Drawing of Random Four-digit Numbers from Independent Tables of Random Two-digit Numbers in Selection of Random Sample

Abstract

By the method of construction of a set of random two-digit numbers, innovated by Chakrabarty in 2013, two independent sets (in the form of tables) each containing 10000 random occurrences of the 100 two-digit numbers 00 , 01 , 02 , 03 , ... , 98 , 99, have been constructed for the purpose of drawing of random four-digit numbers.

Method of drawing of random four-digit numbers from these two independent sets of random two-digit numbers has been discussed with examples.

Keywords: Two-digit numbers; Random occurrences; Independent sets; Drawing of random two-digit numbers

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Introduction

Drawing of random sample is one of the most important components of almost every. The scientific method of selecting a random sample consists of the use of random number table. Several tables of random numbers have already been constructed by the renowned researchers. Some of them are (in chronological order) due to Tippett [1], Mahalanobis [2], Kendall & Smith [3,4], Fisher & Yates [5], Hald [6], Royo & Ferrer [7], RAND Corporation [8], Quenouille [9], Moses & Oakford [10], Rao, Mitra & Matthai [11], Snedecor & Cochran [12], Rohlf & Sokal [13], Manfred [14], Hill & Hill [15] etc. Among these tables, the following four tables are treated as suitable in drawing of simple random sample (with or without replacement) from a population (Cochran [16]):

I. Tippett's Random Numbers Table that consists of 10,400 four-digit numbers giving in all 41,600 single digits selected at random from the British Census report [1].

II. Fisher and Yates Random Numbers Table that comprises 15000 digits arranged in two's [5].

III. Kendall and Smith's Random Numbers that consists of 100,000 digits grouped into 25,000 sets of random four-digit numbers [3].

IV. Random Numbers Table by Rand Corporation that contains of one million digits consisting of 200,000 random numbers of 5 digits each [8].

The proper randomness of these tables is yet to be tested. In a study made by Chakrabarty [17] on the testing of randomness of the table due to Fisher & Yates [3], it has been found that this table, consisting of the 7500 occurrences of the 100 two-digit numbers, is not properly random and deviates significantly from proper randomness. Due to this reason, one table consisting of 6000 random occurrences of the 100 two-digit numbers has been constructed as an alternative/competitor of this table [18]. Also, one table containing 5000 random occurrences of the 1000 three-digit numbers has been constructed by Chakrabarty [19] due to the unavailability of such table of three-digit numbers. Recently, study has been made on testing the proper randomness of the random number tables due to Tippett [20], due to Kendall & Smith [21], due to Rand Corporation [22]. In the studies, each of the tables has been found to be suffered from proper randomness. This leads to think of constructing of table of random four-digit numbers and also table of random five-digit numbers. However, due to the increasing difficulties in the construction of these tables by the method composed by Chakrabarty [18], it has been compelled to think of an alternative approach of drawing of random four-digit numbers. The current study is based on this approach. The approach, thought of here, is to draw random M-digit numbers from independent tables of random m-digit numbers (m<M). As the first attempt, the study on this approach has been made in the context of drawing of random four-digit numbers from two independent tables each containing random occurrences of the 100 two-digit number. Consequently, it becomes necessary for making availability of two independent sets of random two-digit numbers. Of course, one more table of random two-digit numbers was constructed by Chakrabarty [23]. Due to the necessity of two independent sets of random two-digit numbers in drawing of random four-digit numbers, two independent tables have been constructed each consisting of 10000 random occurrences of the 100 two-digit numbers 00 , 01 , 02 , 03 , ... , 98 , 99. The two tables have been constructed independently by the method of construction of a set of random two-digit numbers innovated by Chakrabarty [18]. Method of drawing of random

four-digit numbers from these two independent sets of random two-digit numbers has been discussed with examples.

Construction of Independent Tables of Random Numbers

One method of construction of a set of random two-digit numbers was innovated by Chakrabarty [18].

The method can be summarized as follows:

There are 100 two-digit numbers namely

00 , 01 , 02 , 03 , 04 , 05 , 06 , 07 , 08 , 09 , 10 , 11 , 12 , 13 , 14 , 15 , 16 , 17 , 18 , 19,

20 , 21 , 22 , 23 , 24 , 25 , 26 , 27 , 28 , 29 , 30 , 31 , 32 , 33 , 34 , 35 , 36 , 37 , 38 , 39,

40 , 41 , 42 , 43 , 44 , 45 , 46 , 47 , 48 , 49 , 50 , 51 , 52 , 53 , 54 , 55 , 56 , 57 , 58 , 59,

60 , 61 , 62 , 63 , 64 , 65 , 66 , 67 , 68 , 69 , 70 , 71 , 72 , 73 , 74 , 75 , 76 , 77 , 78 , 79,

80 , 81 , 82 , 83 , 84 , 85 , 86 , 87 , 88 , 89 , 91 , 91 , 92 , 93 , 94 , 95 , 96 , 97 , 98 , 99 .

While constructing a table of random two-digit numbers one is required to note that as per the definitions of probability in practically ideal situation [24], the table will be random at ALOCE (acceptance level of chance error) α if and only if the number of occurrence of each of the 100 two-digit lies between (n + α % of n) and (n−α % of n).

Let us take an opaque container and 100 small identical balls identifying them by the numbers

00 , 01 , ... , 99.

Let the 100 balls be put inside the container and make the balls well shuffled.

If the 100 balls are drawn one by one, by applying the principle of blinding, from the container and the numbers appeared on the balls are listed in the order of their occurrences then 100 observations will be obtained where each of the 100 two-digit numbers will appear once.

If the process is repeated and the observations obtained are combined with the earlier ones then 200 observations will be obtained where each of the 100 two-digit numbers will appear twice.

If the process is continued, 100n observations will be obtained where each of the 100 two-digit numbers will appear n times out of n repetitions (n = 1 , 2 , 3 , 4 , ...).

In this experiment, it is found that

I. Each of the 100 numbers occurs n times out of 100n trials (n = 1 , 2 , 3 , 4 , ...) if we start counting from the (100n + 1) th observation

II. The number of occurrence of each of them lies between n + 1 if we start counting from any observation.

Therefore, the set/table of the observations obtained above will be a random numbers' set/table of the 100 two-digit numbers 00 , 01 , ... ,99. at ALOCE 0.01.

The method has been applied here in the construction of two sets of random two-digit numbers. The two sets have been constructed independently for the 10000 random occurrences (in each set) of the 100 two-digit numbers 00 , 01 , ... , 99 which have been shown in Table 1 and Table 2 respectively.

Features of the two tables

1. In each of the two tables, each of the 100 two-digit numbers occurs n times out of 100n consecutive occurrences (n = 1 , 2 , ...) if we start counting from the observation at the (100k + 1)th position (k=0, 1 , 2 , ...).
2. In each of the two tables, the frequency of occurrence of each of the 100 two-digit numbers out of 100n consecutive trials (n = 1 , 2 , ...) may be one more or less than n if we start counting from any position.
3. The two tables can be treated as random as per the logic behind the two definitions of probability namely definition in theoretically ideal situation and definition in practically ideal situation [24].
4. The two tables are random with respect to the occurrences of the numbers row-wise but not column-wise. Thus while drawing random numbers from any of these two tables, one requires moving row-wise either to the right or to the left starting from any position in the table. The starting position and the direction of movement are to be selected at random by suitable randomized trials in order to keep their randomness intact.

Method of drawing of random two-digit numbers from the table

Each of the two tables, constructed here, can be used in drawing of random two-digit numbers

1. which are distinct and
2. which are not necessarily distinct.

Drawing of distinct random two-digit numbers: Suppose that we want to draw n random two-digit numbers from any one of the two tables such that the drawn numbers are distinct.

Since distinct two-digit numbers are to be drawn, one can draw a maximum of 100 such numbers since the total number of such numbers is 100.

Feature no (2) mentioned in section 2.1. implies that if n two-digit numbers occurred consecutively from the (100k + 1)th position (k = 0 , 1 , 2 , ...) in the table are drawn subject to the feature no (4) then the drawn n numbers will be distinct and random.

Also, feature no (3) mentioned in section 2.1 implies that if n two-digit numbers occurred consecutively in the table are drawn starting from any position then the drawn n numbers may not be distinct. Some of them may occur twice. Thus in order to draw distinct numbers, it is required to exclude the next occurrence of the same number and to draw the next consecutive number occurred in the table following feature no (4).

Thus the drawing of random two-digit numbers consists of the two basic tasks namely selection of the starting position at random and (b) selection of the direction (right or left) of movement at random.

Accordingly, in order to obtain the n random two-digit numbers one is to proceed with the following steps:

- Select the position, from where to start, at random. Since the table contains 10000 random occurrences of the 100 two-digit numbers, accordingly there are 10000 positions of the numbers namely 0000 , 0001 , 0002 , …………… , 9999.

In selecting the starting position, one thus can apply some usual manual randomization technique of drawing one number from among the numbers 0000 , 0001 , 0002 , …………… , 9999.

One method of drawing of such number is as follows:

Take a set of 10 identical small balls distinguishing them by marking with the 10 digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and put them inside a opaque container, say C_1.

Similarly, take another set of 4 identical small distinguishing them by marking L, R, M_1, M_2 respectively and another opaque container, say C_2.

Now, draw one ball at random from the container C_1 containing the 10 balls and note down digit appeared on it. Let the digit is d_1.

Next, draw another ball at random from the container C_1 containing the same 10 balls and note down digit appeared on it. Let the digit is d_1.

Next, draw another ball at random from the container C_1 containing the same 10 balls and note down the digit appeared on it. Let the digit is d_2.

Then, draw one ball at random from the container C_2 putting 2 balls marked with L & R inside it.

If the drawn ball is R then put the digit d_2 at the right position of d_1 and if the drawn ball is L then put the digit d_2 at the left position of d_1.

Thus if the ball R appears then the selected two-digit number will be d_1 d_2 and if the ball L appears then the selected two-digit number will be d_2 d_1. Let the selected two-digit number be d_2 d_1.

Next, draw another ball at random from the container C_1 containing all the 10 balls and note down the digit appeared on it. Let the digit be d_3.

Then, draw one ball at random from the container C_2 putting 3 balls marked with L, M_1 & R inside it and put the digit d_3 at the left position of d_2 d_1 if the drawn ball is L, the middle position of d_2 d_1 if the drawn ball is M_1 & the right position of d_2 d_1 if the drawn ball is R.

Thus the selected three-digit number will be d_3 d_2 d_1 or d_2 d_3 d_1 or d_2 d_1 d_3 in accordance with the selected ball is L or M_1 or R. Let the selected three-digit number be d_2 d_3 d_1.

Finally, draw another ball at random from the container C_1 containing all the 10 balls and note down the digit appeared on it. Let the digit is d_4.

Then, draw one ball at random from the container C_2 putting 4 balls marked with L , M_1 , M_2 & R inside it and put the digit d_4 at the left position of d_2 d_3 d_1 if the drawn ball is L, the 1st middle position (from left) of d_2 d_3 d_1 if the drawn ball is M_1, the 2nd middle position (from left) of d_2 d_3 d_1 if the drawn ball is M_2 & the right position of d_2 d_3 d_1 if the drawn ball is R.

Thus the selected four-digit number will be d_4 d_3 d_2 d_1 or d_2 d_4 d_3 d_1 or d_2 d_1 d_4 d_3 or d_2 d_1 d_3 d_4 in accordance with the selected ball is L or M_1 or M_2 or R.

This selected number will be the required starting position.

- Let the ith position be selected as the starting position. Draw the number that occurs at the ith position in the table.
- Choose whether to move towards left or towards right. The choice can be made at random by performing a random binary trial (for example, by tossing of an unbiased coin or by drawing a number from the container C_2 putting two identical balls, marked with L and R respectively, inside it.
- If it is chosen to move towards right, draw the numbers occurred at the positions i , i + 1 , i + 2 , ………….. , i + n–1 in the table to obtain the n random two-digit numbers.
- If it is chosen to move towards left, draw the numbers occurred at the positions i , i–1 , i–2 , ………….. , i–n + 1 in the table to obtain the n random two-digit numbers.
- It may occur that some number or numbers among those drawn may be occurred twice. In that situation, retain only one occurrence of them and draw additional numbers appeared at the consecutive positions in the table as per requirement.

If k additional numbers are required to draw, then draw the numbers occurred at the positions i + n , i + n + 1 , i + n + 2 , ……….. , i + n + k–1 if it is chosen to move towards right and draw the numbers occurred at the positions i–n , i–n–1 , i–n–2 , ……….. , i–n–k + 1 if it is chosen to move towards left.

Note 2.2.1: Drawing of distinct random two-digit numbers corresponds to the drawing of simple random sample, of size less than 100, without replacement.

Drawing of Random Two-Digit Numbers (Not Necessarily Distinct): The features (1) and (2) in section 2.1 imply that if two-digit numbers are picked up at a gap of g positions (101 < g <), the picked up numbers will not necessarily be distinct.

Thus in order to draw n random two-digit numbers which need not necessarily be distinct, one is to proceed with the following steps:

I. Select one position from where to start at random by the similar method as in the case of drawing of distinct random two-digit numbers mentioned above. Let the ith position be selected.

II. Draw the number that occurs at the ith position in the table.

III. Chose the length of jump that is to be 101 or more and 199 or less at random. It can be chosen by some usual manual randomization technique of drawing one number from among the numbers 101, 102 , 103 , ... , 199. Let the selected length of jump be *h*.
The random selection of the length of the jump can be done by similar method as done in the selection of the starting position.

IV. Chose whether to jump towards left or towards right. The choice can be made by the same method as in the earlier case.

V. If it is chosen to jump towards right, draw the numbers occurred at the positions $i,i+h,i+2h,.........,i+(n-1)h$ in the table to obtain the required n random two-digit numbers.

VI. If it is chosen to move towards left, draw the numbers occurred at the positions $i,i-h,i-2h,.........,i-(n-1)h$ in the table to obtain the required n random two-digit numbers.

Note 2.2.2: Drawing of random two-digit numbers, not necessarily, distinct corresponds to the drawing of simple random sample with replacement.

Drawing of Random Four-digit Numbers

Let $d_1 d_2$ and $d_3 d_4$ be two numbers drawn at random from Table 1 and Table 2 respectively.

The possible values that $d_1 d_2$ assumes are the 100 two-digit numbers 00 , 01 , 02 , ... , 99 and the probability that $d_1 d_2$ assumes any of them is equal which is 0.01.

Similarly, possible values that $d_3\ d_4$ will are the possible 100 two-digit numbers 00 , 01 , 02 , ... , 99 and the probability that $d_3 d_4$ assumes any of them is equal which is 0.01.

Now if these two two-digit numbers are combined together to form the four-digit number $d_1 d_2\ d_3\ d_4$ then possible values that $d_1 d_2\ d_3\ d_4$ assumes are the 1000 four-digit numbers 0000 , 0001 , 0002 , ... , 9999 and the probability that d_1 d_2 d_3 d_4 assumes any one of them is equal which is 0.0001 (since the two numbers $d_1 d_2$ and $d_3\ d_4$ have been drawn independently).

Thus the four-digit number $d_1 d_2 d_3 d_4$ is a random one.

Similarly, the number $d_3 d_4 d_1 d_2$ is also a random one.

If one of these two four-digit numbers is selected by performing a binary random trial, the selected number will be a random four-digit number.

If the process is repeated once, one more random four-digit number can be obtained.

By the repetitions of the trial, one can obtain more random four-digit numbers.

Thus, in order to draw n random four-digit numbers one can proceed with the following steps:

I. Make a choice at random which table's two-digit numbers will be placed at the left position and which table's two-digit numbers will be placed at the right position while combining them in the formation of random four-digit numbers. This can be done by a binary random trial as mentioned earlier.

II. Draw n random two-digit numbers from Table 1 by the steps as outlined in the section 2.2.2.

III. Draw n random two-digit numbers from Table 2 by the same as outlined in the section 2.2.2.

IV. Combine the random two-digit numbers obtained from Table 1 with the corresponding random two-digit numbers obtained from Table 2. to obtain the n random four-digit numbers.

In order to draw n random four-digit numbers one can also proceed with the following steps:

I. Draw two random two-digit numbers one from Table 1 and the other from Table 2 by the same as outlined in the section 2.2.2.

II. Make a choice at random which table's two-digit number will be placed at the left position and which table's two-digit number will be placed at the right position while combining them in the formation of random four-digit number. This can be done by a binary random trial as mentioned earlier.

III. Combine the two numbers as per the selected choice of the position to obtain one random four-digit number.

IV. Repeat the three steps, from the 1st step to the 3rd step, more (n −1) times to obtain n random four-digit numbers.

Example

Example 6.1: Drawing of Distinct Random Two-Digit Numbers:

Let it be wanted to draw 10 random distinct two-digit numbers from Table 1.

Suppose that the starting position selected at random be 0576.

The two-digit number at this position in Table 1 is 20.

Thus this is selected as the 1st one among the tens.

Suppose that it is chosen by random trial to move towards the right direction.

Then the numbers at the positions 0577, 0578, ... , 0585 are to be drawn.

Now the two-digit numbers at the next 9 positions in Table 1 are 65, 37, 45, 86, 92, 02, 71, 14, 49.

Therefore, the 10 random distinct two-digit numbers will be 20, 65, 37, 45, 86, 92, 02, 71, 14, 49.

Example 6.2: Drawing of Distinct Random Two-Digit Numbers:

Let it be wanted to draw 20 random distinct two-digit numbers from Table 2.

Suppose that the starting position selected at random be 9986.

The two-digit number at this position in Table 2 is 51.

Thus this is selected as the 1st one among the 20 numbers to be selected.

Suppose that it is chosen by random trial to move towards the right direction.

Then the numbers at the next 19 successive positions are to be selected.

However, after 13 positions, the table comes to the end.

The remaining 6 positions are then taken from the beginning of the table treating the table to be a circular one.

Thus the 19 two-digit numbers at the next 19 successive positions in Table 1 are

00 , 87 , 19 , 21 , 34 , 40 , 36 , 08 , 44 , 45 , 95 , 61 , 83 , 23 , 85 , 62 , 02 , 51 , 17.

Accordingly, the 20 random two-digit numbers drawn from Table 1 are

51, 00, 87, 19, 21, 34, 40, 36, 08, 44, 45, 95, 61, 83, 23, 85, 62, 02, 51, 17.

Example 6.3: Drawing of Random Two-Digit Numbers (Not Necessarily Distinct):

Let it be wanted to draw 10 random two-digit numbers from Table 1. Which are not necessarily be distinct.

Suppose that the starting position selected at random be 9675.

The two-digit number at this position in Table 1 is 34.

Thus this is selected as the 1st one among the 10 numbers to be selected.

Suppose that it is chosen by random trial to move towards the right direction.

Let the length of jump selected at random be 105.

Then the next 9 positions in Table 1 to be considered (treating the table as circular) will be 9780 , 9885 , 9990 , 0095 , 0200 , 0305 , 0410 , 0515 ,0620.

The number appeared at these positions in Table 1 are 41 , 93 , 46 , 42 , 10 , 72 , 96 , 52 , 27.

Accordingly, the 10 random two-digit numbers drawn from Table 1 are 34 , 41 , 93 , 46 , 42 , 10 , 72 , 96 , 52 , 27.

Example 6.4: Drawing of Random Four-Digit Numbers:

Let it be wanted to draw 15 random four-digit numbers.

Let a random binary trial be performed to choice which table's two-digit numbers will be placed at the left

position and which table's two-digit numbers will be placed at the right position while combining them in the formation of random four-digit numbers. Suppose that Table 2 is found as the choice.

Now let us draw 15 random two-digit numbers from Table 1 by the steps as outlined in the section 2.2.2.

The drawn numbers (with 0475 as the starting position number, 101 as the length of jump & Right as the direction of movement) are 56 , 20 , 89 , 42 , 39 , 40 , 19 , 40 , 97 , 71 , 26 , 32 , 39 , 34 , 54.

Next let us draw 15 random two-digit numbers from Table 2 by the same as outlined in the section 2.2.2.

The drawn numbers (with 7489 as the starting position number, 110 as the length of jump & Left as the direction of movement) are 46 , 27 , 46 , 92 , 68 , 04 , 48 , 74 , 23 , 02 , 82 , 68 , 06 , 66 , 34 .

Thus the 15 random four-digit numbers to be selected will be 4656 , 2720 , 4689 , 9242 , 6839 , 0440 , 4819 , 7440 , 2397 , 0271 , 8226 , 6832 , 0639 , 6634 , 3454 .

Conclusion

The method of drawing random four-digit numbers from two independent tables of random two-digit numbers, discussed here, can be treated as an alternative of drawing the same from a table of random four-digit numbers. Thus random four-digit numbers can be drawn in the absence of a table of random four-digit numbers.

By similar method it can be possible to draw random five-digit numbers from two independent tables one for random two-digit numbers and the other for random three-digit numbers. Therefore, one task for researcher at this stage is to construct two independent sets of random numbers one for random two-digit numbers and the other for random three-digit numbers.

Another task is to construct two independent sets of random three-digit numbers in order to draw random six digit numbers by similar method.

It may be necessary to draw random m-digit numbers (for m > 6) in the situation of drawing of a large sample from a large population (consisting of billions of elements). It can be possible to draw random m-digit numbers (for m > 6) from independent tables of random two-digit numbers and/or independent tables of random three-digit numbers and/or from a combination of independent tables of random two-digit numbers and independent tables of random three-digit numbers. Therefore, there is necessity of constructing of sufficient independent tables for random two-digit numbers and also for random three-digit numbers.

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Conflict of Interest

None.

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