Learning for Innovation in New High Technology Ventures

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ABSTRACT :

Based on the theoretical findings found in the literature in strategic and in knowledge management, I develop a model on the links between organizational learning, innovation and company performance. Constructs are derived and validated on a sample of high tech ventures. The same sample is used to test the model. Findings indicate that there is a positive relationship between organizational learning, innovation and company performance. The age of the companies moderates these results while the size of the companies does not. Comments on how to capture and share the knowledge are given to the new ventures managers.

INTRODUCTION

As firms have to adapt radically and to compete globally, competitiveness is related to the firm's ability to learn faster than its competitors (Easterby-Smith et al., 1998). Harvey and Denton (1999:897) have identified six antecedents that explain the new focus on organizational learning:

- the shift in the importance of production factors from capital to labor to intellectual labor;
- the pace of change in the business environment;
- the widespread acceptance of knowledge as a prime source of competitive advantage;
- the greater demands being placed on all businesses by customers;
- rising dissatisfaction with the traditional management paradigm (top-down command-and-control);
- the intensely competitive nature of global business.

Following the resource-based view (Wernerfelt, 1984 ; Prahalad & Hamel, 1990 ; Grant, 1991), that states that the different products or service a firm can offer are based on several core competencies, researchers have paid attention to the importance of knowledge and knowledge management in building those core competencies and in giving the firm a competitive advantage (Winter, 1987 ; Grant, 1996). The common denominator for these efforts is knowledge.

Thus, the efficiency of a firm will come from the way it creates knowledge, manages it, and learns from it. Nevertheless, there is no agreement in the literature on what organizational learning is (Bell et al., 2002). Learning is a meta-construct involving several sub-constructs, defined in a very abstract manner. Yet, to date, definitions have not been easy to operationalize in a way that helps in theory building. Contrary to some authors (Nevis et al., 1995 : 73), who define organizational learning as "the capacity or processes within an organization to maintain or improve performance based on experience", in our definitions, organizational learning and knowledge management are not necessarily related to performance. In fact, it is even one of the purpose of this paper to verify this point. Based on the literature, we present two clearly different definitions for knowledge management and organizational learning.

We define knowledge management as the process of managing knowledge. It is concerned with the acquisition and communication of knowledge and is at the basis of organizational learning.

Organizational learning is a process or a set of organizational processes. "If we conceptualize each component of knowledge as a stock, then, the underlying learning processes that create them represent flows" (Garud, 1996 : 5). Occurrence levels differentiate the flows (Argyris & Schön, 1978 ; Senge, 1990 ; McKee, 1992) as single-loop (or corrective) learning, double-loop (or generative) learning. But, benefits and side effects of learning processes are unclear. On one hand, competency traps may occur because "prior innovative successes reinforce established routines even as the technological frontier shifts to new areas" (Sorensen & Stuart, 2000 : 87). As a firm's experience grows, so do their competences and, thus, they become less able to assimilate and exploit new information. Accumulation of knowledge through experience, or learning-by-doing, may lead to failing-by-knowing. This myopic view (Levinthal & March, 1993) may see technological leaders replaced by start-ups (Abernathy & Utterback, 1978). More recently, the concept of core rigidities (Leonard-Barton, 1997) states that if companies do not make their core competencies evolve regularly (through organizational learning), they may fail rapidly when they become older. On the other hand, Myers & Marquis (1969) found that small firms with fewer changes in their successive products in term of technology and market perform better than firms emphasizing more diversity, thus advocating for strategic focus.

Based on the different concepts presented, we define organizational learning as the organizational processes aimed at adding value to the knowledge acquired and communicated throughout the firm. This process encompasses the acceptance and the assimilation of knowledge.

1. LEARNING AND INNOVATING

Innovation is an idea, practice, or object that is perceived as new by an individual or another unit of adoption (Rogers, 1965). Literature uses either the term innovation or innovativeness. Innovativeness represents the capacity of a firm to innovate, whereas innovation will be the (expected) result of this capacity. As the ultimate way to validate a capacity is through the result (criterion-related validity), innovation and innovativeness are often used

interchangeably. Compared to theories in strategic management, there are no clear theoretical streams in innovation studies. As stated by Drazin & Schoonhoven (1996) : "we were disappointed to discover that no dominant theoretical perspective had emerged to integrate the multiple streams of innovation research". The conceptualization of innovation has been made in several ways (Damanpour, 1991 ; Gopalakrishnan & Damanpour, 1997) and its effects studied from numerous perspectives (level of analysis, stage of the innovation process, application...).

Cooper (1966) wrote one of the first articles dealing with the problematic of new product development. Since then, many studies have tried to quantify and qualify the factors associated with product innovation or new product development process. Thus, researchers, through conceptual works, quantitative and case studies, have developed several views of the phenomenon without explicitly agreeing on an explanation of product innovation. On the same vein, innovation is represented using a wide spectrum of variables (Yap & Souder, 1994; Lefebvre & Lefebvre, 1993). The result is a "cocktail" of different variables that attempt to explain innovation. Using static or congruency framework, research questions and designs are static and ignore the interplay between the firm and its environment. This is more relevant, therefore, to develop a dynamic framework for studying product innovation in high-tech small firms, where organizational processes are involved.

Consistent with our literature review, we argue that the missing link in the different studies is the complementary between in-house and external know-how accumulation (Rothwell & Dodgson, 1991) and the process behind it, that some authors refer to as "absorptive capacity" (Cohen & Levinthal, 1990 ; Garud & Nayyar, 1994). Knowledge accumulation and internal and external learning is pervasive in most of the studies on strategy, innovation and performance, regardless of the school of thought in strategic management or the conceptual approach chosen (static vs. fit). Thus, we suggest a model involving the process of knowledge accumulation or learning.

2. HYPOTHESES

Following the above discussion, we can hypothesize about the link between knowledge management, learning, innovation and performance. All these dimensions are interlinked, but

a good performance at one is not automatically a consequence of good performance at one or several of the other dimensions.

As this subject is new and empirical studies on learning orientation are very scarce, the hypotheses are based more on theory building than theory validation. Following Nevis et al. (1995), and Sorensen & Stuart (2000), a learning organization will benefit from up-to-dates resources and competencies and thus should perform better than the others in term of innovation and in term of financial performance.

Hypothesis 1 : Organizational learning is positively related to financial performance.
Hypothesis 2 : Organizational learning is positively related to innovation performance.

Again, if our hypotheses seem obvious at first sight, our aim in this paper is to validate on high-tech small firms what has been stated in several conceptual papers but rarely validated in empirical ones. Core rigidities (Leonard-Barton, 1997) and competency traps (Sorensen & Stuart, 2000) have been some of the most powerful concepts developed these last years for the understanding of competencies development and innovation in companies. There authors develop the hypothesis that when firms get older, they have a tendency to rely more on the existing competencies, to put less emphasis on learning new competencies or adding value to the existing ones, and thus to innovate less. Also, because organizational routines are also associated with the growth of the companies in size, an effect of the number of employees could also be hypothesized.

Hypothesis 3a : Age is negatively related to organizational learning.
Hypothesis 3b : Age is negatively related to innovation performance.
Hypothesis 4a : The number of employees is negatively related to organizational learning.
Hypothesis 4b : The number of employees is negatively related to innovation performance.

3. Methods

3.1. Sample

The data were collected by mail on a sample of 1000 companies whose names where gathered from the Hoovers directory of companies in 1999 (www.hoovers.com). This directory was

chosen because it focuses on technology companies. The questionnaire was mailed out in September 2000 to the CEO or President of the company. The companies were chosen based on their affiliation with the technology sectors and their size (less than 500 employees). Questionnaires were answered mainly by CEO or president or vice presidents of the companies. The average job tenure was 7.7 years. The result was 110 questionnaires. This low rate (11%) may be explained by the facts that we targeted small companies and that we deal with a complex subject. The companies studied were incorporated on average on 1982. The average number of full-time employees is 88, with numbers ranging from 4 to 465. The sales for 1999 have an average of 25.8 millions USD (SD=99.8), with an export rate of 24.7 %. Even if the sample is small, the standard deviations show that we nevertheless end with a wide range of companies, at least in terms of sales and number of employees.

3.2. Variables and Validation of the Constructs

The development of any science needs a valid measurement of the theoretical constructs (Peter, 1979). Unfortunately, most of the quantitative studies in strategic management place more emphasis on the statistical results of relationship between different dimensions than on the validity of those dimensions (Schwab, 1980). Our constructs were built using sets of perceptual questions (7-points Likert scales) answered by the CEOs or company presidents. The complete sets of questions are available on request.

Organizational Learning : Five questions were used to capture organizational learning and the dynamic processes behind it. Respondents were asked to rate their company's ability to comprehend innovations developed by other companies, adopt them, combine them with those developed within their companies and implement them. Besides this "absorptive" capacity and in order to complete the process of organizational learning, they were lastly asked to rate their ability to use technologies developed internally to develop innovations.

Innovation Performance : A set of four questions was used to measure innovation performance. Respondents were asked to evaluate their company's performance over the past three years compared to major competitors on product innovation, adoption of new product technologies, new process technologies and transforming R&D results into products.

Financial performance : Respondents evaluate again their own company's performance compared to their major competitors in term of sales growth, benefits, return on sales and

return on investment. Subjective measures are used instead of factual measures because of the small firms CEOs' reluctance to disclose financial data (Lefebvre et al., 1996). Furthermore, they are highly correlated to the factual measures (Sapienza et al., 1988).

Age and Size : The classical measures of the number of years of existence and the log of the number of employees were used to capture age and size.

Following Venkatraman & Grant (1986), the study's constructs were evaluated to establish their unidimensionality, convergent validity, reliability and discriminant validity (see Table 1). Unidimensionality and convergent validity is assessed using a confirmatory factor analysis (CFA). Each construct has satisfactory reliability, unidimensionality and convergent validity. A good alpha (.84) and satisfactory CFI and NNFI scores counterbalance the relatively low score of p for the innovation construct. All factor loadings were significant and sizeable. Furthermore, discriminant validity was assessed and results are available on request. It shows satisfactory results between the three different constructs used.

4. ANALYSIS AND RESULTS

A model is tested to measure the relation between the effect constructs and the cause of the constructs. The method used is the maximum likelihood with estimation of means and intercepts for missing variables (Amos 4.0). This method has proven to be better than replacing missing values (Kline, 1998). Nevertheless, we found that it has a tendency to "over fit" the model. As such, a very conservative approach is necessary on the goodness-of-fit statistics. CFI and NNFI results below .97 will be considered as poor fit.

4.1. Organizational Learning and Performance

Results of the analysis (see Table 2) are all satisfactory from a statistical point of view. CFI, NNFI and RMSEA are above our limits. Loadings of the Organizational Learning construct are high and significant with respectively .308 ($p<.01$) on Financial Performance and .602 ($p<.001$) on Innovation Performance. These first results suggest that organizational learning, as defined in our study, has positive influence on financial performance and innovation performance in our sample of high-tech small firms. We notice that the effect is higher on innovation performance ($R^2=.362$) than on financial performance ($R^2=.095$). H1 and H2 are validated.

4.2. Age and Size

Age and Size were added and two models analysis were performed. Both models achieve satisfactory results from a statistical point of view with good Chi-square, CFI, NNFI and RMSEA scores (see Table 3 and 4).

Results show that age is negatively and significantly related to innovation performance and to organizational learning. In term of explaining power, a R^2 improvement of 4.9% is found for innovation performance and a R^2 improvement of 6% for organizational learning compared to the previous model (H1). If age is not the main constituent, it reasonably influences both organizational learning and innovation performance. H3a and H3b are validated.

Regarding size, no significant relationship is found between the size and neither organizational learning nor innovation performance. On our sample, there is no effect of size on those two dimensions. H4a and H4b are not validated.

5. DISCUSSION

Organizational learning is a complex phenomenon and this paper gives a first insight into it in the context of high-technology small firms. Based on the theories on strategic management, innovation and learning, we developed a model to empirically study the links between those dimensions. This paper presents the first results of this study. Original constructs are proposed and statistically validated. Consistent with previous qualitative findings and theoretical assumptions, the presence of organizational learning processes strongly influences innovation performance. Incorporating new knowledge and using it in the firm leads to more innovation.

Regarding financial performance, the results are also positive and significant but the influence is less important. It implies that, besides organizational learning, a set of other variables helps to transform innovation into financial performance. As presented in our general framework, we hypothesize that several internal and external variables act simultaneously, in a congruent way, to lead to innovation and financial performance, like external linkages or focus on niche markets (Hoffman et al., 1998). As such, organizational learning is only one of the constituents of alchemy, but its influence is far from negligible.

Besides these general results, the sclerosis pointed out by Leonard-Barton (1997) for aging companies which do not engage into organizational learning is found for the high-tech small

firms studied. Interestingly, as the size of the company does not influence organizational and innovation performance, we can hypothesize that it is not the presence of more bureaucratic processes often associated with the growth in number of employees that will influence innovation performance. Nevertheless, this assumption would have to be validated in further analysis. Other factors are definitely in play to explain why age negatively influences organizational learning and innovation.

5.1. Limitations and Further Research

Our first attempt to operationalize organizational learning processes must be improved in further research. Firstly, the same items should be tested on a bigger sample to ensure a stronger validity of the results, specifically when dealing with structural equation modeling. One must very carefully interpret the causal models. Secondly, as we are dealing with a specific type of small firms, we should test the model on a sample of high-tech and low-tech ventures to study possible differences. Furthermore, the variables tested represent only a part of the phenomenon. Relatively small R^2 are found for several of our models. Other variables must be incorporated in the model to fully understand what are the prerequisites of organizational learning and as a consequence of innovation. Other attempts are needed in order to help managers and researchers to better understand what is behind organizational learning and how to successfully implement it in companies. Especially, we believe in the benefits of mixing qualitative and quantitative studies. As such, our model would greatly benefit from case studies validation to shed more light onto the relationship between innovation and organizational learning. We hope that the constructs presented here will be challenged by peers, refined and tested in other contexts to deepen the theoretical models surrounding organizational learning and innovation.

5.2. Implications for Managers

This paper attempts to be directly useful for managers in the sense that it reinforces the existing literature advocating for the development of organizational learning processes in high-tech small firms. The organizational processes of capturing, diffusing and embedding knowledge are beneficial to the firm. Beyond this general statement, the first insight into the factors underlying organizational learning shows that, as the firm gets older, less emphasis is put on organizational learning processes, and the entire process has side-effects on innovation performance. As it is independent of the size, the key may be more through the culture or strategic orientation that the CEO gives to the firm. As such, years after years, firms must be

careful to let organizational learning processes and commitment at an operational level remain high.

CONCLUSION

In the first parts of this paper, we put the light on the difficulties met by researchers to comprehend innovation in companies. In the same vein, if learning is more and more understood from a theoretical point of view, operationalization's attempts were scarce. This research on a group of 110 high-tech small firms gives partial answers to some of the questions raised by the literature and presented in our general framework. We certainly need to go on looking at the influence of organizational learning in companies and its links with innovation and financial performance using our entire database and also replicating the same constructs in other contexts. As small firms have a major economic impact to most of the countries and as they are often presented as less innovative than the larger ones, the practical implications are important. We sincerely hope that the reading of this paper will encourage other researchers to work on the same subject and confront their findings with those presented here.

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ANNEXES

TABLE 1 : Validation of the Constructs: Reliability, Unidimensionality and Convergent Validity

Construct	Nb of items	Reliability	P	CFI	NNFI
Organizational Learning	5	.88	.593	1	1
Innovation	4	.84	.05	.997	.986
Financial performance	4	.77	.75	1	1

Note: They are several indexes to estimate CFA (Kline, 1998). Following several authors (Kline, 1998; Bagozzi and Yi, 1988), we use the p associated with the Chi-square statistic (p should be higher than 0.1), the CFI (Comparative Fit Index), NNFI (NonNormed Fit Index), both should be higher than 0.9, and RMSEA (Root-Mean-Square Error of Approximation), that should lower than 0.1. Reliability was assessed using the usual Cronbach alpha indicator.

TABLE 2 : Results of the Models Testing (H1 & H2)

HYPOTHESES	χ^2	CFI	NNFI	RMSEA	Loading	R^2
H1: Org. Learning → Financial performance	15,3	1	1	0	.308**	.095
H2: Org. Learning → Innovation	38.06†	.996	.994	.065	.602***	.362

Note: † p<.1, ** p<.01, *** p<.001

TABLE 3 : Organizational Learning, Innovation and Age of the Company (H3)

χ^2	CFI	NNFI	RMSEA	Loading Org.Learning→Innovation	Loading Age → Org.Learning	Loading Age→Innovation	R^2 Org.Learning	R^2 Innov. Perf.	R^2 difference (Innov.Perf.)
43.6	.997	.995	.054	.54***	-.25*	-.24**	.06	.411	.049

Note: * p<.05, ** p<.01, *** p<.001

TABLE 4 : Organizational Learning, Innovation and Number of Employees (Log) (H4)

χ^2	CFI	NNFI	RMSEA	Loading Org.Learning→Innovation	Loading Employees → Org. Learning	Loading Employees →Innovation	R^2 Org.Learning	R^2 Innovation Perf.	R^2 difference (Innov.Perf.)
40.47	.998	.997	.046	.60***	-.009	.13	.000	.381	.019

Note: *** p<.001