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ABSTRACT

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# A NEW METHODOLOGY FOR RESEARCH IN THE SCHOOLS AND UNIVERSITIES -NONPARAMETRIC ANALYSIS OF TREND



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## Abstract

Trend analysis is explained in nontechnical language with examples given for both parametric and nonparametric situations. Similarities and differences between parametric and nonparametric trend analyses are conveniently charted. Practical research applications for Directors of Testing and Directors of Institutional Research are stressed. A linear nonparametric trend which serves as a prototype is calculated in a step-by-step manner. The linear and quadratic tests for trend for the three and four level case are programmed in both FORTRAN IV and BASIC. This paper concludes with the explanation of interpreting computer printout.

## Parametric Trend Analysis

Trend analysis is an application of the analysis of variance where the levels of the treatment variable (independent variable) are equally spaced with equal sample size. The treatment variable must be of interval or ratio type. When the dependent variable is of the interval type, we can ask questions concerning means. For example, "Do the group means of the dependent variable increase significantly in a linear fashion with increases in the independent variable?" The above question is concerned with the direction not with the strength of the relationship. A second question about trend may be, "Do the group means increase and then decrease with increase in the independent variable"? The latter question relates to a quadratic trend in the data while the former question relates to a linear trend in the data.

Suppose an investigator is interested in determining whether there is a relationship between level of schooling and hours spent studying per week. Table 1 illustrates a parametric trend example. Level of schooling is then the independent variable and study hours per week is the dependent variable. Sixty students were randomly selected from each level. The three levels are junior high, senior high, and college (excluding final year). Notice that the independent variable is equally spaced, i.e., the junior high includes grades 7, 8, and 9; the senior high includes the next three years and the college level includes the

Table 1

Parametric Example

| | Jr. H.S. | Sr. H.S. | College |
|---|---|---|---|
| Study Hours | N = 60 | N = 60 | N = 60 |

next three years. Years of schooling is construed to be interval type of data and levels of schooling in our example are equally spaced.

Since the dependent variable (study hours per week) is also interval type of measurement, a parametric trend analysis can be performed. We can now deal with such questions as, "Is there a linear trend between mean hours studied and level of schooling?" or stated another way, "Does the mean of hours studied increase significantly in a linear fashion with increases in level of schooling?" Similarly, we may inquire about a quadratic trend between mean hours studied and levels of schooling.

A second example uses the college level as the independent variable. Now the independent variable has four levels - freshman, sophomore, junior, and senior year. The four level case is obviously the usual research situation prevailing in the school studies. The possible research questions now become, "Is there a linear or quadratic trend over academic levels?" Technically, in the four level case, it is possible to extract another trend component called cubic. The cubic trend, however, presents interpretation problems. On this point, Marascuilo (1971) claims that the interpretative difficulties of cubic components diminish their practical value.

The parametric analysis of trend is based on the F statistic. Computational formulae are presented adequately in Ferguson (1971) and Kirk (1969). The BIOMED statistical program called BMD02V has provisions for calculating and printing out the trend components (e.g., linear, quadratic, cubic, etc.). Graphically, the means can be charted and visual inspection of trend can be made as a preliminary check to computer processing. Table 2 illustrates a linear (a), quadratic (b), and cubic (c) relations between independent (Y) and dependent (X) variable.

## Nonparametric Trend Analysis

Very frequently research in the schools and universities consists of dealing with dependent variables which are of the nominal type. As long as the levels of the independent variable can be equally spaced with equal sample sizes, trend analysis can still be performed on nominal data. The $X^2$ statistic is used in nonparametric trend analysis.

An example of nominal data generally encountered is the binary variety of either YES/NO or AGREE/DISAGREE responses. The research question now becomes, "Do the group proportions of the dependent variable increase significantly in linear fashion with increases in the independent variable?". This question relates to a linear trend analogous to the question of parametric linear trend above. In like manner, we can raise the question of a quadratic trend on the proportions, "Do the proportions increase and then decrease with increase in the independent variable?"

Table 3 distinguishes between a parametric and nonparametric trend analysis.

Table 2

Graphs of Various Trends

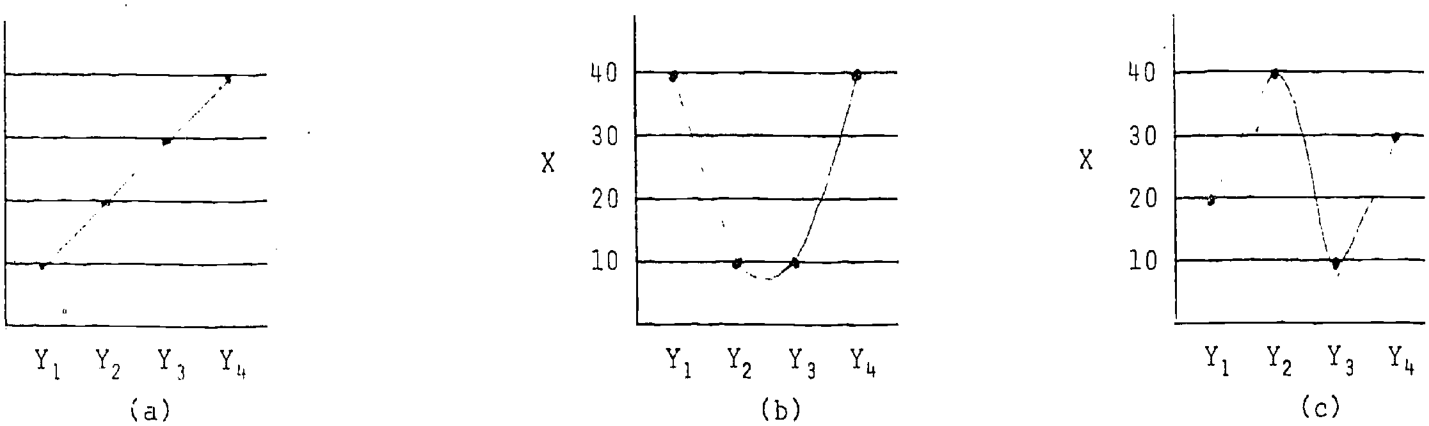

Table 3

Similarities and Differences Between Parametric and Nonparametric Trend Analyses

| | Similarities | | Differences | | |
|---|---|---|---|---|---|
| | Independent Variable | Orthogonal Coefficients | Dependent Variable | Underlying Statistic | Research Question |
| Parametric | Must be interval with (1) equal spacing of levels and (2) equal sample sizes | For equal n, these values are fixed and can be supplied by a table of orthogonal polynominals found in most statistic texts | Interval e.g. test scores, salary | F statistic | Is there a (linear ) (quadratic) trend in the group means? |
| Nonparametric | Same as above | Same as above | Nominal e.g. sex, agree/ disagree, yes/no | $X^2$ statistic | Is there a (linear ) (quadratic) trend in the group proportions? |

For nonparametric trends, Marascuilo (1971) has developed the following confidence interval test which is based on Scheffe's confidence interval tests.

$$\hat{\Psi}_{linear} - \sqrt{X^{2\;1-\alpha}_{K-1}} \cdot \sqrt{\widehat{\text{var}\;\Psi}} \leq \Psi \leq$$

$$\hat{\Psi}_{linear} + \sqrt{X^{2\;1-\alpha}_{K-1}} \cdot \sqrt{\widehat{\text{var}\;\Psi}}$$

If the interval does not contain zero, a statistically significant linear relationship exists for the proportions. A zero within the interval amounts to acceptance of the null hypothesis of no linear trend. Conversely, no zero within the interval amounts to rejection of the null hypothesis.

Using a three level case, let's take a closer look at the confidence interval. The $\hat{\Psi}$ (read as psi hat) is the population estimate which is obtained by multiplying each proportion by a "weight" and then summing. These "weights" are referred to as coefficients and they can be read from Table 4.

Hence,

$\hat{\Psi} = a_1 \cdot p_1 + a_2 \cdot p_2 + a_3 p_3$ where the a's are the orthogonal coefficients and the p's are the proportions.

For the three level case:

$$\hat{\Psi}_{linear} = (-1)p_1 + (0)p_2 + (1)p_3$$

and

$$\hat{\Psi}_{quadratic} = (1)p_1 + (-2)p_2 + (1)p_3$$

Table 4

Coefficients of Orthogonal Polynominals

| Levels of Independent Variable | Polynominal | Coefficients | | | |
|---|---|---|---|---|---|
| 3 | linear | -1 | 0 | 1 | |
| 3 | quadratic | 1 | -2 | 1 | |
| 4 | linear | -3 | -1 | 1 | 3 |
| 4 | quadratic | 1 | -1 | -1 | 1 |
| 4 | linear | -1 | 3 | -3 | 1 |

Research Example

In a recent drug survey (Pascale and Streit, 1972), six hundred students were sampled from each of the following strata - junior high school, senior high school, and college.

Students were assured of anonymity and were administered a brief questionnaire which is presented in Table 5.

Only the results of item 1 will be analyzed and discussed here. The reader can use the item 1 data as a prototype for future trend calculations involving three groups.

The independent variable is educational level which is equally spaced and contains equal sample sizes. The dependent variable is the YES or NO response. The data meets all the prerequisites for nonparametric trend analysis as outlined in Table 3.

Table 6 shows the results of tally of YES/NO responses to the seven items on the questionnaire. Columns 2, 4, and 6 show the proportions of the response variable. The question of interest is not whether there is a significant difference in the proportions of responses but rather is there a significant linear or quadratic trend in the proportions of the three groups. Prior information from adolescent psychology would lead us to hypothesize a linear trend in the proportions since the beginning years of adolescence is marked by gradual shift away from the family envelope.

Table 5

## Drug Questionnaire

Suppose each of the following groups of people gave you advice on the use and abuse of drugs. T whom would you listen? Circle your choice.

| | | |
|---|---|---|
| 1. father or mother | yes | no |
| 2. police officer, lawyer or judge | yes | no |
| 3. teacher or school counselor | yes | no |
| 4. minister, prients, or rabbi | yes | no |
| 5. older brother or sister | yes | no |
| 6. a friend or fellow student | yes | no |
| 7. someone who has used drugs | yes | no |

Table 6

Results of Drug Questionnaire

| | Junior High School | | Senior High School | | College | | |
|---|---|---|---|---|---|---|---|
| Item 1: | N | % | N | % | N | % | $X^2$ |
| Yes | 168 | 84 | 142 | 71 | 126 | 63 | 74.65 |
| No | 32 | 16 | 58 | 29 | 74 | 37 | linear |
| | | | | | | | p<.01 |
| Item 2: | | | | | | | |
| Yes | 150 | 75 | 132 | 66 | 122 | 61 | 29.04 |
| No | 50 | 25 | 68 | 34 | 78 | 39 | linear |
| | | | | | | | p<.01 |
| Item 3: | | | | | | | |
| Yes | 144 | 72 | 124 | 62 | 138 | 69 | 14.16 |
| No | 56 | 28 | 76 | 38 | 62 | 31 | quadratic |
| | | | | | | | p<.01 |
| Item 4 | | | | | | | |
| Yes | 136 | 68 | 116 | 58 | 106 | 53 | 28.94 |
| No | 64 | 32 | 84 | 42 | 94 | 47 | linear |
| | | | | | | | p<.01 |
| Item 5: | | | | | | | |
| Yes | 144 | 72 | 144 | 72 | 146 | 73 | 0.34 |
| No | 56 | 28 | 56 | 28 | 54 | 27 | not |
| | | | | | | | significant |
| Item 6: | | | | | | | |
| Yes | 132 | 66 | 148 | 74 | 166 | 83 | 46.57 |
| No | 68 | 34 | 52 | 26 | 34 | 17 | linear |
| | | | | | | | p<.01 |
| Item 7: | | | | | | | |
| Yes | 132 | 66 | 160 | 80 | 172 | 86 | 11.98 |
| No | 68 | 34 | 40 | 20 | 28 | 14 | linear |
| | | | | | | | p<.01 |

The next part of the confidence interval is:

$\sqrt{\chi^{2\,1-\alpha}_{K-1}}$ . This is simply the square root of the tabled value of the $X^2$ statistic. The $1-\alpha$ subscript refers to the level of significance and the K subscript refers to the number of levels (or number of proportions) of the independent variable. Finally, the

$$\text{var } \hat{\Psi} = \sqrt{a_1^2 \frac{(p_1 q_1)}{n_1} + a_2^2 \frac{(p_2 q_2)}{n_2} + a_3^2 \frac{(p_3 q_3)}{n_3}}$$

which is an estimate of the standard error of the proportions of the three levels or groups.

To evaluate the quadratic component involves a similar procedure with the only difference being the use of a different set of coefficients. For $\hat{\Psi}_{quadratic}$ with three levels, Table 4 shows the "weights" or coefficients to be 1, -2, and 1.

Hand Calculation of Linear Trend

(1) $\hat{\Psi}_{linear} = a_1 p_1 + a_2 p_2 + a_3 p_3$

Table 4 gives us our coefficients ($a_1$, $a_2$, and $a_3$). p represents the proportion of group answering YES. Later we will use q (q = 1 - p) in estimating the standard error of the proportions (the $\sqrt{\text{var } \hat{\Psi}}$ part of Marascuilo's equation).

So, $\hat{\Psi}_L = (-1) .84 + (0) .71 + (1) .63$

$\hat{\Psi}_L = \underline{-.21}$

(2) $\sqrt{X^{2\,1-\alpha}_{K-1}} = \sqrt{X^{2\,(.95)}_{3-1}} = \sqrt{5.991} = \underline{2.718}$

This part of the equation tells us we are working with the $X^2$ statistic at the .05 level of confidence with two (2) degrees of freedom. The number 2.718 is the square root of 5.991 which is the tabled value of $X^2$ statistic.

(3) $\text{var } \hat{\Psi}_L = \sqrt{a_1^2 \cdot \frac{(p_1 q_1)}{n_1} + a_2^2 \cdot \frac{(p_2 q_2)}{n_2} + a_3^3 \cdot \frac{(p_3 q_3)}{n_3}}$

$= \sqrt{(-1)^2 \cdot \frac{(.84 \cdot .16)}{200} + (0)^2 \cdot \frac{(71 \cdot .29)}{200} + (1)^2 \cdot \frac{(.63 \cdot .37)}{200}}$

$= \sqrt{.000672 + 0 + .001165}$

$= \underline{.042}$

Finally, putting all three elements into the Marascuilo equation, we get:

$$-.21 - (2.718 \cdot .042) \leq \Psi \leq$$

$$- .21 + (2.718 \cdot .042)$$

$$-.324 \leq \Psi_L \leq -.096$$

Since the interval for the linear contrast does not include zero, a significant linear trend for the proportions exists.

Let's now determine the significance of the quadratic trend. We follow the same procedure as outlined for the linear trend but we use different values for the coefficients $a_1$, $a_2$, and $a_3$. (Table 4).

(1) $\hat{\Psi} = (1)\ .84 + (-2) \cdot .71 + (1) \cdot .63$

$\hat{\Psi} = .84 - 1.42 + .63$

$\hat{\Psi} = \underline{.05}$

(2) $\sqrt{X^{2\ 1-\alpha}_{K-1}} = \sqrt{X^{2\ .95}_{2}} = \underline{2.718}$

(3) $\text{var}\ \hat{\Psi}_L = \sqrt{(1)^2 \cdot \frac{(.84 \cdot .16)}{200} + (-2)^2 \cdot \frac{(.71 \cdot .29)}{200} + (1)^2 \cdot \frac{(.63 \cdot .37)}{200}}$

$= \sqrt{.000672 + .0010295 + .001165}$

$= \sqrt{.0028665}$

$= \underline{.0535}$

Finally, putting the above three components in the equation, we get:

$$.05 - .0535 \leq \Psi_Q \leq .05 + .0535$$

$$- .0035 \leq \Psi_Q \leq .1035$$

Since the interval for a quadratic contrast includes zero, we conclude there is no statistically significant quadratic trend for the proportions of item 1.

## Computer Programs

The major author is currently analyzing the trends of 250 questionnaire items answered by college students. Another study concerning faculty reaction to collective bargaining practices is also underway. Computer programs were written to handle the large calculations of these two studies. The nature of school and institutional research is such that it could benefit from these two programs to handle routine analyses of many small and even large scale studies. The first study cited in this section is an example of four level case, i.e., K=4 which means there are four levels of the independent variable. The second study is an example of the K=3 case. The levels of the independent variable are assistant professor, associate professor, and full professor. The research question is "Is there a linear/quadratic relationship between faculty rank and attitude toward various aspects of collective bargaining?" More specifically, for the linear trend question - "Do the group proportions of the dependent variable (YES/NO responses of the faculty) increase significantly in linear fashion with increases in faculty rank?"

### Listings

Listings of the two programs are presented in Appendix A and B. Appendix A contains the FORTRAN IV programs. The program for the K=4 case is labeled TREND 4 and the program for the K=3 case is labeled TREND 3.

Appendix B contains the BASIC programs. The program for the K=4 case is called T4 and the program for the K=3 case is called T3. The authors wrote the BASIC programs for use with an IBM 2741 Interactive Terminal. However, the BASIC programs need not be used solely for the interactive mode. They can be easily adapted for batch mode.

Printed Output

The TREND 3 and TREND 4 FORTRAN programs contain Dϕ loops which can provide many trend analyses with one job run of the computer. For example, suppose we wanted to analyze the trend components of the seven items of the questionnaire in Table 5. Simply change card 0001 to read N=7 and format the data deck according to the following:

```
0 0 1 6 8 0 0 1 4 2 0 0 1 2 6
0 0 0 3 2 0 0 0 5 8 0 0 0 7 4
0 0 1 5 0 0 0 1 3 2 0 0 1 2 2
0 0 0 5 0 0 0 0 6 8 0 0 0 7 8
0 0 1 4 4 0 0 1 2 4 0 0 1 3 8
0 0 0 5 6 0 0 0 7 6 0 0 0 6 2
0 0 1 3 6 0 0 1 1 6 0 0 1 0 6
0 0 0 6 4 0 0 0 8 4 0 0 0 9 4
0 0 1 4 4 0 0 1 4 4 0 0 1 4 6
0 0 0 5 6 0 0 0 5 6 0 0 0 5 4
0 0 1 3 2 0 0 1 4 8 0 0 1 6 6
0 0 0 6 8 0 0 0 5 2 0 0 0 3 4
0 0 1 3 2 0 0 1 6 0 0 0 1 7 2
0 0 0 6 8 0 0 0 4 0 0 0 0 2 8
```

Notice that there are two data cards for each item. This was done merely to look like a 2 X 3 matrix which conforms to the conventional setup of $X^2$ contingency tables. Since seven items are being analyzed, there should be fourteen data cards. Each data entry gets a dedicated five column space which is right hand justified according to the format statement 11 which reads (3F5.0/3F5.0). In layman's terminology, the format says there are three fields of five columns each with the decimal point fixed at the end of each fifth column; after column fifteen proceed to the next card which will also have three fields of five columns each. Note that if the first card read

16800|00142|00126

the first cell entry would have been construed to be sixteen thousand eight hundred (16,800) instead of the one hundred sixty eight (168) which is the correct value from Table 5.

The output of the program will look like the following:

| | |
|---|---|
| -.3747699 | -4.523003E -02 |
| -.3939264 | -2.607358E -02 |
| -.3696550 | .469656 |
| -.4184450 | .518446 |

The first row contains the interval for the test of linear trend at the .05 level. The second row contains the interval for the test of linear trend at the .01 level. The third row contains the interval for the test of quadratic trend at the .05 level. The fourth row contains the interval for the test of the quadratic trend at the .01 level.

Interpretation

Recall that if an interval contains zero, there is no significant trend. The interval -.374769 -4.523003 does <u>not</u> contain zero. Therefore, we may conclude that there is a significant linear trend at the .05 level. Let's look at the second row. Since th- interval -.3939264 -2.607358E 02 does not contain zero, we may conclude that the linear trend is significant at the .01 level.

The third and fourth rows of the program output deal with the quadratic trend. Since the third row interval -.3696550 .469656 contains zero, there is no significant quadratic trend at the .05 level. Likewise, inspection of the interval in the fourth row tells us there is no significant quadratic trend at the .01 level.

# Appendix A

## Fortran Program For K=3

```
      READ(5,11) R1C1,R1C2,R1C3,R2C1,R2C2,R2C3
   11 FORMAT (3F5.0/3F5.0)
      SN1=R1C1+R2C1
      SN2=R1C2+R2C2
      SN3=R1C3+R2C3
      P1=R1C1/SN1
      P2=R1C2/SN2
      P3=R1C3/SN3
      Q1=1-P1
      Q2=1-P2
      Q3=1-P3
      AL1=-1
      AL2=0
      AL3=1
      AQ1=1
      AQ2=-2
      AQ3=1
      ALPH05=2.718
      ALPH01=3.034
      VARP1=(P1*Q1)/SN1
      VARP2=(P2*Q2)/SN2
      VARP3=(P3*Q3)/SN3
      PHILI=(AL1*P1)+(AL2*P2)+(AL3*P3)
      VARLI=((AL1**2)*VARP1)+((AL2**2)*VARP2)+((AL3**2)*VARP3)
      ERL01=ALPH01*SQRT(VARLI)
      ERL05=ALPH05*SQRT(VARLI)
      TLP05=PHILI+ERL05
      TLP01=PHILI+ERL01
      TLM05=PHILI-ERL05
      TLM01=PHILI-ERL01
      PHIQ=(AQ1*P1)+(AQ2*P2)+(AQ3*P3)
      VARQ=((AQ1**2)*VARP1)+((AQ2**2)*VARP2)+((AQ3**2)*VARP3)
      ERQ01=ALPH01*SQRT(VARQ)
      ERQ05=ALPH05*SQRT(VARQ)
      TQP05=PHIQ+ERQ05
      TQP01=PHIQ+ERQ01
      TQM05=PHIQ-ERQ05
      TQM01=PHIQ-ERQ01
      WRITE (6,13) TLM05,TLP05,TLM01,TLP01,TQM05,TQP05,TQM01,TQP01
   13 FORMAT (4(2F30.10/))
      CALL EXIT
      END
```

## Fortran Program For K=4

```
      N=3
      DO 6K=1,N
      READ(5,11) R1C1,R1C2,R1C3,R1C4,R2C1,R2C2,R2C3,R2C4
   11 FORMAT (4F5.0/4F5.0)
      SN1=R1C1+R2C1
      SN2=R1C2+R2C2
      SN3=R1C3+R2C3
      SN4=R1C4+R2C4
      P1=R1C1/SN1
      P2=R1C2/SN2
      P3=R1C3/SN3
      P4=R1C4/SN4
      Q1=1-P1
      Q2=1-P2
      Q3=1-P3
      Q4=1-P4
      AL1=-3
      AL2=-1
      AL3=1
      AL4=3
      AQ1=1
      AQ2=-1
      AQ3=-1
      AQ4=1
      ALPH05=2.7954
      ALPH01=3.3682
      VARP1=(P1*Q1)/SN1
      VARP2=(P2*Q2)/SN2
      VARP3=(P3*Q3)/SN3
      VARP4=(P4*Q4)/SN4
      PHILI=(AL1*P1)+(AL2*P2)+(AL3*P3)+(AL4*P4)
      VARLI=((AL1**2)*VARP1)+((AL2**2)*VARP2)+((AL3**2)*VARP3)+((AL4**2)
     **VARP4)
      ERL01=ALPH01*SQRT(VARLI)
      ERL05=ALPH05*SQRT(VARLI)
      TLP05=PHILI+ERL05
      TLP01=PHILI+ERL01
      TLM05=PHILI-ERL05
      TLM01=PHILI-ERL01
      PHIQ=(AQ1*P1)+(AQ2*P2)+(AQ3*P3)+(AQ4+P4)
      VARQ=((AQ1**2)*VARP1)+((AQ2**2)*VARP2)+((AQ3**2)*VARP3)+((AQ4**2)*
     *VARP4)
      ERQ01=ALPH01*SQRT(VARQ)
      ERQ05=ALPH05*SQRT(VARQ)
      TQP05=PHIQ+ERQ05
      TQP01=PHIQ+ERQ01
      TQM05=PHIQ-ERQ05
      TQM01=PHIQ-ERQ01
      WRITE (6,13) TLM05,TLP05,TLM01,TLP01,TQM05,TQP05,TQM01,TQP01
   13 FORMAT (4(2F15.9/))
    6 CONTINUE
      CALL EXIT
      END
```

Appendix B

TR3

```
list
00001 INPUT D1,D2,D3,D4,D5,D6
00002 N1=D1+D4
00003 N2=D2+D5
00010 N3=D3+D6
00020 P1=D1/N1
00030 P2=D2/N2
00040 P3=D3/N3
00050 Q1=1-P1
00060 Q2=L-P2
00070 Q3=1-P3
00080 L1=-1
00090 L2=0
00100 L3=1
00110 U1=1
00120 U2=-2
00130 U3=1
00140 A5=2.718
00150 A1=3.034
00160 V1=(P1*Q1)/N1
00170 V2=(P2*P2)/N2
00180 V3=(P3*Q3)/N3
00190 F1=(L1*P1)+(L2*P2)+(L3*P3)
00200 V4=((L1**2)*V1)+((L2**2)*V2)+((L3**2)*V3)
00210 E1=A1*SQR(V4)
00220 E5=A5*SQR(V4)
00230 T5=F1+E5
00240 T1=F1+E1
00250 M5=F1-E5
00260 M1=F1-E1
00270 F2=(U1*P1)+(U2*P2)+(U3*P3)
00280 V5=((U1**2)*V1)+((U2**2)*V2)+((U3**2)*V3)
00290 E2=A1*SQR(V5)
00300 E6=A5*SQR(V5)
00310 T6=F2+E6
00320 T2=F2+E2
00330 M6=F2-E6
00340 M2=F2-E2
00350 PRINT M5,T5
00360 PRINT M1,T1
00370 PRINT M6,T6
00380 PRINT M2,T2
00390 STOP
EDIT
```

TR4

```
list
00010 INPUT D1,D2,D3,D4,D5,D6,D7,D8
00020 N1=D1+D5
00030 N2=D2+D6
00040 N3=D3+D7
00050 N4=D4+D8
00060 P1=D1/N1
00070 P2=D2/N2
00080 P3=D3/N3
00090 P4=D4/N4
00100 Q1=1-P1
00110 Q2=1-P2
00120 Q3=1-P3
00130 Q4=1-P4
00140 L1=-3
00150 L2=-1
00160 L3=1
00170 L4=3
00180 U1=1
00190 U2=-1
00200 U3=-1
00210 U4=1
00220 A5=2.7054
00230 A1=3.3002
00240 V1=(P1*Q1)/N1
00250 V2=(P2*Q2)/N2
00260 V3=(P3*Q3)/N3
00270 V4=(P4*Q4)/N4
00280 F1=(L1*P1)+(L2*P2)+(L3*P3)+(L4*P4)
00290 V5=((L1**2)*V1)+((L2**2)*V2)+((L3**2)*V3)+((L4**2)*V4)
00300 E1=A1*SQR(V5)
00310 E5=A5*SQR(V5)
00320 T5=F1+E5
00330 T1=F1+E1
00340 M5=F1-E5
00350 M1=F1-E1
00360 F2=(U1*P1)+(U2*P2)+(U3*P3)+(U4*P4)
00370 V6=((U1**2)*V1)+((U2**2)*V2)+((U3**2)*V3)+((U4**2)*V4)
00380 E2=A1*SQR(V6)
00390 E6=A5*SQR(V6)
00400 T6=F2+E6
00410 T2=F2+E2
00420 M6=F2-E6
00430 M2=F2-E2
00440 PRINT M5,T5
00450 PRINT M1,T1
00460 PRINT M6,T6
00470 PRINT M2,T2
00480 STOP
EDIT
```

## Bibliography


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