Paper 380-2008

Reliability and Validity Testing using SAS/STAT

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ABSTRACT

The paper presents the methodology used to develop and validate an instrument that will identify the differences between virtual and traditional teams based on aspects of leadership and group dynamics. We conducted the analysis using SAS/STAT. The instrument was determined to be reliable (overall alpha=0.90, n=174) and offered very good discriminant and predictive ability. One may adapt the code to perform similar analyses for other measures of natural and behavioral phenomenon. Both PROC DISCRIM and PROC LOGISTIC yielded the same results. This paper represents an update of the paper submitted to SESUG 2007.

The underlying theoretical framework and research instrument were submitted as a separate paper to the 2nd International Conference of Globally Distributed Work, in Bangalore, India.

INTRODUCTION

A virtual team is defined as "…a group of people who work interdependently with a shared purpose across time and space, time and organization boundaries using technology." (Lipnack & Stamps, 1997). They are part of the new work place. If they differ substantially from the traditional team in leadership and group dynamics, then there are potential implications for their leadership, the process of selecting team members and the management of day to day activities. The paper presents the methodology used to validate an instrument designed to measure aspects of leadership and group dynamics of virtual teams. It highlights the outcome of the pilot study, prior to the deployment of the survey instrument for the final report.

METHODOLOGY

The scale items were developed in accordance with the steps recommended by DeVellis (2003, p.60-87). The survey was conducted between April 6, 2006 and January 11, 2007. We distributed the instrument to over 800 members of the Academy of Management's (AoM) International Management and Research Methodology Divisions, through their mailing lists and over 150 student members of a class of juniors in the College of Business of the Florida International University in a fully online course in Organization and Management. The response rate was close to 10% for the AoM membership and close to 50% for the FIU CBA juniors. We administered both surveys online-through Surveyconsole.com and WebCT, a web based instructional tool, used by many Universities. We received 114 responses.

The analyses consisted of the following:

(a) reliability test of the internal consistency of the instrument,

(b) factor analysis (Principal Components Method using varimax rotation, and Maximum Likelihood) to determine if the factor score loadings are consistent across the items.

(c) a discriminant analysis of the results to determine its ability to discriminate between groups and correctly predict the group membership of an observation. Thereafter it will be used to determine if there are differences between the groupings under study -virtual and traditional teams.

(d) A logistic regression analysis of the variables identified by the discriminant analysis, with the type of team as the dependent variable.

The analyses were conducted using SAS/STAT version 9, with methodology obtained from DeVellis (2003), and code obtained from Johnson & Wichern (2005) and O'Rourke, Hatcher and Stepanski (2005).

The dependent variable is dichotomous, a trait which violates the normality assumptions required for standard parametric tests. Where normality conditions may not be met, it is suggested that the logistic regression method (PROC LOGISTIC), which is non-parametric in nature be used. (Press & Wilson, 1978). In addition, the PROC DISCRIM (NPAR option, created by SAS, and used for non-normal data) is also presented.

Paper 380-2008

SAS/STAT Code for Descriptive Analysis:

```
OPTIONS LINESIZE=150 PAGESIZE=60 PAGENO=1;
TITLE1 'DATA ANALYSIS-VALIDATION OF SURVEY INSTRUMENT';
DATA COMBINEDAOM;
INFILE 'insert address of your input file';
INPUT  Q1 Q2  Q3 Q4     Q5     Q6     Q7     Q8     Q9     Q10 Q11 Q12 Q13 Q14 Q15
Q16 Q17   Q18    Q19    Q20    Q21    Q22    Q23    Q24    Q25    Q26 Q27      Q28
Q29 VIRTRAD  Q31   Q32  Q33    Q34    TYPETEAM Group;
IF VIRTRAD=1 THEN TEAM='VIRTUAL';
ELSE TEAM='TRADITIONAL';
IF TYPETEAM=1 THEN TYPE='ACADEMIC';
IF TYPETEAM=2 THEN TYPE='STUDENT';
IF TYPETEAM=3 THEN TYPE='MANAGEMENT' ;
IF TYPETEAM=4 THEN TYPE='TECHNICAL';
IF TYPETEAM=5 THEN TYPE='OTHER';
*COMPUTING MEANS;
PROC MEANS DATA = COMBINEDAOM;
VAR Q1--GROUP;
RUN;
*COMPUTING BASIC STATISTICAL MEASURES-MODE, STD DEVIATION, RANGE;
ODS;
PROC UNIVARIATE DATA=COMBINEDAOM;
VAR Q1--GROUP;
RUN;
PROC FREQ DATA=COMBINEDAOM;
RUN;
```

Reliability and Validity testing

The purpose of reliability and validity testing is to evaluate the performance of the instrument - to identify possible issues related to its internal consistency, ability to measure the phenomenon that it is purported to measure, and potential sources of measurement error. Of special importance is its ability of discriminate between virtual and traditional teams.

(a) Reliability Analysis

The instrument measured two constructs, namely the member perceptions of leader behavior (Questions 1-14) and the nature of group processes and interactions (Questions 15-29, 31). Question 30 referred to the type of team (virtual or traditional). Questions 32-34 represented demographic controls. A reliability analysis was performed among the items of each sub-scale to determine their internal consistency. Questions 26 and 28 were reverse coded to reflect the same conditions as the other questions. An analysis of the reliability coefficients (Cronbach's alpha) suggested that items 8 and 26 (reversed) should be removed. The reliability coefficient stood at 0.90 overall, 0.895 for the revised Sub-scale 1 and 0.757 for sub-scale 2.

SAS/STAT Code for Reliability Analysis:

```
PROC CORR DATA = Combinedaomfiuaib ALPHA NOMISS;
VAR Q1--Q7 Q9--Q14;
RUN;
PROC CORR DATA = Combinedaomfiuaib ALPHA NOMISS;
VAR Q15--Q25 Q26R Q27 Q28R Q29;
RUN;
PROC CORR DATA = Combinedaomfiuaib ALPHA NOMISS;
VAR Q1--Q7 Q9--Q14 Q15--Q25 Q26R Q27 Q28R Q29;
RUN;
```

(b) Factor Analyses

The final factor analysis indicated that the first four factors account for just over 50% of the variance of the model. The results suggested that final version of the instrument should exclude Items 8 and 26R. It became necessary to input the Heywood option to address the presence of communalities exceeding 1. The loading of the factors identified by the Principal Components Method, the ML method and the scree plot were consistent with the constructs being measured. The Tucker & Lewis Reliability coefficient, a measure the goodness of fit of a ML factor analysis, was 0.867. The factor analysis revealed the following issues in the leadership of, and group dynamics associated with virtual and traditional teams:

- Member perception of leader facilitation of team building (Questions 1, 2, 4-6, 9, 10-12)
- Member comfort level with group interactions (Questions 23, 25, 27, 28R)
- Member satisfaction with working conditions (Questions 16, 19, 24)
- Group cohesiveness (Questions 13, 14, 20)

SAS/STAT Code for Factor Analyses (P C and Max. Likelihood Methods):

```
PROC FACTOR DATA=Combinedaomfiuaib METHOD=principal SCREE ROTATE=varimax S C;
VAR Q1--Q7 Q9--Q14 Q15--Q25 Q26R Q27 Q28R Q29;
RUN;
PROC FACTOR DATA=Combinedaomfiuaib METHOD=ML HEYWOOD ROTATE=varimax S C;
VAR Q1--Q7 Q9--Q14 Q15--Q25 Q26R Q27 Q28R Q29;
RUN;
```

Discriminant Analysis

The purpose of a Discriminant Analysis is to predict the class in which observations fall. The greater the accuracy of the prediction, the better the model (Johnson and Wichern, 2005). This predictive statistic known as the probability of correct classification of the Discriminant Analysis is akin to the r-square of the regression model. We assigned prior probabilities to each category were based on the sample. All of the model's variance was accounted for by the single canonical discriminant function, based on a canonical correlation of 0.812. The data appeared to be normally distributed with almost all items having a kurtosis of less than 2, and skew close to zero. The instrument appears to have identified two distinct groups, thus displaying the power to discriminate between virtual and traditional teams. The analysis correctly classified almost 100% of the original grouped cases, thus confirming the instrument's capacity to distinguish between, and to predict the membership of the groups.

SAS/STAT Code for Discriminant Analysis:

```
*DISCRIMINANT ANALYSIS WITH  Q8, Q26R and survey REMOVED;
TITLE2 'DISCRIMINANT ANALYSIS FOR VIRTUAL AND TRADITIONAL TEAM DATA';
DATA Combinedaomfiuaib;
INPUT  Q1--Q7 Q9--Q14 Q15--Q25 Q27 Q28R Q29 country  size lengthexist  explifespan
   teambuild comfrtgroup  satwork  cohesiv
;
PROC DISCRIM DATA=Combinedaomfiuaib METHOD=NORMAL POOL=YES SHORT LIST
CROSSVALIDATE;
CLASS VIRTRAD;
PRIORS PROP;
PROC PLOT DATA=Combinedaomfiuaib NOMISS;
PLOT Q1*Q10=VIRTRAD / BOX;
OPTIONS LINESIZE=120 PAGESIZE=60;
TITLE2 'OVERALL SCORES VS TRAD AND VIRTUAL TEAMS';
RUN;
*SELECTION OF VARIABLES USED TO DISCRIMINATE AMONG GROUPS;
PROC STEPDISC DATA=Combinedaomfiuaib METHOD=STEPWISE SLE=0.4 SLS=0.05;
*SLE(S)=SIGNIFICANCE LEVEL OF ENTRY (STAYING)INTO STEPWISE CANONICAL CORRELATION;
CLASS VIRTRAD;
VAR country  size  lengthexist  explifespan group  survey teambuild  comfrtgroup
   satwork  cohesiv ;
TITLE2 'STEPWISE DISCRIMINANT ANALYSIS OF VIRTUAL TEAMS DATA';
RUN;
PROC CANDISC DATA=Combinedaomfiuaib OUT=CANCombinedaomfiuaib NCAN=3;
CLASS VIRTRAD;
VAR       Q1--Q7 Q9--Q14 Q15--Q25 Q27 Q28R Q29  country  size   lengthexist
   explifespan  teambuild  comfrtgroup  satwork  cohesiv;
TITLE2 'CANONICAL DISCRIMINANT ANALYSIS OF VIRTUAL TEAMS DATA';
RUN;
PROC PRINT DATA=CANCombinedaomfiuaib;
RUN;
```

The stepwise discriminant analysis identified the following variables as being different between the two groups at the 5% level of significance:

- Number of countries spanned by the team
- Respondent group
- Length of team's existence

Paper 380-2008

- Composite variable representing member satisfaction with working conditions (Q16+Q19+Q24)
- Member comfort level with group interactions (Questions 23, 25, 27, 28R)
- Member satisfaction with working conditions (Questions 16, 19, 24)
- Group cohesiveness (Questions 13, 14, 20)

Logistic Regression Analysis

The PROC LOGISTIC procedure yielded identical results to that of PROC DISCRIM. It's predictive ability was good with less than 10% of observations being misclassified.

SAS/STAT Code for Logistic Regression Analysis:

```
DATA Combinedaomfiuaib;
SET Combinedaomfiuaib;
IF VIRTRAD=1 THEN NEWVIRTRAD=1; ELSE NEWVIRTRAD=0;
PROC LOGISTIC DATA=Combinedaomfiuaib;
MODEL NEWVIRTRAD = country    size   lengthexist   explifespan   group  survey
   teambuild    comfrtgroup   satwork      cohesiv
 /BACKWARD;
OUTPUT OUT=OUT1 PREDICTED=POSTERIOR;
TITLE2 'LOGISTIC REGRESSION ANALYSIS OF VIRTUAL TEAMS DATA';
RUN;
```

In both instances, the model yielded a negative relationship between the dependent variable (VITRAD/NEWVIRTRAD) and the following variables:

- Member comfort level with group interactions.
- Member satisfaction with working conditions.

Efficiency of the Process

The process can be considered efficient for the following reasons:

1. The code was developed in modules, each of which may be executed separately.
2. Each may also be extracted for subsequent use in other analyses.
3. The logic is similar to the flowcharted processes of SAS Enterprise Guide. The code may be easily converted for use under SAS Enterprise Guide.
4. The approach and code may be used to validate instruments measuring any natural and behavioral phenomenon, especially those requiring the comparison of two or more groups.

CONCLUSION

Both methods yielded similar results. The key differences between virtual and traditional teams seem to lie in the following areas:

- Number of countries spanned by the team
- Respondent group
- Length of team's existence
- Composite variable representing member satisfaction with working conditions
- Member comfort level with group interactions
- Group cohesiveness

The sample from which the respondent came proved to be significant. It appears that different industries or different types of teams may yield different results. This finding suggests the need for further investigation of groups operating in different industries.

The findings suggest the possibility of cross cultural effects being more significant in influencing the activities of virtual teams as compared with traditional teams. Virtual teams, by reason of their relative newness as a workplace phenomenon, may need further consideration of the management of the human resources comprising these teams, to promote trust and greater satisfaction among members.

Member perception of leadership behavior did not prove to be significant in itself. Rather team members were more concerned with the outcome of leader behaviors and actions as manifested in the dynamics of the team in which they interacted.

Paper 380-2008

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Paper 380-2008

APPENDIX

TABLE 1

Reliability Statistics

	Cronbach's Alpha (raw)	N
All items	0.898356	174
Construct 1	0.894618	201
Construct 2	0.757360	183

TABLE 2

Factor Analysis Results

Factor	Question (s)	Related construct
1	1, 2, 4-6, 9, 10-12	Member perception of leader facilitation of team building
2	23, 25, 27, 28R	Member comfort level with group interactions
3	16, 19, 24	Member satisfaction with working conditions.
4	13, 14, 20	Group cohesiveness.

Results of Factor Analyses-Principal Components Method

Table 3 Significance Tests Based on 97 Observations- Maximum Likelihood Method

(with Heywood Option selected)

Test	DF	Chi-Square	Pr > ChiSq
H0: No common factors HA: At least one common factor	351	2157.7418	<.0001
H0: 6 Factors are sufficient HA: More factors are needed	204	279.4261	0.0004

Chi-Square without Bartlett's Correction	303.71131
Akaike's Information Criterion	-104.28869
Schwarz's Bayesian Criterion	-748.73597
Tucker and Lewis's Reliability Coefficient	0.92817

Note: The additional 2 factors, contributed only an additional 12% to variance of the model, than the 4 selected. The scree plot suggested that they could be excluded from the model.

Paper 380-2008

Instrument Capacity for Discrimination among Groups

Table 4(a) Class Level Information

virtrad	Variable Name	Frequency	Weight	Prior Proportion	Prior Probability
1	_1	90	90.0000	0.562500	0.562500
2	_2	70	70.0000	0.437500	0.437500

Table 4(b) Resubstitution- Number of Observations and Percent Classified into VIRTRAD

Number of Observations and Percent Classified into virtrad

From virtrad	1	2	Total
1	90	0	90
	100.00	0.00	100.00
2	0	70	70
	0.00	100.00	100.00
Total	90	70	160
	56.25	43.75	100.00
Priors	0.5625	0.4375	

Error Count Estimates for virtrad

	1	2	Total
Rate	0.0000	0.0000	0.0000
Priors	0.5625	0.4375	

Table 4(c) Crossvalidation- Number of Observations and Percent Classified into VIRTRAD

Number of Observations and Percent Classified into virtrad

From virtrad	1	2	Total
1	90	0	90
	100.00	0.00	100.00
2	0	70	70
	0.00	100.00	100.00
Total	90	70	160
	56.25	43.75	100.00
Priors	0.5625	0.4375	

Error Count Estimates for virtrad

	1	2	Total
Rate	0.0000	0.0000	0.0000
Priors	0.5625	0.4375	

Paper 380-2008

Table 5(a) The STEPDISC Procedure

Statistics for Removal, DF = 1, 187

Variable	Partial R-Square	F Value	Pr > F
country	0.1196	25.40	<.0001
lengthexist	0.0455	8.92	0.0032
explifespan	0.0086	1.61	0.2056
group	0.0837	17.07	<.0001
comfrtgroup	0.0394	7.67	0.0062
satwork	0.0602	11.98	0.0007
cohesiv	0.0454	8.90	0.0032

Variable explifespan will be removed.

No further steps are possible.

Table 7 Analysis of Maximum Likelihood Estimates (LOGISTIC Regression)

Analysis of Maximum Likelihood Estimates

Parameter	DF	Standard Estimate	Wald Error	Chi-Square	Pr > ChiSq
Intercept	1	3.3254	2.2258	2.2322	0.1352
country	1	1.2671	0.3025	17.5476	<.0001
lengthexist	1	0.6202	0.2033	9.3101	0.0023
group	1	-1.8007	0.5471	10.8325	0.0010
comfrtgroup	1	-0.3204	0.1074	8.8968	0.0029
satwork	1	- 0.3177	0.0951	11.1533	0.0008
cohesiv	1	0.2950	0.1046	7.9456	0.0048