Z-Score demystified: a critical analysis of the Sri Lankan university admission policy

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ABSTRACT:

In the year 2001, the University Grants Commission of Sri Lanka successfully appealed to change the method of determining the cut-off scores for university admissions from raw scores to standardized z-scores. This standardization allegedly eliminated the discrepancy caused due to the assumption of equal difficulty levels across all subjects. This paper analyzes the effectiveness of using z-score cut-offs for university admissions compared to raw score cut-offs. For the purpose of the analysis, only those students who were admitted to Sri Lankan universities on the basis of the district quota were considered.

The Wilcoxon Rank Sum test was used for this analysis. The samples that were taken are independent and no assumptions were made on the probability distributions other than the fact that they are continuous.

Keywords: Sri Lanka, standardized z-scores, Wilcoxon Rank Sum test, Advanced Level results.

INTRODUCTION

The education system in Sri Lanka is very competitive with only fourteen national universities and four institutes in the country. Approximately 9% of the students who sit for the G.C.E (Advanced Level) examinations, and approximately 13 to 15% of those who qualify, are admitted to universities (Statistical Handbook of Research and Development Branch, National Evaluation and Testing Service, 2008). In Sri Lanka, the admission of students to universities within the country is based on a quota system with a 40% merit quota, 55% district-wise quota and a 5% quota for educationally underprivileged districts based on their population. This analysis will focus on the 60% of student admissions that are based on the district quotas. Prior to the year 2000, all students applying to universities were required to take four subjects at the G.C.E (Advanced Level) Examination. However, after that year, students had to take only three subjects and combine it with a Common General Test to show competence in general knowledge issues (Admission to Undergraduate Courses of the Universities in Sri Lanka, 2006/2007), This created some discrepancy in the application processes in the years 2000 and 2001 since there were two groups of students applying for identical courses, some having four while other having three subjects. The cut-off scores for universities based on the raw arithmetic mean of four subject scores was ineffective since it assumed that those students who had taken only three subjects had sat for a fourth exam and secured a score equivalent to the mean of the other three, which was not the case. Thus, the z-score equivalent of the raw scores was used as a means of standardizing the application process.

Despite the fact that after the year 2001 homogeneity was achieved in the number of subjects taken by each student, the z-score method continued to be used as it was seen as an effective method of removing inconsistencies caused due to the assumption of equal difficulty levels across all subjects. For example, to apply for a Medicine course, students had the option of taking either a combination of Chemistry, Biology and Physics, or Chemistry, Biology and Agriculture. However, students invariably scored higher in Agriculture than in Physics, giving the second group of students a higher mean and thus, an advantage while applying to universities (Sri Lanka University Statistics 2007). The standardized z-score method claimed to eliminate this problem.

The cut-off scores for each subject vary for different districts. Sri Lanka is divided into twenty five districts namely Ampara, Anuradhapura, Badulla, Batticalao, Colombo, Galle, Gampaha, Hambantota, Jaffna, Kalutara, Kandy, Kegalle, Kilinochchi, Kurunegalla, Mannar, Matale, Matara, Monaragala, Mullaitivu, Nuwara Eliya, Polonnaruwa, Puttalam, Ratnapura, Trincomalee and Vavuniya. The University Grants Commission categorizes these districts into rural and urban, sixteen are categorized as rural and nine as urban, based on their population (Economic and Social Statistics of Sri Lanka, 2009), On an average, the number of functioning schools in the urban districts is greater than those in the rural districts, giving students from urban districts a higher chance of getting into the university. The cut-off scores for students vary with each district, with lower cut-off scores for students from rural districts compared to those from urban districts. The UGC hopes to standardize this discrepancy too using z-scores.

Weinstein (1994) of John Caroll University, USA, examined the use of standardized scores against weighted total points in assessing his accounting students. He used hypothetical data to conduct his research, and concluded that 18% of his students had course grade changes due to the standardization. He brings out the effectiveness and advantage of the usage of standardized scores. His paper highlights two major issues with the commonly used grading system – the lack of instructor subjectivity and the exclusion of the variance of individual components of the final grade. Of these two, only the latter is relevant to this

research. He showed that the ranking of students differed when the z-score was used instead of the total weighted score. The total points system completely ignores the percentage weighting of each component of the final score. He concluded that the z-score analysis was essential to a fairer grading system, and should be used as an additional factor in the grading system, if nothing else.

On the other hand, an analysis conducted by Webber and Clinton (1999), using actual data as opposed to hypothetical data in Weinstein's case, showed that the differences in ranking were not as high as Weinstein had predicted. They compared rankings based on total points against rankings based on z-scores, using twenty eight class sections with two different instructors, five different institutions, graduate and undergraduate courses of differing levels, and different class sizes. Amongst the twenty eight class sections, a change in grade was only seen in eight sections; amongst the 602 student sample, 28 had changes in course letter grades. This resulted in only a 4.65% change as compared to Weinstein's 18%. They concluded that instead of using the total point method alone or the z-score method alone, instructors should combine both to set a balanced cut off score. There was no compelling evidence to use the standardized z-score method except as an addition to the normal grading procedure.

Tracy and Rankin (1967) analyzed residual gain scores in the reading program. The residual gain statistic measures individual differences in improvement that result from training. Essentially, it is the difference between a predicted post-training score and an observed measure. The paper compares two computational methods – the z-score method and the raw score method, analyzing the advantages and disadvantages of each. The raw score method does not provide as much information for interpreting residual gains as the z-score method; but, the raw score is more easily computable and also avoids rounding errors. The paper further includes graphical methods for estimating residual gain. The residual gains obtained from a graph may be used to compare the relative improvement of students or to assign grades in a class. Residual gains were then converted to derived scores based on a normal distribution curve to allow for student interpretation, with a mean of 75 and a standard deviation of 10. A graphical method for estimating derived scores is also included in the paper. They concluded that both crude scores and percentage scores do not take regression effects and its gains into consideration. A student with a low initial score will score higher on a retest even without training, while a student with a high initial score will score lower, due to regression effects. Therefore, the residual gain statistic using either the raw score method or the z-score method is more effective than crude or percentage scores.

THE STUDY, DATA AND ASSUMPTIONS

In examining the differences between using raw scores and z-scores for university admission cut-offs, data from the years 2006, 2007 and 2008 were compared to data from the years 1996, 1997, 1999 and 2000. These selections were suitable for studying the impact of using z-scores for university admissions, as the years 2006, 2007 and 2008 are relatively recent years and in these years the standardized scores were used. Prior to the year 2000, raw scores were used. For this study, only three representative subjects, namely medicine, agriculture and engineering were chosen. The subjects selected are conventional, as students from every district have opted to apply for these majors at the undergraduate level. Some subjects such as information technology and architecture did not meet this condition.

The data from this study was acquired from two sources. The district-wise z-score cut-offs for each subject for the years 2006, 2007 and 2008 were taken from a website maintained by the University Grants Commission of Sri Lanka. The data from the years 1996,

1997, 1999 and 2000 was obtained from the office of the University Admissions Department of the UGC in Sri Lanka.

It is important to note that for the purpose of this study, those students who were admitted to university on the basis of merit were eliminated from the analysis and only those students who came under the district quota were considered. This is because the z-score cut offs for students under the 60% district quota vary for each district. The selection of students otherwise is subject to excellence in fields other than academics such as studies at national/ international level, personnel of armed forces, students with foreign qualifications and so on; however, this study focuses solely on academic achievement in the G.C.E (Advanced Level) Examination of the students admitted on the district quota.

For the statistical analysis, the Wilcoxon Rank Sum test was used (McClave and Sincich, 2003). This method was selected due to the unwillingness to make assumptions about the underlying population probability distributions. In the Wilcoxon Rank Sum test the data is ranked in order of magnitude. The samples are independent and random, and sample sizes are greater than ten. Therefore, the test was conducted using the familiar *z* test.

Since the mean and standard deviation for each subject was not available, the percentage method was used. All raw data was converted into percentages by dividing it by the maximum possible score 300, and then multiplying by 100. All Z-score data was converted into percentages using the area under the standard normal curve corresponding to each z-score value, and then multiplying by 100. The z-scores percentages and raw scores percentages were then ranked in ascending order and the sum of the ranks of all z-scores percentages and the sum of the ranks of all raw scores percentages was calculated. Hypotheses were drawn based on the following formulae:

$$S_{\text{raw-score}} = \sqrt{\frac{n_{z-score} n_{raw-score} (n_{z-score} + n_{raw-score} + 1)}{12}}$$

$$E_{(\text{raw-score})} = \frac{n_{raw-score} (n_{z-score} + n_{raw-score} + 1)}{2}$$

$$z_{\text{test}} = \frac{T_{raw-score} - \frac{n_{raw-score} (n_{z-score} + n_{raw-score} + 1)}{2}}{\sqrt{\frac{n_{z-score} n_{raw-score} (n_{z-score} + n_{raw-score} + 1)}{12}}}$$

where,

$S_{\text{raw-score}}$ - Standard deviation of the raw score
$n_{\text{raw-score}}$ - Number of districts sampled for the raw scores
$n_{\text{z-score}}$ - Number of districts sampled for the z-scores
$E_{(\text{raw-score})}$ – Mean of raw score-Expected value
$T_{\text{raw-score}}$ – Rank sum of raw score

METHOD

Case 1: Standardized Z-score vs. Raw Scores

Case 1a: (Medicine)-2008 z scores vs 1997 raw scores
Case 1b: (Agriculture)-2006 z scores vs 1996 raw scores
Case 1c : (Engineering) 2007 z scores vs 1999 raw scores

Case 2: Urban Districts vs. Rural Districts

Case 2a: (Kandy-Urban Disitirct) 2007 z scores vs 2000 raw scores
Case 2b: (Anuradhapura – Rurual District) 2007 z scores vs 2000 raw scores

The university admission raw cut-off scores and standardized cut-off scores for three subjects will be compared across different years; those subjects in this case will be medicine, agriculture and engineering. Also, the cut-off scores for nine subjects will be compared across urban and rural districts using data from the years 2000 and 2007. In most cases an initial significance level (α) of 0.05 or confidence level of 95% will be used.

Z-score against Raw Score

In comparing z-scores against raw scores, the hypthesis is:

H_{null}: There is no significant difference between the z-score cut off distribution and the raw score cut-off distribution for university admissions.

The alternative hypothesis will be:

$H_{alternative}$: The raw score cut-off distribution are better than the z-score cut-off distribution for univerity admissions.

Case 1a: Medicine

The sample size (number of districts that were sampled) for the z-scores was given by $n_{z\text{-score}}$, where $n_{z\text{-score}} = 25$, and the sample size (number of districts that were sampled) for the raw scores was given by $n_{raw\text{-score}}$, where $n_{raw\text{-score}} = 25$.
"as indicated in Figure1 (Appendix)".

The test statistics for the Wilcoxon Rank Sum test was based on the totals of the ranks for each of the two samples – that is on the rank sums. The rank sum of the z-score percentages was denoted by $T_{z\text{-score}} = 878$ and the rank sum of the raw score percentages by $T_{raw\text{-score}} = 397$. For the test statistic the smaller rank sum was used. In this case the raw-score rank sum was used. Furthermore, the assumptions made were that the samples were random and independent, and that the two probability distributions (the subject-wise mean cut-off across each district) from which the samples are drawn are continuous. The standard deviation of $T_{raw\text{-score}}$ was given by:

$$S_{raw\text{-score}} = \sqrt{\frac{n_{z-score} n_{raw-score} (n_{z-score} + n_{raw-score} + 1)}{12}} = 51.53$$

and the mean was given by:

$$E_{(raw\text{-score})} = \frac{n_{raw-score} (n_{z-score} + n_{raw-score} + 1)}{2} = 637.5$$

Here the hypothesis was that the z-score and the raw score distributions were identical. Z-score probability distribution was denoted by $D_{z\text{-score}}$ and the raw score probability distribution by $D_{raw\text{-score}}$. The null hypothesis was the following:

H_{null}: $D_{z\text{-score}}$ and $D_{raw\text{-score}}$ are identical.

The alternative hypothesis was that the raw-score was better than the z scores for university admission cut-offs. The alternative hypothesis was the following:

$H_{alternative}$: $D_{raw\ score}$ is shifted to the left of $D_{z\text{-score}}$.

This was a left tail test and the significance level α that was chosen was 0.05 (95% confidence level). Then $z_\alpha = -1.645$. The z value for the test was given by the following:

$$z_{test} = \frac{T_{raw-score} - \frac{n_{raw-score}(n_{z-score} + n_{raw-score} + 1)}{2}}{\sqrt{\frac{n_{z-score} n_{raw-score}(n_{z-score} + n_{raw-score} + 1)}{12}}} = -4.667$$

In this case z_{test} value is less than z_α value, indicating that the test is statistically significant at $\alpha = 0.05$, thus it is accepted that at $\alpha = 0.05$ raw score distribution in 1997 is shifted to the left of z score distribution in 2008. Thus in 1997, students with lower scores in medicine were accepted to medical school compared to 2008 at the 0.05 significance level. Thus, there is a 95% confidence level that the z score method gave a disadvantage to most students in 2008 in university entrance exam when it comes to entering the field of medicine. This is very clear in Vavuliya or Monaragala district (see Graph 1). But if one looks at Graph 1 in a different persepctive, the z curve has less extremes compared to the raw score curve. Therefore a student in Colombo district and a student in Monaragala district had comparable z scores in 2008 compared to 1997.

Case 1b: Agriculture

The sample size (number of districts that were sampled) for the z-scores was given by $n_{z\text{-score}}$, where $n_{z\text{-score}} = 25$, and the sample size (number of districts that were sampled) for the raw scores was given by $n_{raw\text{-score}}$, where $n_{raw\text{-score}} = 25$.
"as indicated in Figure 2 (Appendix)".

The test statistics for the Wilcoxon Rank Sum test was based on the totals of the ranks for each of the two samples – that is on the rank sums. The rank sum of the z-scores was denoted by $T_{z\text{-score}} = 684$ and the rank sum of the raw scores by $T_{raw\text{-score}} = 591$. For the test statistic the smaller rank sum was used. In this case the raw-score rank sum was used. Similar assumptions were made as in Case 1a. The standard deviation of $T_{raw\text{-score}}$ was given by:

$$S_{raw\text{-score}} = \sqrt{\frac{n_{z-score} n_{raw-score}(n_{z-score} + n_{raw-score} + 1)}{12}} = 51.53$$

and the mean was given by:

$$E(T_{raw\text{-score}}) = \frac{n_{raw-score}(n_{z-score} + n_{raw-score} + 1)}{2} = 637.5$$

As in case 1a, the hypothesis was that the z-score and the raw score distributions were identical.

H_{null}: $D_{z\text{-score}}$ and $D_{raw\text{-score}}$ are identical.

$H_{alternative}$: $D_{raw\ score}$ is shifted to the left of $D_{z\text{-score}}$.

This was also a left tail test and the significance level α chosen was 0.05 (95% confidence level). Then $z_\alpha = -1.645$. The z value for the test was given by the following:

$$z_{test} = \frac{T_{rawz-score} - \frac{n_{raw-score}(n_{z-score} + n_{raw-score} + 1)}{2}}{\sqrt{\frac{n_{z-score} n_{raw-score}(n_{z-score} + n_{raw-score} + 1)}{12}}} = -0.902$$

In this case z_{test} value is greater than z_α value, indicating that the test is statistically not significant at $\alpha = 0.05$, thus it is accepted that at $\alpha = 0.05$ raw score distribution in 1996 is shifted to the right of z score distribution in 2006. Thus in 2006, students with lower grades in agriculture were accepted to school compared to 1996 at the 0.05 significance level. Thus there is a 95% confidence level that the z score method gave an advantage to most students in 2006 in university entrance exam when it comes to agricuture; for example, look at Puttalam district data in Graph 2. But in a different perspective the z score curve in 2006 has very few

dips compared to the extreme values in the raw score curve in 1996. This test would only be significant at a confindence level of 82.12% or at $\alpha = 0.1788$.

When the raw data for engineering in 1999 was compared to the z score resuts in 2007, similar results were obtained as in Case 1a. – in 1999 the raw score method was advantageous for most students pursuing engineering in rural districts. (Refer to appendix for tabular data and calculations.)

"as indicated in Figure 3 (Appendix)".

The Categorization of Districts as Rural and Urban

The University Grants Commission categorizes the districts as urban and rural on the basis of their population. However, for the purpose of this study, the districts Kandy (urban) and Anuradhapura (rural) will be taken into consideration.

"as indicated by Figure 4 (Appendix)".

"as indicated by Table 1 (Appendix)".

The high schools in Sri Lanka are divided into five categories – Government schools, private fee levying schools, private non fee levying schools, approved/ certified schools and pirivenas. The table above shows the number of functioning schools per district. Kandy has 723 schools while Anuradhapura has only 589. This is one indication of Kandy being urban while Anuradhapura rural.

"as indicated by Table 2 (Appendix)".

"as indicated by Table 3 (Appendix)".

The indicators shown in the table above all show that Kandy is far more urban than Anuradhapura. Kandy has a higher population indicating the migration of people to a more urban district. Urban places also have a higher percentage of poverty. Anuradhapura has more agricultural land indicating that it is rural.

Now the Urban/Rural divide in Sri Lankan Advanced Level examination results will be analysed.

Case 2a: Kandy district (urban)

The sample size (number of subjects that were sampled) for the z-scores were $n_{z\text{-score}} = 9$, and the sample size (number of subjects that were sampled for the raw score) $n_{raw\text{-score}} = 9$.

"as indicated by Table 4 (Appendix)".

"as indicated by Figure 5 (Appendix)".

The test statistics for the Wilcoxon Rank Sum test was based on the totals of the ranks for each of the two samples – that is on the rank sums. The rank sum of the z-scores was denoted by $T_{raw\text{-score}} = 69$ and the rank sum of the raw scores by $T_{z\text{-score}} = 102$. For the test statistic the smaller rank sum was used. In this case the raw-score rank sum was used. Similar assumtions were made as before.

$$S_{raw\text{-score}} = \sqrt{\frac{n_{z-score} n_{raw-score} (n_{z-score} + n_{raw-score} + 1)}{12}} = 11.32$$

and

$$E(T_{raw\text{-score}}) = \frac{n_{raw-score}(n_{z-score} + n_{raw-score} + 1)}{2} = 85.5$$

Similar hypothesis were used as in the previous cases.

This too was a left tail test and the significance level $\alpha = 0.05$ (95% confidence level). Then $z_\alpha = -1.645$. The z value for the test was given by the following:

$$z_{test} = \frac{T_{raw-score} - \frac{n_{raw-score}(n_{z-score} + n_{raw-score} + 1)}{2}}{\sqrt{\frac{n_{z-score} n_{raw-score}(n_{z-score} + n_{raw-score} + 1)}{12}}} = -1.458$$

In this case z_{test} value is greater than z_α value, indicating that the test is statistically not significant at $\alpha = 0.05$, thus it is accepted that at $\alpha = 0.05$, raw score distribution in 2000 is shifted to the right of z score distribution in 2007. Thus in 2007 students with lower scores in all subjects were accepted to the university compared to 2000 at the 0.05 significance level. Thus there is a 95% confidence level that the z score method gave an advantage to some students in 2007 in university entrance exams for students studying different subjects in the Kandy district. This test would only be statistically significant at a confidence level of 92.76% or at $\alpha = 0.0724$. The percentage difference between Engineering and Management is much less in 2007 compared to 2000. One might argue that this is unjust as Enginnering is inherently a harder subject and this standardization is too extreme and does not take the difficulty levels into account.

Case 2b: Anuradhapura district (rural)

The sample sizes were nine for each category.
"as indicated by Table 5 (Appendix)".
"as indicated by Figure 6 (Appendix)".

The test statistics for the Wilcoxon Rank Sum test was based on the totals of the ranks for each of the two samples – that is on the rank sums. The rank sum of the z-scores was denoted by $T_{raw-score} = 59$ and the rank sum of the raw scores by $T_{z-score} = 112$. For the test statistic the smaller rank sum was used. In this case the raw-score rank sum was used. The standard deviation of $T_{raw-score}$ was given by: $s_{raw-score} =$ 11.32 and the mean was given by $E(T_{raw-score}) =$ = 85.5. The hyothesis were the same.

This was a left tail test and the significance level α chosen was 0.05 (95% confidence level). Then $z_\alpha = -1.645$. The z value for the test was, $z_{test} =$ = -2.341. In this case z_{test} value is less than z_α value, indicating that the test is statistically significant at $\alpha = 0.05$, thus it is accepted that at $\alpha = 0.05$, raw score distribution in 2000 is shifted to the left of z score distribution in 2007. Thus in 2000 students with lower grades in all subjects were accpeted to the university compared to 2007 at the 0.05 significance level. Thus there is a 95% confidence level that the z score method gave a disadvantage to students in 2007 in university entrance exams for students studying different subjects in the Anuradhapura district, such as law, dentistry, commerce, computer science, management and so on.

FINAL REMARKS

In each case, whether the analysis was done district wise or subject wise, from the data it is clear that using the z score method in determining university admissions in Sri Lanka is disadvantageous to most students. In most cases, the cut off score was higher than it was when the raw score method was utilized at a 0.05 significant level. In all cases the test can be 80% confident that standardizing the score did not have a positve impact on university admissions in Sri Lanka. Also, this method lacks transparency, as the published data does not

provide the candidates the mean and the standard deviation of each distribtion-subject wise or based on districts.

The Sri Lankan Higher edication department also needs to justify the district based admission process as it is clear that standardized admision scores are not the answer. It is unclear whether better results will be produced if High Schools are ranked and that ranking is used in standardization process. What is clear is the fact that the discourse on whether the introduction of the z score method is viable, and whether it is the only option in standardizing the university admsission process, needs to continue. It is also worth investigating further whether a combination of the raw and the z score methods in conjunction with a ranking of the current High Schools in the country might produce a fairer university admission process than the existing system.

The public provision in Sri Lanka has failed to create a universally available and effective schooling system; however, that does not imply that the solution is a radically different approach in university admisions. Effective solutions are likely to be mixtures of functional resposibilities distributed amoung district school administrations. Sri Lanka has dysfunctional schools, low techinical productivity and stagnant productivity in higher education. The high client responsiveness is the one positive factor that the Sri Lankan educational system can count on. Having a common vision for Sri Lankan higher education will improve the quality of schooling. Mobilizing and allocating resources, without a clear goal, such as the introduction of standardized z score for university admissions, is focused only on limited inputs and process, and is thus, ineffective.

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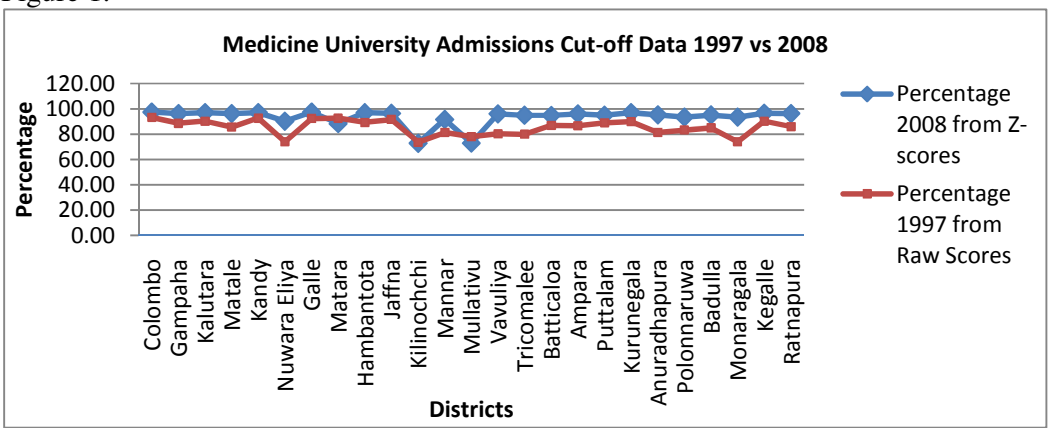
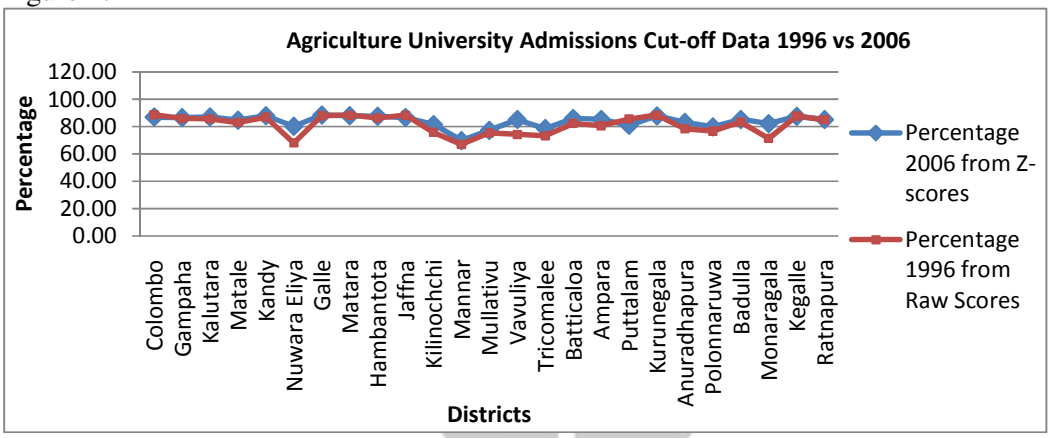
APPENDIX:

Figure 1.



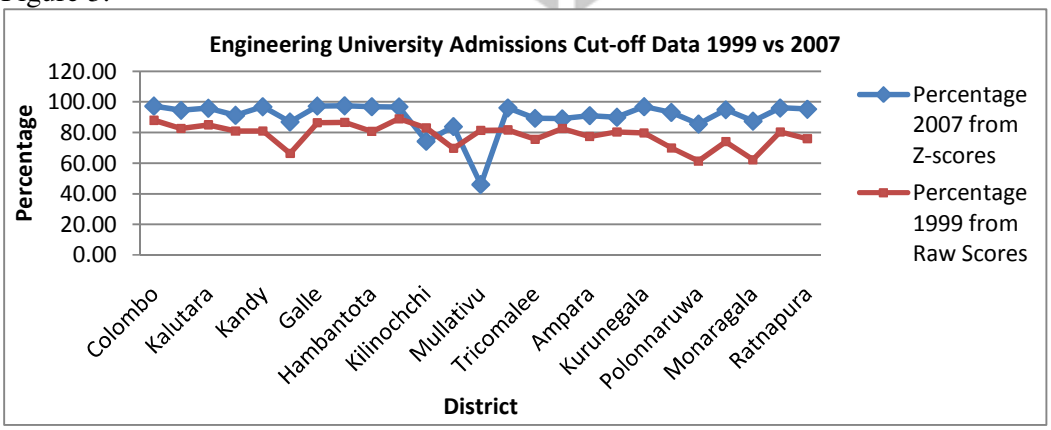
District-wise university admissions cut-off data for Medicine in the years 1997 and 2008.

Figure 2.



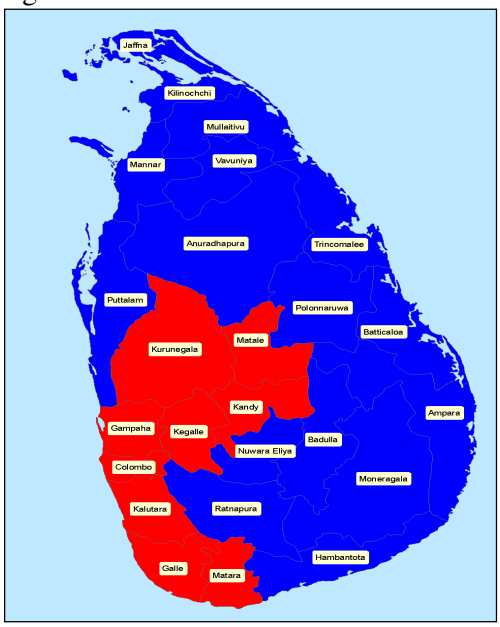
District-wise university admissions cut-off data for Agriculture in the years 1996 and 2006.

Figure 3.



District-wise university admissions cut-off data for Engineering in the years 1999 and 2007.

Figure 4.



Map of Sri Lanka, red areas showing urban districts and blue areas showing rural districts

Table 1. Districts of Sri Lanka categorized as urban and rural

Urban	Rural
Colombo	Ampara
Galle	**Anuradhapura**
Gampaha	Badulla
Kalutara	Batticalao
Kandy	Hambantota
Kegalle	Jaffna
Kurunegala	Kilinochchi
Matale	Mannar
Matara	Monaragala
	Mullaitivu
	Nuwara Eliya
	Polonnaruwa
	Puttalam
	Ratnapura
	Trincomalee
	Vavuniya

Table 2. Number of functioning schools in each district.

Number of functioning schools district wise (2002)			
District	Number of functioning schools	District	Number of functioning schools
Colombo	487	Mullaitivu	100
Gampaha	601	Batticaloa	306
Kalutara	474	Ampara	393
Kandy	**723**	Trincomalee	253
Matale	336	Kurunegala	981
Nuwara Eliya	523	Puttalam	352
Galle	512	**Anuradhapura**	**589**
Matara	442	Polonnaruwa	242
Hambantota	341	Badulla	601
Jaffna	412	Moneragala	273
Kilinochchi	93	Ratnapura	627
Mannar	90	Kegalle	576
Vavuniya	178	Total	5212

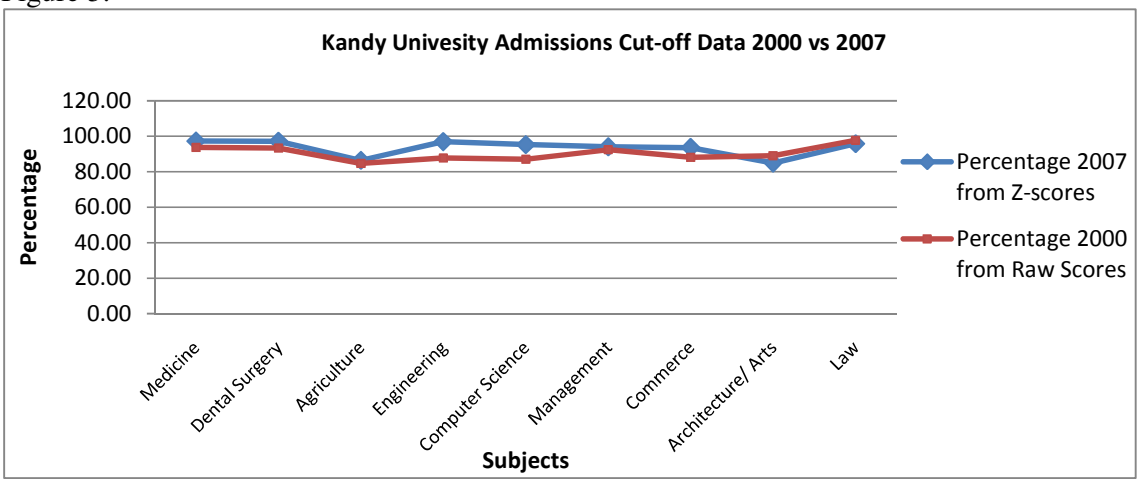
Table 3. Socio-economic indicators for Kandy and Anuradhapura districts

Indicators	Kandy	Anuradhapura
Population (estimated 2009)	1,415,000	820,000
Percentage of poor households (2002)	20.9	17.2
Acres of agricultural land (2002)	233,803	375,112
Number of functioning schools (2002)	723	589

Table 4. Raw scores, z-scores and ranking for Kandy district–2000 vs 2007

Kandy						
Subjects	Raw Scores 2000	Percentage	Rank	Z-scores 2007	Percentage	Rank
Medicine	281	93.67	11	1.9071	97.17	17
Dental Surgery	280	93.33	9	1.8933	97.08	16
Agriculture	254	84.67	1	1.0948	86.32	3
Engineering	263	87.67	5	1.8650	96.89	15
Computer Science	261	87.00	4	1.6618	95.17	13
Management	277	92.33	8	1.5493	93.93	12
Commerce	264	88.00	6	1.5188	93.56	10
Architecture/ Arts	267	89.00	7	1.0291	84.83	2
Law	293	97.67	18	1.7158	95.69	14
					$T_{raw\ score}$	69
					$T_{z\text{-}score}$	102

Figure 5.

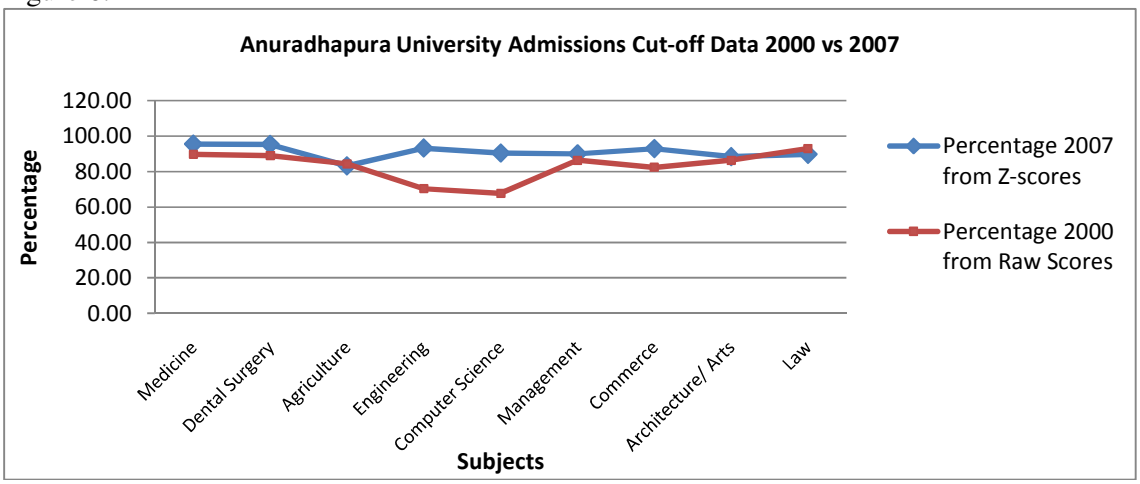


Subject-wise university admissions cut-off data for Kandy in the years 2000 and 2007.

Table 5 – Raw scores, z-scores and ranking for Anuradhapura district–2000 vs 2007

Anuradhapura						
Subjects	Raw Scores 2000	Percentage	Rank	Z-scores 2007	Percentage	Rank
Medicine	269	89.67	11	1.6887	95.44	18
Dental Surgery	267	89.00	9	1.6736	95.29	17
Agriculture	253	84.33	5	0.9620	83.20	4
Engineering	211	70.33	2	1.4919	93.21	16
Computer Science	203	67.67	1	1.3070	90.44	13
Management	259	86.33	6.5	1.2768	89.92	12
Commerce	247	82.33	3	1.4679	92.89	14
Architecture/ Arts	259	86.33	6.5	1.1927	88.35	8
Law	279	93.00	15	1.2626	89.66	10
					$T_{raw\ score}$	59
					$T_{z\text{-}score}$	112

Figure 6.



Subject-wise university admissions cut-off data for Anuradhapura in the years 1999 and 2007.

Table 6. District wise raw scores, z-scores and ranking for Medicine – 1997 vs 2008

Medicine						
District	Raw Score 1997	Percentage	Rank	Z-score 2008	Percentage	Rank
Colombo	280	93.33	30	1.9455	97.41	49
Gampaha	266	88.67	18	1.7933	96.35	42
Kalutara	271	90.33	23.5	1.8864	97.04	47
Matale	257	85.67	13	1.7866	96.30	40
Kandy	278	92.67	28.5	1.8853	97.03	46
Nuwara Eliya	222	74.00	4.5	1.2970	90.27	22
Galle	277	92.33	27	1.9470	97.42	50
Matara	278	92.67	28.5	1.1936	88.37	17
Hambantota	268	89.33	20	1.8744	96.96	45
Jaffna	275	91.67	25	1.8118	96.50	43
Kilinochchi	221	73.67	3	0.6082	72.85	1
Mannar	244	81.33	9.5	1.3855	91.71	26
Mullativu	234	78.00	6	0.6126	72.99	2
Vavuliya	241	80.33	8	1.7555	96.04	38
Tricomalee	240	80.00	7	1.6444	95.00	34
Batticaloa	261	87.00	16	1.6236	94.78	33
Ampara	260	86.67	15	1.7601	96.08	39
Puttalam	267	89.00	19	1.6524	95.08	35
Kurunegala	270	90.00	21	1.8892	97.06	48
Anuradhapura	244	81.33	9.5	1.6758	95.31	37
Polonnaruwa	250	83.33	11	1.5135	93.49	31
Badulla	255	85.00	12	1.6688	95.24	36
Monaragala	222	74.00	4.5	1.5192	93.56	32
Kegalle	271	90.33	23.5	1.8308	96.64	44
Ratnapura	258	86.00	14	1.7890	96.32	41
					$T_{raw\ score}$	397
					$T_{z\text{-}score}$	878

Table 7. District wise raw scores, z-scores and ranking for Agriculture – 1996 vs 2006

Agriculture						
	Raw Score			Z-score		
District	1996	Percentage	Rank	2006	Percentage	Rank
Colombo	266	88.67	50	1.1259	86.99	36
Gampaha	258	86.00	32	1.1087	86.62	34
Kalutara	257	85.67	29.5	1.1309	87.10	38
Matale	249	83.00	20	1.0256	84.75	23
Kandy	261	87.00	37	1.1714	87.93	43
Nuwara Eliya	204	68.00	2	0.8521	80.29	14
Galle	264	88.00	45	1.1949	88.39	49
Matara	265	88.33	46.67	1.1736	87.97	44
Hambantota	259	86.33	33	1.1541	87.58	40
Jaffna	265	88.33	46.67	1.1140	86.74	35
Kilinochchi	227	75.67	8	0.8985	81.55	17
Mannar	201	67.00	1	0.5199	69.84	3
Mullativu	226	75.33	7	0.7494	77.32	10
Vavuliya	223	74.33	6	1.0443	85.18	25.5
Tricomalee	220	73.33	5	0.7933	78.62	12
Batticaloa	247	82.33	19	1.0796	85.98	31
Ampara	242	80.67	15	1.0472	85.25	27
Puttalam	257	85.67	29.5	0.8757	80.94	16
Kurunegala	265	88.33	46.67	1.1698	87.90	42
Anuradhapura	235	78.33	11	0.9573	83.08	21
Polonnaruwa	230	76.67	9	0.8353	79.82	13
Badulla	250	83.33	22	1.0473	85.25	28
Monaragala	214	71.33	4	0.9255	82.26	18
Kegalle	263	87.67	41	1.1505	87.50	39
Ratnapura	255	85.00	24	1.0443	85.18	25.5
					$T_{raw\ score}$	590.01
					$T_{z\text{-}score}$	684

Table 8. District wise raw scores, z-scores and ranking for Engineering – 1999 vs 2007

Engineering						
	Raw Score			Z-score		
District	1999	Percentage	Rank	2007	Percentage	Rank
Colombo	264	88.00	30	1.9334	97.34	49
Gampaha	248	82.67	20.5	1.6022	94.54	38
Kalutara	255	85.00	24	1.7485	95.98	41
Matale	243	81.00	16.5	1.3579	91.28	36
Kandy	243	81.00	16.5	1.8650	96.89	45
Nuwara Eliya	199	66.33	4	1.1252	86.97	28
Galle	259	86.33	26	1.9332	97.34	48
Matara	260	86.67	27	1.9750	97.59	50
Hambantota	242	80.67	15	1.8705	96.93	47
Jaffna	267	89.00	31	1.8468	96.76	44
Kilinochchi	249	83.00	22	0.6540	74.34	8
Mannar	209	69.67	5	0.9908	83.91	23
Mullativu	244	81.33	18	-0.0974	46.12	1
Vavuliya	245	81.67	19	1.7752	96.21	43
Tricomalee	227	75.67	9	1.2444	89.33	33
Batticaloa	248	82.67	20.5	1.2267	89.00	32
Ampara	232	77.33	11	1.3486	91.13	35
Puttalam	241	80.33	13.5	1.2829	90.02	34
Kurunegala	239	79.67	12	1.8678	96.91	46
Anuradhapura	210	70.00	6	1.4919	93.21	37
Polonnaruwa	184	61.33	2	1.0625	85.60	25
Badulla	222	74.00	7	1.6412	94.96	39
Monaragala	187	62.33	3	1.1519	87.53	29
Kegalle	241	80.33	13.5	1.7576	96.06	42
Ratnapura	228	76.00	10	1.6771	95.32	40
					$T_{raw\ score}$	382
					$T_{z\text{-}score}$	893

Case 1c. Engineering

The sample sizes were 25.

The test statistics for the Wilcoxon Rank Sum test was based on the totals of the ranks for each of the two samples – that is on the rank sums. The rank sum of the z-scores was denoted by $T_{z\text{-score}} = 893$ and the rank sum of the raw scores by $T_{raw\text{-score}} = 382$.

$$S_{raw\text{-score}} = \sqrt{\frac{n_{z-score} n_{raw-score} (n_{z-score} + n_{raw-score} + 1)}{12}} = 51.53$$

$$E(T_{raw\text{-score}}) = \frac{n_{raw-score} (n_{z-score} + n_{raw-score} + 1)}{2} = 637.5$$

This was a left tail test and the significance level α picked was 0.05 (95% confidence level). Then $z_\alpha = -1.645$. The z value was $z_{test} = = -4.958$. In this case z_{test} value is less than z_α value, indicating that the test is statistically significant at alpha = 0.05, thus it is accepted that at alpha= 0.05 raw score distribution in 1999 is shifted to the left of z score distribution

in 2007. Thus in 1999 students with lower grades in engineering were accpeted to school compared to 2007 at the 0.05 significance level. Thus there is a 95% confidence level that the z score method gives a disadvantage to students in 2007 in university entrance exam when it comes to engineering.