Risk profile versus portfolio selection: a case study

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Abstract This paper proposes an evaluation of the investors' risk profile in order to satisfy the minimal requirements of the law (d. lgs. 164, 2007) for the Italian financial institutions. Thus we investigate all aspects specific to the risk profile: the investor's knowledge and his/her financial experience (concerning financial instruments and their use), the financial objectives, the personal predisposition to risk /earn and the temporal horizon.
In particular, we suggest to use a Generalized Multidimensional IRT model to take into account the investors' preferences and their psychological attitudes. Therefore we assess a questionnaire whose items describe different characteristics of the main latent variables of the risk profile. As dataset we use some anonymous responses to the questionnaire of the retail category of UBI><Banca. Clearly this case study can be used in a more general context to address properly the investors' choices taking into account the individual risk profile.

Key words: Risk profile, Predisposition to risk/earn, Multidimensional IRT models

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1 Introduction

With the advent of the new technology and the possibility to invest on-line, the number of personal investments has grown in the last decade. For these reasons, many operators have launched and organized web sites where simple and intuitive operations supply investors with suggestions as to potential investment strategies. In the context of investment advice to individual investors, several financial institutions have started to use risk profiles of their clients. These risk profiles used by different banks all over the world are standard questionnaires for potential clients. By applying appropriate risk profiling the institution can help potential clients make decisions that meet the personal predisposition to risk/earn. In some countries, for example in Italy, financial institutions are obliged by law to construct risk profiles that include questions on the investors' knowledge of the financial instruments, on the investors' time horizon and on their risk preferences (see, among others, Barberis, 2000 and Veld and Veld-Merkoulova, 2008). We generally refer to these three aspects as the main characteristics of a unique latent trait that we call the predisposition to risk/earn. This information is generally analyzed to determine the most suitable strategy and the best investment options available for clients. On the other hand, in modern portfolio theory, the optimal choices are consistent with a given risk stochastic ordering that takes into account the investors' behavior and preferences (see Ortobelli *et al*., 2009).
In this paper we propose a methodology for identifying the investor's attitude to take risks on the market. The methodology is based on the analysis of a risk profile questionnaire. As required by Italian laws (d. lgs. 164, 2007), the questionnaire used presents three possible dimensions (knowledge, risk preferences, time horizon) by construction. Since the main objective of risk profiling consists in determining investors' preferences and their personal predisposition to risk/earn, we have to account for various psychological aspects. Thus, we propose to use a Generalized Multidimensional IRT model in order to identify the common relationships among the latent variables. In particular, the proposed empirical multidimensional Rasch analysis permits us to introduce a preliminary pre-selection of the optimal choices among all the possible investments proposed by the bank.
In the next section, we describe the questionnaire and the sample used in the analysis. In section 3, we deal with the analysis to a multidimensional Rasch approach and some preliminary results. We end with some conclusion.

2 The Data

To assess the risk profile in this contribution we consider the questionnaire suggested by the UBI><Banca, one of the most capitalized popular banks in Italy.
The questionnaire consists of 37 questions between items that measure different aspects of the latent trait (i.e. the risk profile) and person factors that emphasize certain social and financial characteristics of the respondent: for example, age, education level, occupation, family composition, income, personal experiences in the stock market or with other financial instruments.
The 12 items identified are divided into three macro areas, which can represent three

different dimensions:

- We have 2 items belonging to the sphere of knowledge (namely K1, K2) and concerning the personal experience with some financial instruments.
- We have 4 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 (namely R1, R2, R3 and R4). A fifth question in this area asks how the subject perceives his/her risk profile in relation to the investor behavior – from risk averse to risk-lover (R5).
- We have 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 (namely, T1,T2,…,T5).

After different trials we decided to recode all items in four categories.
The respondents to the questionnaire are 19685 belonging to the retail profile of the UBI><Banca Group.

3 The multidimensional Rasch model

The *Multidimensional Random Coefficients Multinomial Logit Model* (MRCMLM, Adams et al., 1997) is an extension of the Rasch family of IRT models. In this model, all individual-level parameters (i.e. person locations) are treated as random effects and all the other parameters (i.e. the item parameters and the hyperparameters of the random effects' distribution) are treated as fixed effects. The density of the unobserved person *v* location parameter $\boldsymbol{\theta}^{\mathrm{T}} = (\theta_1, \theta_2, \theta_3)$ is taken to be normal with mean set equal to zero for identification purposes and covariance matrix $\boldsymbol{\Sigma}$. At the item category level, the model can be written as

$$P(S_{vi} = h \mid \boldsymbol{\theta}_v, \boldsymbol{\xi}) = \frac{\exp(\mathbf{b}_{ih}^{\mathrm{T}}\boldsymbol{\theta}_v + \mathbf{a}_{ih}^{\mathrm{T}}\boldsymbol{\xi})}{\sum_{j=0}^{m_i} \exp(\mathbf{b}_{ij}^{\mathrm{T}}\boldsymbol{\theta}_v + \mathbf{a}_{ij}^{\mathrm{T}}\boldsymbol{\xi})}$$

where S_{vi} represents the response "score" of person *v* on item *i*, with values 0, 1, …, m_i; $\boldsymbol{\xi}$ is the vector of item parameters, $\mathbf{b}_{ih}^{\mathrm{T}} = (\mathrm{b}_{ih1}, \mathrm{b}_{ih2}, \mathrm{b}_{ih3})$ is a scoring weights vector of known constants; $\mathbf{a}_{ih}^{\mathrm{T}}$ is a design vector of known constants related to category *h* of item *i*. As said before, we consider the case in which the 12 items $I_1, I_2, ...I_{12}$ do not all measure the same attitude. A test is denoted as multidimensional between-items if it consists of several unidimensional subscales. In our case the test contains three subscales, and we suppose that each item belongs to one particular subscale, as follows: $\{I_1, I_2\}$ is related to the latent trait θ_1 (knowledge subscale); $\{I_3, ...I_7\}$ is related to the latent trait θ_2 (risk subscale); $\{I_8, ...I_{12}\}$ is related to the latent trait θ_3 (temporal horizon subscale). We used a Likert scoring with scores ordered in opposite directions for items 3, 7 and 8 with respect to all the other items.

In this paper the MRCML is estimated by using the program ConQuest (Wu et al., 2007). In particular, the model allows the correlations between latent variables to be estimated *directly*, avoiding the problems associated with the influence of measurement error on computing correlations by using the estimated parameters. Table 1 reports the correlations between each of the three latent traits θ_1, θ_2 and θ_3, under the multidimensional model adopted.

Table 1 - Correlations between the latent variables - Multidimensional model

θ_1	1		
θ_2	0.639	1	
θ_3	0.559	0.944	1
Var	1.956	0.555	0.528

4 Conclusion

The empirical results can be used to opportunely 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 some 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 account for the personal risk tolerance and temporal horizon according to the utility theory under uncertainty conditions. In this context the proposed analysis represents an alternative methodology of choice for the portfolio selection problem.

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