Innovation versus imitation: investigating alternative R & D strategies

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Abstract:

Few topics in industrial organization have received as much attention- theoretical, empirical or policy-related-as has the relationship between market structure, firm size and innovative activity. Two issues have been addressed. First, is it the possession of, or rather the quest for, monopoly power that stimulates innovation? On the one hand, firms with monopoly power may be relatively more innovative (the so-called Schumpeterian hypothesis) owing to their ability both to finance innovation and to appropriate the associated benefits. On the other hand, firms with monopoly power may choose to exploit their position by appropriating the benefits of smaller rivals' innovations and adopt an imitative strategy. Second, is firm size, apart from market power, related to the level of innovative activity?

Keywords: market structure | firm size | R and D | Schumpeterian hypothesis

Article:

I. INTRODUCTION

Few topics in industrial organization have received as much attention- theoretical, empirical or policy-related-as has the relationship between market structure, firm size and innovative activity. Two issues have been addressed. First, is it the possession of, or rather the quest for, monopoly power that stimulates innovation? On the one hand, firms with monopoly power may be relatively more innovative (the so-called Schumpeterian hypothesis) owing to their ability both to finance innovation and to appropriate the associated benefits. On the other hand, firms with monopoly power may choose to exploit their position by appropriating the benefits of smaller rivals' innovations and adopt an imitative strategy.[1] Second, is firm size, apart from market power, related to the level of innovative activity?

[1] According to Arrow (1962), newcomers or firms seeking a larger share of the market are the more innovative. More germane to the competing hypotheses is the Baldwin and Childs' (1969) conclusion that a firm with monopoly power may adopt a 'fast second' R&D strategy and imitate, rather than innovate.

Much of the empirical literature has taken firms' levels of spending on research and development (R&D; often adjusted by sales) as a proxy for the entire innovation process. Accordingly, previous researchers have examined the correlation between R&D spending or intensity and measures of market structure and firm size in order to investigate these two issues.[2] While this line of empirical research has been useful, one may question how well it addresses the theoretical foundation on which it is supposedly based.[3] Firms employ different R&D strategies, generally choosing between innovation or imitation. R&D spending is important for successfully implementing either strategy; therefore, interfirm differences in R&D spending may be a questionable indicator of differences in firms' 'innovativeness'.

In this paper the relationship between market structure, firm size and a firm's choice of an R&D strategy is examined.

II. THE EMPIRICAL ANALYSIS

The empirical analysis is based on the assumption that a firm's R&D strategy can be characterized as either innovative or imitative. Accordingly, the empirical model proposed here asserts that the probability of a firm adopting an innovative, as opposed to an imitative, R&D strategy is functionally related to the size of the firm (SIZE), its market share (MS), and industry concentration (CR), as:

$$\text{Prob}(INNOV) = f(SIZE, MS, CR) \tag{1}$$

The dependent variable in Equation 1 is dichotomous, equalling 1 if a firm's strategy is innovative, and 0 if it is imitative. These data, for 1980, came from extensive telephone interviews with the R&D vice presidents of 76 R&D active manufacturing firms from the Fortune 500.[4] Each R&D vice president was asked, (1) to characterize the nature of his or her firm's R&D strategy as either innovative (referring to something 'new' put into use) or imitative, and (2) whether this dichotomization was meaningful. Each vice president was queried on the validity of a binary categorization of their overall R&D strategy. Surprisingly, all of the vice

[2] Excellent reviews of this literature are in Kamien and Schwartz (1982) and Baldwin and Scott (forthcoming).

[3] The literature has been formulated on the following sequence of propositions: (1) innovation is a process; (2) R&D spending is one input into the innovation process; therefore (3) interfirm differences in R&D spending approximate interfirm differences in innovative activity. Propositions (1) and (2) are valid, but proposition (3) is not necessarily true.

[4] These 76 firms do not represent a random sample of R&D active firms in the US manufacturing sector. In 1980, a survey on the R&D activity of the Fortune 1000 firms was conducted by Link for the National Science Foundation. A subset of 174 firms were willing to participate in a more detailed questionnaire related to the composition of their R&D spending (see Link, 1981, for a summary). The largest firms in that group have continued to take part in National Science Foundation sponsored studies on innovative activity, such as this one. While these 76 firms are not a random sample, they are none the less an important sample, accounting for 36.7 % of 1980 sales of Fortune 500 firms. For the manufacturing sector as a whole the mean company-financed R&D to sales ratio was 2.1 in 1980 (National Science Foundation, 1982); it was 2.8 for this sample of 76 firms. The mean company-financed R&D to sales ratio was very similar to that for selected industries. For example, the mean for the seven sample firms in SIC 2911 was 0.5 compared to 0.5 for all firms in that industry: the mean for the five firms in SIC 283 was 5.4 compared to 6.1 for all firms in that industry. In other instances the comparison is less favourable. The mean for the six firms in SIC 357 was 6.8 compared to 10.4 for all firms in that industry: the mean for the five firms in SIC 371 was 2.4 compared with 4.2 for all firms in that industry. A more detailed description of the sample is available from the authors.

presidents reported that although their firms operated in several lines of business, one dominant strategy characterized the overall R&D effort. The fact that a diversified firm's R&D generally follows one designated strategic thrust has also been shown by others (Wilson *et al.,* 1980; Tassey, 1983). Also, each vice president reported that this strategy had remained constant over the three years 1978-80. While the vice presidents were confident in their ability to identify R&D effort across several lines of business by a single descriptor, it is still possible that the dependent variable reflects a measure of subjective introspection rather than reality. Accordingly, it must be interpreted with caution.[5]

The independent variables in Equation 1 measure the firm's size and market structure. Firm size was measured by the logarithm of 1980 sales in millions of dollars, as reported by Compustat. Market structure was proxied by two variables, the firm's market share and the corresponding four-firm SIC industry concentration ratio. Market share data were 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.[6]

Table 1. Estimated logit results

Independent variables	**(1)**	**(2)**
SIZE	1.875	1.802
	(3.699)[a]	(3.68)[a]
	[0.32]	[0.32]
	{0.25}	{0.25}
MS	0.193	0.202
	(2.43)[b]	(2.52)[b]
	[0.033]	[0.036]
	{0.20}	{0.022}
CR	–0.043	–0.049
	(–1.41)	(–1.51)
	[–0.008]	[–0.009]
	{–0.006}	{–0.007}
RDINT		19.72
		(1.30)
		[3.53]
		{3.10}
–2*x* log Likelihood ratio	43.19	44.99
n	76	76

Asymptotic *t*-statistics in parentheses; partial derivatives evaluated at the mean in brackets; OLS coefficients in braces.

[a] significant at 0.01 level.

[b] significant at 0.05 level.

Owing to the dichotomous nature of the dependent variable, Equation 1 was estimated using conditional logit analysis. The results are reported in column 1 in Table 1. The logit coefficient on *SIZE* is positive and significant at the 0.01 level, suggesting a nonlinear effect on the probability of a firm adopting an innovative R&D strategy. The logit coefficient on *MS* is positive and significant at the 0.05 level. The corresponding calculated partial derivative on *MS*

[5] Data were not available from the firms on the proportion of total R&D expenditures allocated to innovative versus imitative activities. Oearly, these would have been preferable.

[6] These data were provided by Hirschey (1982).

suggests that a one unit increase in a firm's market share increases the probability of a firm's adopting an innovative strategy by 3.3 percentage points. The logit coefficient on *CR* is negative; however, it is insignificant. The data do not support the proposition that industry concentration affects the innovative/imitative R&D strategy choice.

As a preliminary look at the widespread practice of using R&D intensity as a proxy for innovativeness, R&D spending per unit of sales (*RDINT*) was included, as reported by Compustat, as an additional regressor in Equation 1. There is some empirical research to suggest that the relationship between R&D intensity and innovativeness is positive. Mansfield *et al.* (1981) report, on the basis of a small sample of new products developed in the chemicals, drug and electronics and machinery industries, that imitators spend about 65 % as much as innovators in bringing products to market. They also report that applied research costs are a larger proportion of total costs for innovative products than for imitative products. The present unit of analysis is the firm rather than the product. Firms vary in the number of products to which they devote R&D. This interfirm variability may weaken the empirical relationship between R&D intensity and perceived innovativeness. In addition, the relationship may be distorted if the sales of imitative products are on average lower than the sales of innovative products per dollar of R&D.[7] Unfortunately, the present data do not permit disentanglement of these effects. As reported in column 2 in Table 1, the partial correlation between perceived innovativeness and *RDINT* is positive; however, it is not significant at a conventional level.

The possibility of additional industry effects on the adoption of a particular R&D strategy was also investigated. First, a set of two-digit SIC industry variables was included in a separate version of Equation 1.[8] Second, a set of binary variables corresponding to Wilson's (1977) categorization of high, medium and low technological opportunity industries was included in still another version. There was no statistical evidence of separate industry effects on the innovation/imitation strategy choice.

III. INTERPRETATION OF THE RESULTS

This empirical analysis has reconsidered the effects of monopoly power and firm size on innovation by distinguishing firms, to our knowledge for the first time, according to the R&D vice presidents' perceptions of the innovative versus imitative nature of their R&D strategy. This characterization seems more appropriate for investigating aspects of the Schumpeterian hypothesis, and related theory. The findings, although limited by a single, small sample of firm data, support the hypotheses that monopoly power and firm size are important correlates with innovative behaviour (as it was measured), while at the same time cast doubt on those theoretical models proferring a positive relationship between monopoly power and imitative behaviour. In other words, the ability to finance and then appropriate the benefits from innovation provides firms with an incentive to adopt an innovative strategy.

[7] We are grateful to the referee for bringing this point to our attention.
[8] Albeit rough, firms were assigned to a two-digit SIC industry on the basis of the industry corresponding to their primary line of business.

The complexity of the process of innovation has not been fully captured by the exploratory treatment given in this paper. The preliminary findings certainly suggest that further investigation must look beyond the bounds of R&D spending alone.

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