External sources of technical knowledge

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Abstract:

This paper explores the degree to which firms rely on external sources of technical knowledge. The empirical results suggest that larger firms in more competitive markets rely relatively more on external sources.

Keywords: R and D | technical knowledge | Schumpeterian hypothesis

Article:[*]

1. Introduction

Researchers have devoted considerable energy toward understanding the myriad characteristics of innovation and technological change. While of long-standing interest on the basis of its academic merit, this research agenda has taken on considerable policy importance in recent years owing to the persistent decline in productivity growth from the mid-1960s to the early 1980s. Related investigations have focused on R&D spending: there is considerable evidence that R&D is an important input into the innovation process, and thus, one factor associated with technological advancement and productivity growth.[1]

Even with this visible emphasis on R&D, it is important to keep that single activity in perspective. True, R&D does influence innovation (which leads to technological change which, among other things, enhances productivity growth); but, R&D is not the only input into that process.[2] To note, some of the least R&D-intensive industries in the manufacturing sector have experienced above-average rates of total factor productivity growth [Kendrick and Grossman

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[1] For a review, see Nelson (1981) and Link (1986). Also, in light of these relationships, several policy initiatives have been formulated with an eye toward increasing industrial R&D in order to stimulate productivity growth and industrial competitiveness. These legislations include the R&D tax credit portion of the Economic Recovery and Tax Act of 1981, and, more recently, the National Cooperative Research Act of 1984.

[2] For example, Mansfield et al. (1971) showed early on that R&D costs do not account for the lion's share of expenses or time involved in innovation (that process going from research through manufacturing/marketing start-up) in the chemicals, machinery and electronics industries.

(1980), Link (1987)]. On the one hand, firms can be innovative, in a productivity growth-enhancing way, through the perceptive adoption of others' technologically-embodied capital equipment.[3] On the other hand, there are various external sources of technical knowledge available to firms, and these sources may enhance, or even substitute for, indigenous R&D.[4]

This paper explores the degree to which firms do in fact rely on external sources of technical knowledge. Specifically, we examine inter-firm differences in the use of such sources. Our finding that larger firms in more competitive markets rely relatively more on external sources of technical knowledge not only sheds light on a previously unexplored dimension of the innovation process, but also, it helps to further our understanding of the often-tested Schumpeterian hypothesis.

2. The empirical analysis

2.1. The primary data

The R&D vice presidents of 121 major manufacturing firms were asked to evaluate the frequency of use of the ten sources of technical knowledge listed in table 1. Their survey responses were recorded along a Likert scale ranging from 'always used' (= 4) to 'never used' (= 1) as a source of technical information. Complete data were obtained from 113 firms. While this group of 113 firms is not necessarily a representative sample of all manufacturing firms, it is an important sample, accounting for 31.2 percent of company-financed R&D within manufacturing.[5]

Table 1. External sources of technical knowledge

Source	Mean[a]	Standard deviation
Technical equipment suppliers	2.68	0.66
Customers	2.67	0.73
Professional interaction with peers outside of the firm	2.59	0.63
Informal interaction with peers outside of the firm	2.49	0.64
Universities	2.25	0.55
Consulting firms	2.09	0.52
National technical information service	1.93	0.68
Reverse engineering of competitors' products	1.92	0.57
Other government agencies	1.90	0.62
New employees previously working with competitors	1.81	0.62

[a] *n* = 113: response scale is 'always used' = 4, 'often used' = 3, 'sometimes used' = 2, 'never used' = 1.

[3] Relatedly, the idea of technological knowledge diffusing among firms has been explicit in the literature for a number of years. Early empirical efforts to quantify the extent of technology flows, other than through a more accurate measure of vintage capital, were made by Schmookler (1966) and Terleckyj (1974). More recently. Scherer (1982, 1984) and Link (1983) have quantified the impact of R&D-related technology originating in industry *i* on measured productivity growth rates in industry *j*.

[4] There is also some evidence that federally-financed R&D may complement a firm's own R&D activity [Link (1982). Mansfield and Switzer (1984) and Scott (1984)].

[5] These firms represent a group that the authors have worked with on previous survey-based research projects. Given the exploratory nature of the data requested, it was believed that well-known firms would most likely (and most accurately) participate in the study. The original data were collected for the 1981-82 period.

In order to determine if these firms systematically emphasize specific external sources of technical knowledge, a factor analysis on the primary data was performed. Using a varimax rotation, a single factor structure was judged to best capture the response pattern of the firms. From this structure, an overall factor score was computed for each firm.[6]

2.2. The analytical framework

The factor score constructed for each firm represents the relative intensity of use of the ten external sources under study. As such, this score becomes the dependent variable in our analysis. Several firm-specific variables are examined in order to explain inter-firm differences in the use of these sources.

Regarding market structure, it is frequently argued that firms with monopoly power may be relatively more innovative owing to their ability both to finance innovation and then appropriate the associated benefits. If market power does in fact afford firms this ability, then too, it provides an incentive for such firms to rely on proprietary sources of technical information, relative to non-proprietary sources, as inputs into their innovation process. Since the external sources of information examined here have characteristics of publicness (that is, they are available in respective markets), it follows that firms with monopoly power will eschew their usage in favor of own (more appropriable) R&D.

At the firm level, the effect of size on the use of these external sources is, a priori, ambiguous. Larger firms may have a greater ability to identify and use the knowledge inherent in these sources owing to their economies of scope and scale, especially in R& D activity. Alternatively, smaller firms, whose R&D activity is more limited or focused, may perceive that reliance on external sources is requisite for their ability to compete in technological dimensions.

As with firm size, the relationship between R&D intensity and usage of external sources of technical information is ambiguous. If these identified sources are a substitute for own R&D, then the relationship between R&D intensity and source usage may be negative. Or, if firms view these external sources as complements for their predetermined research agendae, then the relationship may be positive.

Finally, the research structure of manufacturing firms varies. Some firms rely heavily on a central R& D laboratory to disseminate technical information and generic R&D-based knowledge throughout their firm. In this role, the central lab acts as a gatekeeper for the output from indigenous R&D. As such, firms with central R&D labs, as opposed to only divisional labs which are generally tied to product-specific research, tend to direct a larger portion of their total R&D budget to basic research [Link (1985)]. Because of this more fundamental research focus, firms with central labs may find the technical information available in external sources less useful than firms with only divisional labs.

In order to test these propositions empirically, the following regression model was estimated:

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[6] Detailed data from this procedure are available from the authors on request.

$$SCORES = \beta_0 + \underset{(-)}{\beta_1 WMS} + \underset{(-)}{\beta_2 WCR} + \beta_3 SIZE + \beta_4 RDINT + \underset{(-)}{\beta_5 CLAB} + \beta_i IND_i + \epsilon \quad (1)$$

The dependent variable *SCORES* represents the factor score constructed from each firm's response to the survey questionnaire. *WMS* and *WCR* represent the firms' weighted market share and their corresponding weighted four-firm concentration ratio. Market share data are adjusted to reflect each firm's involvement in its various industries of operation. Concentration data are a sales-weighted average of the concentration characterizing the various industries in which each firm operates.[7] To the extent that these variables accurately measure market power, then their relationship to *SCORES* is hypothesized to be negative. Firm size, *SIZE,* is measured as the logarithm of 1981 sales, in millions of dollars, as reported by Compustat. Also using Compustat data, R&D intensity, *RDINT,* is calculated as the ratio of company-financed R&D per unit of sales for 1981. We offer no hypothesis as to the direction of influence of either of these variables. Finally, the presence of a central lab (*CLAB* = 1, and 0 otherwise) was determined from the survey data (Link (1985)]. As hypothesized, firms with central labs should make relatively less use of the external sources. Also held constant is a set of industry dummy variables corresponding to the two-digit SIC industry of operation.[8]

The least-squares results from eq. (1) are in table 2. Overall, the regression model explains a sizeable portion of the measured inter-firm variation in source usage: R^2 equals 0.57. As predicted, the sign on the market structure variables is negative; however, only the coefficient on *WMS* is statistically significant.[9] It is also evident that larger firms do indeed make more use of these external sources: the estimated coefficient on *SIZE* is significant at the 0.01 level. R&D intensity does not seem to affect factor usage. Also, as predicted, firms with central labs rely less on external technical information (and presumably more on indigenous R&D) for technical intelligence, although the estimated coefficient on *CLAB* is significant only at the 0.10 level.

Table 2. Least-squares regression results from eq. (1): n = 113 (t-statistics in parentheses)

Independent/variables	**Coefficients**
Intercept	–1.87 (–2.89) [a]
WMS	–1.77 (–3.00) [a]
WCR	–0.26 (–0.42)
SIZE	0.38 (5.31) [a]
RDINT	0.02 (0.06)
CLAB	–0.19 (–1.69)
Industry dummies	—
R^2	0.57
F-level	8.53

[a] Significant at 0.01 level.

3. Concluding remarks

[7] These data were graciously provided by Hirschey (1982).
[8] None of the 113 firms are from industries SIC 21, 25, 27 or 31.
[9] When the unweighted Census of Manufacturers' four-firm concentration ratio is used in place of *WMS* and *WCR,* its coefficient is also negative and insignificant.

These findings should be interpreted cautiously. The topic itself is new to the economics literature. Previous investigations related to innovation and technological change have focused solely on R&D activity, and are void of analyses of alternative information sources (other than those indirectly embodied in newer vintages of capital). Thus, our conceptual approach to this topic is exploratory in its nature. Still, several results are noteworthy.

First, our finding that firms with monopoly power (larger market share) rely less on market-oriented sources is not inconsistent with others' interpretation of Schumpeter, and is quite in line with the recent work of Levin et al. (1985) showing the importance of appropriability on internal R&D spending decisions. Second, the influence of size on the use of external sources is very strong. Still, since all of the firms in the sample were in the Fortune 500 in 1981, we are reluctant to generalize this result over the spectrum of firm sizes in manufacturing. Finally, the fact that we found the predicted direction of relationship between firms with central labs and the use of external source, and a marginally significant coefficient, is encouraging to generate more study into the influence of the R&D organizational structure, holding dollars of investment constant, on innovative activity.

Many issues remain to be investigated such as firms' investment patterns in non-appropriable external sources of technical knowledge and their rate of return. Given the systematic way in which these sources appear to be used by firms, one wonders how complete our understanding of the innovation process actually is in light of studying only R&D-related activities. A broader look at innovation, both as a process per se and as an element of growth, appears warranted.

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