Innovative behavior in small-sized firms

By: Albert N. Link and Barry Bozeman

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Abstract:

This study compares aspects of innovative behavior among small-sized firms. The behavior considered is the acquisition of technical knowledge in the development of new products and production processes, the adoption of new production process technology, and the introduction of new innovative products as a competitive strategy. We find that among small-sized firms, size is important in determining the level of the first two aspects of innovative behavior, but not of the third.

Keywords: production process | process technology | industrial organization | technical knowledge | innovative product

Article:

I. Introduction

Scholars have devoted considerable attention and energy toward understanding the concept of innovation and the related process of technological change. While of long-standing interest on the basis of its academic merits, related research has taken on considerable policy importance in recent years owing to the persistent decline in the rate of productivity growth that began in many industrial nations in the early 1970s and extended through most of the 1980s.

Within the past decade there has been a growing body of literature that focuses on the innovative behavior of small firms. These studies, while significantly fewer in number than those related to large-firm behavior, are often characterized by higher quality data and a richer understanding of the microeconomics of both the innovation and the related R&D process. A number of important conclusions have come from these inquiries.[1] First, small firms are more innovative (in terms of the number of product innovations produced) relative to their size than large firms. And second,

[1] Much of this research is summarized in U. S. Small Business Administration (1986). Important background works include Gellman Research Associates (1982), The Futures Group (1984), Rothwell and Zegveld (1985), Acs and Audretsch (1988) and Rothwell (1989).

product innovations coming from small firms appear to be at least as significant (and in some cases more) than those coming from large firms.[2]

The purpose of this paper is to present the results of an empirical study of innovative behavior in small-sized firms. Three firm-specific innovation measures are examined: (1) the acquisition of technical knowledge in the development of new products and production processes; (2) the adoption of new production process technology; and (3) the introduction of new innovative products as a competitive strategy. We find that among small firms, size is important in determining the Level of innovation associated with the first two measures, but not with the third.

II. Description of the data

A. The sample of firms

The data set analyzed here relates to 284 firms operating in central New York State. These 1985 data come from an industrial technology survey conducted by the Technology and Information Policy Program at Syracuse University.[3] The distribution of firms by various size categories is in Table I.

Table I. Distribution of sample firms by category of size

Category of size	Number of firms
< 50 employees	118
50 to 99 employees	48
100 to 249 employees	83
250 to 499 employees	35
	284

B. Measurement of the innovation variables

For the purpose of this study, firm size, SIZE, is measured as the total number of employees in 1984.

Three specific measures of innovative behavior are considered. The first measure represents the acquisition of technical knowledge in the development of new products and production processes. This variable is a firm-specific composite measure developed from responses to the following survey question: *"In your company's search for technical knowledge relevant to the development of new products and production processes, how important is each of the following sources of knowledge?"* Response categories include: trade publications; professional or scientific journals; government agencies; suppliers; customers; licensed technologies; consultants; universities; and competitors. Each firm responded to each of the eight source items

[2] Relatedly, Rothwell (1983) argues that large and small firms complement each other, and thus their innovative behavior should be examined in a dynamic, Schumpeterian-like context.

[3] A survey questionnaire was mailed to the population of 1,070 industrial firms in central New York State. From this mailing, 477 were returned. First, respondents with more than 10 percent missing data were eliminated. Second, of those remaining, only 284 both were small (< 500 employees) and completed all of the information needed here. More detailed information about this sample is available upon request from the authors.

using a Likert scale where "1 = not a source; 2 = a source but not important; 3 = somewhat important; 4 = very important." Factor analysis was used on the primary response data to develop a single, firm-specific index of information acquisition behavior. Specifically, using a varimax rotation, one factor dimension was judged to capture best the overall response pattern.[4] From this, factor scores were computed for each firm. These firm-specific scores are the values of the variable TECHKNOW.

The second measure of innovativeness relates to the adoption of new production process technology. Survey respondents were asked to respond to the following statement: *"In assessing your company's experience during the last five years with production process technologies (e.g., automation, robotics, numerically-controlled machinery) new to the company, which of the following statements best reflects that experience?"* The original response codes are: "1 = we have not made use of new production technologies; 2 = we have implemented new production technologies and they have generally been successful; 3 = we have implemented new production technologies and they have been successful in some cases and unsuccessful in others; 4 = we have implemented new production technologies and they have generally not been successful." Because the responses were heavily clustered toward response codes 1 and 3, one binary variable was constructed for each firm. PROCTECH = 0 if the firm marked response code 1; PROCTECH = 1 if the firm marked response codes 2, 3, or 4. Thus, PROCTECH only measures if new production process technologies have been adopted; it does not measure the production-related success of such adoptions.

A third measure of firm innovativeness quantifies the use of new innovative products as a competitive strategy. The survey question is: *"Comparing your company's product innovation to those of your competitors, to what extent or the following statement descriptive of your company's strategy?"* The response item is: "We are a leader in developing innovative new products." The response codes are: "1 = strongly disagree; 2 = somewhat disagree; 3 = somewhat agree; 4 = strongly agree." No data reduction technique was applied to this variable, PRODINNO.[5]

The mean values for each of the innovation variables are reported by category of firm size in Table II. For each measure, the mean value increases numerically with successively larger categories of size. Of course, the trend depicted does not account for other factors that may influence the level of innovative behavior of these firms.

Table II. Extent of innovation by category of firm size (mean values reported for the variables)

Category of size	*n*	TECHKNOW	PROCTECH	PRODINNO
< 50 employees	118	–0.207	0.525	2.71
50 to 99 employees	48	–0.096	0.604	2.83
100 to 249 employees	83	–0.014	0.783	2.89
250 to 499 employees	35	0.501	0.857	2.89

[4] The factor dimension derived from these calculations is: trade publications etc., 0.072; government agencies, 0.673; supplier, 0.033; customers, 0.084; licensed technologies, 0.749; consultants, 0.801; universities, 0.776; and competitors, 0.221. The variance explained by this structure is 2.27. This same technique has also been used by Link and Zmud (1987).

[5] Hirsch and Link (1987) have previously compared this element of innovative behavior between unionized and nonunionized firms.

C. Other variables of interest

Several other variables besides firm size are considered as possible determinants of inter-firm differences in innovativeness (as measured by the three variable discussed above) in the multivariate analyses that follow.

One factor that may influence innovativeness is the competitive environment in which the firm operates. While much of the R&D literature argues that market power has a positive influence on innovation, the empirical evidence is mixed;[6] however, some recent empirical work suggests that one key environmentally-related factor is the degree to which firms can appropriate the output from their innovations.[7] Three variables are considered as proxies for various dimensions of the competitive environment of each firm. First, firms are classified as being in the manufacturing sector, or not. MANUF = 1 if the firm operates in this sector, and 0 otherwise. Second, each firm in the manufacturing sector is classified into a single four-digit SIC industry on the basis of their reported major line of business. A weighted four-firm concentration ratio, WCR, is assigned to each firm.[8] Finally, the extent to which foreign competition is a factor (FCOMP) is quantified by each firm's response to a survey question: "1 = there is no significant foreign competition for our products; 2 = we are faced with foreign competition but it is not severe; 3 = we are faced with severe foreign competition; 4 = foreign competition is so great that it threatens the survival of our company."

A second factor that may influence innovativeness is the presence of an in-house R&D laboratory. R&D activity is one input into the innovation process, but it may not be a necessary condition for innovativeness. For example, one can point to the fact that the rate of productivity growth over the past decade has been greatest in some of the least R&D-intensive industries in the manufacturing sector. It is an empirical question, then, as to whether R&D activity is an important correlate with the dimensions of innovativeness considered here. COMPRD is a binary variable equalling 1 for firms conducting in-house R&D, and 0 otherwise. Data on this variable also come from the survey.

Descriptive statistics on all of the variables considered above are in Table III.

Table III. Descriptive statistics on the variables (n = 284)

Variable	Mean	Standard deviation	Range
TECHKNOW	–0.045	0.995	–1.75 to 2.84
PROCTECH	0.665	0.476	0/1
PRODINNO	2.81	0.925	1/2/3/4
SIZE	109.76	109.24	5 to 478
MANUF	0.894	0.3008	0/1
WCR[a]	34.70	16.35	6 to 86
FCOMP	2.03	0.985	1/2/3/4
COMPRD	0.507	0.501	0/1

[a] Available only for the 253 firms in the manufacturing sector.

[6] See, Baldwin and Scott (1987) and Cohen and Levin (1989) for reviews of this literature.
[7] See, Levin, Mowery and Cohen (1985).
[8] These ratios come from the Federal Trade Commission and refer to 1977. See, Weiss and Pascoe (1986).

III. The empirical analyses

A. The general model

The general model investigated seeks to explain inter-firm differences in innovative behavior as a function of selected firm and industry characteristics:

$$\left.\begin{matrix}\text{TECHKNOW}\\ \text{PROCTECH}\\ \text{PRODINNO}\end{matrix}\right\} \text{F(SIZE, MANUF, WCR, FCOMP, COMPRD).} \quad (1)$$

Of particular interest is the independent effect of firm size, SIZE, on each of the three innovation measures. However, no specific predictions are made regarding the directions of influence of this variable or the others. While there is a related empirical literature, its conclusions come primarily from analyses of larger-sized firms.[9]

Table IV. Least-squares results on inter-firm differences in the acquisition of technical knowledge (*t*-statistics in parentheses)

Variables	**(1)**	**(2)**
Intercept	0.142	0.70[a]
	(0.71)	(–3.70)
SIZE	0.0017[a]	0.0014[a]
	(2.98)	(2.35)
MANUF	–0.615[a]	—
	(–3.26)	
WCR	—	0.007
		(1.82)
FCOMP	0.050	0.060
	(0.84)	(0.98)
COMPRD	0.151	0.137
	(1.21)	(1.06)
R^2	0.08	0.08
F-level	6.30	5.13
n	284	253

[a] Significant at the 0.01 level.

B. The empirical analysis and results

Inter-firm differences in the acquisition of technical knowledge (TECHKNOW) are examined using ordinary least-squares analysis. The results are reported in Table IV. Among this sample of smaller-sized firms, size significantly influences the degree to which firms rely on external sources of technical knowledge in the development of new products and production processes. This reliance occurs to a Lesser degree among manufacturing firms. Also, among manufacturing firms (column (2)), their competitive environment (WCR) has little impact on this innovation

[9] In addition to the review articles noted above, see Link, Tassey and Zmud (1983), Link and Neufeld (1986) and Link and Rees (1990) for analyses related to other non-traditional measures of innovation.

measure, holding size constant. Finally, R&D activity is not a sufficient condition for knowledge acquisition, *ceteris paribus.*

Inter-firm differences in the adoption of new production process technology (PROCTECH) were estimated using probit analysis owing to the dichotomous nature of this dependent variable. Those results are reported in Table V. Again, firm size is an important influence on the adoption decision; but, *ceteris paribus,* the probability of such adoption is greater in R&D-active firms. R&D appears to be a necessary condition for this element of innovative behavior. The environmental variables play no significant role in these equations.

Table V. Prob it results on inter-firm differences in the adoption of new process technology (asymptotic *t*-statistics in parentheses)

Variables	**(1)**	**(2)**
Intercept	0.348	–0.198
	(–1.25)	(–0.73)
SIZE	0.003[a]	0.0027[a]
	(3.23)	(2.69)
MANUF	0.192	—
	(0.73)	
WCR	—	0.005
		(0.91)
FCOMP	–0.001	–0.025
	(–0.01)	(–0.28)
COMPRD	0.623[a]	0.507[a]
	(3.62)	(2.81)
–2 × Log likelihood ratio	326.66	292.04
n	284	253

[a] Significant at the 0.01 level.

Table VI. Ordered probit results on inter-firm differences in the introduction of new innovative products as a competitive strategy (asymptotic *t*-statistics in parentheses)

Variables	**(1)**	**(2)**
Intercept	1.48[a]	0.994[a]
	(4.61)	(4.31)
SIZE	0.0002	0.0005
	(0.36)	(0.70)
MANUF	–0.428	—
	(–1.53)	
WCR	—	0.0002
		(0.04)
FCOMP	–0.074	–0.074
	(–1.05)	(–0.99)
COMPRD	0.625[a]	0.591[a]
	(4.49)	(4.01)
–2 × Log likelihood ratio	699.82	636.54
n	284	253

[a] Significant at the 0.01 level.

Finally, as reported in Table VI, R&D activity also appears to be a necessary condition for introducing new innovative products (PRODINNO). Such a competitive strategy is not

influenced by either firm size or the nature of the competitive environment. Perhaps, then, this aspect of innovativeness depends solely on the "inventive environment" associated with the R&D process.

IV. Conclusions

The relationship of firm size to innovation, in all of its complexities, is worthy of the considerable attention that it has received. This study reaffirms that complexity, but at the same time it provides some guidelines to assist in understanding innovation in small-sized firms.

A first guideline is that the relationship of size to innovation is dependent upon one's measure of innovation. In this study we employed three distinct measures of innovative behavior. Just as firms have different business policies and bases of competition, any one of which may be effective in a given environment, firms seem to have different approaches to innovation.

Second, small firms are not homogeneous in their innovative behavior. Hopefully, further investigations on the influence of size on innovation will take into account that 500 employees is not a threshold for generalizing about small-firm behavior.

Third, size and R&D activity often interact such that it is difficult to understand the effect of one of these elements on firms' innovativeness without understanding the effect of the other. Thus, in small firms size appears to be important for some aspects of innovativeness, but not for all.

And finally, the results presented here suggest that R&D, as important as it is, is not a prerequisite for all aspects of innovativeness (as we have measured it). It appears to be important for purchasing and producing technology but not for acquiring related technical knowledge.

Innovativeness is multifaceted.

Note

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References

Acs, Zoltan J. and David B. Audretsch, 1988, ‘Innovation in Large and Small Firms: An Empirical Analysis’, *American Economic Review* **78**, 678–690.

Baldwin, William L. and John T. Scott, 1987, *Market Structure and Technological Innovation*, London: Harwood Academic Publishers.

Cohen, Wesley M. and Richard C. Levin, 1989, ‘Empirical Studies of Innovation and Market Structure’, in Richard Schmalensee and Robert D. Willig (eds.), *Handbook of Industrial Organization*, Amsterdam: Elsevier, pp. 1059–1107.

The Futures Group, 1984, ‘Characterization of Innovations Introduced on the U.S. Market in 1982’, mimeo.

Gellman Research Associates, 1982, 'The Relationship Between Industrial Concentration, Firms Size, and Technological Innovation', mimeo.

Hirsch, Barry T. and Albert N. Link, 1987, 'Labor Union Effects on Innovative Activity', *Journal of Labor Research* **8**, 323–332.

Levin, Richard C., David C. Mowery and Wesley M. Cohen, 1985, 'R&D Appropriability, Opportunity, and Market Structure: New Evidence on Some Schumpeterian Hypotheses', *American Economic Review* **75**, 20–24.

Link, Albert N. and John Neufeld, 1986, 'Innovation Versus Imitation: Investigating Alternative R&D Strategies', *Applied Economics* **18**, 1359–1361.

Link, Albert N. and John Rees, 1990, 'Firm Size, University-Based Research, and Returns to R&D', *Small Business Economics* **2**, 25–31.

Link, Albert N., Gregory Tassey and Robert W. Zmud, 1983, 'The Induce Versus Purchase Decision: An Empirical Analysis of Industrial R&D', *Decision Sciences* **14**, 46–61.

Link, Albert N. and Robert W. Zmud, 1987, 'External Sources of Technical Knowledge', *Economics Letters* **23**, 295–299.

Rothwell, Roy, 1983, 'Innovation and Firm Size: A Case for Dynamic Complementarily: Or, Is Small Really So Beautiful?', *Journal of General Management* **8**, 5–25.

Rothwell, Roy, 1989, 'Small Firms, Innovation and Industrial Change', *Small Business Economics* **1**, 51–64.

Rothwell, Roy and Walter Zegveld, 1985, *Innovation and the Small and Medium Sized Firm*, Boston, Mass.: Kluwer Academic Publishers.

U.S. Small Business Administration, 1986, *Innovation in Small Firms*, Washington, D.C.

Weiss, Leonard W. and George A. Pascoe, 1986, 'Adjusted Concentration Ratios in Manufacturing, 1972 and 1977', U.S. Federal Trade Commission, mimeo.