

TABLE 3.—Regression and correlation analysis—Various lead-lag structures

	Intercept	RD ^a	RD ²	Size	I ₁	D	R ²
		1955	1955		1955	1955-1957	
(1) Y ₁ (1958-1960)....	b 0.357 (0.100)	b -3.360 (1.025)	b 0.351 (0.083)	0.0000159 (0.0000049)	b -0.000000693 (0.000000212)	b -0.109 (0.032)	b 0.31
(2) Y ₁ (1955-1957)....	0.125 (0.076)	-1.193 (0.751)	0.0861 (0.0519)	0.00000649 (0.00000485)	-0.000000172 (0.000000152)	-0.0164 (0.0205)	0.13
(3) Y ₂ (1958-1960)....	b 0.594 (0.122)	b -3.898 (1.252)	b 0.465 (0.102)	b 0.0000171 (0.0000060)	b -0.000000810 (0.000000259)	b -0.118 (0.039)	b 0.32
(4) Y ₂ (1955-1957)....	-0.311 (0.140)	b 4.143 (1.387)	0.0053 (0.0959)	0.00000309 (0.00000895)	0.000000012 (0.000000280)	0.0131 (0.0378)	0.18

^a R and D is measured by the number of professional research personnel.

^b Indicates statistical significance at the 99 percent level.

^c Indicates statistical significance at the 95 percent level.

THE ROLE OF SUPPORTING PERSONNEL

At this point we shall examine the question of whether a large ratio of supporting personnel to professional staff substantially increases the efficiency of a research facility. The relevant variable is defined as the mean ratio in 1955 and 1960, and the analysis is carried out by introducing it into our regression equations.

The coefficients of the ratio of supporting to professional personnel are always negative and in no instances are they statistically significant.²⁴ Thus, we may conclude that supporting personnel play only a minor role in determining the magnitude of research output. High ratios of auxiliary staff to professionals do not seem to increase the productivity of the professional researchers. These results corroborate our earlier observations that the number of professionals seems to be a better measure of research input than the total number of R and D personnel.

THE EFFECT OF GROWTH IN RESEARCH FACILITIES

In this section, we examine the influence on technical change of rapid expansion of R and D activities. Some observers maintain that research efficiency is likely to be impaired if the rate of expansion is large.²⁵ To consider this position, we define two variables and introduce them separately into the regression equations. The first variable, which is designated G_1 , is the ratio of total research personnel in 1960 to the corresponding value in 1955. The second variable G_2 , is the ratio of 1960 to 1955 levels of professional research personnel.

The coefficients of G_1 and G_2 are not statistically significant although they are negative and thereby do take the hypothesized sign.²⁶ As a result, the hypothesis was restated and examined in a different format. It may be that rapid expansion of research facilities does not affect the rate of technical change continuously. Inefficiencies may be created only when growth is pushed above some threshold rate. To investigate this position, three dummy variables are defined according to whether the research establishment showed no growth, moderate growth, or rapid growth, between 1955 and 1960, and the first two dummies are introduced into the regression equations.²⁷

²⁴ When the ratio of technicians to professionals is introduced into equations 1 through 4 of table 1, the estimated coefficients and standard errors are: (1) -0.181, 0.144; (2) -0.149, 0.220; (3) -0.086, 0.139; and (4) -0.161, 0.211. (In equations 2 and 4, the non-significant linear RD variable was omitted when these estimates were obtained.)

²⁵ Mansfield has reported: "There are considerable costs involved in a very rapid expansion of a firm's R and D department, the importance of which was stressed in interviews with various executives." Edwin Mansfield, *The Expenditures of the Firm on Research and Development* (mimeographed), 4.

²⁶ When G_1 is introduced into our original regression equations, the estimated coefficients and standard errors are: -0.124, 0.126 in the case where technical change is measured by Y_1 , and -0.168, 0.185 when Y_2 is used. The corresponding estimates for G_2 are: -0.0229, 0.0958 and -0.061, 0.153. In these calculations, RD is measured by the number of professional research personnel.

²⁷ The dummy variables are defined on the following basis: If, during the period, the laboratory remained stable or declined in size, the firm is listed in the first category; if the facility increased in size but by less than 100%, the moderate growth grouping is designated; while if the research establishment at least doubled in size, it is considered to have experienced rapid growth. The three categories are defined in terms of increases in both total and professional research personnel.