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Comparability of the Effect of Re-Scrutinizing on Two University Selection Methods, ZScore and Common Currency Index (CCI) Method in Sri Lanka

P.S. Yatapana[1]andM.R. Sooriyarachchi[2]
[1]*Institute of Technology, University of Moratuwa, Sri Lanka*
[2]*Department of Statistics, University of Colombo, Sri Lanka*

Abstract: The CCI Method was mathematically and statistically tested and proved as an improved method to the current university selection method, ZScore. Education of Sri Lanka is entirely free and students are selected to limited capacity of the state universities by the GCE(A/L) examination. The CCI method is a simple and easily understood method which selects the top most students in each combination without distorting their earned raw marks at the examination. The raw marks contain values such as ability, efforts made by the student, parents and the society, and the raw marks uniquely determine the level of the student. Two data sets of raw marks for symmetric and more skewed were generated by means of an additive model taking the student intelligent effect and the error measurement as random, and the subject effect as fixed. The generated raw marks of three combinations in each data set were ranked according to the ZScore and CCI method. 3% of the student marks was assumed to be re-scrutinized and increased 5 – 20 marks randomly and ranked. The effect of the re-scrutiny was measured by way of the rank differences made by each selection method for original and re-scrutinized marks and studied descriptively and with Non-Parametric statistical procedures. It was concluded that CCI method is far more robust when compared to ZScore method for re-scrutinizing and it would help to speed up the University selection procedure at least by three months. By introducing CCI method for university selection, Sri Lankan GCE (A/L) examination system can be tuned to select the best set of students for human resource development.

Keywords:CCI, ZScore, Scrutinizing, ranks, GCE(A/L), Selection

1. Introduction

1.1 Background of the study

Sri Lankan national education system which is under free education has been designed to select the best set of students out of the total student body in the country to be admitted to National Universities. The selection is based on the GCE(A/L) Examination, a curriculum based examination. Currently, there are only 14 National Universities and four Institutions in the country. Nearly, 15% of those qualified, are admitted to universities. Hence, University admission is highly competitive.

The selected students are trained to produce the best human resource of the country. If the selected students are not the best, then the quality of the human recourses produced from universities will be weak and thus it will directly affect the economy and the development of the country. Furthermore, the capable students who are not selected will become frustrated and inevitably create a social instability and become anti-social.

Before 2001, there were limited subjects in each field of study, Mathematics, Biology, Commerce and Arts and students had to select four compulsory subjects for the GCE (A/L) Examination and the selection criteria was the average of raw marks. In order to produce more job opportunities and to face the future challenges in the job market, the GCE (A/L) examination system was changed and many new subjects were introduced to GCE (A/L) Examination. The selection criteria too was changed to Zscore method in order to avoid unnecessary advantages gained by offering easy subjects to enter the University. Accordingly, since 2001, the students have had to opt for three subjects out of the many subjects in different study fields and sit for a common general paper for their GCE (A/L) examination. In order to qualify for university admission, students have to get at least three passes and a minimum mark of 30% for the common General paper.

Several researchers have studied the selection criteria, ZScore method and proved that the Zscore method is not an efficient method to select the best set of students to Universities and have suggested better methods to the zscore (Yatapana, Sooriyachchi, 2006),. (Yatapana, Sooriyachchi, 2014 (1), (Yatapana, Sooriyachchi, 2014(2)), (Senarathne,Wijekoon, 2016).

The methodologies used in other countries for university admission cannot be applied to Sri Lanka because, the purpose, the design of the education system and the design of examination papers and marking system are specific to Sri Lanka and is totally different from other countries. But, the UK examination system is similar to ours, though examinations are conducted by different boards. However, this is not under a free education system. (Goldstein and Cresshwell, 1996)

Currently, in Sri Lanka, after conducting the GCE (A/L) examination, the results are released in three months together with the grading of their subjects, Zscore values and their ranks. Next, students, if required, are allowed a one-month time to apply for re-scrutinizing. Afterwards, it takes another one to two months to complete the re scrutinizing process and to release the cutoff mark levels together with the new Zscore values and new ranks of all students for University admission. But, before, 2001 University ranks and the selection index values were released only once and students were selected for admission. Changes due to re-scrutinizing were informed to those students applied for re-scrutiny and selections were performed afterwards. Because of the ranks based on the Zscore values vary dramatically, University admission is delayed until re-scrutinizing process is completely over. Therefore, this study is aimed to compare the effect of re-scrutinizing on the Z score method and the Common Currency Index (CCI) method.

2. Material and Methods

2.1 Selection Methods

2.1.1 ZScore

The current University selection method in Sri Lanka is the ZScore method and the ZScore is calculated with the Equation 1,(Yatapana, Sooriyachchi, 2006).

If X_j is the raw mark of a student for the j[th] subject in any selected combination where $j = 1,2,3$ then,

$$Zscore = \frac{1}{3}\left[\frac{X_1 - \overline{X_1}}{S_1} + \frac{X_2 - \overline{X_2}}{S_2} + \frac{X_3 - \overline{X_3}}{S_3}\right] \quad .....(1)$$

Where , $\overline{X_j}$ and S_j are the mean and the standard deviation of the jth subject of that particular combination respectively. Ranking for University admission is performed, after considering all the Zscore values of the students in all the combination of subjects.

2.1.2 Common Currency Index (CCI) Method

The concept of exchanging different currencies is considered as the basis of this method. This method is simple, transparent and can be understood by the general public as people are familiar with currency conversion. Further, it selects the top most students in each combination without distorting their earned raw marks at the examination.

For example, to compare Sri Lankan Rs. 200 and 35$ and find out which amount is more valuable, the SLR 200 can be converted to dollars or 35$ can be converted to SLR or both 200 and 35 $ can be converted to the third type of currency (Say Euro) and then it can be identified which amount is higher.

So, in the same way the raw marks average (Combination Marks) of all students in each combination are converted to a same type of combination marks and rank according to the converted marks. In order to perform this conversion, it is important to calculate the conversion factor for each currency, which is called the Common Currency index (or combination effect) of each combination. It is the weight of one combination mark in terms of any particular type of combination marks. (the lowest combination effect type mark is better as converted marks do not exceed 100, the maximum mark of an examination paper). These combination effects are calculated by equating the average of combination marks of all the students in each combination considering only the Between Combination Competitors 'marks.

The Common Currency Index method is explained in detail in following web pages;
http://www.iaea.info/documents/paper_226e234744.pdfand
https://www.atiner.gr/papers/EDU2014-0923.pdf.

2.2 Generation of Subject Raw Marks depending on their subject and the student effect

Two data sets, symmetric and more skewed were generated by means of a linear model taking the student effect and the error measurement as random, and the subject effect as fixed. Then, raw marks for five subjects were generated for each data set and made combinations for three subjects separately for each data set.

Since, the GCE (A/L) examination is a curriculum based examination and the examination papers are marked according to a marking scheme, the marks of an examination paper on a subject is calculated by adding the marks given to each step. Since, raw marks are additive, subject raw marks in any combination are generated using an additive model. Consequently, the raw mark of the i^{th}student in the j^{th} subject (y_{ij}) is assumed to be a linear combination of Subject Effect (Su_j), students' level of intelligence (St_i) and the random error (e_{ij}). Accordingly, the additive model (2) is used to calculate the subject raw mark (y_{ij}).

$$y_{ij} = \mu + Su_j + St_i + e_{ij} \qquad (2)$$

Where,

y_{ij} = raw marks of the i^{th} student for the j^{th} subject,

Su_j = effect of the j^{th} subject (fixed)

St_i = i^{th}student's ability (student ability includes his intelligence level and his devotion) which is random

e_{ij} = random error for the j^{th} subject of the i^{th} student, μ is the grand mean, an arbitrary constant.

Here, the Subject Effect is considered as a fixed effect since the particular subject is common to all the students in any combination. The Student Intelligence is considered as random effect, because it depends on the individual student's ability which includes his intelligence level and his devotion.The student's social factors other than intelligence and devotion are the major part of the unexplained error variation. The variation ofY_{ij} is controlled up to some extent in an examination because WC competition students are subjected to similar subject contents, level of difficulties of exam papers, time duration given for theexamination etc. It is assumed that St_i has a particular distribution and error, the $e_{ij}$is the unexplained variation where $e_{ij} \sim N(0, \sigma^2)$.

Table 1: Distributions of the Students' ability and the random errors used to generate raw marks along with their parameters

Data set	Student Ability	Random Errors				
		Subject - 1	Subject - 2	Subject - 3	Subject - 4	Subject - 5
1	N (0,12^2)	N(0,10^2)	N(0,8^2)	N(0,5^2)	N(0,7^2)	N(0,6^2)
2	Exp (0.2)	N(0,10^2)	N(0,8^2)	N(0,5^2)	N(0,7^2)	N(0,6^2)
3	N (0,20^2)	N(0,10^2)	N(0,8^2)	N(0,5^2)	N(0,7^2)	N(0,6^2)
4	G (2,25)	N(0,10^2)	N(0,8^2)	N(0,5^2)	N(0,7^2)	N(0,6^2)
5	Sev (0,5)	N(0,10^2)	N(0,8^2)	N(0,5^2)	N(0,7^2)	N(0,6^2)
6	U (0,20)	N(0,10^2)	N(0,8^2)	N(0,5^2)	N(0,7^2)	N(0,6^2)
7	U (0,4)	N(0,10^2)	N(0,8^2)	N(0,5^2)	N(0,7^2)	N(0,6^2)

The distributions of Student Ability in Table 1.1, are denoted as Normal (N), Exponential (Exp), Gamma (G), Smallest Extreme Value (Sev) and Uniform (U) with their parameters.

Seven data sets were generated and in each set, student intelligence effects and random errors were generated as shown in Table 1 for 1000 students, taking subject effects as 60, 50, 40, 50 and 60, arbitrary values for five subjects. Let the names of the subjects be, Subject - 1, Subject - 2, Subject - 3, Subject - 4 and Subject -

5 respectively (The subjects were named as above for easy explanation, but these subjects can be in any combination and in any one of study streams.).

2.2.1 Statistical Techniques used to study the effect of re-scrutinizing

Arbitrary parameters of the above distributions were considered to make different shapes of distributions. For each data set, raw marks of students were generated according to the model 2. By observing the shapes of the above seven distributions two extreme data sets, Data set-1 and Data set 2 were used for the analysis in this study. The total set of students in each data set was made up of 300 students from each Combination-1 and Combination-2 and 400 students from Combination-3 and assumed as the composition for the BC competitions. Each set of passed students (if raw marks of all three subjects are $\geq$ 40, then the student is considered as a passed student) were ranked according to each selection method before and after re-scrutinizing. Here, 3% of the marks in each subject were re- scrutinized by adding 5 – 20 marks randomly. Then the effect of the re-scrutinizing was measured by the rank differences made with respect to CCI and Zscore methods for each student. Those rank differences were studied separately for WC and BC Competitions for each extreme dataset. Absolute rank differences were studied for each selection method ZScore and CCI Method. Analysis was performed using Descriptive statistical procedures, calculating Means, standard deviations and drawing box plot diagrams and Non Parametric Statistical procedures, Friedman test and Speaman's rank correlation.

3. Results and Discussion

3.1 Descriptive analysis of the ZScore and CCI method ranks

3.1.1 Comparison of means and standard deviations of absolute rank differences by each selection method for different combinations

Marks of each data set ranked according to Zscore and CCI method for BC competitors before and after re-scrutinizing and then absolute rank differences of each method were calculated separately for data set-1 and data set-2. Next, means and standard deviations of absolute rank differences were calculated by combinations separately for Zscore and CCI methods and tabulated in Table 2.

Table 2: Means and Standard deviation of Absolute Rank Differences of before and after re-scrutinizing with respect to each selection method

	Method	**Combination**	**Mean**	**StDev**
Data set-1	CCI	1	58.73	64.66
		2	44.45	69.45
		3	23.99	57.54
		Total data	42.39	63.88333
	ZScore	1	99.63	77.63
		2	96.31	84.05
		3	130.20	84.83
		Total data	108.7133	82.17
Data set-2	CCI	1	14.22	19.04
		2	25.52	34.98
		3	28.33	37.65
		Total data	22.69	30.55667
	ZScore	1	200.1	178.7
		2	72.45	61.41
		3	119.85	85.39
		Total data	130.8	108.5

According to the Table 2, it could be clearly seen that the means of absolute rank differences before and after re- scrutinizing values for CCI method for each combination (WC Competition) are lesser compared to those of Zscore values for both extreme data sets. Similar results were also obtained for other datasets explained in Table 1. Standard deviations of those absolute rank differences corresponding to each combination have

similar pattern for both extreme data sets. Therefore, it can be concluded that the effect of re-scrutinizing on CCI method is comparably low with respect to that of the Z score method.
The same conclusion can be drawn for the BC Competition selection from the results of the total data sets, data set-1 and data set-2.

3.1.2 Graphical illustration of Comparison of ranks before and after re-scrutinizing with respect to the Zscore and CCI methods by each combination.

The raw marks were ranked before and after re-scrutinizing by each selection method separately for data set-1 and data set-2. Then those ranks were separated by each combination and the scatter plots were drawn for both data sets and displayed in Fig-1 and Fig-2.

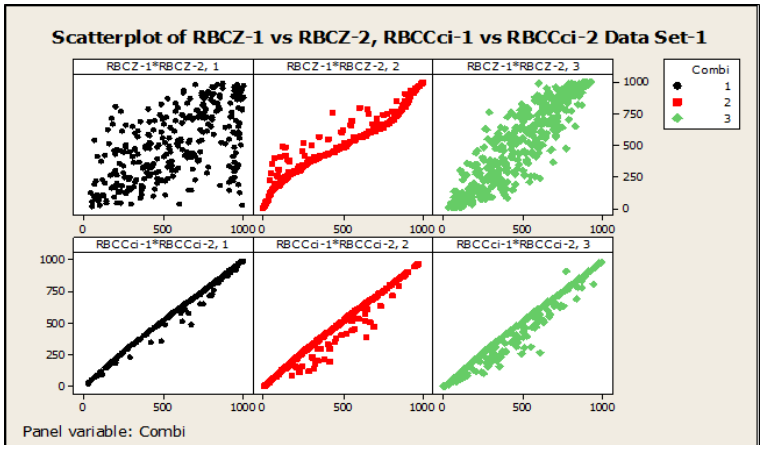

Fig1. Comparison of Ranks of each selection Method before and after re-scrutinizing for Data Set-1

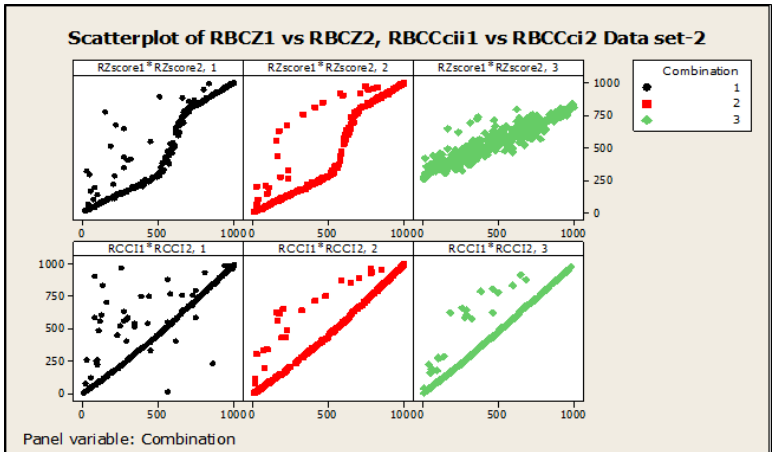

Fig2. Comparison of Ranks of each selection Method before and afterre-scrutinizing for **Data** Set-2

Those figures clearly illustrate the relationship of ranks before and after re-scrutinizing of marks. The top three plots in both Fig. 1 &2 are related to the ZScore method and bottom three plots are related to CCI method for three combinations. The panels (top 3 plots) corresponding to Z score in both data sets, exhibits different pattern in different combinations and also substantial scatter could be seen. But the panels corresponding to CCI (bottom 3 plots) in both data sets exhibits a similar linear pattern, as all the combination marks are in the same currency.

The reason behind that may be the distribution of the ranks of ZScore values by different combinations are different which implies that the raw marks in different combinations do not fall in to the same scale. Hence,

it can be concluded that the differences by combinations are not eliminated by using ZScore method and will create unfair advantage by students in different combinations.

The panels corresponding to CCI method in both figures 1 &2, have same linear pattern in all the combinations which implies that the effects due to the same changes in raw marks is comparatively less. Combining all the combination marks using CCI method, like currency conversion, the raw marks differences in different combination fall into the same scale (similar to one currency) eliminating the combination differences. It does not create unfair advantage to enter University and selects the best set of students.

Further the changes of ranks due to re-scrutinizing can be identified while others ranks are robust. This is a very good outcome, that the university selection results can be released at once at the earliest time. Then the university admission process can be continued while re-scrutinizing process is going on. The ranks of re-scrutinized students can be released and they can be allocated to relevant university courses later which will not affect the rest of the student body.

Also, when examining table 2 and figure 2 it can be seen that the means and the standard deviations of the absolute rank differences before and after re-scrutinizing is very much smaller for the CCI method compared to the Z-score method respectively for means and standard deviations, which goes on to show the superiority of the CCI method over the Z-Score Method.

3.1.3Graphical illustration of Comparison of absolute rank differences before and after re-scrutinizing by each selection method

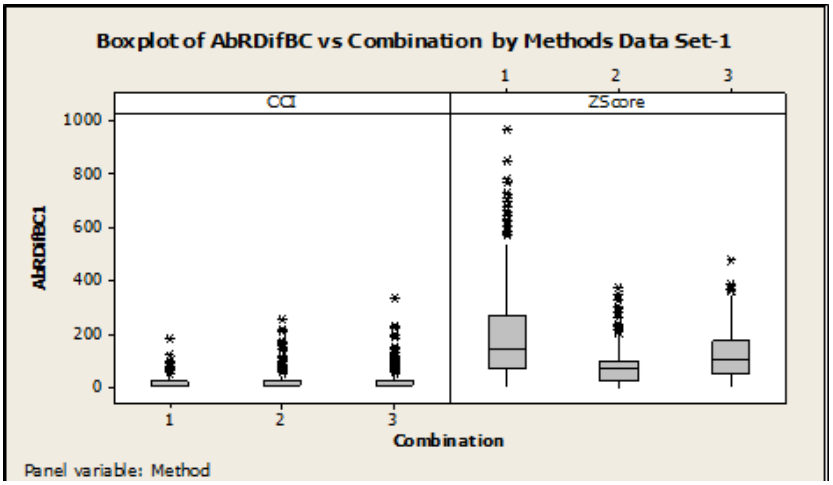

Fig. 3 Boxplot diagrams of absolute rank differences for Zscore and CCI methodsby each combination of Data Set-1

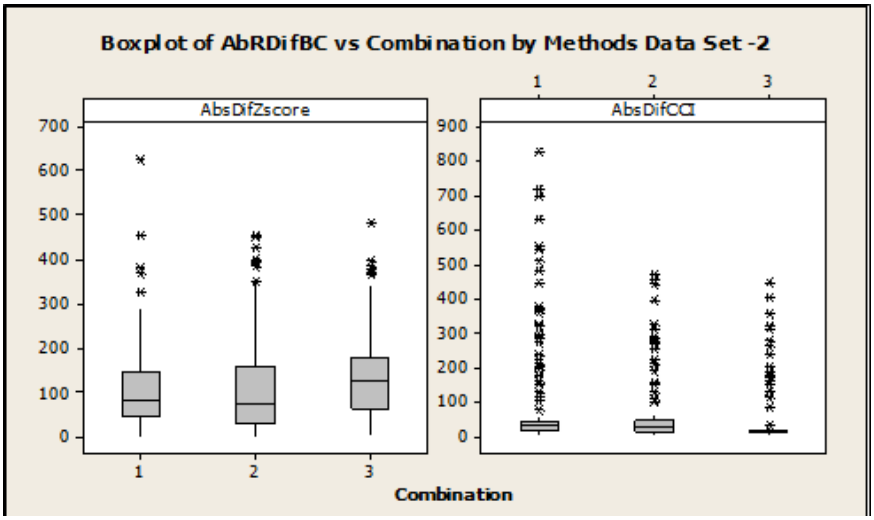

Fig. 4Boxplot diagrams of absolute rank differences for Zscore and CCI methodsby each combination of Data Set-2

Fig.3 and Fig.4 illustrate the absolute deviations of rank due to re- scrutinizing by combination for the two extreme data sets. It shows that the absolute deviations of CCI method before and after re- securitized ranks are very small compared to those of Zscore ranks for both extreme data sets. Thus, the effect of re-scrutinizing of CCI method is negligible when compared to that of Zscore.

3.2 Comparison of the effect of re scrutinizing on selection methods using Statistical techniques

3.2.1 Use of Spearman's Rank Correlation Coefficient for comparison of the ranks before and after re-scrutinizing by selection methods.

The Spearman correlation coefficient matrix was calculated between the ranks of the selection indices before and after re-scrutinizing of raw marks. The results are displayed for the two extreme data sets in the table 3, comparison of the effect of re scrutinizing of raw marks by each method, Zscore and CCI.

Table 3: The Spearmen's rank correlation test for comparison of ranks before and after re-scrutinizing

	Method	(r)Sample Correlation	P-value
Data set-1	CCI	0.990	0.000
	ZScore	0.803	0.000
Data set-2	CCI	0.949	0.000
	ZScore	0.884	0.000

$\Pr ob > |r| \;\; under\; H_0 :\; \rho = 0 \; are\; given\; as\; p\text{-}value$ `

Where, r is the rank differences between the selection index values before and after re-scrutinized.

The results indicate, that the ranks of before and after re-scrutinizing the raw marks are highly correlated for both methods. But the Spearman's rank correlation coefficient is almost closer to one for the CCI method for both data sets, although for ZScore method those coefficients are respectively 0.803and 0.884 for data set- 1and data set- 2 suggesting that the effect of re-scrutinizing on CCI method is highly robust due to re-scrutinizing.

3.2.2 Friedman Test for Comparison of absolute differences of ranks before and after re- scrutinizing of raw marks between the two selection methods.

For BC competition, the absolute deviation between the ranks of the selection method values before and after re- scrutinizing of raw marks were considered as treatments for each selection method. As the deviations do not show the actual picture of the total deviations due to cancelling the effects, absolute deviations were taken instead. In the Friedman Test, the absolute rank differences were considered as the response variable, the methods were considered as treatments and the student index numbers as blocks.

H_o: Treatment effects are equal

H_1: Treatment effects are not equal

Treatment-1: $|Rank \text{ corresponding to Zscore before} - Rank \text{ corresponding to Zscore after}|$

Treatment-2: $|Rank \text{ corresponding to CCI before} - Rank \text{ corresponding to CCI after}|$

Table4: Friedman Test statics for Absolute rank differences versus Selection Method blocked by Index No.

	Treatment (Method)	**N**	**Median**	**Est.Sumof ranks**	**d.f**	**Test Statistic(adjusted for ties)**	**P-value**
Data set1	TRt-1 (CCI)	1000	18.88	1094.0	1	659.34	0.000

	Trt2 (ZScore)	1000	93.18	1906.0	1	663.32	0.000
Data set2	Trt-2 (CCI)	1000	30.13	1089.5	1	674.04	0.000
	Trt-2 (ZScore)	1000	89.88	1910.5	1	680.16	0.000

As p-values are zero, the difference in treatments are highly significant for both extreme data sets. Also the estimated medians and the sum of ranks corresponding to CCI method are significantly lesser than those of Zscore method for both data sets. Hence, it can be concluded that the absolute differences of ranks corresponding to before and after re- scrutinizing separately for Zscore and CCI methods are in the following order with respect to median and the sum of ranks.

Data Set-1: CCI Method <ZScore Method
Medians 18.88 < 93.18
Sum of ranks 1094.0 <1906.0

Data Set-2: CCI Method <ZScore Method
Medians 30.13 < 89.88
Sum of ranks 1089.5 < 1910.5

Hence, for the extreme data sets in Table 1, the least absolute rank differences were observed in CCI Method compared to ZScore Method. Therefore, it can be concluded that the effect of re-scrutinizing of CCI method is significantly lesser compared to ZScore method.

4. Conclusion

In this study the sample raw marks were generated according to an additive linear mixed model to form the actual mark of a student in a particular subject. Accordingly, the student effect was taken as random because it depends on each student's, ability, devotion and other inputs pertaining to the student. Hence, this student effects were generated randomly from probability distributions with different shapes. Subject effect was taken as a fixed effect since a subject effect is the same for all the students that sat for a particular subject. Further, the error measurement was taken as random as there can be different social effects taken place on the student while studying for the examination. Since, the examination papers of the GCE (A/L) Examination in Sri Lanka is a curriculum based examination and the marking is done based on a marking scheme, the examination marks are additive and the mixed model used for generation of raw marks was considered as additive. Then the raw marks generated for arbitrary parameters for three combinations of subjects for 1000 students in the ratio of 3:3:4. Subsequently, the raw marks in all three combinations were ranked according to the ZScore and CCI methods. To compensate for re-scrutinizing, 5 – 20 marks were added randomly to3% of each subject marks. Thereafter, the marks were ranked according to the ZScore and CCI methods separately and observed the effect of re-scrutinizing by comparing these ranks using statistical techniques.

According to the descriptive analysis, the means and standard deviations of the absolute rank differences with respect to CCI method are comparatively lesser than those of ZScore for all three combinations in both extreme data sets. Also, the drawn scatter diagrams between before and after the changing of marks for both extreme data sets illustratedvaluable information which implies that, the ranks due to re-scrutinizing for the ZScoremethod changes dramatically and differently within all three combinations (WC). The CCI method ranks do not change much in all three combinations and have similar linear relationships.

If the ranks are pooled together for Between Combination selection, it is observed that the different distribution of the ZScore ranks in different combinations will not be eliminated insecure method. But for CCI method the combination wise ranks have the same linear pattern and the pooled ranks also follow the same pattern suggesting that application of CCI method eliminates the combination vice differences and converts into a same combination marks.

The boxplot diagrams drawn also show that the effect of re-scrutinizing is comparably lesser in CCI Method for all three combinations compared to the ZScore method. A similar conclusion could be obtained by

the Non Parametric methods used in the study. Therefore, it can be concluded that the effect due to re-scrutinizing on CCI ranks is significantly lesser than that of ZScores. For higher re-scrutinizing percentages and for higher changes of raw marks, the effect made on ZScore may be tremendous compared to CCI method.

5. Recommendation

The GCE(A/L) examination papers have to be designed in such a way that selection of students shall be on a competitive basis. That is the examination papers should be able to differentiate weak and good student performances having a larger range of raw marks. That is the questions should be included according to SOLO Taxonomy (Biggs, Collis, 1999) in the examination papers.

By implementing CCI method, the University admission process can be expedited at least by three months. Since CCI method is simple and transparent, students earned raw marks, CCI values and the ranks can be released, which will help to understand the student's real standard and can be used for University admission as well as to select any other course or for a job.

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