ON THE USE OF THE COMPUCORP STATISTICIAN 344

IDS/TP 6

by

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Technical Paper No.6

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INTRODUCTION

The Institute for Development Studies has had the Statistician 344 for some months. It is accompanied by a User's Handbook which explains the operation of the machine very well. For most problems the user will have no difficulty following this manual; but the machine can do much more than the manual indicates. This paper seeks to describe and illustrate some of these additional possibilities, but in fact, these possibilities are limited primarily by the user's ability and imagination.

In illustrating the use of the machine I will place the symbol of the key to be pressed in quotation marks. A series of steps will be separated by a comma. Page references in this paper refer to the User's Handbook.

1. POSSIBLE USES FOR THE STATISTICIAN 344

There are limits to the use of the machine. For simple addition, multiplication, division, etc., the other machines at the Institute are preferable. The keys are somewhat hard to press and the probability of error seems higher. One reason for this is that on occasion the number one wants to divide changes to 1 after pressing " ÷ ". Also, on occasion, especially on pressing " ÷ ", one receives an "E ——" message. This means the user has done something illegal, but the message occurs even if he has not. It merely means pressing "reset" but this is frustrating especially if one is in the midst of a string of calculations which have to be started over again.

Given these limitations, there are numerous calculations for which the machine can save much time. These are:

- raising a number to any power;
- taking logarithms or anti-logs of a number;
- taking the inverse of a number;
- calculating means and standard deviations (PP.4-8);
- calculating Z scores (PP. 19-20);
- taking the square root of a number;

- obtaining the exponent of a number;
- calculating a t- statistic to test for the independence of two means;
- linear regression for two variables (PP. 9-12);
- calculations involving the same operations on a set of numbers (see programming below);
- calculations which require the use of a number of memories;
- calculation of growth rates (see below).

With reference to this list several points can be made. First, note input of data is identical for "t- statistic" and "linear regression" so the output can be obtained for both should this be relevant. Second, the "delete" key (P.21) can be used to eliminate an observation in order to re-calculate one of these statistics without a particular observation already entered. Third, for some regressions one may obtain an "E ——" because some part of the operation involves dividing by a number too close to zero. If one knows the relevant formula P.21 of the manual can be used to retrieve the relevant information to determine the location of the problem. Fourth, for all standard deviations the machine subtracts $(\Sigma x)^2/_n$ from Σx^2 rather than summing the square of the difference between the observation and the mean. Professor Scott, the former Director of the Computer Centre, evidently wrote a paper demonstrating how the formula such as used by the machine could result in errors in the standard deviation up to 30 per cent if the standard deviation is small. This need not present any problem. If a standard deviation less than one is obtained and a resulting test is on the border between significant and insignificant, then the relevant standard deviation can be re-calculated by using the mean obtained already and a programme given below. If the standard deviation is larger than one, it is not likely to make any difference.

2. THE DECIMAL

The calculator does not round off to the nearest decimal. If one wishes to round off it is necessary to set the decimal one higher than required (see P.2). The machine calculates and holds numbers with many decimals, so if more decimals for a given answer on display are desired it is merely necessary to press "set/DP" and the number of decimals desired. The number of decimals which has been set does not affect the number of decimals used by the machine during calculations. My guess is internal calculations are based on at least 8 and possibly 12 decimal points.

3. THE USE OF MEMORIES

The machine has 10 explicit memories, 0 to 9 (PP.27-8), plus additional memory abilities in the form of parentheses (PP.24-5), constant muliplication, addition, subtraction and division (the first of two numbers entered), and a second function key. Therefore, possibilities are extensive.

If "STn" is pressed plus a number, then the number on display will replace any existing number in that memory. This has advantages and disadvantages. One time I pressed "STn" when I had intended to press "RCLn" and I lost 15 minutes worth of calculations. On the other hand, this provision makes it possible to build into a programme repeated use of a particular memory without clearing it first. For example, in calculating the percentage age distribution for each district, one must divide many numbers by the total population in the district. I created a programme to do this. The first step of the programme was "STn", '0' which served to place the district population total in memory 0. As I moved to the next district I punched its population total and "start/stop" which caused the second district population total to replace the first in memory 0.

Conversely, in order to sum a series of numbers in a particular memory, for example memory 7, then one must press "STn", " + ", "7" to do this. The " - ", "x" and " ÷ " operators can be used in a similar way. When a memory is used in this way, it will add to what is already in memory, so it is essential to clear the memory before starting. It should be noted that for calculating standard deviations and for linear regression certain memories are used automatically by the machine (see p.21), so they must be cleared before beginning and they cannot be used for other calculations while doing these two types of operations.

The memories can be cleared in several ways. Turning the calculator off will clear the memories, but destroy any programme as well. If the "group" key is on 1, then pressing "clear/group" will clear memories 1, 2 and 3. If "group" is on 2 pressing "clear/group" will clear memories 4, 5 and 6. Pressing "clear/group," "XY" will clear memories 0 to 6. I have not discovered a way to clear memories 7, 8 and 9 other than by subtracting the amount in the memory out of the memory. For example, for memory 7, this can be done with the following sequence: "RCLn", "?", "STn", " - ", "7". If memories are to be cleared frequently, a programme can be written to clear all of them and then this can be done merely by pressing "start/stop".

The "EXCHn" key allows viewing what is in a particular memory without losing the number on display (see p. 27).

4. CALCULATING GROWTH RATES[1]

Frequently we need to calculate the rate of growth of a variable over time and we want a cumulative growth rate (like compound interest) rather than a simple annual average of the total percentage change. This can be done with the following sequence using Kenya's 1969 and 1962 population totals as the observations:
"10733202", " ÷ ", "8365942", "$_a x^y$", "7" "$^1/_x$", " - ", "1", "=". Multiply the result, .0362, by 100 and you have the annual percentage increase. The "7" used is the number of years, or time periods, over which the growth rate is being calculated, in this case 1969 minus 1962. In order to fill in the population totals for 1963 to 1968, assuming a constant rate of growth, one continues after "=" above as follows:
"+", "1", "=", "X", "8365942", "=", which will give 8669101 for 1963. By pressing "=" again for 1964, etc., up to 1969 a check on the accuracy of the work is obtained. This method is much quicker and more accurate than the logarithm approximation.

5. USE OF PROGRAMMES

The calculator has two programme facilities identified by the "prog" key. Each programme has a capacity of 80 characters (punching of keys) and the number used is indicated at the right of the display window. If one attempts to enter more than 80, the programme will automatically revert to 1 and override the beginning of the programme. If more than 80 is needed, the programme must be broken at some appropriate point, "start/stop" pressed, "run-load" moved to "run", "prog" switched to the other programme, and then the second programme facility loaded with the continuation of the programme. While operating such a programme, it will be necessary to keep switching "prog" at the appropriate points in the series of calculations.

The programme can save much time when doing the same calculations to a series of numbers. When the programme is loaded it goes through the series of calculations automatically and the user merely has to punch in the observations in the right sequence and press "start/stop" after each observation has been entered.

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1. This formula was worked out by John Cross.

In loading a programme one goes through the series of calculations needed with "run-load" on "load". "Start/stop" needs to be pressed before every observation to be entered and at the end of the programme. Then "run-load" is moved to "run" and the calculator will go through the loaded sequence automatically if "start/stop" is pressed as many times as it was when the programme was loaded.

One should start off by writing out the exact series of calculations needed. Then the programme is loaded. Here is an elementary example, adding the products of two sets of numbers (e.g. (5x3) + (2x4)). The observations are 5,6, 2 and 4 and we wish to repeat this series of calculations many times with different numbers. The machine has right and left parentheses, so we can use them as needed. Proceed as follows: "5", "run-load" to "load", "X", "start/stop", "6", "=","+", "(", "start/stop", "2","X", "start/stop", "4", ")", "=", "start/stop", "run-load" to "run". Now any set of four numbers can be entered and if "start/stop" is pressed after each entry the answer after the fourth "start/stop" will be the sum of the two products for the four numbers. The programme will remain as long as the calculator is switched on unless another one is loaded over it, in which case it will be replaced by the new programme automatically. Other calculations can be done on the machine without affecting the programme. Also, it is possible to do calculations on the machine and merely enter the answer into the existing programme as an observation by pressing "start/stop" after realising the answer. If one wishes to reduce the lenth of the programme, the first "=" can be omitted because the "+" will automatically obtain the product of the first two observations. If one wishes to record the answer of the second multiplication, one merely needs to insert an additional "start/stop" between ")" and "=" while loading the programme.

It is possible to read into a particular memory and recall from a memory as a part of a programme. If operating with a constant, the number will be punched into the programme without pressing "start/stop" before doing so. If the constant is large, it will use up many of the 80 characters, so characters can be saved by placing the constant in a memory first and then, while loading the programme, merely recalling it from the memory. Also, in doing linear regression one can write a programme to do calculations before pressing "XY" and "=". For example, I wanted to regress the growth of the labour force on the change in the employment rate between 1964 and 1972. The numbers for the first observation were 8.2 for labour force growth, 70 for the 1964 employment rate and 64 for the 1972 employment rate.

The programme was:

"70", "run-load" to "load", " - ", "start/stop", "64", "=", "XY", "start/stop", "8.2", "=", "start/stop", "run-load" to "run". Now I entered the three numbers in the right sequence for all the districts and I obtained regression results (pp.9-12) and t - statistics (pp.14-15). This facility could be very useful if one wants to regress the logarithms of observations.

In my work I frequently wanted the standard deviation of the percentage distribution of a variable in each district from the comparable percentage distribution for Kenya. Because this is a deviation from a weighted mean I could not use the "$\Sigma/n-x-x^2$" facility. The mean was known, so this was no problem. For example, the standard deviation for the percent of males age 0-4 for all districts would require the following programme. First, I placed the mean, 9.67 (I.D.S., W.P.142, p.2), in memory 0 by punching "9.67", "STn", "0". Then the programme, using Nairobi as my first observation (I.D.S., W.P.142, p.12) is:

"7.68", "run-load" to "load", "-", "RCLn", "0", "=", "a^x", "2", "=", "STn", "+", "1", "start/stop", "run-load" to "run". After punching the observations for each district, and pressing "start/stop", I had accumulated in memory 1 the sum of the squared differences. I then pressed "RCLn", "1", "÷", "40", "=", "$\sqrt{\ }$" and I had the standard deviation. (40 is the number of observations minus 1.) I then pressed "STn", "2", moved "prog" to "2" and loaded the following programme.

"7.68", "run-load" to "load", "-", "RCLn" "0", "=", "÷", "RCLn", "2", "=", "start/stop", "run-load" to "run". I now had a second programme which told me whether an observation was above or below the mean and how many standard deviations from the mean. By moving "prog" back to 1, pressing "clear/group" (provided "group" is on 1) and placing a new mean in memory 0, I was ready to continue with the next age category. By using this programme I cut calculation time by two-thirds from using alternative calculator with a memory but without programming facilities.

For Working Paper 160, I wanted the percent in eight household categories based on Table 2 of Vol.III of the 1969 Population Census. First I calculated the distribution for Kenya's total population. Then, with a judicious use of memories and combination of both programmes, I punched in the 18 numbers for each district and obtained the percentage distribution for the eight variables as well as accumulating the sums of the squares of the deviations from the respective means in eight memories. At the end of the calculations I could calculate the standard deviation for each of the eight variables.

The programme for calculating a series of growth rates, as described in 4 above, is: "10733202", "run-load" to "load", "÷", "start/stop", "8365942", "a^x", "7", "1/x", "-", "1", "=", "start/stop", "run-load" to "run". In order to insert the capability to calculate the annual number between 1962 and 1969, the following must be placed between "start/stop" and "run-load" moved to "run":

"+", "1", "x", "start/stop", "8365942", "=", "start/stop", "=", "start/stop", "=", "start/stop", "=", "start/stop", "=", "start/stop", "=", "start/stop", "=", "start/stop". In doing this, 8365942 should be read into memory when it is punched in the first time and them recalled in the latter part of the programme. Then "start/stop" is not needed after "x".

6. "E - - -" MESSAGES

The frequency of these messages is annoying. The machine seems to prefer a firm, quick press of the keys. Any dragging of the fingers on the keys, especially on "÷", can readily produce an "E - - -". If an "E - - -" occurs press "reset" but remember:

- any calculation in progress (e.g. addition, subtraction, division, etc., including the use of parentheses) has to be started over from the beginning;
- numbers in memories are not affected in any way;
- if it occurs while loading a programme it is best to terminate the load and start loading again;
- if it occurs in the middle of the operation of an existing programme any calculation in progress is destroyed, but one remains at that particular sequence in the programme. Therefore, one must press enough "start/stops" to get to the beginning of the programme. This latter action will affect memories if reading into memories is part of the programme;
- in doing linear regression, an "E - - -" before pressing "XY" has no effect. That observation must be started over. If it occurs while or after pressing "XY", one must start over, but I am not sure what effect it has on the numbers in the memories.

The machine can save much calculation time but it is necessary to spend some time with the machine to appreciate its capabilities. Imagination, plus some knowledge of basic statistics, no doubt helps. I have never used the "int/fr" or "exp" keys so someone else can revise this paper once their use has been determined and explored.