The ϵ_i are assumed to be independent and normally distributed with mean 0 and variance σ^2, and the β_i's are the unknown parameters to be estimated. The multivariate extension of this model is

$$Y_i = B_0 + B_1X_{i1} + \ldots + B_pX_{ip} + \epsilon_i \quad = B_0 + B'X_i + \epsilon_i$$

where $Y_i = (Y_{i1}\ Y_{i2} \ldots Y_{iq})'$ is a vector of q response variables for observation i, the X_j are independent variables, the B_j are q × 1 vectors containing the regression parameters,and the ϵ_i vectors are the errors (assumed to be independent and to have a q-variate normal distribution with mean **0** and covariance matrix Σ).

1.40 MANOVA Multivariate Regression Analysis

MANOVA provides estimates of B_0, B, and Σ and tests the hypothesis that B = 0. The constant vector B_0 is included in the model unless the subcommand

```
METHOD=ESTIMATION(NOCONSTANT)/
```

is included in the MANOVA run. When NOCONSTANT is specified, the regression line or plane is forced to pass through the origin (i.e., B_0 is assumed to be **0** in the equation). Four test statistics (described in Section 1.32) are given for testing the hypothesis that B = 0: Pillai's criterion, Hotelling's trace, Wilks' lambda, and Roy's largest root. All of these are functions of the nonzero eigenvalues of $S_hS_e^{-1}$, where S_h is the regression SSCP matrix and S_e is the error SSCP matrix.

In Figure 1.40a (taken from Finn, 1974), the dependent variable consists of two divergent measures of achievement, synthesis (SYNTH) and evaluation (EVAL), and the independent variables are a general intelligence index (INTEL) and three measures of creativity (CONOBV, CONRMT, and JOB). Three cross products between the creativity measures and INTEL are formed to represent the interaction terms of the model. Figure 1.40a shows the standard SPSS command file for this problem. COMPUTE statements are used to create the interaction terms.

Figure 1.40a

```
RUN NAME        MULTIVARIATE MULTIPLE REGRESSION
COMMENT         DATA ARE TAKEN FROM FINN(1974)  C-3
VARIABLE LIST   SYNTH EVAL CONOBV CONRMT JOB INTEL
INPUT MEDIUM    CARD
INPUT FORMAT    FREEFIELD
MISSING VALUES SYNTH TO INTEL(9.9)
N OF CASES      UNKNOWN
COMPUTE         CI1=CONOBV*INTEL
COMPUTE         CI2=CONRMT*INTEL
COMPUTE         CI3=JOB*INTEL
MANOVA          SYNTH EVAL WITH INTEL CONOBV CONRMT JOB CI1 CI2 CI3/
                PRINT=DISCRIM(RAW,STAN,ESTIM,COR)/
READ INPUT DATA
5 1 20.0 5.0 13.0 106.0
0 0 13.0 3.0 10.0  97.0
6 2  9.9 4.0  5.0  90.0
4 2 10.0 3.0 15.0 121.0
1 2 12.0 2.0  4.0  99.0
7 1 25.0 5.0 23.0 120.0
1 2 21.0 3.0 11.0  91.0
  .   .   .    .     .
  .   .   .    .     .
  .   .   .    .     .
3 2 15.0 4.0 12.0 107.0
6 6 22.0 10.0 23.0 143.0
0 0 12.0 2.0 13.0 101.0
4 1 12.0 6.0 10.0 115.0
3 0 10.0 5.0 10.0  97.0
3 1 21.0 3.0 20.0  92.0
END INPUT DATA
```

Note that no factor variables are specified in the MANOVA procedure card and the keyword WITH is used to separate the response and independent variables.

The standard output includes multivariate significance tests and the statistics for parameter estimation described in Section 1.32. The following tests and statistics are of particular interest:

1 Tests of H_0:B=**0** and H_0:B_0=**0**. These are automatically printed, along with the multiple R^2 and adjusted R^2 for each response variable regressed on the independent variables. This portion of the output for Figure 1.40a is given in Figure 1.40b.