Development and Validation of Unidimensional Psychological Scales: A Scalogram Analysis Approach

Qudsiya Jamal Khader Basha[1,*], Murugan P. P[2] and Mahandrakumar K[3]
[1]*Freelance Researcher & Educator, Extension Education, Texas, U.S.A.*
[2]*Extension Education, TNAU, Coimbatore, India*
[3]*Department of Agrl. Extension and Rural Sociology, AC & RI, Kudimiyanmalai, India*

Keywords: Guttmann Scale, Scalogram Technique, Psychological Scale, Coefficient of Scalability, Coefficient of Reproducibility, Test-Retest Reliability, Concurrent Validity, Extension Research.

Abstract: This research article presents a comprehensive methodology for developing and validating unidimensional psychological scales using the Scalogram technique, with a particular focus on the Guttmann Scale. The study operationalizes key constructs such as Economic Motivation, Scientific Orientation, and Risk Orientation, offering a nuanced understanding of farmers' attitudes toward adopting new ideas and technologies in agriculture. The procedure involves meticulously identifying and scrutinizing items through literature analysis and expert consultation. The article details the step-by-step process of Scalogram analysis, encompassing the calculation of the Coefficient of Reproducibility (CR) to assess unidimensionality and the Coefficient of Scalability (CS) to evaluate scalability. The study emphasizes the importance of achieving a CR of 0.90 or higher and a CS of 0.60 or higher for a scale to be considered acceptable. The analysis results, including error minimization and deviation from perfect reproducibility, contribute to the refinement of the scales. Reliability and validity of the developed scales are established through the Test-Retest method for reliability and concurrent validity through correlation with existing psychological variables. The final scales are standardized using established scoring procedures. The article concludes with insights into the administration and scoring of the finalized scales, providing a comprehensive guide for researchers and practitioners interested in robust psychological scale development. This research contributes to the Extension research field by offering a systematic and statistically sound approach to understanding and measuring complex psychological constructs within the context of agricultural decision-making.

1 INTRODUCTION

The development of psychological scales is a crucial endeavor in understanding and quantifying complex human attitudes and behaviors. One method that has gained prominence in this process is the Guttman Scale, pioneered by Louis Guttman.

It is a cumulative unidimensional scale, "A unidimensional scale is characterized by a pattern where endorsing the item representing the extreme position leads to endorsing all items that are less extreme as well."

This technique developed by Louis Guttman commonly known as Scalogram analysis involves presenting a series of statements to which a respondent indicates their level of agreement or disagreement. (Ray and Mondal, 2011), allowing for the orderly arrangement of items along a continuum.

This approach offers a systematic and rigorous methodology for creating unidimensional psychological scales, ensuring that responses align with a distinct pattern.

2 METHODOLOGY

The brief procedure for development of the scales using Guttmann's scalogram analysis is detailed as follows.

This study operationalizes and measures key psychological constructs. "A scale serves as a tool for measuring a particular attribute or dimension. Scaling

*Corresponding author

Basha, Q. J. K., P. P, M. and K, M.
Development and Validation of Unidimensional Psychological Scales: A Scalogram Analysis Approach.
DOI: 10.5220/0012882600004519

In *Proceedings of the 1st International Conference on Emerging Innovations for Sustainable Agriculture (ICEISA 2024)*, pages 103-109
ISBN: 978-989-758-714-6

techniques are employed to arrange a series of items in a sequential order along an orderly defined continuum." (Ray and Mondal, 2011).

Table 1: Initial scales developed for testing and validation.

Sl. No	Statements	Yes	No
I	**Economic Motivation**		
You do agriculture			
1.	To become rich and have a luxurious lifestyle		
2.	To have a decent living		
3.	To sustain my livelihood		
4.	Since I have nothing to do other than agriculture		
5.	Since I have known nothing other than agriculture		
6.	Since others are doing		
II	**Scientific Orientation**		
What farming method you would prefer/wish to do			
1.	Remote/ mobile based farming method		
2.	Automated farming method		
3.	Motorized farming method (tractors, fuel/ power operated machineries)		
4.	Manual faming (tools and implements)		
III	**Risk orientation**		
If you were provided with credit assistance from bank which farming, you would prefer			
1.	Export business-oriented farming		
2.	Value addition and food processing		
3.	Organic farming and marketing of organic certified products		
4.	Seed production-oriented farming		
5.	Conventional crop production		

Items to measure the economic motivation, scientific orientation, and risk orientation of farmers were identified through thorough literature analysis. Furthermore, expert discussions with extension specialists from the Department of Agricultural Extension and Rural Sociology of TNAU and Madurai were conducted for scrutiny. Thus, through literature analysis and expert consultation, items are carefully identified and scrutinized to capture the nuances of the targeted constructs.

2.1 Economic Motivation

It is operationalized in terms of an individual's prioritization of economic goals and the willingness for profit maximization.

2.2 Scientific Orientation

It is operationalized as the extent to which a farmer is inclined toward utilizing scientific methods in agricultural and allied practices.

2.3 Risk Orientation

Risk orientation pertains to the extent to which individuals are inclined towards taking up risk and uncertainty with the courage to handle existential challenges. The goal was to establish an ordinal value for each scale using the selected items and to use the value in a variety of statistical analyses.

Based on the preliminary discussion items were selected and ordered for each scale to be developed. The developed scales are to be calculated for its coefficient of reproducibility and coefficient of scalability for standardization.

2.4 Calculation of Co-Efficient of Reproducibility

The complete list of items, arranged in a simple yes/no format, was presented to 30 farmers in a non-sample area via a survey. Each respondent indicated their agreement or disagreement with each item. The data were organized into a matrix where rows represented respondents and columns represented items, with entries of ones and zeros denoting agreement or disagreement with each item, respectively.

In assessing errors of inclusion and omission within a Guttman Scale, two methods were typically employed. The first, proposed by Guttman (1950), is known as the minimization of error approach. It involves counting the minimum number of responses that need to be altered to transform a respondent's response pattern into an ideal scale. Here, the ideal scale reflects the order of items and doesn't consider the total number of items a respondent may have.

The second method, deviation from perfect reproducibility, is more conservative. It determines errors based on an ideal response pattern considering both the order of responses and the total number of items a respondent possesses, as described by Goodenough (1944) and Edwards (1983). ‘

The coefficient of reproducibility (CR) for each scale is derived from this method, serving as a measure of the unidimensionality of the items within the scale.

$$CR = 1 - \frac{number\ of\ \ errors}{number\ of possible\ errors} \qquad (1)$$

The CR is calculated using a specific formula. The Coefficient of Reproducibility (CR) assesses the degree of unidimensionality exhibited by the items within the scale and it is calculated by using the given formula.

As per Guttman's measure, a scale is deemed acceptable if it possesses fewer than 10 percent erroneous entries. Therefore, a coefficient of reproducibility (CR) equal to or exceeding 0.90 is considered evidence that a set of items is unidimensional in its scaling.

2.5 Calculation of Coefficient of Scalability

The Coefficient of Reproducibility (CR) has a limitation in that it is influenced by extreme marginal distributions both in terms of items and individuals, which means that a high CR can be achieved even with random responses of the sample respondents (Menzel, 1953; McIver and Carmines, 1981).

For instance, if an individual randomly responds "yes" to 90 percent of the items on a list, it becomes relatively easy to predict whether this individual has a "yes" for any given item based solely on this fact.

This phenomenon is referred to as the extremeness of individuals. Similarly, if 90 percent of farmers respond "yes" to a particular item, predicting whether any given individual has this item becomes rather straightforward, within a 10 percent margin of error, without any additional information.

This scenario is known as the extremeness of items. In either case, accurate predictions of data arrangement can be made simply by using the category with the highest frequency (i.e., the modal category).

Therefore, although the data may exhibit relatively few scale errors, resulting in a high CR, they may not necessarily reflect scalability or departure from randomness. Scalability implies that categories and individuals can be meaningfully arranged from highest to lowest, and the ability to predict order solely based on marginals undermines such meaningfulness.

Menzel (1953) suggested that the degree of success in reproductions is influenced by three factors: (1) the extremeness of items, (2) the extremeness of individuals, and (3) the scalability of the items for the given individuals. Therefore, to determine if the data truly exhibit scalability, it is necessary to control for extreme responses.

To address this issue, Menzel (1953) used the Coefficient of Scalability (CS), which measures the predictability of the scale relative to the level of prediction achieved solely by considering the row and column marginals. The formula is given as follows.

$$CS = 1 - \frac{number\ of\ scale\ errors}{number\ of\ marginal\ errors} \quad (2)$$

Marginal error refers to the count of non-modal frequencies within the obtained dataset. When the proportion of marginal errors compared to total errors is higher, it increases the CS. As the scale exhibits fewer errors than anticipated by chance, the CS approaches 1.0. Menzel recommends a CS of 0.60 or above as acceptable.

The initial analysis of the selected items for risk orientation and economic motivation produced a respectable CR of 0.83, CS of 0.23 and CR of 0.87, CS of 0.58 respectively but, hoping to achieve a CR of 0.90 and CS of 0.60, various deletions was tried. There are several ways to do these deletions, but the easiest is to look for the item with the most errors.

By removing certain items, a higher CR and CS can be achieved. In the present study, a CR of 0.900, a CS of 0.643, with three items for economic motivation, a CR of 0.907, a CS of 0.655, with three items for scientific orientation, a CR of 0.947, a CS of 0.821 using three items for risk orientation were achieved for the final scale.

Table 2: Coefficients of Scalability and Reproducibility of the developed scales.

Results	Coefficient of Scalability	Coefficient of Reproducibility
Scales	CS	CR
Economic motivation	0.643	0.900
Scientific orientation	0.655	0.907
Risk orientation	0.821	0.947

2.6 Reliability of the Scales Developed

The developed scales were further standardization through the establishment of their reliability. According to Kerlinger and Lee (2000), reliability pertains to the accuracy or precision of a measuring instrument. To assess the reliability of the attitude scale, the Test-Retest method was employed. Validity, which essentially denotes truthfulness, refers to "the degree to which a test measures what it claims to measure" (Ray and Mondal, 2011).

2.6.1 Test-Retest Reliability

The test-retest method involves administering the developed scale twice and then computing the reliability coefficient between the two sets of test scores. Therefore, the developed scales were administered to the farmers with a fortnight interval, the significance of the correlation was achieved known as the reliability index.

2.7 Concurrent Validity

Concurrent validity was utilized to gauge the validity of the scale. Concurrent validity was established by examining its correlation with a criterion that is currently available.

In this study, scores on the newly constructed scales measuring economic motivation, scientific orientation, and risk orientation were correlated with scores obtained from existing scales of psychological variables developed by Supe (1969).

2.7.1 Standardized Scale for Validity

Each scale consisted of six statements, incorporating a mix of positive and negative items to capture nuanced responses from participants.

For detailed descriptions of these scales and their individual items, please refer to Appendix 1 of this study, where each scale is provided along with instructions for administration and scoring. The operationalization of the scales are as follows. The economic motivation was assessed using a scale developed by Supe (1969). Each statement was rated on a five-point continuum, ranging from strongly agree to strongly disagree. The scale comprised six statements, with one being negative and the remaining being positive statements. The scores for each item were summed to determine the economic motivation score for each respondent, which ranged from 6 to 42.

Supe's (1969) Scientific Orientation Scale was employed in the study. This scale comprised six statements, with one statement being negative and the others positive. The scores from each item were summed to determine the scientific orientation score of each respondent, which fell within a range of 6 to 42.

The measurement of risk preference utilized Supe's (1969) Risk orientation Scale. This scale comprised six statements, with two being negative and the remainder positive. The scores for each item were summed to calculate the risk orientation score for each respondent, ranging from 6 to 42. According to Singh (1977), the resulting correlation coefficient serves as an indicator of concurrent validity. Therefore, both the newly constructed scales and the standard scales were administered to 30 farmers from a non-sample area. Using SPSS, the Pearson Product Moment correlation coefficient (r) was calculated for each scale. The significant correlation observed serves as a measure of the concurrent validity of the developed scales which is presented in table 3.

Table 3: Validity and reliability of the developed scales.

Results	**Validity (Concurrent validity)**	**Reliability (Test-retest reliability)**
Scales	Pearson Product Moment Correlation (r)	Reliability Index
Economic motivation	0.533**	0.96 **
Scientific orientation	0.633**	0.76 **
Risk orientation	0.457*	0.79 **
*Significance at 5% level ** Significance at 1% level		

2.8 Scoring of Final Scales

Based on the coefficient of reproducibility and scalability the items were ranked for each scale in the descending order. The final scale adopted is presented in Table 4 along with the scoring of the individual scales developed.

Table 4: Final Scales developed using Scalogram approach.

I	**Economic motivation**	
You do agriculture		
Sl. No	**Statements**	**Score**
1.	To become rich and have a luxurious lifestyle	3
2.	To have a decent living	2
3.	To sustain my livelihood	1
	Scientific Orientation	
What farming method you would prefer/wish to do		
1.	Remote/ mobile based farming method	3
2.	Motorized farming method (tractors, fuel/ power operated machineries)	2
3.	Manual faming (tools and implements)	1
III	**Risk orientation**	
If you were provided with credit assistance from bank which farming, you would prefer		
1.	Export business-oriented farming	3
2.	Value addition and food processing	2
3.	Conventional crop production	1

3 CONCLUSIONS

The Scalogram analysis approach is particularly valuable in capturing the intricacies of human attitudes, as the Guttman Scale Scalogram method emphasizes the need for responses to follow a clear pattern, endorsing fewer extreme items if the most extreme item is endorsed.

The research process involves refining the scales based on analysis results, addressing errors, and aiming for the desirable CR and CS thresholds for

scale acceptability. This approach, detailed in the article, ensures the unidimensionality and scalability of the developed scales.

The calculation of the Coefficient of Reproducibility and Coefficient of Scalability helps in assessing the reliability and validity of the scales, with thresholds of 0.90 and 0.60 respectively indicating acceptability.

Furthermore, the study establishes reliability through the Test-Retest method and concurrent validity through correlation with existing psychological variables. The standardized scoring procedures facilitate ease of administration and interpretation of the scales. Overall, this research contributes significantly to the Extension research field by offering a systematic and statistically sound approach to measuring complex psychological constructs in the context of agricultural decision-making.

The Guttman Scale Scalogram approach provides researchers with a robust and statistically sound framework to delve into the complexity of psychological constructs, offering valuable insights into human attitudes and behaviors. These reliable and valid psychological scales that can be utilized for various research and practical applications.

REFERENCES

Edwards, A. L. (1983). *Techniques of attitude scale construction*: Ardent Media.

Goodenough, F. L. (1944). Expanding opportunities for women psychologists in the post-war period of civil and military reorganization. *Psychological Bulletin, 41*(10), 706.

Guttman, L. (1950). The basis for scalogram analysis.

Menzel, H. (1953). A new coefficient for scalogram analysis. *Public Opinion Quarterly, 17*(2), 268-280.

McIver, J., and Carmines, E. G. (1981). *Unidimensional scaling* (Vol. 24): Sage.

Kerlinger, F., and Lee, H. (2000). Foundations of behavioral research, United States of America: Wadsworth Thomson Learning. In: Inc.

Singh, K. K., Patrin. M. L. and H. C. Sharma. 2000. Environmental protection and sustainable agriculture. Intensive agriculture, 38 (1-2): 12-16.

Supe, S. V. (1969). *Factors related to different degrees of rationality in decision making among farmers.* IARI, Division Of Agricultural Extension; New Delhi.

Ray, G., and Mondal, S. (2011). *Research methods in social sciences and extension education*: Kalyani Publishers.

APPENDIX

Table 4: Standardized scales developed by Supe (1969) used for reliability testing.

I	**Economic motivation**					
Sl.No.	**Statement**	**SA**	**A**	**UD**	**DA**	**SDA**
1	A farmer should work towards larger yields and economic benefits					
2	The most successful farmer makes most profit.					
3	A farmers should try new farming methods					
4	A farmer should grow HYVs to make good profit.					
5	It is difficult for farmer's children to make good start unless he provides them with economic assistance.					
6*	A farmer should earn his living but the most important thing in life can't be defined in economic terms.					
II	**Scientific Orientation**					
1	New methods of farming give better results to a farmer than old methods					

2*	The way of farmers' forefathers farmed is still the best of way to farm today					
3	Even a farmer with lots of experience should use new methods of farming					
4	A good farmer experiments with new ideas in farming					
5	Though it takes time for a farmer to learn new methods in farming it is worth the efforts					
6	Traditional methods of farming have to be changed in order to raise the level of living of a farmer					
III	**Risk orientation**					
1*	A farmer should grow more number of crops to avoid greater risks involved in growing one / two crops.					
2	A farmer should take more of chance in making a big profit to be constant with smaller but less risky profits.					
3	A farmer who is willing to take greater risks than the average farmer actually does better financially					
4	It is good for a farmer not to take risk when he known his chance of success is fairly high.					
5*	It is better for a farmer not to try new farming methods unless mostly other farmers have used it with success					
6	Trying an entirely and new method in farming by a farmer involved risks but it is worth.					

***Negative statements**

SA – Strongly agree, A- Agree, UD- Undecided, DA- Disagree, SD – Strongly disagree

The scoring procedure followed for the above standard scales is as follows.

Response	**Strongly Agree**	**Agree**	**Undecided**	**Disagree**	**Strongly Disagree**
Positive statements	7	5	4	3	1
Negative statement	1	3	4	5	7