Testing the Unidimensionality of Risk Perception: An Empirical Study Using Cronbach's Alpha on Online Surveys

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Abstract. This manuscript presents a rigorous examination and reconstruction of a risk preference questionnaire, identifying opportunities for augmenting its diagnostic precision. An initial analysis underscored a significant disparity in the responses to the first and latter halves of the questionnaire. The in-depth statistical probe, employing Cronbach's Alpha - a key metric for assessing internal consistency, revealed satisfactory coherence for the first twelve questions. In contrast, the final twelve questions exhibited troubling inconsistency, indicative of respondent confusion. To remedy this, a transformational step was initiated. The responses to the latter twelve questions were recast into categorical variables, hinging on their correlation with the expected value or loss. This innovative transmutation, when measured through variance, demonstrated a noteworthy enhancement in internal consistency. The Cronbach's Alpha for these sections vaulted from a meager 0.17 and 0.18 to a robust 0.87 and 0.88, respectively, underlining the profound impact of our intervention. Nonetheless, the challenges spawned by the high stakes in the first half of the questionnaire and the reliability issues in the latter half emphasize the necessity for a behavioral orientation in risk evaluation as an alternative to self-reporting. Subsequent analysis identified the most optimal versions of the questionnaire, suggesting potential for its condensation without undermining its risk assessment efficacy. The paper advocates for further research to refine our understanding and quantification of risk propensity, underscoring the utility of variance as an analytic tool. It emphasizes the importance of broadening the participant pool and clarifying the typology of risk assessed for future inquiries. Through its comprehensive scrutiny and transformation of the risk preference questionnaire, the study elucidates the multifaceted complexities of risk preference, offering valuable insights into the merits of iterative refinement and adaptability in the formulation of research tools. Associated data, calculations and code can be found on https://github.com/a1441/AMEE_Cronbach to assist with reproducibility.

INTRODUCTION TO THE PROBLEM STATEMENT

Risk propensity, or the likelihood of an individual's willingness to take risks, is a crucial factor in both engineering and economic decision-making processes. The measurement of this propensity, however, remains challenging due to its inherent subjectivity. Among various methods, questionnaires are commonly used, based on the assumption of unidimensionality - the belief that varied items measure a single construct. This study questions this pervasive premise, utilizing Cronbach's Alpha to test unidimensionality within risk propensity online surveys. This research aims to invigorate discussion on the methodological and mathematical standards in individual risk propensity studies, contributing to a refined understanding of its theoretical foundations.

Traditionally, the measurement of risk propensity in engineering and economics has relied on questionnaires, with their unidimensional characteristics often taken for granted. However, the validity and reliability of questionnaires that presume to measure a singular construct through diverse content remain largely untested, prompting the need for rigorous verification.

Accurate assessment of individual risk propensity is pivotal in engineering and economic contexts, influencing decision-making on both individual and policy levels. Robust risk propensity assessment can shape policy formulation, inform safety interventions, tailor communication strategies, and provide vital insights into how individuals respond to potential hazards or financial crises. Thus, the importance of accurate and reliable risk measurement tools in better understanding and managing the potential impacts of individual risk propensity cannot be overstated.

To address this research gap, an empirical study was conducted to examine the unidimensionality of risk propensity within online surveys. Cronbach's Alpha, a statistical tool esteemed for its ability to assess internal consistency, was utilized in this study, offering a robust methodology to test the unidimensionality hypothesis.

The primary objective of this study is to challenge the prevailing assumptions about questionnaires' effectiveness in risk propensity studies and contribute to the evolving conversation on appropriate measurement tools in the realms of engineering and economics. Findings from this research are expected to shed light on the theoretical underpinnings of risk propensity assessment and stimulate discussion on methodological standards within these disciplines.

LITERATURE REVIEW

A relevant literature review revealed that risk-taking propensity exhibits moderate stability across the adult lifespan, with individuals maintaining a relatively stable inclination towards risk-taking behaviors. Personality traits, cognitive abilities, and life events contribute to the stability or change in risk-taking behavior (Josef et al., 2016).

Risk preference, assessed through questionnaires, is a multidimensional construct influenced by cognitive and affective processes, personality traits, demographic factors, and societal context (Mata et al., 2018). The General Risk Propensity Scale (GRiPS) has been developed and validated as a reliable and valid instrument for measuring individuals' general propensity for taking risks (Zhang et al., 2018).

The Domain-Specific Risk-Taking (Dospert) scale reveals a general risk factor underlying risk-taking tendencies across different domains, contributing to the understanding of risk-taking behavior and the measurement of risk propensity (Highhouse et al., 2016).

Risk preference shares the psychometric structure of major psychological traits, such as extraversion, neuroticism, and openness, providing insights into its multidimensional nature (Frey et al., 2017). However, the use of questionnaires for risk assessment raises methodological concerns, particularly the assumption of unidimensionality.

Risk propensity is a significant aspect of understanding decision-making behavior among individuals. This review explores the role of prospect theory and tradeoff matrices in measuring risk propensity and providing insights into individuals' risk preferences and decision-making processes.

Prospect theory, developed by Kahneman and Tversky (1979), suggests that individuals' decision-making is not always rational when faced with risky choices. Instead, subjective evaluations of probabilities and outcomes influence their behavior. For instance, individuals tend to exhibit risk aversion when dealing with gains and risk-seeking behavior when confronted with losses, which is known as "loss aversion." By incorporating prospect theory into the measurement of risk propensity, researchers can capture these tendencies and gain a deeper understanding of individuals' preferences for risk-taking.

To assess individuals' risk preferences and decision-making behavior, researchers often use tradeoff matrices in questionnaires. These matrices present participants with hypothetical choices involving risks and rewards, requiring them to select their preferred option from each pair. By systematically varying the levels of risk and reward in the presented choices, researchers can examine how individuals weigh potential gains and losses. This approach allows for a comprehensive understanding of risk propensity by considering the complex interplay between risk, reward, and decision-making processes.

It is important to note that prospect theory and tradeoff matrices represent just one approach among many for understanding risk propensity. Researchers often combine multiple theoretical frameworks and measurement tools to gain a comprehensive assessment of risk propensity in different domains and populations. Additionally, advancements in the field involve exploring and refining measurement tools, contributing to a deeper understanding of the theoretical foundations of risk propensity and its implications in various fields such as engineering and economics.

Cronbach's Alpha is a valuable tool for assessing the internal consistency of risk propensity questionnaires and challenging the prevailing assumptions about their effectiveness (Tavakol et al., 2011). Addressing this gap, this study aims to examine the unidimensionality of risk propensity within online surveys using Cronbach's Alpha, contributing to the ongoing conversation on appropriate measurement tools in engineering and economics and refining the understanding of risk propensity's theoretical foundations.

RISK QUESTINAIRE AND DISGN METHODOLOGY OF THE STUDY

Our research initiative, aimed at probing the intricate landscape of financial risk tolerance, prompted the development of a nuanced instrument - the Risk Preference Questionnaire (RPQ). This questionnaire endeavors to foster a comprehensive understanding of risk attitudes, thereby challenging the traditional binary classification of risk behavior as simply risk-averse or risk-seeking.

The RPQ, split into four unique segments, scrutinizes diverse aspects of decision-making under conditions of uncertainty. It alternates between scenarios offering guaranteed gains or losses, and those presenting a 50-50 probability of doubling the return or securing no return. The instrument meticulously integrates a broad spectrum of monetary stakes, spanning from €2 to €200,000, to evaluate their impact on decision-making dynamics.

The RPQ commences by gathering demographic information, followed by 24 instrumental questions designed to appraise the respondent's risk tolerance. These questions form the structural bedrock of the RPQ and are bifurcated into four distinct categories.

Data collection for this risk study employed an inclusive online questionnaire methodology. There were no respondent limitations based on specific criteria, and the questionnaires were broadly distributed to student and non-student participants alike, ensuring a diverse and representative sample. This strategy aimed to encapsulate a vast array of perspectives and experiences pertaining to risk. Efforts were taken to include individuals from various socio-demographic backgrounds, facilitating generalization of findings and providing more comprehensive insights into risk attitudes and behaviors within the target population.

The first two categories of questions present respondents with a choice between two immediate deals. The first deal guarantees a certain profit or loss (value X), while the second deal offers a 50% probability of either doubling the profit or yielding no gain (0 euros) or doubling the loss or incurring no loss. The range for X is €1 to €100,000 for profits and -€1 to -€100,000 for losses. Respondents are prompted to make a decision for each value of X, streamlining the data collection process without sacrificing a thorough examination of risk tolerance across different monetary stakes.

The latter two question categories propose respondents envisage a hypothetical situation requiring a choice between a certain profit or loss and a risky proposition. The questionnaire primarily assessed participants' attitudes towards monetary tradeoffs. It is critical to note, however, that no actual monetary transactions were involved. This survey functioned as a simulated environment designed to explore risk propensity rather than measure real-world financial decision-making. Clarifying that the questionnaire served as a simulation, the study aimed to capture participants' risk propensity in a controlled and experimental manner, enabling an understanding of risk attitudes independent of real-life financial concerns.

The risky proposition offers a 50% chance of either yielding a specific amount (Y euros) or no return (0 euros) in terms of profits, and a 50% chance of incurring a specific loss (Y euros) or no loss for losses. Respondents are then asked to designate the amount of certain profit or loss from the initial transaction that would cause them to reject the risky proposition. The range for Y is €2 to €200,000 for profits and -€2 to -€200,000 for losses.

The RPQ's innovative approach allows for a more profound exploration of risk behavior compared to the traditional binary categorization. We anticipate that through the RPQ's diverse scenarios and variable (but fictional) financial stakes, we can uncover intricate individual risk preferences, thereby aiding in the development of more precise financial strategies and policies. The ultimate goal is to deepen our understanding of risk tolerance, going beyond the traditional practice of merely labelling individuals as risk-averse or risk-seeking.

This methodology aligns with the key tenets of prospect theory, enhancing our understanding of individual risk propensity. Proposed by Kahneman and Tversky, it suggests an asymmetrical perception of potential losses and gains. It postulates a general propensity for loss aversion, where people are more sensitive to losses than equivalent gains. This asymmetry directly influences decision-making under uncertainty, prompting diverse reactions to prospects framed as potential losses versus equivalent gains.

The RPQ utilizes this asymmetry in its design. By dedicating separate sections to potential profits and losses, it provides a framework to understand differing responses to the same financial stakes, depending on whether they are framed as potential gains or losses. This enables the capture of the individual's risk trade-off point, informing our understanding of the level of financial risk an individual is willing to tolerate for a specific potential return, thereby revealing their risk propensity.

Aligning the questionnaire's design with prospect theory's principles positions us to unearth a nuanced understanding of individual risk preferences. This allows us to probe deeper into their risk tolerance, which may vary based on whether they are considering potential gains or losses. Thus, the RPQ, enriched by the insights of prospect

theory, presents a sophisticated tool for understanding and predicting individual financial decision-making under uncertainty.

In our analysis, we aim to calculate Cronbach's alpha for each group of six questions to ascertain the internal consistency within these subsets. This ensures that we are measuring the same dimension of risk propensity consistently within each section of the questionnaire.

The equation we employ is:

$$\alpha = \left(K/(K-1)\right) * \left(1 - \left(\sum (i = 1 to K)\sigma_i^2\right)/\sigma_T^2\right)$$

Source: Cronbach, L. J., 1951

Where:

- K represents the number of items (in this case, six for each subset)
- σ_i^2 is the variance of each individual item (each question within a subset)
- σ_T^2 is the variance of the observed total scores for that subset.

Upon the completion of this initial stage, we will compute Cronbach's alpha values pairwise between each group of questions. By undertaking this, we aim to assess whether different subsets of the questionnaire are congruent in the dimension of risk propensity that they measure. This will facilitate our understanding of whether different sections, despite having different contexts or phrasing, are still engaging with the same construct of risk propensity.

Finally, we will compute Cronbach's alpha for the entire set of 24 questions. This will provide an overall indication of the internal consistency across the questionnaire, essential for confirming that we are consistently measuring the same underlying construct (risk propensity) throughout.

A high alpha value, typically above 0.7 (Nunnally & Bernstein, 1994), would suggest that the questions within and across subsets, as well as the questionnaire itself, are consistently measuring the dimension of risk. Conversely, a low alpha value might indicate that certain questions are not consistently capturing risk propensity, prompting us to reconsider their inclusion. The comprehensive, multi-step implementation of Cronbach's alpha will assist in refining our questionnaire to ensure its reliability in measuring an individual's risk propensity.

The proposed comprehensive statistical framework, anchored in Cronbach's alpha analysis, promises to reveal subtle and internally consistent dimensions of risk propensity. By segmenting the analysis at both subset and overarching levels, we can mathematically affirm the coherence of the risk dimensions our questionnaire seeks to measure.

Employing Cronbach's alpha, a widely recognized reliability statistic, seeks to ensure a high level of internal consistency and robustness of our questionnaire. Notably, the alpha coefficient provides a robust estimate of the lower bound of true reliability, effectively offering a conservative measure of our questionnaire's internal consistency.

An alpha coefficient above 0.7 will indicate that the itemized questions are collectively engaging with a unified construct both within and across the questionnaire's different sections. Conversely, a lower alpha value would necessitate the reconsideration of certain items, a process that is inherently iterative and crucial in refining our questionnaire to a level of statistical robustness.

This systematic approach aids in upholding the integrity of the overall research design and is instrumental in ensuring that our findings reflect a true measure of risk propensity, rather than incidental statistical noise. By doing so, our methodology holds the potential to deliver valuable insights into the realm of individual risk-taking behavior.

EXPLORING THE LIMITATIONS OF DICHOTOMOUS SCENARIOS IN UNDERSTANDING RISK INCLINATION

Characterizing an individual's risk propensity is a complex task that requires a multidimensional perspective beyond traditional simplifications. Dichotomous risk scenarios, which offer a simplistic, linear view, may be convenient to administer and interpret but have fundamental limitations in understanding the intricate nature of financial risk propensity.

Dichotomous queries, with their binary structure, strike a balance between ease-of-use and depth of insight. By providing respondents with a choice between safe and risky options, these questions offer a straightforward measure of risk tolerance, providing a basic understanding of an individual's overall risk orientation.

However, when dichotomous questions are used in isolation, they reveal several shortcomings. Their main constraint lies in their tendency to overlook the inherent diversity in risk preferences. By assuming a homogeneity in risk behavior, dichotomous scenarios neglect the multitude of factors that influence risk, such as outcome magnitude, probability, and decision context. By limiting respondents to predefined options, we may unintentionally suppress the revelation of personalized risk thresholds, resulting in a potentially distorted and diluted assessment of risk propensity.

To overcome these limitations and enhance our understanding of risk propensity, an integrative methodology that incorporates a trade-off matrix within the dichotomous framework is recommended (Jaccard & Becker, 2002). Departing from the binary format, the matrix approach allows respondents to specify their precise, individualized thresholds that would shift their preference from a certain outcome to a riskier proposition, or vice versa.

This inclusion of a dimension adds granularity to our assessment of risk propensity. By enabling respondents to define their unique risk thresholds, we accommodate a broader range of risk behaviors, facilitating a more detailed and individualized profile of risk preferences.

From a variance analysis perspective, this methodological enhancement adds depth and sensitivity to our dataset. The data derived from the trade-off matrix enriches our ability to differentiate subtle variations in risk propensity across the respondent pool. Furthermore, this approach enables complex statistical explorations, enabling analysis of how risk propensity varies in response to different potential gains or losses. Therefore, while dichotomous risk scenarios serve as a useful initial assessment tool, they may not fully capture the complexity and diversity of individuals' risk propensities when used alone.

Open-ended Questions as a Medium to Unveil Personalized Risk Thresholds.

The Risk Preference Questionnaire (RPQ) is a finely nuanced tool that aims to dig deep into the various facets of financial risk tolerance. Comprising four unique sections, it paints a comprehensive picture of a person's attitude towards risk.

The first and second sections (questions 1-12) feature binary options involving certain profits or losses and their respective risky alternatives. The participants are asked to choose between a sure outcome and a gamble that could either double their return or result in nothing.

In contrast, the third and fourth sections (questions 13-24) operate in a more flexible, open-ended format. The respondents are asked to indicate a guaranteed amount that would make them reject a risky proposition, which offers a chance at a specific profit or no profit, and a specific loss or no loss.

By incorporating a wide range of potential financial outcomes, from €2 to €200,000 or -€2 to -€200,000, the RPQ can capture subtle variations in risk behavior across different financial stakes. These open-ended questions empower respondents to express their risk tolerance more specifically, offering an enriched view of their risk preferences.

The responses can be used to calculate an average risk propensity measure, scaled from 0 (maximum risk aversion) to 1 (maximum risk-seeking behavior). This measure represents an individual's average risk tolerance across different financial scenarios, providing a comprehensive and personalized insight into their risk preference. By measuring risk tolerance in this intricate and dynamic manner, the RPQ transcends traditional binary categorizations of risk behavior.

The formula for this calculation is as follows:

$$\text{risk-result} = \frac{6 + \frac{Q13 + Q19}{2} + \frac{Q14 + Q20}{2} + \cdots + \frac{Q18 + Q24}{2}}{12}$$

Source: Own

This sophisticated measurement approach is fundamentally unachievable with binary questions. The binary format, by its nature, restricts responses to two predefined options, curtailing the possibility of capturing personalized risk thresholds. Consequently, the richness of insight offered by the open-ended format, the intricate understanding of individualized risk-tradeoffs and the consequent capacity to calculate a scaled, average risk propensity – remains inaccessible through binary queries alone.

The inherent flexibility of the open-ended format, thus, proves indispensable in capturing a nuanced, holistic understanding of financial risk propensity. By giving respondents the liberty to express their personalized risk

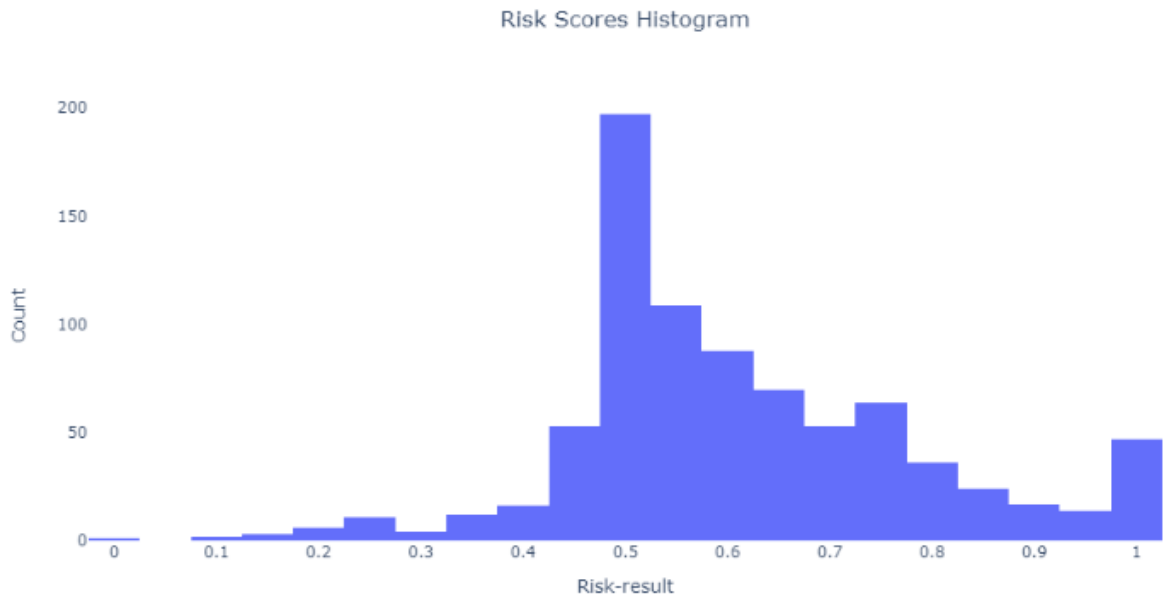
thresholds, we are afforded a deeper, more precise insight into individual risk behavior – an understanding that is crucial in developing robust, personalized financial strategies and policies.

Examining the Intricacies of Individual Risk Tolerance

The observed skewness of risk responses between 0.5 and 1 (Fig.1) might signal the need for a more rigorous method of testing the internal consistency of the questionnaire, such as Cronbach's alpha. It's possible that the specific phrasing or framing of the questions, the choice of the stakes, or selection bias, as mentioned above, could be affecting the responses in a consistent manner that is not reflective of genuine risk preferences. This disparity raises questions about the internal consistency of the questionnaire used to assess risk and suggests the possibility of factors that may be influencing participants' responses. In this paragraph, we delve into the implications of this skewness and explore the need for a more rigorous evaluation method to ensure the questionnaire's validity. By scrutinizing potential sources of bias or inconsistency, we can gain valuable insights into the true nature of risk perception and enhance our understanding of human decision-making processes.

For instance, respondents might be consistently selecting riskier options due to the way potential gains are presented, or due to an overrepresentation of individuals with high ambiguity tolerance in the sample population.

FIGURE 1. Risk-result Individual Propensity Distribution



Source: Own

By applying Cronbach's alpha, we can better understand the extent to which these factors might be contributing to a consistent deviation in responses. This metric will reveal the internal consistency of the responses to our questionnaire, providing insights into whether the questions are all reliably measuring the same construct - in this case, risk propensity.

If we observe a high Cronbach's alpha value, it would indicate a strong internal consistency, which could suggest that the skewness in results is not due to inconsistencies in the questionnaire but potentially a characteristic of the sample population or an inherent attribute of the risk scenarios presented.

Conversely, a low Cronbach's alpha might suggest that the questions are not consistently measuring risk propensity, pointing to the possibility that the skewness is due to some issues with the questionnaire itself. This could signify a need for refinement or reconsideration of certain questions.

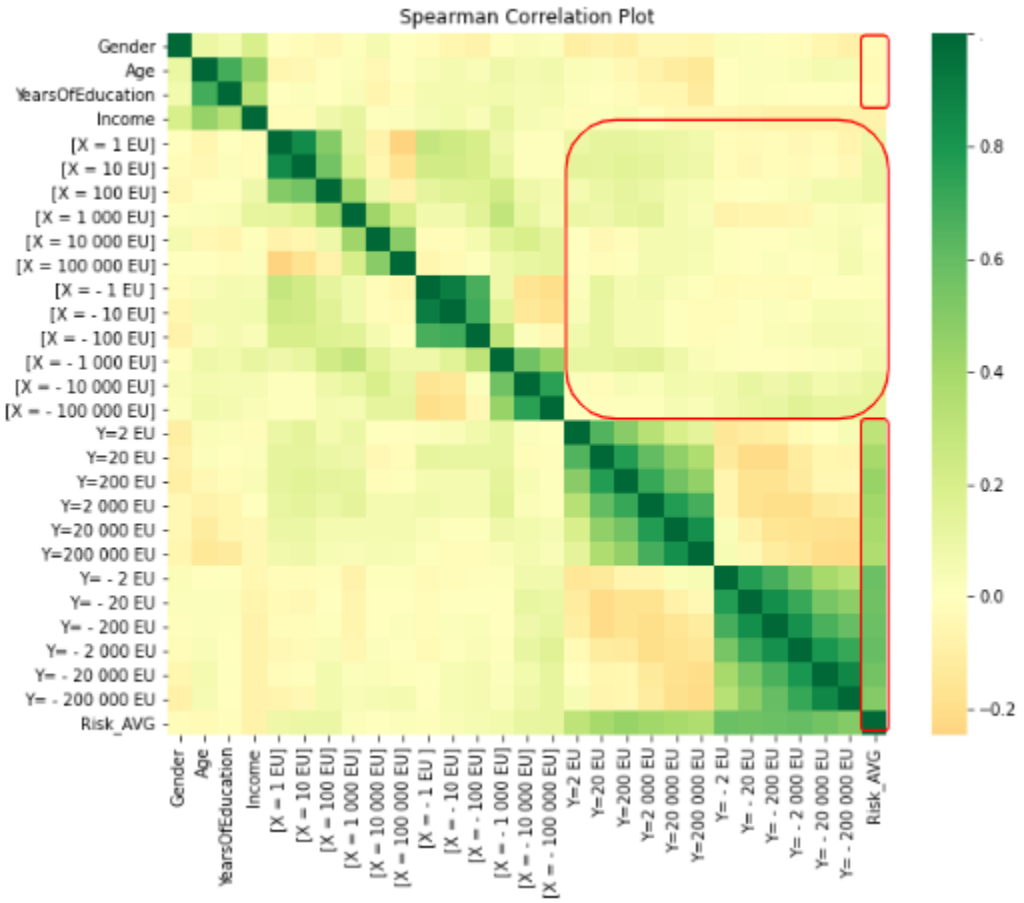
Thus, the application of Cronbach's alpha in this context serves as an imperative statistical tool to diagnose potential inconsistencies and systematically refine our questionnaire. Its utility extends beyond just the assessment of internal reliability, paving the way for a more nuanced understanding of the observed skewness in risk responses. By meticulously unravelling these complexities, we could ultimately enhance the robustness and reliability of our risk propensity assessment.

To reinforce the credibility of our questionnaire and ensure that it is accurately capturing the desired dimensions of risk propensity, it is paramount to administer a series of statistical tests to the obtained data. The results from these statistical tests will not only ascertain the reliability of our questionnaire but will also reveal any possible shortcomings.

The first among these statistical tests is Spearman's correlation (Spearman, 1904). It is a non-parametric measure of rank correlation that examines the strength and direction of the association between two ranked variables. What makes Spearman's correlation particularly well-suited to our analysis is its robustness and resistance to outliers.

Spearman's correlation does not operate under the assumption of a linear relationship between variables. Therefore, it is an apt choice for analyzing our questionnaire data, which may not adhere to a linear pattern. Furthermore, by being less sensitive to outliers, it guarantees that a handful of extreme responses do not skew the analysis disproportionately (Myers & Sirois, 2006).

FIGURE 2. Spearman Correlation of RPQ Data



Source: Own

The application of Spearman's correlation to our study disclosed several intriguing results that offer valuable insights into the limitations of the questionnaire. Notably, the correlation coefficients between the risk metric and

demographic data were insignificant, contradicting the typical expectations posited by the literature. For instance, we anticipated an inverse correlation between risk tolerance and age, a positive correlation with education and income levels, and a higher risk propensity among males. However, these predicted correlations were absent in our study.

The first half of the questionnaire, comprising the initial 12 questions, did not exhibit any significant correlation with the risk metric (Fig.1). This observation indicates a potential drawback of these questions; they might not be effectively capturing aspects of risk preference, or they could be tapping into other dimensions not encompassed by our risk metric.

These findings underscore the necessity for potential refinements in our questionnaire. They also pave the way for further research into the multifaceted nature of risk preference, propelling us to delve deeper into this intricate terrain.

Upon encountering the absence of significant correlation between the initial 12 questions of the questionnaire and our risk metric, we turned to the reliable statistical tool known as Cronbach's Alpha. This measure enables the assessment of internal consistency, a critical aspect of reliability within our questionnaire.

Employing Cronbach's Alpha in our analysis serves multiple key purposes. First, it affords a reliability check, allowing us to evaluate whether the first half of the questionnaire effectively gauges the underlying construct – in this case, risk preference. Secondly, it offers a diagnostic tool for identifying item redundancy. Specifically, if the alpha value noticeably escalates upon the removal of a question, it could signify that the question is either redundant or not contributing valuable information. Lastly, Cronbach's Alpha plays a role in questionnaire refinement, guiding us in the rewording, replacement, or elimination of certain questions. The application of this method bolsters the integrity and efficacy of our questionnaire, ensuring it accurately encapsulates the complex nature of risk preference.

Cronbach's alpha provides an estimate of the proportion of the total score variance attributable to the true score variance, relative to the total score variance. Higher alpha values denote a greater proportion of reliable variance in the measure, thus suggesting heightened internal consistency. By implementing Cronbach's Alpha, we aim to continually refine our questionnaire and effectively capture the multifaceted nature of risk propensity.

CONSISTENCY ANALYSIS & DECISION PATTERNS

The first subset of questions, Q1-Q6, was primarily designed to evaluate participants' risk preferences when faced with the potential for profit. Upon applying Cronbach's Alpha to this set of questions, we obtained an alpha value of 0.62, which is slightly below the generally accepted threshold of 0.7 for satisfactory internal consistency. This initial result hinted at potential inconsistencies in responses within this subset, prompting a further investigation into the impact of each individual question.

When each question was systematically removed, we found that the exclusion of Q6, the scenario involving the high stakes amount of 100,000 EUR, led to the highest Cronbach's Alpha value of 0.658. Although this value still falls short of the accepted threshold, the increase in alpha highlights an interesting phenomenon: as the amount at stake increases to an exceedingly high value, the consistency of respondents' risk decisions appears to falter.

TABLE 1. Internal Consistency of Q1-Q6

Question	Cronbach's Alpha	Lower CI	Upper Ci
Value after removing Q1 - 1 EUR	0.583	0.537	0.627
Value after removing Q2 - 10 EUR	0.560	0.511	0.606
Value after removing Q3 - 100 EUR	0.520	0.466	0.570
Value after removing Q4 - 1000 EUR	0.515	0.461	0.566
Value after removing Q5 – 10 000 EUR	0.598	0.553	0.640
Value after removing Q6 – 100 000 EUR	**0.658**	0.620	0.694

Source: Own

The finding suggests that respondents may not respond as consistently when faced with the prospect of risking such a large sum. This observation was further reinforced by the Sankey diagram displaying the choice breakdowns

across the varying amounts. As the stakes were raised beyond 10,000 EUR, a clear trend emerged - respondents increasingly opted for less risky decisions.

These findings highlight the nuances of risk propensity under high-stake scenarios and emphasize the need for careful interpretation of responses in such contexts. They also signal potential areas for refinement in the structure of the questionnaire to better capture these nuances. Future iterations may need to reconsider the inclusion of exceedingly high-stake scenarios or devise ways to enhance the reliability of responses in such instances.

The second subset of our questionnaire, questions Q7-Q12, shifts the context from potential gains to losses. It presents respondents with the option to either accept a certain loss or risk a proposition that could either double their loss or eliminate it. The possible losses ranged from -1 EUR to -100,000 EUR.

Applying Cronbach's Alpha to this question set revealed an alpha value of 0.67, once again slightly below the general benchmark of 0.7. This suggested potential inconsistency within the responses to these questions and warranted an investigation into the potential impact of individual questions on overall reliability.

Consistent with our findings in the first subset (Table 1), we found that removing Q12 - the high-loss scenario of -100,000 EUR - resulted in the highest alpha value of 0.678, a minor increase but still below the acceptable threshold. This increase in Cronbach's Alpha when Q12 was removed indicates that respondents' consistency in their risk decisions declines as they confront the prospect of large potential losses.

TABLE 2. Internal Consistency of Q7-Q12

Question	Cronbach's Alpha	Lower CI	Upper Ci
Value after removing Q7 - 1 EUR	0.638	0.598	0.676
Value after removing Q8 - 10 EUR	0.622	0.580	0.662
Value after removing Q9 - 100 EUR	0.591	0.545	0.634
Value after removing Q10 - 1000 EUR	0.584	0.538	0.628
Value after removing Q11 – 10 000 EUR	0.648	0.609	0.685
Value after removing Q12 – 100 000 EUR	**0.678**	0.642	0.712

Source: Own

A notable trend becomes evident as potential losses reached -1000 EUR, where respondents begin to increasingly avoid riskier decisions. This pattern points to heightened risk aversion under high-stake loss scenarios.

These findings underscore the complexity of risk behavior under potential loss conditions and the necessity of cautious interpretation in these contexts. They also suggest potential areas for improvement in the questionnaire's design to better capture these complexities. Considerations for future questionnaire iterations could include the reassessment of extremely high loss scenarios or the development of mechanisms to improve reliability of responses in these cases.

The latter subsets of RPQ, Q13-Q18 and Q19-Q24, invite respondents to determine a guaranteed profit or loss amount that would prompt them to refuse a risky proposition offering a chance at a specific profit or no profit, and a specific loss or no loss, respectively. The conceivable amount in these scenarios ranges from 2 EUR to 200,000 EUR for profit, and from -2 EUR to -200,000 EUR for loss.

Upon the application of Cronbach's Alpha, we were confronted with a paradoxical situation. The alpha value for Q13-Q18 stood at 0.17, while for Q19-Q24, it was 0.18, both alarmingly lower than the generally accepted benchmark of 0.7. These results indicate poor internal consistency, implying a significant dispersion in the respondents' answers.

Such dispersion and subsequent low Cronbach's Alpha values prompt an inquiry into possible issues in the latter half of the questionnaire. A few plausible explanations might include:

- Question Complexity: The questions might be too complex or confusing for respondents, thereby leading to inconsistent responses.

- Respondent Fatigue: By the time respondents reach the latter half of the questionnaire, they might experience fatigue, affecting their ability to answer consistently.
- High-Stake Scenarios: The high monetary values involved might be leading respondents to exhibit inconsistent risk preferences.
- Other Factors: There may be other underlying psychological, cognitive, or contextual factors influencing respondents' answers.

This necessitates a comprehensive examination of the questionnaire design, question formulation, respondent understanding, and the overall process of data collection. Improving these elements can aid in enhancing the reliability of our risk propensity metric, ensuring it more accurately captures the intricacies of risk behavior.

BOOSTING QUESTIONNAIRE RELIABILITY THROUGH STRATEGIC RESPONSE TRANSFORMATION AND REEVALUATION

Confronted with sub-optimal reliability in the latter half of our questionnaire, we ventured into strategic rectifications that yielded promising results. The responses for questions 13-24 were reorganized into categories based on their relation to the expected value or loss, facilitating a more accessible interpretation of respondent's risk positions.

For questions QT13-QT18 (T stands for 'transformed'), we denoted responses exceeding, matching, or falling short of the expected value as 'premium,' 'neutral,' and 'discount,' respectively. This approach was similarly applied to questions 19-24, with responses reflecting less than, equal to, or greater than the expected loss categorized as 'premium,' 'neutral,' and 'discount.'

TABLE 3. Internal Consistency of QT13-QT18

Question	Cronbach's Alpha	Lower CI	Upper Ci
Value after removing QT13 - 2 EUR	**0.887**	0.874	0.899
Value after removing QT14 - 20 EUR	0.840	0.823	0.857
Value after removing QT15 - 200 EUR	0.829	0.810	0.847
Value after removing QT16 - 2000 EUR	0.818	0.780	0.837
Value after removing QT17 – 20 000 EUR	0.832	0.813	0.849
Value after removing QT18 – 200 000 EUR	0.859	0.844	0.874

TABLE 4. Internal Consistency of QT19-QT24

Question	Cronbach's Alpha	Lower CI	Upper Ci
Value after removing QT19 - 2 EUR	**0.897**	0.886	0.908
Value after removing QT20 - 20 EUR	0.872	0.858	0.886
Value after removing QT21 - 200 EUR	0.829	0.841	0.872
Value after removing QT22 - 2000 EUR	0.860	0.845	0.875
Value after removing QT23 – 20 000 EUR	0.876	0.862	0.889
Value after removing QT24 – 200 000 EUR	0.887	0.875	0.889

Source: Own

After these modifications, a reassessment of the questionnaire using Cronbach's Alpha demonstrated a remarkable improvement in internal consistency. For questions 13-18, the Alpha score improved from a mere 0.17 to an impressive 0.87, and further increased to 0.887 when the first question was removed. Questions 19-24 experienced a similar trend, with the Alpha score leaping from 0.18 to a robust 0.88, and further to 0.897 upon omitting the first question.

In the transformed questions 13-24, it was low monetary values that seemed to be obscuring the respondents' true risk profile. Despite a marked improvement in overall consistency following the recategorization, we observed that respondents' risk perceptions were not adequately captured when dealing with smaller sums.

This suggests a potential cognitive bias where respondents perceive the stakes as being too low to fully reflect their risk aversion or risk-seeking tendencies. It may also be indicative of the potential insensitivity to lower monetary values, leading to responses that may not be entirely representative of the individuals' inherent risk preferences.

The contrast in respondent behavior when faced with high and low sums accentuates the complex interplay between risk and monetary values. These findings underscore the necessity of accounting for such behavioral nuances when designing questions to assess risk preference, and further substantiate our commitment to refine our questionnaire to ensure its effectiveness and reliability.

To further verify the efficacy of these adjustments, we combined the reworked latter half with the initial 12 questions and reassessed the consistency.

The Cronbach's Alpha for the reworked set, comprising the initial 12 questions and the recategorized last 12, clocked in at approximately 0.734. Surpassing the acceptable threshold of 0.7, this result underscores the reliability of our questionnaire in measuring the underlying construct — risk preference.

These findings and the improved internal consistency bear testimony to the efficacy of our transformed questionnaire as an instrument for gauging risk preference. The conversion of responses into categorical variables has not only streamlined the interpretation process, enhancing the clarity of data, but has also facilitated a more insightful understanding of how respondents perceive and manage risk.

EVALUATING QUESTIONNAIRE CONSISNTENCY AROUND OPTIMAL INTERNAL CONSISTENCY

Our study also sheds light on the intriguing fact that certain combinations of questions exhibited higher degrees of internal consistency, as quantified by Cronbach's Alpha. This outcome is reflective of our commitment to refine and enhance the questionnaire for a more accurate depiction of risk preference.

Our investigation identified the combination of transformed questions QT13-QT24 as the most consistent subset, with a robust Cronbach's Alpha value of 0.74. This superior level of internal consistency suggests a high degree of interrelatedness among these questions, hinting at their collective efficacy in capturing a common underlying construct — risk preference.

The comprehensive questionnaire, embracing all the questions, posted a Cronbach's Alpha of 0.733, mirroring the consistency achieved by the former combination. This demonstrates that the questionnaire, despite the diverse range of questions it encompasses, maintains good internal consistency.

Fascinatingly, the combination of questions Q1-Q6 and QT13-QT24 yielded a sturdy Cronbach's Alpha of 0.722, highlighting the strength of internal consistency within this grouping. Similarly, the combination of Q7-Q12 and QT13-QT24 registered a Cronbach's Alpha of 0.729, underlining the commendable internal consistency of this subset.

These findings present valuable insights into our investigation:

- Potential for Questionnaire Refinement: The results suggest that our questionnaire could potentially be shortened without hampering its capacity to effectively gauge risk preference. Such strategic reduction would streamline the process for respondents while maintaining the integrity of data.
- Signaling Risk Preference: Our data indicates a stronger signal for risk aversion than risk-seeking behavior among respondents. This trend presents a valuable hint for refining future questionnaire design and interpreting the collected data.
- The discerned insights are set to be pivotal in informing our continual refinement of the questionnaire design and enhancing our understanding of risk preference. This ongoing commitment to improvement is essential to ensure that our instrument remains a reliable tool in the multifaceted study of risk propensity.

Understanding Behavioral Risk Preference Beyond Self-Reporting

A striking revelation from our study points to a significant discrepancy between respondents' self-reported risk preference and their behavior as reflected in their responses. A clear misalignment was observed between the thresholds of risk as indicated by the respondents and their actual choices made in the questionnaire. This presents a key challenge in risk assessment, underscoring the limitations of relying solely on self-reporting methodologies to quantify risk preference.

Our findings echo the broader literature in the field of behavioral economics, which suggests that individuals often struggle to accurately articulate their own risk tolerance, largely due to the complex, multifaceted nature of risk preference. This complexity is compounded by the fact that risk preference is not static — it can fluctuate based on a multitude of factors, ranging from the individual's current emotional state to their past experiences and perceptions of future uncertainties. (Loewenstein, Weber, Hsee, & Welch, 2001)

The discrepancies we observed highlight the need for a paradigm shift in how we approach risk assessment. The significant improvements in Cronbach's Alpha, following our strategic reformulation of questions, illustrate the value of moving beyond traditional self-reporting techniques. It's clear that direct self-reported measures of risk preference may not adequately capture the nuance and fluidity inherent in this concept.

Moving forward, our work will focus on developing methods that assess risk preference based on observed behavior. By harnessing the insights gained from the study, we aim to refine our understanding of risk preference, crafting questionnaires that can better capture this elusive construct. The goal is to reach a more nuanced, accurate portrayal of risk preference, one that integrates both self-reported perspectives and behavioral observations to provide a more comprehensive and reliable assessment.

DISCUSSION AND CONCLUSIONS

In the endeavor to delve into the labyrinthine domain of risk preference, this study embarked on an in-depth analysis of our initial questionnaire. While our current risk metric unveiled some intriguing insights, it emerged that it required further refinement to yield optimal results.

One of the major advancements in our study was the transformation of responses into categorical variables, a strategy that markedly improved the internal consistency of our questionnaire. However, as we enhanced the reliability of the RPQ tool, we encountered a perplexing paradox — the underlying concept of risk being measured by these transformed questions remained elusive. This realization underscores the complexity of the concept of risk and calls for a more nuanced approach to its measurement.

Our study has taken significant strides towards refining our questionnaire and enhancing its reliability, yet the quest to robustly and reliably define and quantify risk propensity is far from over. Risk preference remains a multifaceted construct — its measurement and understanding necessitate ongoing research and development of innovative methodologies.

The demographic composition of our study — predominantly composed of students with low income — was another significant consideration. While insightful in its own right, the limitation of our participant pool may have contributed to skewed results. As established by the existing literature, risk preference is influenced by a host of factors, including income level (Dohmen et al., 2011). Therefore, our approach to sampling respondents might limit the generalizability of our findings. As we move forward, diversifying our participant pool even more extensively will be a priority. Future studies should strive to replicate this research with a broader range of representative groups. Such a comprehensive approach can offer a more accurate panorama of risk preference across different demographics, thereby enhancing the generalizability of our findings.

Another crucial aspect of our future endeavor is the clarification of the concept of risk. As we refine our questionnaire, we need to clearly define the type of risk we aim to assess. This will entail a rephrasing and refinement of the latter half of the questionnaire, aligning it more closely with our evolving conceptual understanding of risk. To ensure this, a rigorous process of pilot testing of questionnaire revisions will be undertaken, coupled with consultation from subject-matter experts.

The journey to understand risk preference is complex and challenging, filled with iterative refinements and new learnings. However, with each step forward, we glean fresh insights, enhancing our understanding of this elusive concept. As we continue to refine our methodologies and broaden our participant pool, we inch closer to a more accurate, reliable measurement of risk preference — one that promises to offer significant insights in a world replete with uncertainty and risk.

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