An Improved Regression Model of Group Rationality by Group Member Traits: Group Decision-making under Limited Rationality by Problem-solving and Persuasion [1)]

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ABSTRACT

The purpose of this experiment is to present a regression model which describes the relationship between group rationality and group member traits, especially group member characteristics. There are many problems to be solved in the world, but our rationality to challenge them is limited. If problem-solving or decision-making within groups is an important part of our lives, and if group rationality (which determines the problem-solving or decision-making level) depends on group member traits, then it is essential to estimate the relationship between group rationality and group member traits.

Although a large number of studies have been made in this field, there has been only limited success. However, this experiment shows that member traits have a statistically strong relation to group decision-making or group rationality.

This study analyzed the data from 587 university students in 2, 3, 4 or 5 person groups that made 175 groups in total. Rationality of a group member and a group was measured by a questionnaire, and characteristics of each group member were assessed by the Maudsley Personality Inventory (MPI), Japanese edition.

The preceding model developed by GOTO (2002) succeeded in structuring the relationship between group rationality and member traits namely, member rationality and member characteristics. Unfortunately due to poor R^2, the model was not useful for prediction.

In this experiment, we succeeded in raising the accuracy of the model by making an effort to find dummy variables. The new regression model developed here could offer useful information for improvement in group rationality and in effective personnel management. In addition, this model proved that MPI was useful. Furthermore, by using MPI and dummy variables, we can expect to raise group rationality.

Introduction

The purpose of this study is to present a regression model which describes the relationship

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1) This paper is based on the paper “An Improved Regression Model of Group Rationality by Member Rationality and Characteristics: Group Decision-making under Limited Rationality by Problem-solving and Persuasion” that was read at the “International Conference Experiments in Economic Sciences: New Approaches to Solving Real-world Problems” held in Okayama and Kyoto (14–17 December 2004).

between group rationality and group member traits, especially group member characteristics. There are many problems to be solved in the world but our rationality to challenge them is limited. If problem-solving or decision-making within groups is an important part of our lives, and if group rationality (which determines the problem-solving or decision-making level) depends on group member traits, it is essential to estimate the relationship between group rationality and group member traits.

Although a large number of studies have been made in this field, there has been only limited success (Williams and Sternberg, 1988; Heslin, 1964; Mann, 1959). However, even with poor R^2, the model developed by GOTO (2002) showed that member traits had a statistically strong relation to group decision-making or group rationality.

In order to improve poor R^2, this experiment developed some dummy variables, which brought successful R^2.

This experiment does not, however, treat all types of group decision-making and group member traits. First, group decision-making under limited rationality with conflict may be classified into four major types, according to March and Simon (1958): (1) problem-solving, (2) persuasion, (3) bargaining and (4) politics. Group decision-making in this study covers only problem-solving and persuasion processes. Furthermore, member traits in this paper only mean member rationality scored from a questionnaire and the E and N score from the Maudsley Personality Inventory (MPI). Although member traits in this paper are limited, they will act as useful factors in regression analysis.

The aim and the method of this experiment

The aim of this experiment is to develop a regression model which shows group rationality structured by group members' traits.

(1) The subject of this experiment

Five hundred eighty-seven university students were divided into two, three, four or five-person groups which made one hundred seventy-five groups in total. In the grouping process, the following three criteria were employed for simplification.

a. Group members already know one another.
b. In a group, members are on an equal status. Therefore, members of a group are composed of the same grade university students.
c. Groups have only male or female members. Thus, there are no gender-mixed groups in this experiment.

(2) Measurement of personal characteristics

The Maudsley Personality Inventory (MPI, Japanese edition) was employed.

(3) Measurement of rationality

Personal rationality of a group member as well as group rationality were measured by a game developed by Hikaru YANAGIHARA (1982). In this game, the lower the point total, the higher the rationality.

In the beginning of this experiment, participants are asked to answer the following questionnaire for themselves.

In 1972, Japanese young people were asked to select the most important item in their life among the following eight items.

Guess the first item they selected and give the item one point. Next, give two points to the second item, three points to the third item and so on. Thus the last item gets eight points. Don't use the same point more than once.

a. Release from restraint
b. No special reasons for life
c. Money and status
d. Sincerity and love
e. Devotion to the state and society
f. A rewarding job
g. Devotion to international cooperation
h. Religious salvation

There is, of course, a correct answer which comes from an actual investigation done by the Prime Minister's Office of Japan in 1972. However, participants can only guess at the correct answer. As a result their rationality is limited and their decision-making standards are not optimal, but satisfactory.

After completion of the questionnaire, participants were asked to do the same questionnaire by a consensus of group members. At the same time, they were asked to make a consensus not by majority rule but by persuasion.

The data for personal rationality (PR) of a participant were measured by the following formula.

$$PR = \sum_{i=1}^{8} |X_i - x_i|$$

X_i: Points for the correct answer for the i-th item
x_i: Points for a personal answer for the i-th item

And the data for group rationality (GR) were obtained from the next formula.

$$GR = \sum_{i=1}^{8} |X_i - z_i|$$

X_i: Points for the correct answer for the i-th item
z_i: Points for a group answer for the i-th item

Model

The preceding model developed by GOTO (2002)

$$GR = \beta_0 + \beta_1 MRAV + \beta_2 EAV + \beta_3 EAV^2 + \beta_4 NAV + \beta_5 NAV^2 + \beta_6 D + \varepsilon$$

The variables in the equation mean as follows.

GR: Group Rationality
MRAV: Average of Member Rationality
EAV: Average of Members' E score from MPI
NAV: Average of Members' N score from MPI
D: Dummy variable; male=1, female=0

This model passed the test of heteroscedasticity by Goldfeld-Quandt test.
The results were estimated as follows.

β_0: 12.604 (t = 3.931)
β_1: 0.764 (t = 9.214)
β_2: –0.501 (t = –2.911)
β_3: 0.008 (t = 2.944)
β_4: –0.343 (t = –2.520)
β_5: 0.008 (t = 2.671)
β_6: –1.006 (t = –2.061)
corrected R^2=0.380 (P-value=1.21E–16)

This model succeeds in structuring the relation between group rationality and member traits, namely member rationality and member characteristics. The dummy variable D in the model tells that group rationality of the female group is lower than that of the male group. But because of poor R^2, this model is not useful for prediction.

In order to improve poor R^2, this experiment developed a new model [2].

$$GRC = \beta_0 + \beta_1 MRAV + \beta_2 DMRAV2 + \beta_3 DMRSTD1 + \beta_4 DMRSTD2 + \beta_5 DESTD2 + \beta_6 DNAV1 + \beta_7 DNAV2 + \beta_8 DNSTD1 + \beta_9 DNSTD2 + \varepsilon$$

The variables in the equation mean as follows.

GRC: Group Rationality(GR) expressed by 0~100.
(GRC was converted from GR.)
MRAVC: Average of Member Rationality(MRAV) expressed by 0~100.
(MRAVC was converted from MRAV.)
DMRAV2: Dummy variable on Average of Member Rationality
DMRSTD1·2: Dummy variables on Standard Deviation of Member Rationality
DESTD2: Dummy variable on Standard Deviation of Members' E score from MPI
DNAV1·2: Dummy variables on Average of Members' N score from MPI
DNSTD1·2: Dummy variables on Standard Deviation of Members' N score from MPI

This model has three new points.

① The preceding model had variables of secondary degree. But, these variables were omitted in the new model to simplify the relationship.

2) This improved model was developed by MIZUTANI under the direction of GOTO.

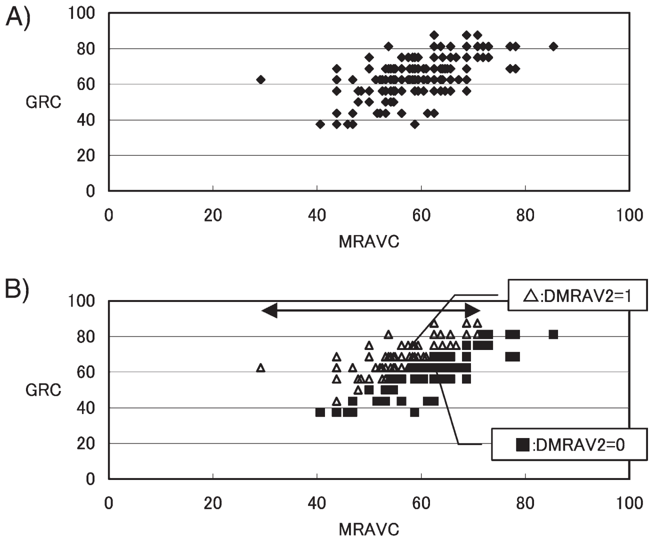

Fig. 1 A) shows the relationship between Group Rationality (GRC) and the Average of Member Rationality (MRAVC). B) shows that data are divided into two groups by factor 2. Here, factor 2 means the average of the scores for principal component 2. Data points expressed by △ correspond to the group of high rationality. Data points expressed by ■ correspond to the group of poor rationality.

② Dummy variables were added to the new model.

③ And in this model, the score of Group Rationality (GR) and the Average of Member Rationality (MRAV) were expressed by 0~100.

So, the names of GR and MRAV were changed to GRC and MRAVC. In the preceding model, the lower the point total, the higher the rationality. But, in this model, as a result of conversion, the higher the point total, the higher the rationality. It is necessary to note this point.

Dummy variables in this model were constructed by principal component analysis [3].

(1) Principal component analysis applied to GRC and MRAVC made two dummy variables of DMRAV1 and DMRAV2. However, because of poor t-value, DMRAV1 was eliminated in regression analysis. (Fig. 1)

(2) Principal component analysis applied to GRC and the Standard Deviation of Member Rationality made two dummy variables of DMRSTD1 and DMRSTD2. (Fig. 2)

(3) Principal component analysis applied to GRC and the Standard Deviation of Members' E score from MPI made two dummy variables of DESTD1 and DESTD2. However, because of poor t-value, DESTD1 was eliminated in regression analysis. (Fig. 3)

(4) Principal component analysis applied to GRC and NAV made two dummy variables of DNAV1 and DNAV2. (Fig. 4)

(5) Principal component analysis applied to GRC and the Standard Deviation of Members' N score from MPI made two dummy variables of DNSTD1 and DNSTD2. (Fig. 5)

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3) At the end of this paper, Figs. 1–5 visualizes the determination processes of each dummy variable.

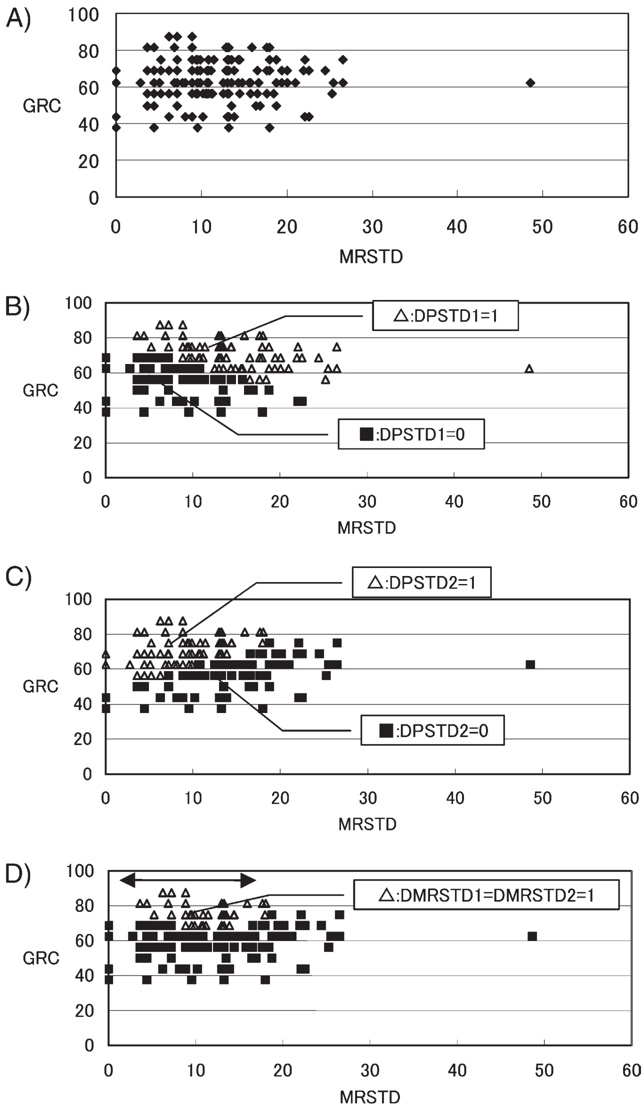

Fig. 2　A) shows the relationship between Group Rationality (GRC) and the Standard Deviation of Member Rationality (MRSTD). B) shows that data are divided into two groups by factor 1. C) shows that data are divided into two groups by factor 2. Here, factor 1 means the average of the scores for principal component 1. Factor 2 means the average of the scores for principal component 2. Data points expressed by △ correspond to the group of high rationality. Data points expressed by ■ correspond to the group of poor rationality. D) shows that two dummy variables (of DMRSTD1 and DMRSTD2 discovered by principal component analysis) specified the group of high rationality.

This model passed the test of heteroscedasticity.

$$\hat{u}_i^2 = \beta_0 + \beta_1 MRAV + \beta_2 DMRAV2 + \beta_3 DMRSTD1 + \beta_4 DMRSTD2 + \beta_5 DESTD2 + \beta_6 DNAV1 + \beta_7 DNAV2 + \beta_8 DNSTD1 + \beta_9 DNSTD2 + \varepsilon$$

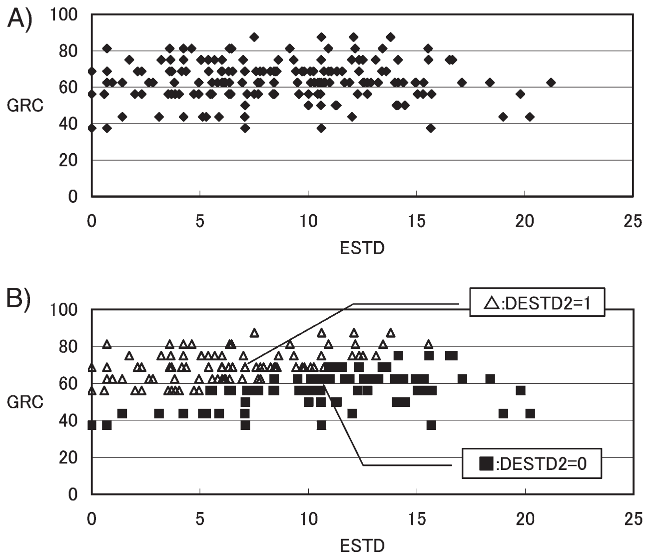

Fig. 3 A) shows that the relationship between Group Rationality (GRC) and the Standard Deviation of Members' E score from MPI (ESTD). B) shows that data are divided into two groups by factor 2. Factor 2 means the average of the scores for principal component 2. Data points expressed by △ correspond to the group of high rationality. Data points expressed by ■ correspond to the group of poor rationality.

β_0: 42.278 (t = 1.836)
β_1: –0.383 (t = –0.892)
β_2: 0.426 (t = 0.071)
β_3: 1.137 (t = 0.192)
β_4: –3.299 (t = –0.585)
β_5: –3.633 (t = –0.720)
β_6: –4.162 (t = –0.723)
β_7: 0.038 (t = 0.007)
β_8: –2.708 (t = –0.488)
β_9: 4.436 (t = 0.786)

The results were estimated as follows.

β_0: 25.227 (t = 7.263)
β_1: 0.417 (t = 6.435)
β_2: 5.343 (t = 5.867)
β_3: 5.057 (t = 5.672)
β_4: 3.308 (t = 3.887)
β_5: 1.562 (t = 2.053)
β_6: 2.727 (t = 3.141)
β_7: 2.716 (t = 3.330)
β_8: 3.450 (t = 4.119)

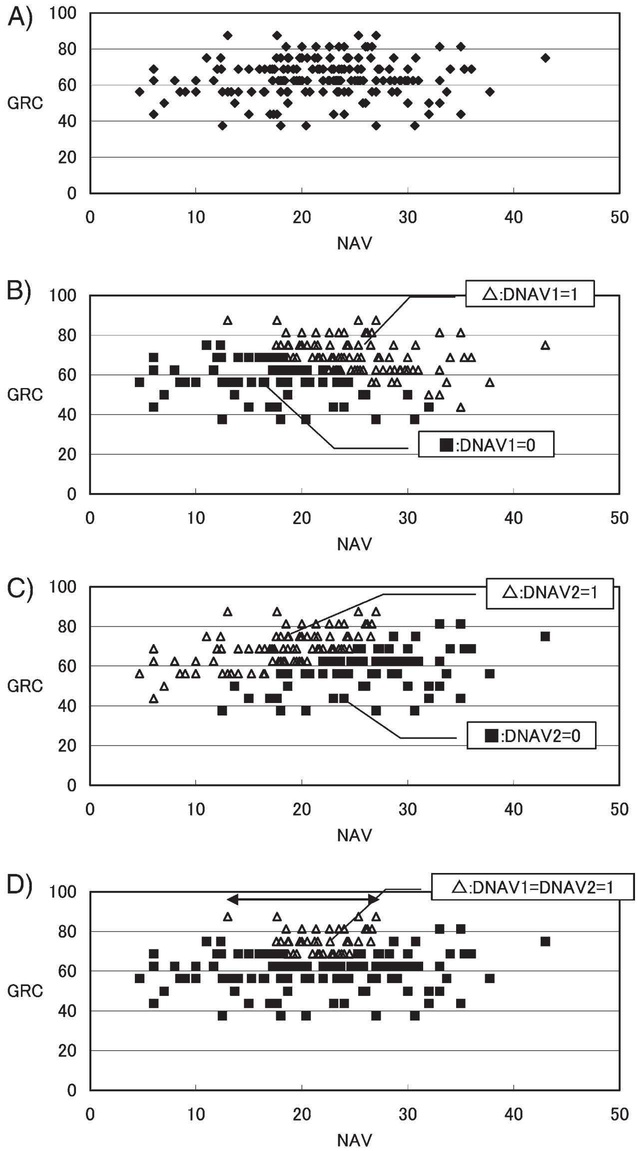

Fig. 4 A) shows the relationship between Group Rationality (GRC) and the Average of Members' N score from MPI (NAV). B) shows that data are divided into two groups by factor 1. C) shows that data are divided into two groups by factor 2. Here, factor 1 means the average of the scores for principal component 1. Factor 2 means the average of the scores for principal component 2. Data points expressed by △ correspond to the group of high rationality. Data points expressed by ■ correspond to the group of poor rationality. D) shows that two dummy variables (of DNAV1 and DNAV2 discovered by principal component analysis) specified the group of high rationality.

β_9: 3.348 (t = 3.934)

corrected $R^2 = 0.860$ (P-value=1.47E−67)

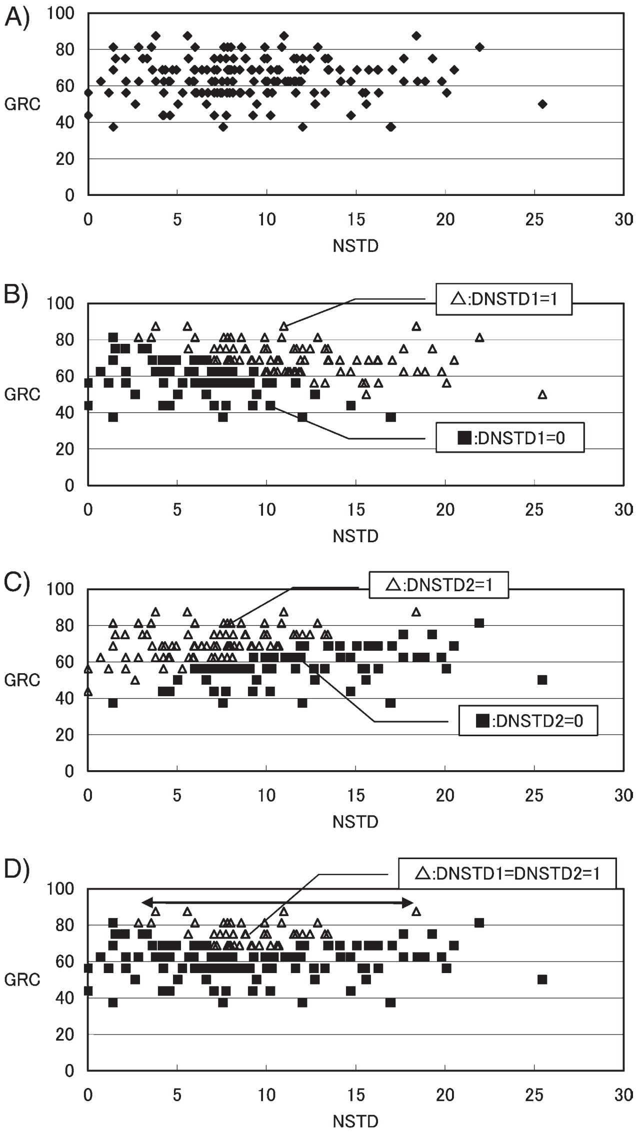

Fig. 5 A) shows the relationship between Group Rationality (GRC) and the Standard Deviation of Members' N score from MPI (NSTD). B) shows that data are divided into two groups by factor 1. C) shows that data are divided into two groups by factor 2. Here, factor 1 means the average of the scores for principal component 1. Factor 2 means the average of the scores for principal component 2. Data points expressed by △ correspond to the group of high rationality. Data points expressed by ■ correspond to the group of poor rationality. D) shows that two dummy variables (of DNSTD1 and DNSTD2 discovered by principal component analysis) specified the group of high rationality.

This model succeeded in structuring the relationship between group rationality and member traits, namely member rationality and member characteristics. Furthermore, this model has sufficient R^2 for prediction.

Conclusion

In this experiment, as a result of making an effort to find dummy variables, we succeeded in raising the accuracy of the model. The new regression model developed here can offer useful information for improvement in group rationality and in effective personnel management. This model also proved that MPI was useful. Furthermore, by using MPI and dummy variables, we can expect to raise group rationality. A series of our studies will contribute to the experimental study of economics in subject selection.

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メンバーの個人的特性によるグループの合理性についての回帰モデル
ー合理性が制限された状況における，問題解決や
説得の方法を用いたグループの意思決定ー

水　谷　　　覚
後　藤　文　彦

本稿の目的は，グループの合理性とメンバーの個人的特性との間にある関係をとらえた回帰モデルを開発するところにある．今までに，多くの研究がこの分野でなされてきたにもかかわらず，十分な成果はまだ得られていない．

後藤（2002）において開発されたモデルでは，グループの合理性とメンバーの特性，特にメンバーの性格特性との間にある関係を構築することに成功した．しかしながら，統計分析の結果，決定係数の値が十分ではなく，モデルの精度に課題を残していた．

そこで，本稿では，主成分分析によって導出されたダミー変数を用いることでモデルに改良を施し，それによってモデルの統計的精度を向上させることに成功した．

このモデルによって，MPI（モーズレイ性格検査）の有用性が実証されるとともに，グループの合理性の改善や個人のマネジメントに対しても有益な情報を提供することが期待できるであろう．