eqi_I \end{bmatrix}$$

The ranked FMC QI ($\boldsymbol{REQI}_{\bar{t}}$) is defined as the vector that presents the elements in $\boldsymbol{EQI}_{\bar{t}}$ ranked from the highest to the lowest:

(A8) $$\boldsymbol{REQI}_{\bar{t}} = \begin{bmatrix} 100 \\ \dots \\ reqi_r \\ \dots \\ 0 \end{bmatrix}$$

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