A Study of Schumpterian (Radical) vs. Kirznerian (Incremental) Innovations in Knowledge Intensive Industries

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In this study we draw upon Schumpeterian and Kirznerian theories of innovation, to frame through use of U.S. patent data for the pharmaceutical and biotechnology industries for investigating the value of an organization's knowledge through its intellectual property. Measures for both radical and incremental are developed and tested against firm performance. Our findings support the perspective of knowledge generation increasing financial and market performance returns for ventures concentrating their resources on the pursuit of Schumpeterian radical innovations through a strong organizational emphasis on the knowledge impact compared to lower performance returns for ventures which sought incremental innovation.

INTRODUCTION

In the Schumpeterian system entrepreneurial firms include people who are assigned with the responsibility of introducing new processes of production – of producing new products or producing old products in new ways (Schumpeter, 1942). The results of these innovator-entrepreneurs' endeavors, such as corporate entrepreneurs/intrapreneurs, is the effective disturbance of the previously even flow of production, and, more broadly, of the market, by creating new products and processes. In fulfilling this role he/she is at the same time creating profits for their organization.

By breaking away from routine activity, Schumpeter's corporate entrepreneur is able to generate temporary gaps between the price of inputs and the price of outputs. As such, the previously accepted tendency for the "value of the original means of production to attach itself with the faithfulness of a shadow to the value of the product is for a brief period successfully defied" (Schumpeter, 1934, p. 160) by those within the organization who are daring enough, or who are charged with the responsibility to, challenge dominant logic and blaze new trails. Until imitators once again force process and cost into conformity, the innovator is able to secure real pre-profits for their organization and, in many cases, secure additional leverage or advantage by legally protecting this new found knowledge.

Kirzner (1973) expressed dissatisfaction with the role assigned to the entrepreneur in the Schumpeterian system. Kirzner labeled the element of alertness to possibly newly worthwhile goals and to possibly newly available resources – which is absent in the notion of economizing but very present in that of human action – the *entrepreneurial element* in human decision-making. It is this entrepreneurial element that is responsible for the understanding and interpretation of human action as active, creative, and human rather than as passive, automatic, and mechanical. This alertness to opportunities, often brought about from previously introduced radical innovations, leads to superior economic rents vis-à-vis the exploitation of incremental innovations.

Kirzner further discussed the entrepreneurial element in human action in terms of *alertness* to information, rather than its possession (p. 68). Ultimately, the kind of "knowledge" required for entrepreneurship, from a Kirznerian perspective, is "knowing where to look for knowledge" rather than knowledge of substantive market information, or in a word…*alertness.*

Moreover, Barney emphasizes how knowledge may be one of the most valuable firm resources. Noble, et.al. (2002) further posit that high performing firms not only gather market intelligence, but translate knowledge into learning and strategic actions, where exploration is an active process for discovery of new resources and technologies, perhaps being more valuable than exploitation on firm performance in the shift between customer and competitor orientations. A consequence of an organizational learning orientation is increased knowledge and one form of tangible evidence of this learned knowledge throughout the organization is through organization-wide innovativeness.

Innovation has been defined as "the willingness to place strong emphasis on research and development, new products, new services, improved product lines, and general technological improvement in the industry" (Slevin & Covin, 1990: 43). Success in innovation typically requires strong managerial support and resource commitment (Burgelman & Sayles, 1986; Covin & Slevin, 1991; Fujita, 1997). Even then, less than 20% of all new product introductions succeed (Crawford, 1987) and the projects that do survive are unprofitable during their first few years (Block & MacMillan, 1993).

These different theoretical perspectives underpin our two core research questions. First, if we treat learning as a capability of an entrepreneurial organization and knowledge as a resulting scare resource of the learning capability, how then should managers allocate their knowledge resources to maximize their profitability and stock market returns? Linking our three knowledge strategies with corporate entrepreneurship and the resulting innovations, our second question focuses on which strategy most consistently results in producing an innovation (radical versus incremental) which provides the greatest venture profitability and market valuation. Specifically, drawing from Schumpeterian and Kirznerian perspectives, do radical or incremental innovations deliver the greatest venture returns on assets and stock market valuations? Which of these corporate entrepreneurial initiatives will have the strongest positive influence on venture performance are theoretical and empirical questions that to date remains unresolved and is a significant contribution of this research?

We proceed as follows. The literature review and hypothesis sections are presented next, followed by the methods and results sections. The manuscript concludes with a dissemination of our findings in the discussion and implications section, where we also provide our extensions to theory and implications for managers, as well as table the limitations of the current project and present the opportunities we have identified for future research projects.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Innovation & Knowledge

Innovation is a strategic decision that is critical to many organizations as it provides one important way to adapt to changes in markets, technology, and competition (Dougherty & Hardy, 1996). Innovation is likely to influence, and be influenced by, a firm's strategic initiatives, processes, and organizational structure. For example, as innovation entails considerable risk taking (Edgett, Shipley, & Forbes, 1992), successful implementation of an innovation strategy requires making significant systemic changes in a firm to promote risk taking.

Examinations of innovation have been divided into two major research streams (Brown & Eisenhardt, 1998). The first stream examines issues related to the diffusion of innovations across nations, industries, and organizations (e.g., O'Neill, Pouder, & Buchholtz, 1998). In this stream, an innovation is defined as a technology, strategy, or management practice that a firm is using for the first time, whether or not other organizations or users have previously adopted it, or as a significant restructuring or improvement in a process (Nord & Tucker, 1987). The second stream examines the influence of organizational structures, processes, and people on the development and marketing of new products (e.g., Zirger & Maidique, 1990). Within this second research stream, an innovation refers to a new product that an organization has created for the market and represents the commercialization of an invention, where invention is an act of insight (Myers & Marquis, 1969). New products may take different forms, such as upgrades, modifications, and extensions of existing products.

A commonality between the two definitional streams of innovation is knowledge. Knowledge is a natural outgrowth of resource-based theory (Fernhaber, McDougall-Covin, & Shepherd, 2009). Knowledge is critical to knowledge intensive industries as the flows of innovations are the life blood of these ventures. For this study, an organization's codified knowledge is manifested through three forms: patent counts (Patel & Pavitt, 1995), patent cycle time, and patent citations. This form knowledge is transparent to the marketplace, which will be particularly important to this research in order to compare between firms and across an entire industry.

In many parts of the economics literature, patent counts are accepted as one of the most appropriate indicators that allow researchers to compare the innovativeness of companies in terms of new technologies, new products and new processes (Pavitt, 1988; Freeman & Soete, 1997; Cantwell & Hodson 1991; Albert, et.al., 1991). Patents are distinct, transparent measures of technology that can show how technology develops, shifts, and propagates in the marketplace (Basmann, McAleer, & Slottje, 2003).

There are a number of advantages to the use of patent data. For a patent to be issued, the innovation must be novel and legally definable, non-obvious that a skilled practitioner would not have known it, and useful for a commercial purpose (Scherer, 1965). In addition, one of the most important pieces of a patent's technical write up is the use of technological antecedents of the innovation, including citations to previous patents. These are important legal functions as they define and limit the scope of rights awarded for the patent. Furthermore, these citations can be studied in order to understand the linkages between the patents use of prior art and the strength of the patent citations (Albert, et.al., 1991; Jaffe and Henderson, 1993). A patent that has been heavily cited by other patents is viewed as having greater impact, since the law requires citing of all previous work that is relevant to the patent being issued. If a citation is included that is not needed, the patent office and examiner will take it out (Albert, et.al., 1991).

The use of definable patent measures has been used extensively in both the present and future valuations of firms innovative capabilities (Ernst, 1998; Pavitt, 1988). Hagedoorn and Duysters (2002) analysis of the international computer industry showed a correlation of 0.9 between patent counts and R&D inputs. In their book, "Innovation and Market Value," Barrel and Mason (2000) focus on specific measures collected and organized extremely well from academic research streams in economics, management, and marketing. In a cross-sectional study of the determinants of market value, with a focus on R&D variables, Ben-Zion (1984) finds that both R&D expenditures and patents are significant in explaining the volatility of market values. Moreover, the total number of patents granted in an industry is a powerful variable relative to the number of patents granted to a particular company, suggesting that the growth and development opportunities available in a certain field may be more important than an individual company's efforts. Following this logic, we present our next set of hypotheses.

> H1a: The extent of a corporate venture's patent count will be positively associated with venture profitability.
> H1b: The extent of a corporate venture's patent count will be positively associated with venture market valuation.

In addition, the value of resources increases with the heterogeneity (Conner, 1991). This is very apparent in a firm's knowledge, and absorptive capacity (Cohen & Levinthal, 1990). Moreover, Barney

(1991) emphasizes how knowledge may be one of the most valuable firm resources. Noble, et.al. (2002) posit that high performing firms not only gather market intelligence, but translate knowledge into learning and strategic actions, where exploration is an active process for discovery of new resources and technologies, perhaps being more valuable than exploitation on firm performance and market valuation. Patent cycle time is measuring how fast a firm is able to scan the environment collecting knowledge and be able to create a new unique piece of knowledge that can be codified and add to the firm's competitive advantage. Given the strong influence of patent cycle time, therefore, we are able to in Hypotheses 2a and 2b suggest:

> H2a: The extent of a corporate venture's patent cycle time will be positively associated with venture profitability.
> H2b: The extent of a corporate venture's patent cycle time will be positively associated with venture market valuation.

Also germane to this study, DeCarolis (2003) uses the number of a firm's patent citations as a measure of the inimitability of a firm's knowledge. The worldwide knowledge economy has changed the way firms must view multiple roles of customer, competitor, and collaborator (Day & Montgomery, 1999). Knowledge being an operant resource, can give firms a competitive advantage, but also must be used in their internal marketing definition to the firm (Im & Workman, 2004; Vargo & Lusch, 2004; Hult, et.al., 2003). Firms must now think of marketing on a local and international level. Competitors in one market may be collaborators in another, creating "coopetition" (Brandenburg & Nelebuff, 1996; Tsai, 2002; Luo, et.al., 2006). If a firm has a history of consistently producing innovative technology that is market changing, market defining, and spawns new technology in the future, they are valued more in their marketplace (Narver, et.al., 2000; 2004).

Organizational learning along with the benefits of gained organizational knowledge has been described as a critical ingredient in an organization's renewal (e.g., Argyris & Schon, 1978; Baker & Sinkula, 1999; Hurley & Hult, 1998; Nonaka, 1994). The organizational knowledge provides the depth and quality to the innovation, essentially what impact the firm's knowledge produced has on both the firm and the marketplace, which leads us to finally hypothesize:

> H4a: A focus on innovativeness which produces radical innovations (patent index) will be positively associated with venture profitability.
> H4b: A focus on innovativeness which produces radical innovations (patent index) will be positively associated with venture market valuation.

A radical innovation is one which transform or moves the industry paradigm leading to changes in the supplier or consumer relationships and the displacement of existing dominant products (Salomo, Gemunden, & Leifer, 2007). Although each burst of entrepreneurial innovation leads to a new equilibrium situation, this type of entrepreneurial organization is presented as a disequilibrating, rather than an equilibrating, force in the broader market sense. The Schumpeterian innovator-entrepreneur therefore is encouraged to be the decision maker who is able to depart from the routine repetitive working of widely known opportunities, the realm of incremental innovators. In this research, we are interested in investigating the benefit in mature technology organizations of Schumpeterian entrepreneur-innovators whose activities lead to the introduction of radical innovations and those who are Kirznerian entrepreneur-producer types whose activities culminate in their producing incremental innovations, and distilled our first hypotheses as follows.

METHOD

Although similar theoretically to academic citations, a patent citation is much more rigorous in how they are used in the creation of a new patent. A patent must meet the minimum criteria (1) novel and legally definable, (2) non-obvious that a skilled practitioner would not have known it, and (3) useful for a commercial purpose (Scherer 1965). This substantially raises the bar on the value of a citation, since the patent office demands that all citations be defended for their inclusion, in both the recognition of the new patent and the distinction of why the new technology is different from the others cited. Citations can also be excluded based on the same criteria. Essentially, a patent citation going forward or backwards is necessary in order to establish the pattern of how this new technology is definitively different and novel in its potential utility (Griliches, 1990; Decarolis, et.al., 1999).

Sample

For the purpose of this study, a sample was chosen from the biotechnology and pharmaceutical industries, which are known to be driven heavily by exploration of knowledge creation and subsequent exploitation of the codified intellectual property (Girotra, et.al., 2007; Danzon, et.al., 2005). A critical component to these firms is searching and developing knowledge capabilities for future innovative success (Nicholson, et.al., 2005; Kogut, et.al., 1992; Powell, 1998). The ability of firms to turn this knowledge into specific, codified, patentable technology, hinges greatly on their ability to be able to tap into streams of knowledge that are both within their organization as well as beyond their boundaries into the network in which they compete (DeCarolis, et.al., 1999; Teece, 1986). The sample of firms was obtained from the United States Patent and Trademark Office. The USPTO's database contains complete, current patent information worldwide.

All firms must of had have more than five U.S. patents over the five year period in order to capture firms that are active in turning knowledge into distinct innovation that can be awarded a patent (Barrell & Mason, 2000; Ahuja, et.al., 2001). Furthermore, firm size will be a control variable used in the model. By taking a five-year period of all patent activity, we adhere to Rumelt's (1991) warning that the reliance on a single year of data can result in an inability to detect the true correlation, of the relationship investigated.

The data contains both product and process innovations by using the combination of all utility, design, and plant patents awarded to a firm in a given year. Furthermore, by taking all patents awarded we are controlling for innovation type (radical and incremental) since all new innovations are being measured. By using the average results of firms for the five year period, we are able to capture more of the impact of the individual firm's innovation in the marketplace, as certain innovations may take longer than others before they are recognized and valued by the market, and spawn further innovation (Albert, et. Al., 1991; Ernst, 1998; Trajtenberg, 1990). Using the sample criteria, 384 firms met the minimum criteria of innovation activity for the time period of 1998-2003.

The next criteria for obtaining the sample needed for model testing was to review the 384 firms for public companies. By restricting the sample to public companies we are able to collect accurate data on firm performance that is required to be reported to shareholders in their 10Q's and annual reports. We examined all of the 384 firms of which 163 were publicly held companies, and confirmed that 163 firms were public by examining them through the Mergent Online database for validating that they were publicly held for the years of 2004-2007, as all three years of publicly held data will be needed for analysis. Two firms were taken private through leveraged buy-outs; another firm had gone out of business before the end of 2006, leaving a sample size 160.

Finally, the corresponding measures of firm performance were collected over the sample of firms and the corresponding time period of 2004 through 2007. This data was collected from secondary data sources of the publicly traded companies. All publicly held firms are required to disclose this information in their 10Q's and Annual reports. All financial measures contained within the firm's public documents were manually collected through Mergent Online, Hoovers, and the firms' own websites.

The final sample yielded 160 firms, with 48,670 individual patents recorded, and 3 years of all firm performance measures individually calculated (ROE, ROA, ROI, Market-to-Book).

First, the sample size of 160 meets the requirements of a minimum number of observations of 130 to ensure statistical power of .8 at an alpha level of .05 (Hair, et.al., 1998). Multiple regression requires a sample size of between five and twenty observations per independent variable (Hair, et.al., 1998), with the higher number preferred when also looking at overall correlations.

Measures

A contribution of this study is the use of realized measures of a firm's innovations that can then be used to examine realized measures of firm performance. A review of the literature on technological innovativeness studies indicated a need for additional measures of radical and incremental innovation (Kirca, et.al., 2005). There is a paucity of measures of radical and incremental innovation, prompting the authors to express the need for additional measures of both radical and incremental innovation that can extend across an entire firm for capturing a more robust measure of total market innovativeness of a firm and industry.

Knowledge Measures

Patent Count

The patent count for a firm is the total number of patents awarded to a firm for a given time period, in relation to other firms in the industry. This is the first measure of a firm's innovativeness, as it represents the ability of the firm to take explicit codified knowledge and develop new distinct innovations. Firms are reacting to the knowledge and expressed needs of the marketplace in order to create a clearly definable, patentable, piece of technology. This was illustrated graphically in Figure 1. The reach and impact of the technology, is yet to be determined. The patent count is calculated using:

$$PC_j = \sum_{i=1}^{N} x_{ij}$$

where x_i is the number of patents for firm j in year i, and N is the number of years.

Patent Cycle Time

Patent cycle time is defined as the median age in years of U.S. patents cited as prior art in the company's patents. This is a measure of a firm's innovativeness because it tracks the ability and speed in turning prior research and innovation into new, distinct, and codified intellectual property by the firm. The calculation of this measure is as follows:

$$PCT_j = Med(a_{ij})$$

where *Med* is the median, and a_{ij} is the age of patent i for firm j.

This can be calculated for one year, or across a defined set of years.

These measures indicate the market influence a firm derives from its patent portfolio. New innovations by a firm will spawn large amounts of additional research and contributions by the market, and will subsequently be heavily cited. Patents act as codified knowledge provided for the market for additional innovation and knowledge creation in the present and future.

Current Citation Index

This measure shows the significance of a company's patents by examining how often its U.S. patents are used as the basis for other innovation in a defined time period. Hall, et.al. (2005) find a correlation of one extra patent citation increasing market valuation by as much as 3%. The measure is an aggregation of the citations for a firm's patents, aggregated over multiple years and normalized against an industry average. A value of one represents average frequency. A value of 1.6 would indicate a company's patents are referenced 60% more often than the industry average (Albert, et.al., 1991; Narin, et.al., 1997). The calculation of this measure is as follows:

$$CI_{jk} = \frac{\dfrac{\sum_{i=1}^{n_{jk}} x_{ijk}}{n_{jk}}}{\sum_{j=1}^{N} \sum_{i=1}^{n_{jk}} \dfrac{x_{ijk}}{n_{jk}}}$$

Where n_j is the number of patents for firm j, x_{ij} is the number of citations for patent i for firm j, k is the year, and N is the number of firms.

The current citation index is calculated from the historical data. This time period allows me to assess this realized firm innovativeness on firm performance at the given time period of 1998-2003. The patent measures in Table 1 provide an example of 10 firms out of the sample of 160 used in the study. Both radical and incremental measures are contained in Table 1.

TABLE 1
MEASUREMENTS OF INCREMENTAL AND RADICAL INNOVATION

COMPANY	Number of Patents	Patent Cycle Time	Current Index
Sumitomo Chemical Co.	321	9.2	0.42
Caliper Technologies Corp.	47	6	5.9
Affymetrix Inc.	50	11.4	3.57
Symyx Technologies	45	8.4	3.59
Roche Holdings Ltd.	312	8.9	0.5
Bristol-Meyers Squibb Co.	197	9	0.66
Abbott Laboratories	141	9.6	0.74
Merck & Co. Inc.	162	7.9	0.52
GlaxoSmithKline	189	9.3	0.44

Looking at Table 1, Merck & Co. Inc. has a large number of patents within the ten firms listed in the given time period, with an average of 162 a year. Merck's current citation index is only 0.52. Interestingly, Caliper Technologies Inc. has one tenth the amount of patents for the same time period, but their current index of 5.9 dwarfs Merck's .52. Caliper Tech. Inc. is producing patents that are cited 560%

more than the industry average while Merck, is producing patents cited 52% less than the industry average. Furthermore, when looking at the patent cycle time, Caliper is turning around new technology to the marketplace at an average rate of 6 years, 1.9 years faster than Merck. This is a good illustration of how these patent measures not only look at the amount of technology being produced, but also the speed, impact, and reach realized over the marketplace. In addition this example demonstrates within the sample that there is a great deal of variation from firm to firm in levels of radical and incremental innovativeness within an industry.

Firm Performance

Past studies have suggested that the level of a firm's innovativeness will result in higher performance in variety of measures of new product success and firm innovation (Atuahene-Gima, 1995; Desphande, et.al., 1993; Han, et.al., 1998; Jaworski & Kohli, 1993: Slater & Narver, 1994). In constructing the study sample, we considered only biotech/pharmaceutical firms that are publicly held in order to be able to obtain objective, publicly available performance data. Accordingly, data was gathered on four performance variables; ROE, ROI, ROA, and Market to Book (Lawless MW, Anderson PC. 1996) for the years 2004-2007 and averaged. The measures for firm performance were computed as followed.

Return on Equity

Return on equity was calculated as follows:

$$ROE = \frac{\text{Net Income}}{\text{Equity}}$$

where net income shall be the average net income of the company for the last 12 quarters, equity shall be the average value of equity as per the last 12 quarters. (Note: when calculating the ratio on the grounds of the data in a consolidated report, only the net profit of the group shall be taken into account.)

Return on Investments

Return on investments was calculated as follows:

$$ROI = \frac{\text{Net Income}}{\text{Book Value of Assets}}$$

where net income shall be the average net income of the company for the last 12 quarters, and book value shall the average value of assets as per the last 12 quarters. (Note: when calculating the ratio on the grounds of the data in a consolidated report, only the net profit of the group shall be taken into account.)

Return on Assets

Return on assets was calculated as follows:

$$ROA = \frac{\text{Net Income}}{\text{Total Assets}}$$

where net income shall be the average net income of the company for the last 12 quarters, and total assets shall be the average value of the total assets as per the last 12 quarters. (Note: when calculating the ratio on the grounds of the data in a consolidated report, only the net profit for the group shall be taken into account.)

Market-to-book

Market-to-book was calculated as follows:

$$Market - to - book = \frac{\text{Market Capitalization}}{\text{Book Equity}}$$

where market capitalization shall be the average market capitalization of the company for the last 12 quarters, and book equity shall be the average value of the book equity minus goodwill as per the last 12 quarters. (Note: when calculating the ratio on the grounds of the data in a consolidated report, only the net profit for the group shall be taken into account.)

Control Variables

This study used the control variables of firm age in years and number of employees. Firm age and size are important control variables because they address the ongoing debate in the literature over whether smaller, younger, entrepreneurial firms are more effective and successful innovators than larger established firms (Christensen, 2003; Colarelli & O'Connor, 1998). While large firms enjoy resource advantages, they also are more susceptible to inertia. Sales and assets were considered as control variables when designing this study and were ruled out primarily due to the nature of the industries chosen. Many biotechnology and pharmaceutical companies have a great deal of knowledge and technology stores, but have limited sales and assets due to the fact they may be engaged in R&D that has not resulted in commercial sales, on the collection of balance sheet assets (Albert, et.al., 1991). This problem would be further compounded by large, fortune 100 pharmaceutical with extremely large sales growth and assets from legacy products. For these reasons, number of employees was chosen as the control variable for resource availability.

Analysis

Screening Data File

All original printed data for each observation was proofread against the excel file created to check for accuracy. The file was exported to SPSS for initial exploratory screening of all variables and missing data. Four observations had one year of the measures of ROE and ROA missing. The averages of these observations from the two years remaining was checked against the mean of the average of all the observations for both variables and were within the minimum and maximum and were kept in the data file. All variables, except for SIC code, are continuous variables.The observations' ranges, means, standard deviations, histograms and scatter plots were checked for possible outliers. Two observations had outliers in all financial performance variables. Initial normality of the variables was assessed through the descriptives, scatter plots, and histograms. Additionally, the financial measures' means were compared to previous published studies of the pharmaceutical and biotechnology industry (Sharma & Lacey, 2004, DeCarolis, 2003) and were consistent with the industry averages.

Summary of Descriptive Statistics

In the control variables, age in years ranges from a minimum of 6 to a maximum of 143, with a mean of 43.2. Age in years was determined by the last incorporation date from the Mergent Online database to keep a consistent measurement of firm age throughout the sample. The range of ages of firms is a good representation of the industries being studied, having firms that started business in the 90's as well as those that have been around for almost five decades, all producing new technology being captured in the reactive and proactive patent measures.

In the patent measures, number of patents ranges from an average of 3 per year to 522 per year with a mean of 60.83. In patent cycle time the fastest firm is taking 1.9 years to take knowledge from the marketplace and produce new technology, with a maximum of 13.5 years and mean of 8.74. In the radical and incremental measure we see a similar amount of variance within the sample in terms of the impact of technology being produced. In the proactive measure of current index, a ratio with an industry average equal to 1.0, firms range from a minimum of 0.16 to a maximum of 12.28 with a mean of 0.98. Moreover, that the worst performing firm is producing technology that is used only 16% of the time for creating new technology, while the best performing firm's technology is being used over 1200% more than the industry average.

In the firm performance measures there is a great deal of variance among the internal measures of the firm's balance sheet containing the ROI, ROE, ROA,. From reviewing other publications examining these variables (Hall, et.al., 2005, Girotra, et.al., 2007), these wide ranges are to be expected, especially within the industries being studies. The market-to-book ratio assumes that a company's approximate worth, tangible assets plus intangible assets, is indicated by its market value. Therefore, the difference between book value shown on the company's balance sheet and market value gives an approximate measure of the intellectual capital that is part of the total company worth that does not appear on the balance sheet. The markets are valuing firms' intellectual properties and capabilities, with a range of 1.03 to 19.01 and a mean of 7.57.

Regression Models Tested

For each regression model, tolerance and variance inflation factors were checked for multicollinearity. An F test was used to determine whether there was support for the overall relationship at the .05 level, and t tests of individual coefficients were used to see if the individual hypotheses were supported. The unstandardized betas are reported along with the intercept for each model. In addition, each regression was examined for the assumptions of ordinary least squares (Hair, et.al., 2006).

Regressions for Models 1-4

1. ∫ROIAVG = TechPower + NumberPatents + CurrentIndex + PCycleTime + AgeYears + Employees + e

2. ∫ROEAVG= TechPower + NumberPatents + CurrentIndex + PCycleTime + AgeYears + Employees + e

3. ∫ROAAVG = TechPower + NumberPatents + CurrentIndex + PCycleTime + AgeYears + Employees + e

4. ∫M2BAVG = TechPower + NumberPatents + CurrentIndex + PCycleTime + AgeYears + Employees + e

RESULTS

Regressions Explaining a Firm's Innovativeness on Venture Profitability and Market Value

Our regression results in Table 2, we are directly comparing a firm's patent count, patent cycle time, and current index to venture profitability and market valuation in hypotheses H1, H2, and H3. Four ordinary least square regressions models were tested with the three individual measures of venture profitability; ROA, ROE, ROI, and the venture market valuation measure Market-to-Book.
Collinearity diagnostics were examined for each regression output. All tolerances and variance inflation factors indicated that collinearity was not a problem (Hair, et.al., 2006). In addition, residual scatter plots were examined for each OLS regression for the normality and linearity of the dependent variable scores.

Models 1 through 4, we compare the independent variables, including the control variables to each dependent variable of venture profitability and market valuation. In model 1 the overall model was significant ($F = 15.64$, $p < .001$*), with an adjusted r-square of .315. The measure of radical innovation (Current Index) had a significant influence ($B= .579$, $p< .001$*) on return on investment. Neither number of patents or patent cycle time was significant. In model 2 the overall model was significant ($F = 17.64$, $p < .001$*), with an adjusted r-square of .344. The measure of radical innovation (Current Index) had a significant influence ($B= .608$, $p< .001$*) on return on assets. Neither number of patents or patent cycle time was significant.

In model 3, testing the individual variables to return on equity, the overall model was not significant ($F = 15.64$, $p < .001$*), with the measure of number of radical innovation (Current Index) had a significant influence ($B= .579$, $p< .001$*) on return on investment. Neither number of patents or patent cycle time was significant.

In model 4, testing the individual variables to Market-to-Book the overall model was significant (F = 18.69, p < .001*), with an adjusted r-square of .358. The measure of radical innovation (Current Index) had a significant influence (B= .609, p< .001*) on Market-to-Book. Neither number of patents or patent cycle time was significant.

TABLE 2
REGRESSION RESULTS

	Model 1		Model 2		Model 3			Model 4	
	ROI		ROA		ROE			Market –to-Book	
	B	t	B	T	B	t		B	t
Intercept	0.282	0.224	1.35	1.9	3.968	2.889	Intercept	0.186	0.877
NumberPatents	-0.019	-0.19	0.015	0.157	-0.02	-2.02	NumberPatents	0.129	1.367
CurrentIndex	.579***	8.53	.608***	9.153	-0.211	-0.76	CurrentIndex	.609***	9.267
PCycleTime	0.087	1.26	0.083	0.004	0.009	0.059	PCycleTime	0.008	0.124
AgeYears	-0.037	-0.48	0.027	0.353	-0.012	-1.12	AgeYears	-0.042	-0.56
Employees	-0.012	-1.21	-0.017	-0.17	0.094	1.765	Employees	-0.036	-0.38
F	15.64***		17.64***		1.65		F	18.67***	
R^2	0.337		0.364		0.051		R^2	0.378	
Adj R^2	0.315		0.344		0.02		Adj R^2	0.358	

*p<.10
**p<.05
***p<.001

Radical Innovation's Effects on Venture Profitability and Market Value

Summary of Hypotheses

The first sets of hypotheses, H1a-H3b, were to test the effects of the three components of firm innovativeness on the venture profitability and market value of the firm. H1a predicted a positive relationship between patent count and venture profitability, and H1b predicted a positive relationship between patent count and market value neither was supported.

H2a predicted a positive relationship between patent cycle time and venture profitability, and H2b predicted a positive relationship between patent cycle time and market value neither was supported.

H3a predicted a positive relationship between current index and venture profitability, and H3b predicted a positive relationship between the current index and market valuation, both hypotheses were supported.

The fourth set of hypotheses H4a-H4b predicted a positive relationship between radical innovation and venture profitability, and H4b predicted a positive relationship between radical innovation and market value. Hypotheses H4a-H4b had mixed results for hypothesis H4a. There is a significant positive relationship between radical innovation and return on investment, but no significant relationship between radical innovation and the other venture profitability measures. H4b predicted a positive relationship between radical innovation and market value, which was supported.

DISCUSSION AND IMPLICATIONS

In this manuscript, we addressed the following research questions: (1) How should managers allocate their knowledge resources to maximize their profitability and stock market returns? (2) Should managers focus their entrepreneurial intent on securing as much knowledge as possible to increase their organization's intellectual property vis-à-vis their competitors? (3) Should managers instead emphasize efficiency in the cycle time surrounding the creation of knowledge by being quicker to obtain intellectual property than their competitors? (4) Do radical or incremental innovations deliver the greatest venture profitability and stock market valuations?

The results point to some surprising points, and are encapsulated in our four contributions to the literature. First, managers should take a more patient perspective and acknowledge that the real benefit is in generating intellectual property that will generate, ultimately, the best firm performance and evaluation, which this study has shown means to review the impact the knowledge has on the firm and marketplace through review of their current index. Second, a focus on numbers of patents and the efficiency of the patent cycle do not increase either profitability or market valuation. In effect, creating knowledge to create knowledge does not naturally lead to increased venture performance. An organization should stress the creation of knowledge which will lead to significant levels of innovative breakthroughs such as a range of more radical innovations. Third, an emphasis on generating knowledge to create incremental innovations has limited returns on venture profitability and in the stock market. Fourth, creating knowledge and the resulting innovations which have a high impact (citation index) will lead to increased profits and market valuations.

One of the most interesting points of our study is the generation of knowledge. Regardless of size, we find that ventures which produce knowledge which is used by themselves and others, as indicated through patent citations and current index, are more successful than organizations which focus on producing greater numbers of patents and at the fastest patent cycle times. This result may infer that some organizations are more interested in seeing the productivity of their scientists in terms of the number of patents generated as a metric for their success, rather than the actual impact this knowledge has. Likewise, it could possibly imply that these organizations are creating more basic knowledge which is more difficult to apply. In either instance, a lack of coordination and applicability to what consumers want seems to be an implication of our findings.

In regards to the efficiency of improving cycle time, this is in part driven by two motivations. First, an organization desires to be a first-mover in the market or to utilize absorptive capabilities to create unique innovation. Speed is said to be critical in the development of knowledge; however, our results provide evidence to the contrary. Speed in the form of cycle time reduction in the patent process does not produce significant results for increasing profits or market valuations. Second, an organization may wish to improve the cycle time process due to a need to cut costs out of R&D and focus on the near term, as a result of impatient capital demands from investors. Once again, our findings may suggest that a broad based cost-cutting approach to R&D does not increase probability of future financial success and market value, though it may reduce costs in the near term.

From Schumpeterian and Kirzner perspectives, our data infers that a Schumpeterian perspective provides more robust performance returns; whereas, the incremental, or Kirznerian approach, provided limited returns. A limitation of our study is that we do not gauge the level of risk directly for either radical or incremental innovations, which was outside the scope of our study. The extant literature is replete with studies which suggest that incremental innovation is more certain and less risky approach to innovation than attempting to create a radical innovation. Though this may be true, our results give rise to the belief that entrepreneurial organizations which strive to create radical innovations based on knowledge which have a high patent citation index will greatly outperform their competitors which look to produce more incremental innovations.

Limitations, Managerial Implications and Future Research

For managers, our findings suggest that past ventures, which have emphasized patent citations, were able to increase returns in both profitability and market valuation. Comparably, firms which placed a much stronger emphasis in their corporate entrepreneurial strategy on generating patents through an efficient cycle time demonstrated a non-significant relationship to profitability and market valuation. Similarly, innovations which changed the marketplace and industry structures resulted in more robust economic rents for the organization. Though an incremental approach provides more certainty than a radical innovation, it does not produce nearly the same strength of relationships on firm performance. Managers may wish to use this argument to assist in their discussions with their corporate boards which may resist committing large investments to fund potentially lucrative projects (i.e., radical innovations) due to the perceived risk of the investment compared to the relatively less risky investment and expected payoffs of incremental innovations.

Future research should build on these findings by applying a similar approach to a broader range of industries. It would be interesting to see if the same pattern toward radical innovations would hold true across different industries, or that in fact, what industries where incremental innovations provided a greater return on venture profitability. Likewise, the use of a qualitative method in conjunction with the current study to capture the nuance relationships would be interesting. Lastly, a focus on the internal motivations of managers which drive them to place a greater emphasis on more certain investments such as incremental innovations and not radical would provide a greater understanding of personnel risks linked with the level of venture risk.

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