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Forecasting and Control of Aptitude Test Scores: A Human Resource Management Analysis

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ABSTRACT

The present research study is designed to investigate the factors affecting aptitude test score of undergraduate students of a leading coaching class of India. The variables under consideration were the GRE score (student's grades/marks) as a dependent variable and the initial marks in Verbal, Quantitative, 10^{th} Grade, 12^{th} grade, father/guardian social economic status, and daily study hours were independent variables. The data is collected from 722 students of Swati Jain Academy through separate structured questionnaire, using the simple random sampling technique and through an initial mock GRE evaluation test. For analysis, linear regression model, correlation analysis, and descriptive analysis were used. The findings revealed that father/guardian social economic status, the percentage of 10^{th} and daily study hours significantly contribute to the academic performance of graduate students. A linear model was also proposed that will be helpful to improve the GRE/GMAT/SAT score of students from countries like India.

Keywords: Educationmetric, Coaching, Aptitude Test, Forecasting, Control

1. INTRODUCTION

In this educationometric study an attempt has been made to estimate the relationship of Graduate Record Exam (GRE) score and its determinants and there by forecast the GRE score and control its determinants.

More than seven lacs students per year from the whole world take GRE and many other similar tests like Graduate Management Test (GMAT), Scholastic Aptitude Test (SAT).

Out of these one lac are from India itself (OIE, 2013). Many students take professional coaching for improving their scores. The significant change in the scores of students will confirm the hypothesis that a successful coaching curriculum is helpful in improving their performance at final GRE score.

My twenty five years experience as a successful coach of aptitude tests has encouraged me for an educationometric study to find out determinants which can forecast and control the scores of these tests. The significant change in the scores of students of my own Academy confirms my belief that a successful coaching curriculum can control the parameters of aptitude tests.

This study is based on a comprehensive data from the students taking these tests. The students were enrolled in Swati Jain Academy for last five years. In all 722 students are taken into study.

An assumption underlying the interpretation of these scores is that students are well prepared by their schools for the basic skills tested. Yet, not all the students perform well in these tests and are unable to get admission into the colleges of their dreams. Critics for these tests question the appropriateness or accuracy of numerical measures of individual's worth, especially when it is multiple-choice questions (Owen, 1985). They also ask if the test measures the full range of aptitude and intelligences that American education seeks (Gardner and Hatch, 1989).

2. REVIEW OF LITERATURE

"Assessment is a process which involves the systematic collection, analysis, and integration of information; the main goal of the educational assessment process is to interpret learning patterns for students" (1994, Hoy). One

of the most important goals of education is assessment of knowledge and capabilities. Educating people from different cultures and their assessment is a challenge for global education. One of the goals of "Education for All" refers to 'recognized and measurable learning outcomes' being achieved by all (Goldstein, 2004).

Assessment of student's performance is often characterized as either formative or summative evaluation (kozleski.et.al, 2000). The former is conducted on a regular basis and later is conducted after a lengthy period of study. Cumming says the main goal of assessment is to evaluate how efficiently students perform (skill), what conviction they hold (values, attitudes), how much potential they have for learning (aptitudes).

Sui (589-618 A.D.) emperors of China are believed to have first developed the rigorous forms of evaluation of formal educational achievement (Miyazaki, 1981). Then it expanded to west. According to Ikuo Amano (1990) Prussia in 1748 was the first European society to rely on written assessment tests and then middle nineteenth century he called as the age of examinations. University education became prerequisite for seeking government office, thus leading to competition for university entrance (Ringer, 1974).

In this multicultural environment, it becomes important to find the determinants of global tools for measuring the achievement and attitudes of students from all cultures and nations. As Blum et al. (2001) points out there are certain things that are culturally or educationally specific so that exact translations are impossible, and in many cases it is not possible to predict in advance which these item are.

GRE Guide to the Use of Scores by ETS says, "Men generally have higher mean scores in these standardized tests. Non-U.S. women have a higher mean score on the verbal measure and mean scores for non-U.S. citizens are higher than those for U.S. citizens on the quantitative and analytical measures, and lower on the verbal measure" (Educational Testing Service [ETS], 2005). There are large discrepancies in the abilities of students to perform well in these exams and coaching serves to level the playing field. Kumar **(2011**) establishes correlation between IQ and test scores.

Besides citizenship and gender there are other factors like culture, bilingualism, aptitude and high school training that affects in the scores in the individual section of the test takers. Ali(2013) concludes that the parents having high income cause of high test score. Study time is one of the most important factors affecting the student scores. The correlation strength among test score and study hour is positive and greater than the age and income factor. Research conducted by ETS shows that, "An applicant with 300 on the verbal measure and 800 on the quantitative measure is very different from an applicant with 800 on verbal and 300 on quantitative. The former applicant might do well in a mathematics program, but the latter probably would not. Similarly, the student with 800 on the verbal measure might have a high probability of success in an English literature program." (Educational Testing Service [ETS], 2005, p. 4). Since one of the criteria for judging a students' eligibility for admission into top universities is the score in these standardized tests, many students seek out coaching with well designed courses with the hopes that they can improve their test scores. Students who do not score well in these tests because of the quantitative section; sometimes are very bright in reading and writing. Just because of their deficient mathematical knowledge they drop the idea of attending a good university. Now, in the multidisciplinary era, it is becoming more important for universities to admit students who have good mathematical skills. Wheelock writes the words by Iris Carl, "There has been a mentality that you have to be ... special to be successful in mathematics, that you have to be the best and the brightest. Well, we are demystifying mathematics. We can no longer say that there is any segment of society that doesn't need mathematics." (Wheelock, 1998, p.227). With mathematics, coaching plays an important role in closing the gap between students' abilities.

Test preparation did improve test scores, but the effects were primarily from preparation practices via narrowing the curriculum, especially drilling. Although the effects were small in absolute terms, they represented almost one third of the effects from the pretest.(Quin, 2013). My twenty five years of experience as a testing coach confirms my belief that a successful coaching curriculum engages the mental, emotional, philosophical, and spiritual parts of students; the term "coaching", when applied to test preparation programs, involves maintaining rapport between the instructor and student through matching the general degree of eye contact, noticing and adjusting to any unique cultural, language, etiquette or behavioral norms, noticing key facial expressions, and observing personal space perimeters (Bandler & Grinder, 1986).

Coaching has been determined to be a critical factor for attaining successful results with adult learners (Reece, 1993). Coaching programs that adhere to strict practice, drill, and feedback show a significant positive effect on math scores for adult students (Reynolds & Oberman, 1987).

3. HYPOTHESIS AND RESEARCH METHODOLOGY

3.1.1 Hypotheses Related with the Causal Educationometric Analysis

The marks in verbal section x_{2i} which a student gets in his first evaluation test is an important determinant and is hypothesized to be positive and significant determinant for the estimation of final GRE score . The

marks in the quantitative section x_{3i} which a student gets in his first evaluation test is an important determinant and is hypothesized to be positive and significant for the estimation of final GRE score.

The marks in 10^{th} grade x_{4i} which a student gets in his first evaluation test is an important determinant and is hypothesized to be positive and significant determinant of final GRE score. The marks in 12^{th} grade x_{5i} which a student gets in his first evaluation test is an important determinant and is hypothesized to be positive and significant determinant of final GRE score. The Financial background of parents x_{6i} is an important determinant and is hypothesized to be negative and significant determinant of final GRE score. The number of hours spent per day for studies (also called stamina) x_{6i} after the class is an important determinant and is hypothesized to be positive and significant of final GRE score.

3.1.2 Residuals(Observed Test Score- Estimated Test Score) are Useful for Ranking of the Students.

3.1.3 The Mean Final GRE Score is Greater than Mean Score Before GRE.

3.1.4 The Estimated Causal Model is Valid for Forecasting of Final GRE Score.

3.1.5 The Estimated Model is Useful for Controlling of the Determinants.

3.2 Research Methodology

This section describes the research methodology needed to empirically test the previous chapter. This study explores the determinants of GRE score and its forecasting and control.

3.2.1 Multiple Regression Equation for Determinants

$$Y_i = \beta_1 + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_4 \ldots\ldots\ldots\ldots \beta_k x_k + u_i \quad \ldots 3.1$$

Where Y = Final GRE score in the actual exam

$x_{2i}, x_{3i}, x_{4i}, \ldots\ldots\ldots\ldots\ldots\ldots x_k$ are determinants of GRE.

Description of variables for analysis of determinants

x_{2i} – English Score when student joins

x_{3i} – Mathematics Score when student joins.

x_{4i} – % of 10^{th} class

x_{5i} – % of 12^{th} class

x_{6i} – Financial background

x_{7i} – Stamina of the student(hours for GRE preparation/day)

3.2.2 Analysis for Ranking of Performance

Using the multiple regression 3.1 all residuals (722) will be calculated and the highest positive residual will be observed. The positive residual related student is the best and highest negative residual student will have the last rank in the GRE performance.

3.2.3 Comparison of Mean Score using Regression on Dummy Variable

$$Y_i = \alpha_1 + \alpha_2 D_i + u_i \quad \ldots(3.2)$$

$D_i = 1$ for Final GRE score

$D_i = 0$ for initial GRE score

Mean final GRE Score: $E(Y_i / D_i = 1) = \alpha_1 + \alpha_2$

Mean initial GRE Score: $E(Y_i / D_i = 0) = \alpha_1$

The difference is α_2. If α_2 is positive and significant the coaching may be treated beneficial.

3.2.4 Forecasting of GRE Score

Using estimated equation 3.1 forecasting of GRE score is proposed on various combinations of the determinants.

3.2.5 Control

Using estimated equation 3.1 controlling of determinants is proposed.

4. DATA

4.1 Database

Data is collected from one of the leading coaching class of India situated in Indore. This is a collection of data from the year 2006 to 2013.

The number of students was not predetermined; a questionnaire was distributed to know the number of hours devoted to study and income of their parents. The population of the study included all students admitted in the coaching class of Indore. These students were taking GRE test in order to be admitted to University abroad. The sample size was students from a single coaching class of Indore. No specific sample size of students was predetermined but the process of judgment sampling was adopted. However, only those students were taken who were admitted in last 5 years. The students were from 12^{th} to final year students and also some of them were working. The age group was between 18 to 25 years in general.

The total sample size of 722 students was taken. The students included in the sample frame were students from all financial backgrounds, girls and boys both, all age groups, all disciplines like Engineering, Medical, Agriculture, Dental, Management, and High school. This entire group was chosen from Indore only.

The study was restricted to the Indore city in Madhya Pradesh state. Indore is Educational hub of MP. The city has 3 Medical colleges, 50 Engineering Colleges and all kinds of best colleges. The coaching is 25 years old and catering to almost all kinds of students.

The study is fully based on primary data. The tools constructed for data collection was questionnaire and a test given to students from a sample collected from coaching.

4.2 Dependent Variable (GRE Score)

The objectives of this study was forecasting and controlling the results of an Aptitude Test like GRE and identifying the factors controlling the scores. The dependent variable is GRE score. Understanding the relationship of score with the determinants through which it can be calculated. Data screening process was done to ensure that questionnaire obtained was appropriate for the research in terms of completeness. It was then followed by statistical analysis and finally data was subjected to descriptive and inferential analysis through Linear Regression Model and Comparative Equation for Means (Regression on Dummy variable).

4.3 Independent Variables (Determinants)

Working with the Hypotheses that GRE score can be estimated if we note certain factors such as the initial background of a person, the independent variables are noted down for continuously 5 years. All variables are chosen as it is. For example, the GRE score varies from 400-1600, so individual scores are taken without any calibrations. Similarly, the verbal and quantitative scores varies from 200-800. They are also taken as they were noted. The 10^{th} and 12^{th} percentage was taken as from 0-100%. The income was noted from 3-15 lacs per annum. The number of hours given are noted as stamina and were asked by the students.

The information collected and filled questionnaire was categorized according to research variable and constantly compared to the related literature review in order to clearly understand the particular phenomenon understudy and the research into particular context.

The educational background related questions consisted of percentages in 10^{th} ,12^{th} and undergraduate classes. The schooling from what type of High School whether private, public or semiprivate. The occupation of parents and their socio-economic status, whether in business or government job, or private company job were the questions included. Finally a survey was conducted about the number of hours given for studies.

An evaluation Test consisting of various items of aptitude test is given to students. The questions are based on reading passages such as inference, factual, nonfactual, main idea. Also, sentence completion and analogies questions are asked in verbal section. The marks are obtained out of 38. In quantitative section word problems and quantitative comparison problems are asked. The marks are obtained out of 30. Finally, the raw scores obtained are doubled. For example if a student got 24 in verbal and 25 in quantitative, so his score was taken as 48 and 50. These scores were converted in an edited score through a table in appendix-A. So the edited scores were 520 and 720, which were used for calculating the final score. Here the final score is 1240 out of 1600. Hence scores are controlled and forecasted.

The marks are noted. A form is given to student to understand his family background. Final scores are asked from students once they have takes final test and noted down which is dependent variable.

5. EMPIRICAL ANALYSIS

Understanding the determinants of aptitude tests and the forecasting of score has become a serious concern as these days almost all exams for higher education or jobs have aptitude tests. Can these test be predicted or can be forecasted and controlled is the objective of this study.

In the present chapter, the empirical analysis and interpretation of the study "Determinants of Aptitude Test Scores with Forecasting and Control" conducted on the students of a coaching class in Indore Madhya Pradesh. The data collected were redrafted and tabulated in order to forecast and control the scores of aptitude tests.

5.1 Estimated Multiple Regression Equation

$$\hat{Y}_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i.....} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_7 \qquad (...5.1)$$

$$\hat{Y}_i = 722.488 + 0.249x_{2i} + 0.217x_{3i} + 5.026x_{4i} + 0.228x_{5i} - 13.376x_{6i} + 3.820x_{7i}$$

Stan.err→(37.772) (0036) (0.022) (0.315) (0.297) (0.798) (1.434)

t → (19.148) (6.841) (9.669) (15.944) (0.768) (16.766) (2.663)

sig→ (0.000) (0.000) (0.000) (0.000) (0.442) (0.000) (0.008)

R square = 0.707

Adjusted R square = 0.705

F = 287.875

sig (0.000)

The overall model is highly significant. All other coefficients of determinants are highly significant except x_5 [% of 12^{th}]. The coefficient of x_5 is less hence its contribution is less too. Hence, income versus GRE relationship is negative. This is significant too. Hence income and 10^{th} grade marks are important in estimating GRE score.

5.2 Estimates of the Residual Analysis for Ranking of Performance

The highest residual is 279.393 The student (no. 182) has got highest positive residual. He has x_2 =370; x_3=340 ; x_4= 85; x_5 = 55; x_6 = 15; and x_7= 6

$$Y_{182} = 722.488 + 0.249x_{2,182} + 0.217x_{3,182} + 5.026x_{4,182} + 0.228x_{5,182} - .376x_{6,182} + 3.820x_{7,182} + u_{182}$$

$$= 722.488 + 92.13 + 73.78 + 427.29 + 12.54 - 200.55 + 22.92 + u_{182}$$

$$1430 = 1150 + u_{182}$$

$$U_{182} = 1430 - 150$$

$$= 280$$

The observed score (final GRE score) of the student is 1430. The estimated value as per regression model is 1150. The difference is positive and equal to 280. In the causal modeling the student number 182 is relatively the best. Causal ranking of students can be made using the residuals. The details of residuals are mentioned in appendix B. The highest negative residual related student is having last rank relatively.

5.3 The Effectiveness of Coaching

This is calculated through comparative means equation (dummy variable).

$$\hat{Y}_i = 838.463 + 373.878D_i$$

S.E → (6.630) (9.3790)

t → (126.447) (39.860)

sig → (0.000) (0.000)

The initial mean GRE score = 838.463

The final mean GRE score = 838. 463 + 373.878

= 1212.34

The difference (α_2 = 373.6) between means is positive and significant with 100% confidence level. Hence it may be concluded that the coaching is effective and beneficial.

5.4 Forecasting of the Final Score

The forecasting of the final scores of the students admitting can be done based on residual.

$$\hat{Y}_i = 722.488 + 0.249x_{2i} + 0.217x_{3i} + 5.026x_{4i} + 0.228x_{5i} - 0.376x_{6i} + 3.820x_{7i}$$

Let a student gets 500 in verbal and 600 in quantitative in the first evaluation. He has 50 % in 10^{th} grade and 60% in 12^{th}; his parent's income is 15 lacs per annum and has a capacity to study (outside the class) for 3 hours/day then

$$\hat{Y} = 722.488+.249(500)+.217(600)+5.042(50) +.228(60) - 13.37(15) +3.82(3)$$

$$= 722.488+124.5+ 130.2+252.1+ 13.68 - 200+11.46$$

$$= 1054$$

Similarly for other possible combinations, the forecasting of GRE score can be made.

Table- 5.1

S.No.	Y FORECASTED	VERBAL x_2	QUANT x_3	10^{th} % x_4	12^{th} % x_5	INCOME x_6	HOURS/DAY x_7
1	1348.332	290	690	85	75	5	7
2	1268.498	320	660	75	75	7	6
3	1337.32	370	700	75	75	4	8
4	1332.256	590	710	60	75	3	8
5	1416.314	540	720	85	55	5	8
6	1328.954	530	550	75	65	5	8
7	1097.186	200	380	75	40	13	8
8	1260.458	420	700	85	75	15	10
9	1057.978	180	340	85	85	20	10
10	1241.998	450	570	85	85	15	10
11	1252.24	200	610	*75*	*65*	5	6
12	1071.58	200	470	*45*	*85*	7	12
13	1279.578	450	590	*65*	*85*	5	10
14	1184.806	280	240	*75*	*85*	7	10
15	1181.108	250	740	*75*	*95*	15	10

5.5 Controlling of the Score

Controlling of the score is estimated by

$$\hat{Y}_i = 722.488 + 0.249x_{2i} + 0.217x_{3i} + 5.026x_{4i} + 0.228x_{5i} - 13.376x_{6i} + 3.820x_{7i}$$

A student who has 400 verbal, 600 quant (1000 total) and parent's income is 3 lacs /year got 90% in 10^{th} and also 90% in 12^{th} wants to score 1420, then he has to spend 10 hours outside the class.

$$1420 = 722.488 + 0.249(400) + 0.217(600) + 5.026(90) + 0.228(90) - 13.37(3) + 3.820x_{7i}$$

By this model the control of GRE score may be made by changing one or more determinants (x_i) to plan for Y_i. However, in the present empirical control analysis apart from 2 hours regular common class, other determinants are fixed for individuals. An hour estimates are as follows:

Desired score (Y=1300)	X_2 verbal	X_3 quant	X_4 10th %	X_5 12th %	X_6 parent income	X_7 controlled) hour/day
1100	400	600	90	90	3	-74.6173
1200	400	600	90	90	3	-48.4393
1300	400	600	90	90	3	-22.2613
1350	400	600	90	90	3	-9.17225
1380	400	600	90	90	3	-1.31885
1390	400	600	90	90	3	1.298953
1400	400	600	90	90	3	3.916754
1420	**400**	**600**	**90**	**90**	**3**	**9.152356**
1440	400	600	90	90	3	14.38796
1460	400	600	90	90	3	19.62356
1470	400	600	90	90	3	22.24136
1600	400	600	90	90	3	56.27277

As per the table above, we can see that a student with 1000 initial scoreout of 1600, 90% in 10^{th} and 12^{th}, and 3 lacs as family income, needs to spend about **nine** hours outside the class– reading English newspaper, reading novels, doing practice tests online, going over preparatory material, etc – in order to get 1420 score. In the table no. of hours spend has a range in negative numbers (from -74 to -1) suggesting the amount of attention the student pays in the class. If he pays little attention, he can get 1100; similarly, if he pays meticulous attention and absorbs most of the content of the class, he can easily get 1380. Also, it is difficult for the student to get more than 1460.

6. CONCLUSION AND POLICY IMPLICATIONS

This study is an attempt to estimate the causal scholastic relationships between GRE score and its determinants (initial verbal and quantitative score, percentages of 10^{th} and 12^{th}, parental income and number of hours/day given outside the classroom coaching.

Empirical analysis of the data through Estimated Multiple Regression Equation was conducted. It was found that the overall model is highly significant. All other coefficients of determinants are highly significant except percentage of 12^{th}. The coefficient of percentage of 12^{th} is small; hence, its contribution is less. Also, family income versus GRE score relationship is negative. This is significant too. Family income and 10^{th} grade marks are most important in estimating GRE score. Ranking of GRE performance is reported.Using the multiple regression equation, all residuals (722) were calculated and the highest positive residual was observed.

The estimation of the best student is done by Highest Positive Residual model. The student who got the highest positive residual was concluded to be the best student, even though student's score was not the highest. The predicted value as per regression model is calculated and based on mean score it is estimated. The original values of Y (GRE score) and its determinants related with this highest positive residual was a standard combination for relevant policy purpose.

The effectiveness of coaching is calculated through comparative means equation (dummy variable). The difference between means is positive and significant with 100% confidence level. Hence it is concluded that the coaching is effective and beneficial.

This educationometric study forecasts and controls the determinants of the aptitude test – Graduate Record Exam (GRE). And, this research finding is also applicable to other similar tests designed by Educational Testing Service (ETS), New Jersey, USA with Graduate Management Test(GMAT) and Scholastic Aptitude Test(SAT).

Forecasting of the final score of a student entering is estimated based on estimated regression model. Similarly, for other possible combinations, the GRE score can be forecasted based on estimated regression model.

Controlling of the score is estimated by Regression Equation. The only controlling parameter in the equation is the time that a student spends outside the class to study, keeping all other parameters constant. Through the results estimated by Regression Equation, it is observed that sometimes students cannot get desired score even if they study for 24 hours. Also sometimes

even with good marks in 10th grade and other positive factors, one may not get a great GRE score in the final exam. The reason may be related to anxiety during exam, some natural calamity, accident or death in the family or may be illness during or before exam.

The data analysis made it clear that through proper coaching a good score can be achieved by students. This research can be used to know the extent to which coaching helps in the preparation of standardized tests. A significant improvement is observed in the scores of students from the day they join the class to the day they take the final test. These better results are because of time spent at coaching for greater clarity of the fundamentals, practice-drills, psychological support, exposure to real exam, and weaknesses improvement.

The results show that the most important controlling factor after a student joins is the time utilized at and after the coaching. In general, the results are very significant and can be used in policy making.

Hence, the causal educationometric analysis that estimates the relationship between GRE score and its determinants is useful for predicting the GRE score and controlling the maximum possible determinants especially the study hours to increase the score. The coaching is significantly useful. The relative causal ranking of the performance is also useful in the relevant policy analysis.

This research work could be used for human resource management of the students appearing in GRE/GMAT/SAT/ACT and other such examinations.

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