Technological Innovation and the Market Value of Firms

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Abstract

Most previous research in this area has conceptualized innovation through one or more dimensions of a firm's innovative capability such as R&D of a firm. The measurement of the construct has thus reflected this narrow conceptualization with a single measure such as R&D expenditure of a firm being the most often used proxy. This study utilizes a broader definition of organizational innovation capabilities that includes the generation, dissemination and strength of innovative activity in a firm. Such a composite measure is then used to predict market value of a firm. The unique features of this study are that it uses multiple indicators of firm innovation, it uses 10 year cross sectional, longitudinal data on a firm's innovation profile along with lagged measures of market value.

INTRODUCTION

Knowledge and the innovative capability of firms driven by technology are considered key factors in internationalization and performance (Sher &Yang, 2005; Weikl & Grotz, 1999). Lately the "Knowledge Based View (KBV)" has emerged as a novel, if not radically new perspective to examine the nexus between innovation and firm performance (Gopalakrishnan *et.al.*, 1999). Chetty & Campbell-Hunt, (2003) and Davenport, *et.al.*, (2003) argued that technology driven strategy of firms help them leverage their strengths toward obtaining international significance. Other interpretations of the important role of innovation in determining a firm's destiny include innovation as a barrier for entry and exit of competitors (Porter, 1983), as an instrument in increasing the market value of the firm (Toivanen *et.al.*, 2002), as a strategic rent generating asset (Teece *et.al.*, 1997) and as a tool for organizational change (Birkinshaw *et.al.* 2002).

Innovation has been defined as an "internally generated or (externally) purchased device, system, policy, program, process, product or service that is new to the adopting organization" (Damanpour, 1991: p. 556). Thompson (1965) defined innovation as the *generation* of new ideas, processes and products or services. But according to Feeney and Rogers (2003) innovation is the *application* of new ideas to the products and processes of a firm's activities and according to Amabile et al. (1996), it is the successful *implementation* of creative ideas within an organization. As can be seen there is fair amount of debate on what actually constitutes organizational innovation. We argue that a comprehensive definition of innovation should include all the above dimensions.

The present study intends to address the above issues on a sample of 64 firms over a 9 year period by examining the relationship between a variety of innovation dimensions including generation, dissemination and strength of innovation that constitutes a firm's "innovation capability profile" and, Market value of firms. The following hypotheses will be empirically verified.

H1) A firm's capacity for innovation generation is positively associated with its market value.

H2) A firm's capacity for innovation dissemination is positively related to its market value.

H3) A firm's strength of innovation is positively related to its market value.

2. DATA AND VARIABLES

Data for the independent variables of Innovation capability profile were obtained from the patent database called "TECH–LINE® maintained by CHI Research. The use of patents and patent citations to measure innovation and knowledge of a firm has precedent in the studies by Jaffe (2000) and Fung & Chow (2003). Data for dependent variable market value were obtained from Research Insight® data base. Table 1 explains the variables and their operationalization.

Table 1: Operationalization of Variables

INNOVATION GENERATION **Number of patent (PAT)**
Number of patents - This identifies technologies receiving increasing emphasis and those in which innovation is slackening off. It also identifies companies increasing their technological development, and those whose R&D is played out.
INNOVATION DISSEMINATION **Current Impact Index (CII)**
The number of times a company's previous five years of patents is cited in the current year, relative to all patents in the U.S. patent system. Indicates patent portfolio quality. A value of 1.0

represents average citation frequency; a value of 2.0 represents twice average citation frequency; and 0.25 represents 25% of average citation frequency. In a Tech-Line company report, you can identify the technologies in which companies produce their best work. The CII has been found to be predictive of a company's stock market performance.
INNOVATION STRENGTH **Technology strength (TECH)**
Quality-weighted portfolio size, defined as the number of patents multiplied by current impact index. Using Technology Strength you may find that although one company has more patents, a second may be technologically more powerful because its patents are of better quality.

EMPIRICAL MODEL

For the panel data analysis, the data set consists of i = 1,…..,N cross sections (number of firms), and several points of time series for each firm t = 1,….,T(i), or a cross section of N time series each of length T(i). To break down the effect of R&D together with innovation generation, innovation dissemination and innovation strength, the following linear models is estimated:

I) Ordinary Least Squares (OLS).

$FV_{it} = \lambda_i + \beta' G_{it} + \alpha' D_{it} + \gamma' S_{it} + \phi' X_{it} + \mu_{it}$ (1)

where FV_{it} is the firm value in firm i =1,……, N, year t = 1,….,T(i). G_{it} is the vector of generation of innovation variables. D_{it} is the vector of dissemination of innovation variables. S_{it} is the vector of strength of innovation variables. X_{it} is the R&D expenditure. λ_i is the overall constant term, which is the same for all firms. μ_{it} is independently and identically distributed among firms and years.

ii) Fixed Effects.

$FV_{it} = \eta_1 \delta_{1it} + \eta_2 \delta_{2it} + \ldots\ldots\ldots + \beta' G_{it} + \alpha' D_{it} + \gamma' S_{it} + \phi' X_{it} + \mu_{it}$ (2)

Where FV_{it} is the firm value in firm i =1,……, N, year t = 1,….,T(i). G_{it} is the vector of generation of innovation variables. D_{it} is the vector of dissemination of innovation variables. S_{it} is the vector of strength of innovation variables. X_{it} is the R&D expenditure. δ_{jit} is the firm specific year dummy variables. η_i is the individual specific constant or the firm effect. μ_{it} is a classical disturbance term with $E[\mu_{it}] = 0$, $var[\mu_{it}] = \sigma^2_{\mu}$.

EMPIRICAL RESULTS

In Tables 2, 3 and 4 we present the model selection test (F-stat). In all the three cases, the F-statistics are significant indicating that fixed-effects model is preferred to pooled OLS. Thus, our discussion will be focusing on the fixed effects model. In Table 2, regression results of the R&D for 64 firms are reported. Parameter estimates of R&D were strongly positive and significant in the one year lag and three year lag. This confirms the expectation that R&D spending positively impact the firm value immediately and over time. To further investigate the impact on various components of R&D on the firm value, we regress various other independent variables. In the fixed effects model, the number of patent (PAT), a proxy for innovation generation, is positive but not significant in the one year lag. However, PAT is highly positive and significant in the three year lag. This indicates that patent applications impact the market value of firm with a time-lag.

Table 2: Regression results of R&D

VARIA-BLE	1 YEAR LAG		3 YEAR LAG	
	OLS	FIXED EFFECTS	OLS	FIXED EFFECTS
Constant	-1572***		-102.17	
R&D	41.43***	47.21***	45.22***	13.69***
Adj. R2	0.73	0.82	0.599	0.841
F-Statistic	1516.78***	41.62***	826.77***	47.36***
Model selection test (F-stat)		14.32***		44.02***

Note: ***, **, * denote significance at 1%, 5%, and 10%, respectively.

Table 3: Regression results of R&D, Patent and CII

VARIA-BLE	1 YEAR LAG		3 YEAR LAG	
	OLS	FIXED EFFECTS	OLS	FIXED EFFECTS
Constant	-2987***		-3965***	
R&D	42.26***	42.11***	47.06***	11.62***
PAT	-3.68	7.23	-8.32	10.95**
CII	1140.37**	-179.99	3051.48***	2132.38***
Adj R2	0.735	0.834	0.609	0.843
F-Statistic	509.72***	43.40***	287.54***	46.66***
Model selection test (F-stat)		14.31***		44.22***

Note: ***, **, * denote significance at 1%, 5%, and 10%, respectively.

In terms of innovation dissemination, the fixed effects model in Table 3 provides some interesting results too. Current Impact Index (CII), a proxy for innovation dissemination is negative and insignificant in the one year lag. However, in the three year lag the coefficient becomes highly positive and significant. Table 6 provides regression results for technology strength (TECH), a proxy for innovation strength. It appears that for the fixed effects model, TECH is positive but insignificant in one year lag. In the three year lag TECH becomes highly positively significant at the 1% level.

Table 4: Regression results of R&D and Tech

VARIABLE	1 YEAR LAG		3 YEAR LAG	
	OLS	FIXED EFFECTS	OLS	FIXED EFFECTS
Constant	-1989***		-560.26	
R&D	37.95***	42.334***	41.37***	10.81
TECH	7.84***	11.900	8.68***	7.03***
Adj R2	0.744	0.837	0.607	.84405
F-Statistic	797.97***	45.03***	427.60***	47.68***
Model selection test (F-stat)		14.12***		44.30***

Note: ***, **, * denote significance at 1%, 5%, and 10%, respectively.

CONCLUSION

This study attempted to examine factors that determine the technological innovation profile of a firm. By using data that originated from a company's patenting activities, we were able to create such a profile consisting of the generation, dissemination and strength of a firm's innovations. We also aimed to predict the market value of a firm using these dimensions of technological innovation in a panel data analysis. While we were moderately successful in identifying a pattern, we realize that additional data along with some new dimensions of a firm's technological strength such as "management" of a firm's innovation profile could possibly shed better light on this issue.

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