RISK PROFILE USING PCM AND RSM

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Abstract: *In this paper we describe the investors' risk profile in order to meet the minimal requirements that Italian financial institutions must satisfy by law. The risk profile focus on three latent traits of the investor: knowledge of financial instruments, the investor's personal predisposition to risk/earn, and the investor's temporal horizon. We specifically identify a questionnaire whose items describe different characteristics of these three latent variables. In order to take into account the investor's preferences and his/her psychological attitude we propose analyzing the knowledge of financial instruments with two different sub-models of the polytomous Rasch model: the Partial Credit Model (PCM) and the Rating Scale Model (RSM). Finally, we discuss the possible uses of the proposed analysis in a financial context.*

Keywords: *MiFID, risk profile, partial credit model, rating scale model.*

1.   Introduction

The law d. lgs. 164, 2007/09/17 introduced, in Italy, the European directive 2004/39/EC on markets in financial instruments. The Markets in Financial Instruments Directive (MiFID) [1] revolutionized the rules of financial intermediation in the European Union through the introduction of four pillars considered to be essential to the limitation of information asymmetries. The first pillar is the principle of *Mutual Recognition* that allows intermediaries authorized to operate throughout the European Community. The second - *Principle of Fragmentation of Trade* - extends the area of interest of the regulation to the Multilateral Trading Facilities and Systematic Internalizers, taking an increase in the levels of transparency and efficiency pre-and post-trade. Two other important changes introduced by MiFID are stretched to offering greater protection to weak counterparties, i.e. those identified as retail customers. The *Principle of Best Execution* requires the investment firm to always seek the most favorable result

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to the client, while the *Know your Customer Rule*, by introducing the concept of appropriateness and modifying the adequacy of investment, provides useful tools in selection of best suited investments to the customer.

To meet the requirements of the MiFID [2], intermediaries are obliged to submit a questionnaire to their clients that summarize the clients' risk profile. Following the guidelines set out in the MiFID, the questions of the questionnaire relate to three different aspects of the costumer risk profile: knowledge of financial instruments, time horizon and risk preference that are considered to be three latent traits. The first latent trait is measured by a Likert scale; for this reason we submit the results of this part of the questionnaire to a polytomous Rasch analysis that considers the intrinsic psychological aspects.

In this paper we discuss the results obtained with two different sub-models of the polytomous Rasch model: the Partial Credit Model (PCM) [3] and the Rating Scale Model (RSM) [4]. The proposed analysis is alternative to the one proposed by [5], where the authors discuss a multidimensional Rasch approach to evaluate the investor's risk profile. Moreover, this preliminary study should be used by the bank to better address the investors' choices among the universe of the admissible ones, as discussed in [6].

According to a polytomous Rasch model the probability that a subject responds to an item in a category is a function of the difference between two parameters: 1) a person parameter, often called *ability* (or trait, or proficiency; examples of hypothetical traits are skills, attitudes, preferences and achievements), and 2) an item parameter, which in turn is the sum of an item location parameter (often called item *difficulty*) and a threshold parameter. By *ability* we refer to the level of knowledge. Under model expectations, for each item a person with higher ability always has a higher probability of endorsement, or success, than a person with lower ability. Likewise, a more difficult item always has a lower probability of being endorsed by respondents, regardless of individual ability.

Therefore using these different Rasch analyses of the questionnaire we are able to characterize each latent variable. Doing so, the financial institution can propose proper solutions to their clients, taking into account all the Directive's requirements.

In the next section, we describe the questionnaire and the sample used in the analysis. In section 3, we consider the main features of PCM and RSM. In section 4, we present the results obtained using these two models. In the last section, we provide concluding remarks.

2.   The questionnaire and the data

In this work we use simple modifications to adapt, for our purposes, the questionnaire proposed by UBI><Banca Group to its clients. Then we submit the questionnaire to a sample of 199 Economics and Business Administration students from the University of Bergamo. Among these 199 students, 48% are male (52% female); 60% follow a degree course, 26% post-graduate studies and 14% other specializations. With regard to personal or family experience in the fixed income and stock markets, we observe that there are generally people in the respondent's family with experience in the fixed income and stock markets, while only a few students have direct experience on the markets.

Our questionnaire consists of 33 questions: 26 items that measure different aspects of the three latent traits considered and 7 questions that characterize certain social and financial factors: gender, graduate or post-graduate studies, personal or family experiences in the fixed income market, stock market, or with other financial instruments.

The 26 items, as indicated in the questionnaire suggested by UBI><Banca, are divided into three subsections, which can represent three different dimensions described in the MiFID.

There are 15 items belonging to the dimension of knowledge, (namely I1a, I1b, …, I1q). The formulation of the items of this dimension is "Could you indicate your level of knowledge of the following financial products and instruments?" Government bonds (I1a), Deposit certificates (I1b), Stocks (I1c), Bonds (I1d), Implicit derivatives (I1e), Structural bonds (I1f), Investment funds (I1g), SICAV-ETF-ETC (I1h), Insurance policies (I1i), index-linked or unit-linked Policies (I1l), Certificates (I1m), Warrant and covered warrant (I1n), Asset management (I1o), Hedge funds (I1p), Derivatives on OTC (I1q). For each item we have considered only three possible response categories: no knowledge (score 0), some knowledge (score 1) and good knowledge (score 2).

There are 6 items directed at investor preferences in liquidity, risk and financial instruments and that consider the growth of investment in the medium-to-long term with limited or strong fluctuations and 5 items that deal with the investor's temporal horizon in order to determine what percentage of the financial assets should be allocated to investments in the very short, short, medium, long, very long term. For the items that evaluate the percentage of assets to be invested within a given temporal horizon, or with a given risk position, the possible response categories don't form a Likert scale and for this reason the items can not be studied using the Rasch analysis.

3. The Partial Credit Model and the Rating Scale Model

In this work we consider two different variations of the polytomous Rasch model: the Partial Credit Model (PCM) [3] and the Rating Scale Model (RSM) [4].

The former model in logit form (i.e. the logarithm of the ratio between the probability that the subject responds in category h and the probability that the subject responds in category $h - 1$), can be written as:

$$\ln\left(\frac{P(h|\vartheta_v,\gamma_i)}{P(h-1|\vartheta_v,\gamma_i)}\right) = \vartheta_v - \gamma_i - \tau_{ih}$$

where ϑ_v $(v = 1, 2, …, n)$ is the person parameter, γ_i is the item location parameter ($i = 1, 2, …, k$) and τ_{ih} is the h-th threshold parameter ($h = 0, 1, …, m$) of item i (for convenience $\tau_{i0} = 0$ and $\sum_{j=1}^{m}\tau_{ij} = 0$).

In the latter model the logit form is equivalent to:

$$\ln\left(\frac{P(h|\vartheta_v,\gamma_i)}{P(h-1|\vartheta_v,\gamma_i)}\right) = \vartheta_v - \gamma_i - \tau_i.$$

In the PCM the centralized thresholds are not constant for all items, while in the RSM the centralized thresholds are constant.

4. The Results

All results presented in this section were obtained using the packages "eRm", "labdsv" and "psy" installed on the R software version 2.13.2.

In this section we propose to choose the optimal configuration between PCM or RSM. The former is optimal if the thresholds are actually different for each item, while the latter may be chosen if the thresholds are the same for each question.

The items on knowledge don't highlight serious problems; this may be due to the number and clarity of items and the well defined within the questionnaire.

The item-person map and the plot of the person parameters (see Figure 1) lead to the same conclusions. The scores are in a range between -4.39 and +4.66 logit, and well distributed along the *continuum* for both subjects and items (the person separation index is equal to 0.681). The difference between the average of the item and the subject is quite high (about 0.8 logit).
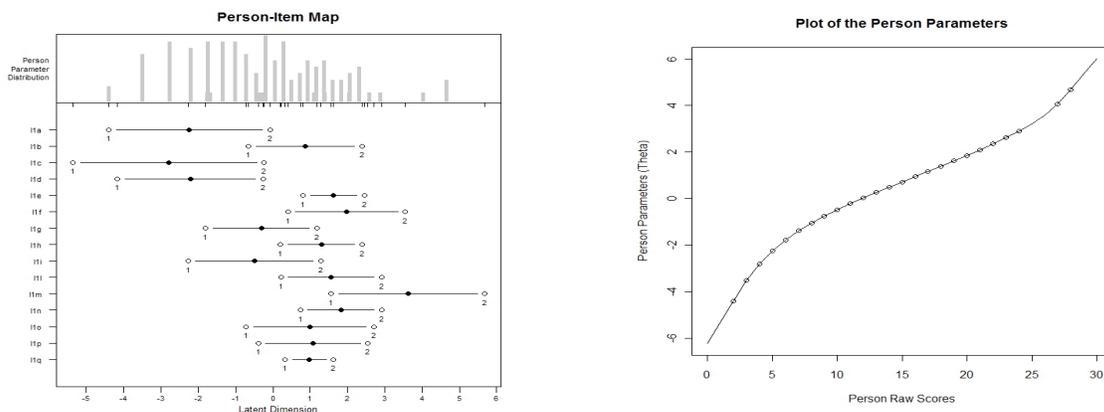

Figure 1. The person-item map and plot of the person parameters.

Therefore, the group of respondents, although it includes subjects who are able to face even the most difficult questions, has on average a low level of knowledge when compared with the average of the item difficulty. Nevertheless it seems that the scale is well representative, in fact all subjects are able to find questions within their reach, and a few items (more precisely two thresholds) have no subjects to deal with. The distribution of subjects in relation to the results leads to the same conclusions: there is, in fact, the presence of scores ranging between -4.39 and +4.66, with the absence, however, of persons situated in the range between 2.87 and 4.03.

In order to evaluate the fit of an item to the model we considered the t-outfit (standardized unweighted mean square) and t-infit (standardized weighted mean square) statistics [3]. The bad fitting of an item means that this item does not measure the same latent trait of the other ones.

The analysis of the t-outfit and t-infit statistics (see Table 1) would exclude items I1i I1p as they have extreme values together, because the optimal values for t-outfit and t-infit statistics are between -2 and 2 (at 5% level).

Table 1. Locations, Thresholds, Outfit and Infit values for items.

Item	Location	Threshold 1	Threshold 2	t-outfit	t-infit
I1a	-2.24	-4.40	-0.08	-1.95	-2.03
I1b	0.86	-0.66	2.39	0.98	0.02
I1c	-2.79	-5.36	-0.23	-1.95	-1.99
I1d	-2.22	-4.17	-0.26	-1.97	-2.00
I1e	1.63	0.81	2.45	-1.96	-2.08
I1f	1.98	0.40	3.55	-0.95	-1.41
I1g	-0.31	-1.80	1.18	-2.08	-2.02
I1h	1.30	0.21	2.39	0.33	-2.05
I1i	-0.50	-2.28	1.28	**6.61**	**8.31**
I1l	1.56	0.21	2.91	2.87	-1.43
I1m	3.62	1.56	5.68	1.23	1.77
I1n	1.83	0.73	2.92	0.03	0.92
I1o	0.99	-0.72	2.70	-0.12	0.26
I1p	1.07	-0.40	2.55	**-3.46**	**-4.16**
I1q	0.98	0.33	1.62	-1.03	-0.09

In Table 1 we can also read the locations and thresholds for each item. Therefore it can conclude that the financial instruments better known by students are stocks (I1c), bonds (I1d) and government bonds (I1a), while the most difficult are implicit derivatives (I1e), warrant and covered warrant (I1n), structural bonds (I1f) and above only one respondent claims to have a good knowledge on the certificates (I1m).

The results obtained by applying the two models – PCM and RSM – lead us to reject the rating scales model, because of the variability of the thresholds. This significantly affects the fit of data to the model. Furthermore, RSM would imply a considerable reduction in the range of scores.

5. Concluding remarks

This preliminary analysis extended to the other dimensions (personal predisposition to risk/earn and temporal horizon), can be used to rescale the three dimensions so that we can prospect different situations that characterize the investors' choices. In particular, for each investor, we can describe, in a tri-dimensional space, the percentage that should be invested in certain typical financial instruments (contingent claims, stocks, bonds, treasury bills) considering their characterization with respect to the latent traits. This first pre-selection should be further improved in a more detailed portfolio selection that satisfies personal risk tolerance and the temporal horizon according to the utility theory under uncertainty conditions as discussed in [6]. In this context the proposed analysis represents an alternative methodology of choice for the portfolio selection problem.

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