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10 Firm versus Industry Variability in R & D Intensity

John T. Scott

In this paper I show that (1) company effects as well as industry effects explain a substantial proportion of the variance in R & D intensity, (2) the apparent impact of seller concentration is collinear with, and apparently a result of differences in, types of products, and (3) government subsidization of R & D does not displace private R & D spending.

10.1 The Inverted-U in Theory

Empirical studies of nonprice competition have hypothesized and found an "inverted-U" relation between media advertising or company-financed R & D and seller concentration. These studies include Greer (1971), Strickland and Weiss (1976), Scott (1978), Martin (1979), and Scherer (1967; 1980a, p. 437), as well as others cited by these authors. There is nonetheless good reason to question the *cause* of the relation in conventional cross-sectional studies where firms operating in many different industries contribute to the variance in nonprice competition. The relation could be explained by variance across industries in (1) the value or cost of nonprice competition, (2) the opportunity (the odds for success) for it, (3) the condition of entry, or (4) the ability to "collude" (tacitly or otherwise) on nonprice competition while holding constant the ability to "collude" on price competition (Scott 1981b).

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This paper presents evidence about the *cause* of the inverted-U relation between seller concentration and nonprice competition. If observed inverted-U's result for reasons (1) or (2) only, then they do not imply collusion and, therefore, do not imply concern with "wasteful competition." The variance in nonprice competition across firms and industries may have nothing to do with the conjectural interdependence and mutual dependence recognized among sellers, but instead may reflect differing prospective rewards to R & D or advertising *in the absence of* conjectural interdependence. The observations studied here are for the 3388 manufacturing lines of business of the 437 firms reporting for 1974 to the Federal Trade Commission's Line of Business (LB) program.[1] The results are that a statistically significant inverted-U relation exists for these observations if one does not attempt to control for differences across firms and industries in the value, costs, and "opportunity for" nonprice competition apart from that correlated with concentration, but once controls are added in *the form of a fixed-effects model* the relation disappears. The fixed-effects model may not, of course, be the appropriate way to control for the varying economic potential for nonprice competition. As discussed later, one cannot unambiguously conclude that the "collusion" hypothesis is rejected. But despite considerable variation in concentration within two-digit industries, it apparently has no impact on behavior within them.

10.2 The Inverted-U in Fact

Table 10.1 shows that the inverted-U relation between company-financed R & D intensity and seller concentration is statistically significant in the LB sample. Table 10.2 controls for company and two-digit industry effects as well as Weiss's (1980) adjusted four-firm seller concentration ratio at the four-digit FTC industry level and its square. The inverted-U relation does not remain once differences in value, costs, and opportunity for nonprice competition are controlled for *with a fixed-effects model.*

Apparently, the inverted-U results because firms face different opportunities apart from those inherent in concentration and because, for example, breakfast cereals and cold-rolled steel and chemicals are very different products for which the value of innovative investment differs even without consideration of the extent of sellers' interdependence. I believe my interpretation is valid even though the two-digit industry dummies will capture the variance in concentration to the extent that

1. See U.S. Federal Trade Commission (1979, 1981) for a description of the program. I also present the R & D model for the 3550 manufacturing lines of business of the 474 firms reporting for 1975 in 260 FTC four-digit manufacturing categories. Scott (1981a) presents evidence for advertising intensity analogous to that presented here for R & D intensity.

Table 10.1 The Inverted-U for 1974: 3388 Manufacturing LB's[a]

Company-financed R & D Intensity: (R/S) for an LB (the operations of a firm in a FTC four-digit manufacturing industry) as a function of four-firm seller concentration ($C4$) in the four-digit FTC industry.

$$R/S = \underset{(.43)}{.00094} + \underset{(4.5)^{b}}{.00049(C4)} - \underset{(-3.1)^{b}}{.0000038(C4)^2}.$$

Since one extraordinary outlier was excluded from the sample, degrees of freedom = 3384; F-value for significance of the equation as a whole = 25, significant at the .0001 level; R^2 = .015. R/S reaches its predicted maximum when $C4$ = 64.

[a]The intensity variables are ratios with LB sales as the denominator. I scale by LB sales to control for types of company-specific effects that are correlated with the firm's LB sales in the manufacturing category. $C4$ is Weiss's (1980) adjusted ratio in percentage form. The t-ratios are in parentheses below the coefficients.

[b]Significance level (two-tailed test): b = .01.

Table 10.2 Controlling for Company and Industry Effects: 3388 Manufacturing LB's, 437 Companies, 20 FTC Two-Digit Industries[a]

Company-financed R & D Intensity: (R/S) for an LB (the operations of a firm in a FTC four-digit manufacturing industry) as a function of four-firm seller concentration ($C4$) in the FTC four-digit industry.

$$R/S = b_0 + \underset{3.7^{b,c}}{\sum_{c=1}^{436} b_c} + \underset{7.5^{b}}{\sum_{i=1}^{19} b_i} + \underset{.02}{f(C4)} + \underset{.06}{g(C4)^2}.$$

F-value for null hypothesis of no effect in complete model given below the coefficients. Here and throughout the paper, whenever coefficients are shown as letters, it is because the statistical package used provided only the F-values for the effects. Since one extraordinary outlier was excluded from the sample, degrees of freedom = 2929; F-value for significance of the equation as a whole = 3.8, significant at the .0001 level; R^2 = .37.

[a]See note a of table 10.1. Also note that to reduce the size of the $X'X$ matrix for computational purposes, the company effects were absorbed. Hence, the F-test for their significance in the complete model is not computed. It is computed later for the "best" model.

[b]Significance level: b = .0001.

[c]F-test for the significance of the company effects alone—given only the intercept—not controlling for the other variables. That is, the reduction in the sum of squares because of the company effects is what results when they are fitted first, not last. See note a.

concentration is homogeneous within two-digit industries. In the extreme case, one could not control at the two-digit level for different types of goods, say food in general versus chemicals in general, *and* seller concentration at the four-digit level. In fact, such control is possible. In general, for the 259 four-digit FTC industries, 74 percent of the variance in concentration is within two-digit industries. In the specific 3388 observation sample, 68 percent of the variance in concentration is within two-digit industries.

The inference that collusion does not cause observed inverted-U's may well be inappropriate for two reasons. First, industry seller concentration alone may not be the appropriate control for mutual dependence recognized. Market power may have more to do with *firm share*, given that seller concentration is sufficiently great for recognized mutual dependence. Long (1981) is currently exploring the implications of such Cowling-Waterson (1976) conjectural interdependence equilibria for nonprice competition. In any case, the results here at least imply that traditional interpretations of the collusion hypothesis do not hold up once the fixed effects are used as controls.

The second reason for cautious interpretation of the results is that fixed effects may simply not be the appropriate way of controlling for the differentiability of products, the potential for R & D, the need for informative advertising, and so forth. True, the fixed-effects models explain more variance than the simple structural models. Table 10.3 shows the pure fixed-effects model unalloyed with the structural variables.[2] But these fixed-effects models have many times the number of regressors as the simpler models. In terms of a probability-of-F-test comparison of the models, structural models look quite good. Further, and related to the first concern, the company effects may well be picking up firm-specific aspects of market power.

As noted above, even the significance of firm-specific effects and the insignificance of seller concentration need not imply that industrywide recognition of mutual interdependence is absent. Cowling-Waterson (1976) conjectural interdependence equilibria can imply company-specific differences in R & D intensity caused by "collusion" within industries. Table 10.4 explores that possibility and, perhaps more importantly, provides descriptive information about "part-of-company" effects and narrow-industry effects within broad industry categories by estimating the fixed-effects model for each two-digit FTC industry. The twenty models for R & D intensity provide strong support for the importance of company effects within industries. Of the twenty models for R & D, the company effects are significant at the .05 level for nine cases rather than the one "expected."

In conclusion, the evidence from the fixed-effects models suggests caution when interpreting cross-sectional, multi-industry, inverted-U relations between seller concentration and nonprice competition. This is not to say that with intricate interactive simultaneous-equations modeling of various factors other than firm effects, opportunity classes at the

2. I tested the sensitivity of the results to the inclusion or exclusion of the observations for which R & D is zero. The models in table 10.3 were rerun, dropping all observations for which R & D was zero from the R & D model. The results were virtually the same as those in table 10.3.

Table 10.3 **Pure Company and Industry Effects Model: 3388 Manufacturing LB's, 437 Companies, 259 FTC Four-Digit Manufacturing Industries, 20 FTC Two-Digit Industries[a]**

	Dependent Variable	
	R/S[d]	*R/S*
F-value for null hypothesis of no effect in the complete model		
436 company dummies	3.7[b,c,d]	3.7[b,c]
258 FTC four-digit industry dummies	3.5[b,d]	—
19 FTC two-digit industry dummies	—	7.8[b]
Degrees of freedom	2817[d]	2931[e]
F-value for equation as a whole	3.6[b,d]	3.9[b]
R^2	.49[d,f]	.37

[a]See note a of table 10.2.

[b]Significance level: $b = .0001$.

[c]*F*-test for significance of company effects alone—given only the intercept—not controlling for industry effects. That is, the reduction in the sum of squares due to the company effects is what results when they are fitted first, not last. See note a of table 10.2.

[d]This result is for the 3550 manufacturing LB's of the 474 firms reporting in 260 FTC four-digit manufacturing industries in 1975. Thus, there were 473 company dummies and 259 FTC four-digit industry dummies. The 1975 observations were used because there were no extraordinary outliers in 1975, and thus, the validity of the 1974 results could be checked.

[e]Since one extraordinary outlier was dropped, only 3387 LB's were used.

[f]The explanatory power (but see note c) was divided as follows: For *R/S* 32.1 percent from company effects, 16.4 percent from industry effects. Inspection of table 10.5 shows that one can get roughly the 32 percent with either the company effects or the industry effects and get the remaining 16 percent with whichever is left. One could say then that about 16 percent is clearly from company effects, about 16 percent is clearly from industry effects, and about 16 percent is confounded in the two types of effects. Note that, as shown below, the company effects *are* significant in the complete model.

broad industry level, and concentration, or simply more control variables, that the positive correlation or the inverted-U would not be found. Rather, since we find a strong inverted-U in the data without control for variance in opportunity across observations, but eliminate that relation once the opportunity controls are added, there is the presumption that all such previously adduced correlations may be artifacts of insufficient control for opportunity. On the positive score, the results suggest that company-specific and FTC industry-specific effects can explain a large amount of the variance in nonprice competition. Clearly, the evidence suggests that company policy may influence the technological progress of the economy. One cannot explain R & D activity simply by observing the industries within which a company operates. There is more to be understood.

Table 10.4A **Company and Industry Fixed-Effects Model of R & D Intensity[a] for Two-Digit Manufacturing Industries[b]**

FTC two-digit industry	20	21	22	23	24	25	26	27	28	29
No. of companies sampled = c	60	10	65	38	44	44	68	58	52	41
No. of FTC four-digit industries sampled = i	10	3	12	7	5	6	11	9	5	3
No. of LB's sampled = n	119	14	125	83	91	57	161	98	63	50
Degrees of freedom[c] $= n - c - i + 1$	50	2	49	39	43	8	83	32	7	7
R^2	.99	.81	.85	.71	.91	.90	.82	.60	.95	.999
F-value for	57	.76	3.8	2.2	8.9	1.6	4.8	.75	2.5	144
the model[b]	.0001	.69	.0001	.007	.0001	.26	.0001	.84	.11	.0001

F-value for the null hypothesis: all company effects are zero in complete model[b]	62 .0001	.72 .70	3.8 .0001	2.3 .005	9.5 .0001	1.6 .24	3.7 .0001	.76 .82	2.4 .11	145 .0001
F-value for null hypothesis: all industry effects are zero in complete model[b]	3.0 .007	1.3 .44	1.2 .34	.27 .95	1.3 .28	1.6 .28	2.6 .008	1.6 .17	1.5 .30	1.9 .22

[a]R & D intensity is defined as company-financed R & D/sales for the LB, i.e., the company's operations in the FTC four-digit industry category. To reduce the cost of estimating these models, subsets of the two-digit industry's four-digit industries were sampled randomly when the number of companies and industries were otherwise large.

[b]Below the F-values are the related probability statements. Each statement gives the probability of $F \geqq$ the observed value if in fact the null hypothesis of zero coefficients in the linear model specified were true.

[c]In those special cases where an industry and a company dummy coincide (for example, where a single-manufacturing-LB company is the sole producer in its manufacturing industry category), the degrees of freedom will be greater since the number of dummies is reduced until no linearly dependent columns are in the X matrix.

Table 10.4B Company and Industry Fixed-Effects Model of R & D Intensity[a] for Manufacturing Industries[b]

FTC two-digit industry	30	31	32	33	34	35	36	37	38	39
No. of companies sampled = c	10	17	76	81	63	61	73	70	73	56
No. of FTC four-digit industries sampled = i	3	4	18	5	5	10	10	5	9	8
No. of LB's sampled = n	14	21	134	103	70	107	119	86	104	69
Degrees of freedom[c] $= n - c - i + 1$	2	1	41	18	4[c]	37	37	12	23	7[c]
R^2	.83	.98	.76	.79	.99	.83	.84	.71	.81	.99
F-value for the model[b]	.91 .63	2.8 .44	1.5 .093	.83 .72	4.5 .075	2.5 .0014	2.4 .002	.40 .99	1.2 .31	16 .0008
F-value for the null hypothesis: all company effects are zero in complete model[b]	.39 .87	2.1 .50	1.2 .22	.71 .85	4.5 .076	2.3 .004	1.8 .033	.34 .997	1.2 .35	17 .0006
F-value for null hypothesis: all industry effects are zero in complete model[b]	.38 .73	.96 .62	.72 .76	2.9 .05	8.6 .033	2.5 .026	2.6 .019	.88 .50	.53 .83	82 .0001

[a]See note a of table 10.4A.

[b]See note b of table 10.4A.

[c]See note c of table 10.4A.

10.3 Government R & D Financing on Company R & D Expenditures

Several studies have suggested low private returns to government-financed R & D. Scherer (1980b, pp. 19–20, 26–27, 29; 1981, pp. 16–17) finds that patent output per dollar of private R & D spending is significantly lower when government financing of R & D is high. Griliches (1980, pp. 439, 445–46) and Terleckyj (1974; 1980, p. 362, 367) find that the rate of return to government-financed R & D appears far lower than that for company R & D.

Griliches (1980, pp. 445–46, and note 14) and Scherer (1980b, p. 20) explain that such results may be because of externalities and restrictions on the appropriability of innovations. Levy and Terleckyj (1981) suggest further that government-financed R & D may have an indirect influence on productivity by increasing the amount of private R & D above what it would be in the absence of government funding.

Here I present a simple test of the extent to which government R & D spending is a substitute for, and therefore displaces, *or* is a complement to, and therefore increases, company-financed R & D spending. Although the methodology is different, the question is the same as one of Mansfield's (this volume). The test uses the 3388 observations on lines of business for the 437 companies reporting in 259 FTC four-digit manufacturing categories in 1974 to the FTC's Line of Business (LB) program. The company and industry fixed-effects model for these data discussed in section 10.2 shows that, with 1975 data, 49 percent of the variance in the ratio of company-financed R & D to LB sales is explained by the company and industry effects. Here, the 1974 data are used and one additional explanatory variable is added—the ratio of government-financed R & D to LB sales. The question is, other things equal: Is company-financed R & D intensity greater or lower in LB's where government-financed R & D is greater?

Table 10.5 provides the answer, although it is certainly possible to question causal stories since random disturbances in company- and government-financed R & D might reasonably be correlated. Equation (1) shows that government financing goes to firms that do a lot of R & D in a LB. Equation (2) shows that the relation is not simply the result of funds going to firms that characteristically do a lot of R & D. Equation (3) shows that we are not simply observing that funds go to firms in R & D-intensive industries. Equation (4) shows that the relation is not simply the result of government funds going to R & D intensive firms in R & D intensive industries. The substitution hypothesis is rejected. There appears to be stimulation rather than substitution.

There is, however, the possibility of spurious results in table 10.5's specifications because sales appear in the denominator on both sides of the equation (see Kuh and Meyer 1955). Table 10.6 presents results that show that the positive relation, other things equal, between government-

Table 10.5 **Company R & D Intensity (R/S) and Government-Financed R & D Intensity (G/S) for an LB**[a]

(1)
$$R/S = .013 + .10\,(G/S).$$
$$\quad (29)^b \qquad (9.9)^b$$

The t-ratios are in parentheses below the coefficients. Degrees of freedom = 3385; F-value for significance of the equation = 98^b; R^2 = .028.

(2)
$$R/S = b_0 + \sum_{c=1}^{436} b_c + .076\,(G/S).$$
$$(3.6)^{b,c} \quad (58)^b$$

The F-values are in parentheses below the coefficients. Degrees of freedom = 2949; F-value for the significance of the equation = 3.7^b; R^2 = .36.

(3)
$$R/S = b_0 + \sum_{i=1}^{258} b_i + .091\,(G/S).$$
$$(6.0)^{b,c} \quad (62)^b$$

The F-values are in parentheses below the coefficients. Degrees of freedom = 3127; F-value for significance of the equation = 6.2^b; R^2 = .34.

(4)
$$R/S = b_0 + \sum_{c=1}^{436} b_c + \sum_{i=1}^{258} b_i + b_g(G/S).$$
$$(4.4)^{b,c} \quad (3.6)^b \quad (40)^b$$

The F-values are in parentheses below the coefficients. Degrees of freedom = 2691; F-value for significance of the equation = 4.2^b; R^2 = .52.

[a]A line of business (LB) is the operations of a company in a FTC four-digit manufacturing industry. The intensity variables are ratios with LB sales as the denominator. I scale by sales to control for types of company-specific effects that are correlated with the firm's LB sales in the manufacturing category. One extraordinary outlier was excluded from the sample; thus 3387 LB observations were used.

[b]Significance level is .0001.

[c]To reduce the size of the $X'X$ matrix for computational purposes, these effects were absorbed. Hence the F-test for their significance in the *complete* model is not computed. That is, the reduction in sum of squares due to these effects is what results when they are fitted first, not last. The F-test for the significance of the company effects in the complete model is computed later for the "best" model.

financed R & D and company-financed R & D is not spurious. The relation is, however, far less significant in the specifications used in table 10.6, suggesting that variance in the denominators of the intensity variables did affect the high level of significance for the intensity of government-financed R & D.

In table 10.6, all LB observations for which company-financed R & D was zero were dropped. We are, after all, interested in whether companies that do private R & D do more when government financing is present. The following variables are used:

LR = the natural logarithm (ln) of company-financed R & D (R) in the line of business (LB);

LS = ln of LB sales (S);

Table 10.6 Regressions with *LR* as the Dependent Variable

Independent Variables	Equation (1)	Equation (2)	Equation (3)	Equation (4)
Intercept	−3.5	b_0	b_0	b_0
	$(t = -9.6)^a$			
LS	.91	.88	.99	$F = 1709^a$
	$(t = 40)^a$	$(t = 41)^a$	$(t = 43)^a$	
LG	.081	.075	.060	$F = 2.9^c$
	$(t = 2.3)^b$	$(t = 2.3)^b$	$(t = 1.6)^c$	
X	−.49	−.20	−.10	$F = .15$
	$(t = -1.8)^c$	$(t = -.78)$	$(t = -.41)$	
Company effects		$F = 7.7^{a,d}$		$F = 10^{a,d}$
		394 effects		394 effects
Industry effects			$F = 8.5^{a,d}$	$F = 3.5^a$
			254 effects	253 effects[e]
Degrees of freedom	2476	2082	2222	1829
R^2	.44	.70	.66	.80
F-value for equation	655[a]	12[a]	17[a]	11[a]

[a,b,c]Significance levels: [a] = .0001; [b] = .05; [c] = .10.

[d]See note c, table 10.5.

[e]An additional industry dummy had to be dropped. See note c, table 10.4A.

LG = ln of government-financed R & D (G) if $G > 0$, ln(1) if $G = 0$; $X = 0$, if $G > 0$, 1 if $G = 0$; and various fixed effects.

The difference in significance in tables 10.5 and 10.6 for the government-financed R & D variable is a result of the new functional form and *not* a result of dropping the zero R & D observations, since the specifications in table 10.5 yield similar results with and without the zero observations.

It must be noted that I have said nothing more than what is apparent. In particular, I have said nothing about productivity. It is entirely possible that government subsidies stimulate "wasteful" private spending. Nonetheless, the results suggest some complementarity between private and government-financed R & D and are remarkably similar to the results in Mansfield (this volume).[3] An incidental finding in table 10.6 is that there is no evidence that company-financed R & D increases more than proportionately with LB size.

One more fact provides a useful conclusion. Although my primary interest is in whether an impact for seller concentration or government-financed R & D remains after controlling for company effects (either idiosyncratic reporting or real R & D activity) and industry effects, many

3. When $R = G$ so that slope and elasticity are the same, my results in table 10.6 are very close to Mansfield's result. Holding constant S and therefore using the estimate of $d(R|S)/d(G|S)$ to estimate dR/dG, my results in table 10.5 are also quite close to Mansfield's results, although somewhat larger.

readers may want to see the F-test *in the complete model* for company effects. I have therefore computed one such test (for what seems to me to be the "best" model). All such tests would be similar, so there is no need to do them all.

Using sums of squares from equations (3) and (4) from table 10.6, the test of the hypothesis that *in the complete model* $b_c = 0$ for all 394 effects is given by:

$$F = \frac{\begin{bmatrix}\text{reduction in residual sum of squares from fitting the} \\ \text{394 effects after fitting the other variables/394}\end{bmatrix}}{[\text{the residual sum of squares for the complete model/1829}]}$$

$= 3.3$ with 394 and 1829 degrees of freedom, highly significant by classical standards.

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Comment Albert N. Link

Professor Scott presents the results from two interesting, and competently done, empirical experiments. Using the FTC's line of business data for the domestic manufacturing sector, he examined the separate relationships between company-financed applied research and development (AR & D) expenditures per unit of sales and both seller concentration and government-financed AR & D expenditures per unit of sales. This study is useful because it illustrates some fundamental R & D–related relationships that have previously been clouded by the inability of researchers to disaggregate by line of business.

Company AR & D Expenditures and Concentration

The first of Professor Scott's two analyses is motivated by the economic literature on nonprice competition: nonprice competition, it is hypothesized, will increase with seller concentration to a point, and then will

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decline as a result of collusive-like activities that hamper all forms of rivalry. He illustrates in tables 10.1 and 10.2 that the line of business AR & D per unit of sales to concentration relationship exhibits an inverted-U; however, once differences in value, costs, and opportunities for nonprice competition are controlled for this relationship is no longer significant.

I have two comments on this section of the paper. The first is a general comment on the use of line of business AR & D data for measuring nonprice competition, and the second is a specific comment on the particular specification used in the estimation.

Professor Scott's argument for examining nonprice competition at the line of business level is quite valid, I think. There is no a priori reason to believe that firms' nonprice competition is homogeneous across industry bounds. But when AR & D is the form of nonprice competition, several conceptual questions arise that should be considered. The first relates to a characteristic of AR & D. AR & D often leads to a secondary product, knowledge. If, for example, AR & D expenditures are process related and are allocated in one line of business, might the knowledge obtained from implementing the associated technology be adaptable to a second line of business? If the answer is yes, and I think it is, then the ratio of AR & D to sales in the second line of business may understate the relevant degree of technology-related competition. The second question relates to the source of technology. Companies can invest in technology-related nonprice competition in at least two ways: they can induce the technology through their own AR & D activities, or they can purchase the technology in the form of new or improved capital equipment. As I have shown (Link, Tassey and Zmud 1983), this decision to induce or purchase (make versus buy) is related, in part, to the stage of the industry's product life cycle. Consequently, if at a given time industries (lines of business) with the same degree of seller concentration are at different stages in their life cycles, then a comparison of just AR & D expenditures may be misleading.

Finally, I have a general comment about the line of business file. I realize that at the time of Professor Scott's study data were available for only one year. Consequently, his cross-sectional analysis assumes that AR & D expenditures can accurately reflect interline business difference across firms in AR & D effort. Economists using cross-sectional data often make such an implicit assumption, but some statistical controls seem warranted if this study were to be extended. Not all firms have a centralized R & D unit, but those that have such a unit conduct long-term applied research that often influences the level and successfulness of divisional AR & D as reported in the FTC's file. (A case in point is the research done at General Electric on synthetic industrial diamonds.) Consequently, two firms could have the same level of AR & D expenditures for comparable lines of business, but one could be significantly more capable of nonprice competition because of previous research conducted in its central R & D unit. Would firm dummy variables indicating the presence of a central R & D unit control for this problem?

More germane to the actual empirical analysis is the issue of how accurately 436 company and 19 two-digit dummy variables (see table 10.2) can control for differences in the value, costs, and opportunities for nonprice competition. Technological opportunities are clearly a difficult, yet important, concept to quantify. I suspect, however, that the company dummies are controlling for many more things than intended. One suggestion for future work might be to replace the company effects with a single vector of the percentages of company-financed R & D allocated to basic research which can be calculated from the FTC file. Perhaps firms, through their own profit calculus, engage in relatively more basic research the fewer the direct opportunities for nonprice competition?

And, of course, there is the issue of simultaneity between R & D (and presumably AR & D) and concentration, which has already been discussed by Professors Levin and Reiss at this conference.

Company AR & D Expenditures and Government AR & D Financing

In section 10.3 of his paper, Professor Scott again imaginatively employs a fixed-effects model to test whether government AR & D spending is a substitute for, or a complement to, company-financed AR & D expenditures. This is an important issue, and there is a paucity of evidence related to it. Some speculations can be traced to the "pump priming" versus "substitution" hypothesis of Blank and Stigler (1957). On the one hand, new knowledge resulting from federal R & D enlarges the firm's scientific base and thus expands the opportunities for additional company-financed R & D. On the other hand, increases in federal allocations may displace private investments if (1) the resulting R & D output can be internalized by the firm, or if (2) federal obligations cause the firm to reach its capacity for technical operations. Professor Scott's finding (table 10.5) of a positive correlation between the two variables leads him to conclude that government-financed AR & D does indeed stimulate the level of company AR & D.

My comments here are similar to those directed to this issue in the first section of Professor Scott's paper. To what extent do the results of government-financed AR & D spill over to other lines of business within the firm and thus augment the efficiency of that AR & D? In other words, does government-financed AR & D contracted to the company's first line of business impact on company-financed AR & D in its second line of business? Concomitantly, how mobile are R & D scientists between line of business activities? To what extent might they embody AR & D related human capital?

My own work in this area, using firm level data, suggests that the relationship between government-financed and company-financed R & D (or even company productivity growth) is more subtle than Professor Scott's analysis reveals (Higgins and Link 1981; Link 1981). This subtlety can be detected by disaggregating R & D by category of use. I have found that government-financed R & D not only augments the level of company-financed R & D, but also alters the composition of that R & D. For example, a marginal dollar of government-financed R & D increases the probability of a private dollar of R & D being allocated to process-related, as opposed to product-related, R & D activities. Also, some interesting results have been obtained by analyzing the composition of government-financed R & D. For example, I have estimated a negative relationship between company-financed basic research and government-financed basic research expenditures while holding the financing capabilities of the firm constant (Link 1982). Perhaps, then, federal funds not only increase the level of corporate R & D but also alter its relative composition as well.

I realize my comments raise questions that are beyond the scope of the FTC's line of business file. Still, these questions should be discussed if we are to better comprehend the robustness of Professor Scott's findings and if we are to model corporate R & D decisions more accurately in future research.

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