THE EFFECT ON GAME PERFORMANCE OF DIFFERENT MEASURES AND UNITS OF ANALYSIS IN QUANTITATIVE ANALYSIS

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ABSTRACT

This paper compares the results from several analyses of variables influencing game performance in a total enterprise simulation. All games were played in teams and analyses were made both on an individual and a team basis. Antecedents included in the analyses are students efforts, time spent on decision making, grades, age and gender. The regression analyses on team basis gave a substantially higher R square than the analysis on individual basis. Also different measures for the dependent variable (performance) influenced results to a great extent.

INTRODUCTION

Numerous studies have been done by ABSEL members and others examining the relationship between game performance and a variety of independent variables including respondent characteristics, team characteristics, simulation characteristics and environmental characteristics. Many review articles (Faria, 2000; Keys, 1977; Keys & Wolfe, 1990; Miles, Biggs & Shubert, 1986; Wolfe, 1985) have summarized the research.

For many of the published studies in this field it is possible to detect all or most of the methods used in the research process (for instance Badgett, Brenenstuhl & Marshall, 1978; Gosenpud & Washbush, 1991; Hornaday, 2001; Hornaday & Wheatley, 1986; Lynch & Michael, 1989) while others do not go into details to the same degree. Also the choice of variables, both the dependent and the independents, and the measures, shows great variation. This fact could make a problem when comparing the results of different studies. Also other types of differences exist between studies, for instance the situational conditions. According to Gosenpud (1987) no independent variable consistently predicts simulation performance. Situational conditions are always important. No wonder there are many conflicting (and confusing) results regarding performance and possible explanations!

The purpose of this study is to detect possible differences in results when the unit of analysis and/or the measure for the dependent variable is altered. In order to do that this study is based on data from a previous study of undergraduate business students involved in total enterprise simulation (Glomnes, 2004). The main purpose of that study was to detect possible effects on game performance from variables connected with the students' efforts throughout the game. In addition several personal background variables like grades, age and gender were included in the study. The dependent variable was game performance measured as the value of the company at the end of the simulation. The games were played in teams. However, all the analyses were made on an individual basis. The study showed a positive and significant relation between performance and the students' efforts at carrying out special tasks and analyses and between performance and the students' expected grade in the course. Also males outperformed females. No significant relation was found between performance and variables like age, average grades from secondary school or college (GPA), time spent on decision-making or the students' use of a budget model.

The research questions in this study are:

1. To what extent will analysis on a team basis give different results from analysis on an individual basis when teams, not individuals, play?
2. To what extent will different ways of measuring the dependent variable give different results?

METHOD

The study is based on data from four different simulations in the years 1997-2001. The Norwegian simulator NHH-7 was used for all the games. Participants were second year university college students attending a business management course.

The games were played in teams and each team determined its own composition concerning the number of participants, gender, age etc. The teams consisted of two to five undergraduate students. The aim of the participants was through all the simulations to maximize long-term profits after tax and thereby the value of the companies. It is worth noting that the performance of the teams constituted no part of the grade obtained in this course. The students played with relatively little interference from the instructor's side through the whole game. The number of periods or decision cycles in each game varied between ten and twelve. The simulations went over three to five weeks. The number of periods per week varied between two and four.

The sample characteristics are shown in Table 1.

The sample equals the total population of 150 participants. An average response rate of seventy for the four years is considered acceptable. Both genders are equally well represented. However, a closer investigation of the sample shows that male losers and female winners are

TABLE 1
Sample characteristics

Year	1997	1998	2000	2001	Total
Number of groups	12	6	8	8	34
Of this: Female groups	4	1	0	0	5
Male groups	4	2	1	0	7
Mixed groups	4	3	7	8	22
Number of participants	48	24	40	38	150
Of this: Women	22	14	27	26	89
Men	26	10	13	12	61
Number of returned questionnaires	38	13	34	20	105
Of this: Women	18	6	23	15	62
Men	20	7	11	5	43
Response rate	79	54	85	53	70
Of this: Women	82	43	85	58	70
Men	77	70	85	42	70

underrepresented. This fact will influence the results to a certain degree.

The dependent variable (game performance) was the adjusted value of the company (measured as equity with smaller adjustments for inventory value, goodwill etc.) at the end of the game. The computer reported equity for each company after every period of the game. Because the adjusted value fluctuated from game to game, it has been categorized and related to the average adjusted value for each of the four games. The scale was as follows:

Adjusted value (7 categories)	Code
+ 25 per cent above average	7
15 - 25 per cent above average	6
5.1 – 14.9 per cent above average	5
Average +/- 5 per cent	4
5.1 – 14.9 per cent below average	3
15 - 25 per cent below average	2
+ 25 per cent below average	1

A dependent variable with seven categories could represent a lack of valuable information since adjusted value is a continuous variable. Therefore analysis with thirty one categories has also been carried out. In this case adjusted value could vary from 77 per cent below average up to 77 per cent above average with intervals of five percentage points:

Adjusted value (31 categories)	Code
72.1 – 77.0 per cent above average	31
67.1 – 72.0 per cent above average and so on	30
2.6 – 7.0 per cent above average	17
Average +/- 2.5 per cent	16
2.6 – 7.0 per cent below average and so on	15
67.1 – 72.0 per cent below average	2
72.1 – 77.0 per cent below average	1

In this study also rank points (based on adjusted value) has been used in an alternative analysis. Rank was categorized with eight different values:

Rank	Code
1.	7
2.	6
	and so on
7.	1
8.	0.5

The antecedents and measures were the following:

1. The number of special tasks and analyses each group carried out during the simulation (4 categories). The types of special tasks and analyses were: Developed one or more Excel models, made an income budget for one or more periods, made a balance budget for one or more periods, calculated demand functions for one or two products without the use of regression analysis, calculated demand functions for one or two products using regression analysis, calculated the effect of advertising and product development on price and/or quality, made investment analyses, made calculations for pricing,

made profitability analysis or other tasks/analyses specified by the students.
2. To what extent the team made active use of the budget model throughout the game (5 point Likert scale).
3. The time spent on making decisions per period per participant (4 categories).
4. Gender (female = 1, male = 2).
5. Age (4 categories).
6. Average grade from secondary school (9 categories).
7. Average grade from college (GPA, 6 categories).
8. Expected grade in the business management course (11 categories).

Data collection was carried out just after the simulations were finished. Data from the four years 1997, 1998, 2000 and 2001are included in the study.

All the information on grades was given by the students themselves and was not checked in any way. In addition to answering the questions the students used the opportunity to give comments. The participants answered the questionnaire under the condition of anonymity.

Also data was collected from the computer generated reports after each period of the simulations.

The analysis is carried out both on an individual basis and on a team basis.

a) Individual basis: Team performance and team characteristics were assigned to each individual in the team. In addition personal variables have been included in the analysis. Here N = 105 students.
b) Team basis: Team performance, team characteristics and personal variables were assigned to each team. Average values for the teams have been calculated for all the independent variables. In this case N = 34 teams.

Correlation and linear regression analyses has been used for the analysis of data. All the data from the four years have been treated as one big set of data.

RESULTS

Table 2 shows the correlation matrix both for the analysis on team basis and (in parenthesis) the analysis on individual basis.

TABLE 2
Correlation Matrix Analysis on team basis and (in parenthesis) on individual basis

	Mean	S.D.	ADV	NTA	UBM	TSD	GEN	AGE	GSS	GPA
ADV = Adjusted value (7 –point scale)	4.21 (3.93)	1.90 (1.61)								
NTA = Number of tasks and analyses	1.93 (1.90)	.82 (1.00)	.21 (.32**)							
UBM = Use of budget model	2.29 (2.35)	1.33 (1.47)	-.02 (.08)	.45* (.41**)						
TSD = Time spent making decisions per period	2.21 (2.20)	.65 (.71)	.07 (.16)	.54** (.49**)	.24 (.39**)					
GEN = Gender	1.41 (1.41)	.39 (.49)	.381* (.30**)	.17 (.14)	.03 (.06)	.081 (-.07)				
AGE = Age	23.72 (24.04)	2.12 (3.29)	.11 (.12)	.51** (.25*)	.24 (.20*)	.40* (.25*)	.08 (.09)			
GSS = Grades from secondary school	4.19 (4.18)	.37 (.53)	-.07 (-.01)	-.17 (-.04)	.17 (.14)	-.19 (-.01)	-.10 (.01)	-.04 (.04)		
GPA = Grades from college	2.34 (2.38)	.42 (.51)	.22 (.23*)	.16 (.09)	.38* (.27**)	-.29 (-.06)	.11 (.04)	.27 (.24*)	.38* (.25*)	
Expected grade from course	2.58 (2.58)	.34 (.41)	.30 (.29**)	.17 (.16)	.38* (.19)	-.13 (.08)	-.04 (-.03)	.16 (.25*)	.41* (.20*)	.78** (.67**)

**significant at the 0.01 level (2-tailed)
*significant at the 0.05 level (2-tailed)

The matrix shows only one correlation coefficient as high as .78 (expected grade from the course - GPA). This suggests that multicolinearity generally is not a great threat, but further analysis is done both with and without the independent variable GPA.

Table 3 shows the results of the regression analysis when the dependent variable is adjusted value (7 categories).

The model summary shows R square = .410 for the analysis on team basis against .277 for that on individual basis. This is a substantial difference! R square adjusted, however, is a little smaller for the analysis on team basis. Also most of the t-values decrease when the analysis is on team basis due to the reduced number of respondents.

TABLE 3
Regression analysis
Analysis on team basis and (in parenthesis) on individual basis
Dependent variable: Adjusted value (7 categories)

Model summary:		
R square	.410 (.277)	
Adjusted R square	.196 (.212)	
F	1.913 (4.301**)	
N	34 (105)	
COEFFICIENTS:	**BETA**	**T**
Number of tasks and analyses	.448 (.226)	1.887 (2.061*)
Use of budget model	-.322 (-.064)	-1.577 (-.594)
Time spent making decisions per period	-.068 (.090)	-.281 (.806)
Gender	.349 (.324)	2.022 (3.517**)
Age	-.092 (-.118)	-.428 (-1.208)
Grades from sec. school	-.078 (-.029)	-.409 (-.316)
Grades from college (GPA)	-.094 (.066)	-.285 (.504)
Expected grade from course	.471 (.288)	1.660 (2.306*)

Beta = standardized regression coefficients

**significant at the 0.01 level
*significant at the 0.05 level

As can be seen from the beta values, the three most important independent variables in the analysis on team basis are:

1. Expected grade from course
2. Number of tasks and analyses and
3. Gender.

When the analysis was made on an individual basis, the same three variables were still the most important, but the rank was different:

1. Gender
2. Expected grade from course and
3. Number of tasks and analyses.

In both cases these three variables all have a positive effect on game performance but this effect is only significant in the case of analysis on individual basis (sig. between .05 and .01). The explanation is that N is much bigger in this case (N=105 compared to N=34).

If the variable GPA is excluded from the analysis, naturally the t-values for the variable expected grade from the course improves both for the analysis on individual basis (from 2.306* to 3.168**) and the analysis on team basis (from 1.660 to 2.098*).

Analysis with a 31category dependent variable is shown in table 4

This analysis shows relatively small increases in R square, adjusted R square and most of the t-values when the analysis is done on a team basis, but a decrease in both R square, R square adjusted and t-values when the unit of analysis is individuals. Obviously the shift from seven to thirty one categories gave limited new information. The three most important variables are still expected grade from the course, gender and the number of tasks and analyses. All three variables still have a positive effect on game performance but the effect is only significant for the number

TABLE 4
Regression analysis
Analysis on team basis and (in parenthesis) on individual basis
Dependent variable: Adjusted value (31 categories)

Model summary:		
R square	.438	(.235)
Adjusted R square	.234	(.164)
F	2.145	(3.303**)
N	34	(105)

COEFFICIENTS:	**BETA**		**T**	
Number of tasks and analyses	.517	(.187)	2.229*	(1.541)
Use of budget model	-.353	(-.059)	-1.773	(-.513)
Time spent making decisions per period	-.118	(.050)	-.502	(.421)
Gender	.323	(.341)	1.915	(3.449**)
Age	-.093	(-.097)	-.445	(-.922)
Grades from sec. school	-.016	(-.022)	-.086	(-.229)
Grades from college (GPA)	-.149	(-.004)	-.462	(-.030)
Expected grade from course	.521	(.289)	1.882	(2.170*)

**significant at the 0.01 level
*significant at the 0.05 level

TABLE 5
Regression analysis
Analysis on team basis and (in parenthesis) on individual basis
Dependent variable: Rank points

Model summary:		
R square	.516	(.273)
Adjusted R square	.341	(.208)
F	2.938*	(4.178**)
N	34	(105)

COEFFICIENTS:	**BETA**	**T**
Number of tasks and analyses	.574 (.246)	2.667* (2.208*)
Use of budget model	-.219 (.018)	-1.183 (.163)
Time spent making decisions per period	-.333 (-.175)	-1.522 (-1.559)
Gender	.453 (.376)	2.899** (4.034**)
Age	-.183 (-.192)	-.948 (-1.948)
Grades from sec. school	.133 (.060)	.769 (.638)
Grades from college (GPA)	-.114 (.031)	-.382 (.235)
Expected grade from course	.341 (.171)	1.330 (1.349)

**significant at the 0.01 level
*significant at the 0.05 level

of tasks and analyses in the case of analysis on a team basis and for gender and expected grade from the course when the unit of analysis is individuals.

If the variable GPA is excluded from the analysis, the t-values for the variable expected grade from the course improves both for the analysis on individual basis (from 2.170* to 2.622**) and the analysis on team basis (from 1.882 to 2.232*).

Analysis with a rank variable (8 categories) as dependent variable is shown in table 5.

It is interesting to see that R square in this case increases to .516 and that R square adjusted moves up to .341when the analysis is on a team basis. The F-value has now become significant. This result clearly shows that the choice of measure for the dependent variable has a substantial effect on the results. The rank variable obviously catches valuable information not reflected in the other dependent variables in use. In both types of analysis the variables number of tasks and analyses and gender show a positive and significant effect on game performance.

If the variable GPA is excluded from the analysis, the t-values for the variable expected grade from the course improves both for the analysis on individual basis (from 1.349 to 1.821) and the analysis on team basis (from 1.330 to 1.523).

CONCLUSION

According to Gosenpud (1987) there is a problem using participant characteristics to predict team simulation performance because of the mixture of characteristics that is to be found in teams of three members or more. It seems reasonable to assume that team characteristics can best

predict team performance and individual characteristics individual performance.

In this study team and individual characteristics have been used to predict team performance. Unit of analysis has been both teams and individuals. The study shows that regression analysis on team basis gives a substantially higher R square than analysis on individual basis, and in two cases of three also higher R square adjusted. The variables number of tasks and analyses, gender and expected grade from course all have a positive (but not always significant) effect on game performance in both types of analyses. The answer to the first research question of this study is therefore that different units of analysis can give very different results. This supports the above mentioned view of Gosenpud (1987).

When the measure for the dependent variable is changed, the results will of course vary. This study shows that the introduction of a rank variable (8 categories) increases both R square and R square adjusted considerably and significantly compared to analyses with both a seven and a thirty one categories dependent variable. The answer to the second research question must therefore be that different ways of measuring the dependent variable can give very different results.

The conclusions here are probably not dramatic, but it is perhaps worth while to reconsider from time to time methods used when we carry out and compare results from research on simulation performance. At least the author of this paper has learned from carrying out and comparing these analyses.

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