

Examination of Proper Randomness of the Numbers Generated by Rand Corporation (1955) Random Number Table: t-test

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ABSTRACT: Proper randomness of the numbers generated by Rand Corporation has been tested by B.K. Sarmah, D. Chakrabarty and N. Barman, IJESM 5 (1) : January – March, 2015, 97-119 by applying the Chi-square test for testing the significance of difference between observed frequency of each of the digit in the table and the corresponding theoretical (expected) frequency .

In this paper, the randomness of the digits have been tested by applying t-test for amount of deviation of the observed number of occurrences and the theoretical (expected) number of occurrences of the respective digits and hence the numbers.

The test shows that the numbers generated by Rand Corporation deviated significantly in most the observations from proper randomness.

KEYWORDS: Random number generated by Rand Corporation , student t-test, testing of randomness.

I. INTRODUCTION

Drawing of random sample has been found to be vital or basic necessity in most of the researches and investigations especially of applied sciences. The convenient practical method of selecting a random sample consists of the use of Table of Random Numbers. Existing tables of random numbers, used commonly, are the ones due to Fisher and Yates (Constructed in 1938), L.H.C. Tippett (Constructed in 1927), Kendall and Babington Smith (Constructed in 1939) and Rand Corporation (constructed in 1955)

The random number tables have been subjected to various statistical tests of randomness. These tests have limitations to decide on proper randomness of the numbers occurring in the corresponding tables. As a Consequence it is not guaranteed that the numbers in each of these tables are properly random. This leads to think of testing the proper randomness of the numbers in the tables. In the present study, an attempt has been made to test this. The study, here, has been made on the testing of randomness of the table of numbers constructed by *Rand Corporation* only. By the existing statistical methods, it is only possible to know whether the randomness of the numbers of a table is proper. It is only possible to know whether the deviation of the degree of its randomness is significant. In order to test the proper randomness of the random numbers table constructed by *Rand Corporation*, t-test has been applied. The test shows that *Rand Corporation*'s Random numbers table deviate significantly from proper randomness.

II. MATERIALS AND METHODS

Rand Corporation random number table consists of a total of one million random digits grouped into 2,00,000 sets of 5 digit random numbers . Here a sample of 50000 digits are considered out of one million digits for testing Randomness.

To know whether the number in random numbers table of **Rand Corporation** are proper or not student's t-test for amount of deviation is applied.

Let 'd' be the variable denoting the measure of the deviation (amount of deviation) of the observed number of occurrences of the respective digit.

Suppose, $d_i (i=0,1,\dots,9)$ are independent observed values of the deviation variables.

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If the table of number is random then $d_i=0$, for all i , in the ideal situation . However, due to chance error, d_i may assume non zero value.

Thus the values of d_i 's are due to chance error but not due to any assignable error if the table is random.

The chance variables are i.i.d. $N.(0,\sigma)$ variables.

Thus testing of randomness is equivalent to testing of the hypothesis H_0 .

That $E(d_i) = 0$, for all i ,

Let us consider the statistic t for testing H_0

$$\text{i.e. } t = \frac{\bar{d} - E(\bar{d})}{S.E.(\bar{d})} \sim t_{n-1}$$

where,

$$\bar{d} = \frac{1}{n} \sum_{i=1}^n d_i$$

We have,

$$E(\bar{d}) = \frac{1}{n} \sum E(d_i) = 0$$

When H_0 is true

Also,

$$\text{var}(\bar{d}) = \frac{\sigma^2}{n}, \sigma^2 \text{ is unknown}$$

However unbiased estimate of σ^2 is

$$s^2 = \frac{1}{n-1} \sum (d_i - \bar{d})^2$$

$$= \frac{1}{n-1} \left[\sum d_i^2 - \frac{(\sum d_i)^2}{n} \right]$$

Which implies unbiased estimate of

$$\text{var}(\bar{d}) = \frac{s^2}{n}$$

$$\text{and } S.D.(\bar{d}) = \frac{s}{\sqrt{n}}$$

Therefore statistic t for testing H_0 becomes

$$t = \frac{\bar{d}}{s/\sqrt{n}} \text{ when } H_0 \text{ is true and this } t \text{ follows student's } t \text{ distribution with } (n-1) \text{ d.f.}$$

III. STEPS IN THE METHOD

In order to test the proper randomness of the numbers of **Rand Corporation** table one is required to proceed with the following steps:

- Step1: In the first step, observe the occurrences of the digits 0 to 9 for first 2000 trails, second 2000 trials up to 25th 2000 trails as shown in the table.
- Step2: In the second step, compute the theoretical expected frequencies. This is done by dividing trails i.e. 1st 2000 and 25th 2000 trails by 10 assuming that the digit 0 to 9 occurs equal number of times.
- Step 3: In the third step, compute the amount of deviation of observed occurrences of digits and expected occurrences of digits.
- Step 4: In the fourth step, compute the value of student's t for each of the trails.
- Step 5: Compare the value of t -statistic with corresponding theoretical (expected) values.
- Step 6: Draw conclusion as per the result obtained in step 5.

IV. RESULTS AND DISCUSSION

The results obtained on operating the steps (Nos. 1 to 5) on the random numbers table constructed by **Rand Corporation** have been observed. It is observed from the table that occurrences of digit 0 to 9 are not equal.

V. CONCLUSION

From the table prepared for observed frequency of occurrence of digits along with respective expected frequency (shown in bracket) it is observed that the calculated value of t is significant in all most of the cases except

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3rd, 7th, 20th, 23rd, 25th 2000 trails. That is calculated value of 't' have been found to be significant on comparing them with the corresponding theoretical values for most of the cases (trails).

Hence it may be concluded that the table of numbers constructed by **Rand Corporation** deviates significantly from proper randomness.

Therefore Rand Corporation Random Numbers Table Cannot be treated as properly random, as per results obtained by applying t-test.

TABLE

Observed frequency of occurrence of digits along with the respective expected frequency (Shown in bracket), amount of deviation (di) and the values of students 't' statistic from **Rand Corporation** .

Digits	0	1	2	3	4	5	6	7	8	9	Value of t
1 st 2000	6 206 (200)	16 184(20 0)	16 184(20 0)	0 200(20 0)	24 224(200)	11 211(200)	3 197(20 0)	4 204(200)	16 184(200)	6 206(20 0)	4.04
2 nd 2000	3 197 (200)	19 219 (200)	15 215 (200)	6 206 (200)	15 185 (200)	19 181 (200)	8 192 (200)	5 205 (200)	0 200(200)	0 200 (200)	4.21
3 rd 2000	2 202 (200)	11 189 (200)	3 203 (200)	15 215 (200)	26 226 (200)	2 198 (200)	17 183 (200)	5 195 (200)	2 202 (200)	13 187 (200)	3.21*
4 th 2000	8 192 (200)	24 224 (200)	18 182 (200)	11 189 (200)	24 224 (200)	4 196 (200)	5 205 (200)	1 199 (200)	8 192 (200)	3 197 (200)	4.00
5 th 2000	7 207 (200)	7 207 (200)	14 186 (200)	25 175 (200)	13 213 (200)	7 193 (200)	10 210 (200)	14 214 (200)	2 202 (200)	7 193 (200)	5.00
6 th 2000	8 208 (200)	7 193 (200)	11 189 (200)	15 215 (200)	16 216 (200)	3 203 (200)	12 188 (200)	12 188 (200)	3 203 (200)	3 197 (200)	6.91
7 th 2000	4 196 (200)	4 196 (200)	8 192 (200)	7 207 (200)	1 199 (200)	0 200 (200)	21 221 (200)	11 211 (200)	21 179 (200)	1 199 (200)	3.28*
8 th 2000	19 181 (200)	11 211 (200)	19 219 (200)	11 189 (200)	5 195 (200)	17 217 (200)	10 210 (200)	11 189 (200)	7 193 (200)	4 196 (200)	7.27
9 th 2000	9 191 (200)	0 200 (200)	1 199 (200)	10 210 (200)	10 210 (200)	9 191 (200)	19 219 (200)	1 199 (200)	20 180 (200)	1 201 (200)	3.59
10 th 2000	11 189 (200)	1 199 (200)	19 181 (200)	4 196 (200)	10 190 (200)	16 184 (200)	16 216 (200)	22 222 (200)	15 215 (200)	8 208 (200)	5.53
11 th 2000	31 169 (200)	3 197 (200)	11 189 (200)	8 192 (200)	6 194 (200)	27 227 (200)	13 187 (200)	18 218 (200)	5 205 (200)	22 222 (200)	4.11
12 th 2000	8 108 (200)	0 200 (200)	9 191 (200)	9 209 (200)	9 191 (200)	21 221 (200)	2 198 (200)	28 228 (200)	29 171 (200)	17 183 (200)	3.60
13 th 2000	26 174 (200)	12 188 (200)	23 177 (200)	9 209 (200)	18 218 (200)	15 185 (200)	0 200 (200)	8 192 (200)	34 234 (200)	23 223 (200)	4.65

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14 th 2000	11 211 (200)	15 185 (200)	9 209 (200)	3 197 (200)	1 201 (200)	2 198 (200)	12 188 (200)	9 209 (200)	8 200 (200)	6 194 (200)	4.85
15 th 2000	15 215 (200)	16 194 (200)	29 171 (200)	2 202 (200)	7 207 (200)	16 216 (200)	9 191 (200)	7 207 (200)	1 199 (200)	2 198 (200)	3.91
16 th 2000	17 217 (200)	12 188 (200)	6 194 (200)	2 202 (200)	3 203 (200)	13 187 (200)	5 195 (200)	8 208 (200)	6 206 (200)	0 200 (200)	4.80
17 th 2000	14 214 (200)	23 177 (200)	22 222 (200)	17 183 (200)	9 209 (200)	2 202 (200)	7 207 (200)	2 198 (200)	12 188 (200)	0 200 (200)	4.63
18 th 2000	3 203 (200)	14 186 (200)	8 192 (200)	11 211 (200)	1 201 (200)	15 185 (200)	1 201 (200)	10 210 (200)	9 209 (200)	2 202 (200)	4.56
19 th 2000	25 175 (200)	15 215 (200)	32 232 (200)	30 170 (200)	3 197 (200)	5 205 (200)	1 201 (200)	9 191 (200)	17 217 (200)	3 197 (200)	3.91
20 th 2000	2 202 (200)	3 203 (200)	2 198 (200)	6 194 (200)	1 199 (200)	7 207 (200)	2 202 (200)	3 197 (200)	15 185 (200)	13 201 (200)	3.12*
21 st 2000	25 175 (200)	25 225 (200)	16 216 (200)	8 192 (200)	4 196 (200)	29 171 (200)	9 209 (200)	22 222 (200)	14 214 (200)	20 180 (200)	5.75
22 nd 2000	7 207 (200)	11 211 (200)	6 194 (200)	7 207 (200)	14 214 (200)	2 202 (200)	5 205 (200)	20 180 (200)	6 194 (200)	14 186 (200)	4.32
23 rd 2000	23 223 (200)	6 206 (200)	34 166 (200)	2 198 (200)	2 202 (200)	0 200 (200)	3 203 (200)	0 200 (200)	10 210 (200)	8 192 (200)	2.25*
24 th 2000	18 182 (200)	19 219 (200)	14 214 (200)	11 211 (200)	1 199 (200)	7 193 (200)	1 199 (200)	8 208 (200)	29 171 (200)	4 204 (200)	3.96
25 th 2000	4 196 (200)	3 203 (200)	9 209 (200)	29 171 (200)	6 194 (200)	3 197 (200)	14 214 (200)	1 201 (200)	14 214 (200)	1 201 (200)	3.14*

*Indicates the values which are less than theoretical values of $t_{0.01,8}=3.36$

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