

Organizational Learning and Innovation in High-Tech Small Firms

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Abstract

This paper explores the influence of the processes of learning in organizations on innovation performance in high-tech small firms. After reviewing the literature on learning and innovation, the paper defines the concepts of knowledge management and organizational learning and how they are interlinked. Hypotheses on the link between organizational learning and innovation are presented. An original construct, based on 5 dimensions, is derived to evaluate the degree of organizational learning. The validities (reliability, unidimensionality and convergent validity) of the construct are then assessed using confirmatory factor analysis. Then, the influence on innovation is tested through structural equation modeling (SEM) from a database of 110 US high-tech small firms from different industries. Specifically, the influence on innovation and financial performance are tested. The results show that the presence of organizational learning is related to innovativeness among high-tech small firms. The results are moderated by the age (in years) of companies, the strategic posture and the environment's threat. The paper discusses ways to improve the innovative performance of learning organizations.

1. Introduction

Organizational learning is now a part of management theory vocabulary. Several factors explain this [15]. First of all, the crucial assets for companies have moved from production to capital to labor and finally, to intellectual capital. Secondly, the phenomenon of globalization and acceleration of the businesses put the emphasis on the

companies' awareness of their environments. Finally, according to resource-based theory [37][28][11][12][13], knowledge is presented as the main source of competitive advantage [26][38]. As such, competitiveness is related to the firm's ability to create knowledge, manage it and to learn faster than its competitors [8].

2. Learning and its dimensions

As stated by Schein [29], we do not have a clear understanding of the words 'organizational' and 'learning'. Learning is a fuzzy construct, involving several dimensions or sub-constructs. Yet to date, though several theoretical definitions are available, most of them are not easy to operationalize. Learning encompasses three levels: knowledge management, organizational learning and the learning organization.

2.1 Knowledge management

We define knowledge management as the process of managing knowledge. As such, we limit knowledge management to the activities that do not add value to knowledge. In our definition, knowledge management is concerned with the acquisition and communication of knowledge. Knowledge management is at the foundation of organizational learning.

2.2 Organizational learning and its components.

What researchers admit is the fact that knowledge is created by individuals [34] and thus exists outside of the organization. An organization learns through its individuals [2][17][13][34].

Kim [19] gives a clear example of this:

“Imagine an organization in which all the physical records disintegrate overnight. Suddenly, there are no reports, no computer files, no employee record sheets, no operating manuals, no calendars, - all that remain are the people, buildings, capital equipment, raw materials, and inventory. Now imagine an organization where all the people simply quit showing up for work. New people, who are similar in many ways to the former workers but have no familiarity with that particular organization, come to work instead. Which of these two organizations will be easier to rebuild to its former status?”

Nevertheless, if knowledge only belonged to individuals, companies could change only through employee turnover [21]. It implies that knowledge is transformed through its passage in an organization. Organizational learning is more than the sum of learning by individual members of the organization [24].

In the same vein, Huber [17] distinguished four constructs: Knowledge acquisition, Information distribution, Information interpretation and Organizational memory and Nevis et al.[27] derive a three-stage model: knowledge acquisition, knowledge sharing and knowledge utilization. From the knowledge management processes, the assimilation process or organizational memory seems to be the most difficult to apprehend [17][27].

From the presentation below, it is clear that 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” [9]. The different flows are differentiated by their occurrence levels [2][32][24], as single-loop (or corrective), double-loop (or generative) and meta - (or institutional) learning. Moreover, the benefits and side effects of learning processes are unclear. On the one hand, competency traps may occur because “prior innovative successes reinforce established routines even as the technological frontier shifts to new areas” [33]. As companies’ experience grows, so do their competences and 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 myopia of learning [23] may see technological leaders replaced by start-ups [1].

On the other hand, Myers and Marquis [25] found that small firms that made fewer changes in their successive products, in terms of technology and market, perform better than firms that emphasize more diversity, thus advocate for strategic focus. Zirger and Maidique [41] also argued that firms must choose development projects that use the existing organizational, marketing and technological competences.

Based on the literature, we define organizational learning as the organizational processes aimed at adding value to the knowledge acquired and communicated throughout the firm. As such, organizational learning processes encompass the acceptance and the assimilation of knowledge into the firm.

3. Learning and innovating

As for innovation, learning may occur at the individual, group, organization and industry levels. As new outputs, innovations may come from new knowledge as well as from the combination of existing knowledge to create architectural innovations [16], using combinative capabilities [21]. Radical and incremental innovations refer to high and low degrees of new knowledge [7], involving high and low degrees of organizational transformation.

Thus, is there a difference between learning and innovating ? As researchers argue that learning means integrating new knowledge or mixing existing knowledge in different ways, learning leads to newness, and thus to innovation. Innovation will be the by-product of a learning organization. A learning organization is an innovative organization.

The contribution of the literature to the understanding of knowledge and learning is vast and encompasses different epistemological and conceptual dimensions. As our aim is to develop a definition of learning that is operationalizable, we have to focus on the most concrete determinants of learning. Thus, we can deduce several features from our analysis:

- . Organizational learning is a process involving individual, group, organizational and inter-organizational levels

- . Learning is concerned with three stages: acquisition, communication and exploitation of knowledge. Acquisition and exploitation will occur again at the different levels suggested above and will be influenced by several factors coming from these same levels. The more complex, the more tacit and the more systemic knowledge is, the more difficult it will be to acquire and exploit it.

. As for any other organizational features, organizational learning processes will be influenced by the strategy of the firm.

. Organizational learning should be positively related to innovation. If a company is good at acquiring new knowledge and articulating existing knowledge with new knowledge or existing knowledge in a different way, this company should be good at producing innovations (product or process). Furthermore, the better the organizational learning process is, the greater the capacity to develop radical innovations (product or process) will be.

. Organizational learning is not necessarily related to innovation's success. Innovation and innovation's success are two different dimensions. A successful learning organization leads to the capacity to innovate [4], which is the ability of the organization to adopt or implement new ideas, processes, or products successfully [18].

Specifically, if the innovation is not in line with the strategy and the environment of the firm, the innovation may fail and thus the learning-innovation link will not be related to performance.

Learning more or faster does not imply that you learn what you have to in order to perform better than your competitors. A company could be learning oriented, meaning it is willing to learn and does learn and that makes it a learning organization, but one that is poor in terms of processes that lead to learning, that is organizational learning. Thus, questions remain concerning the bridges between knowledge and organizational learning, organizational learning and the learning organization, the learning organization and innovation, and innovation and performance. Specifically, what are the constituents or variables that favor or impede a successful passage from one level to another. If several researches (see [5][6][10] for a literature review) have studied effects of single individual, organizational or environmental variables on innovation, links between organizational learning and innovation are still to be studied.

4. Model and 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. Furthermore, from a strategic perspective, the dimensions and the positive or negative links between the dimensions will be affected by environmental and internal variables. The conceptual model represents these different interrogations (Figure 1).

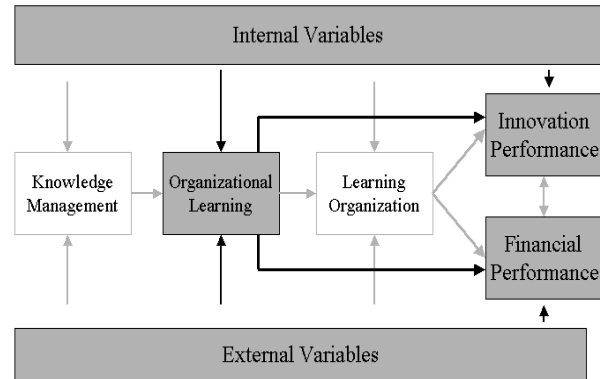


Figure 1 - Learning and Innovation General Framework

In this article, we focus on the link between organizational learning and innovation. The internal variables will be represented by the strategic orientation of the CEO, defined as the strategic posture [35]. Environment influence is represented by the environment's threat to survival perceived by the companies.

Hypotheses

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.* [27], Leonard-Barton [22] and Sorensen and Stuart [33], a learning organization will benefit from up-to-date resources and competencies and thus should perform better than the others in terms of innovation and in terms of financial performance.

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

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

Regarding the strategic posture, Senge [32] states that, "the more effective defensive routines are, the more effectively they cover up underlying problems, the less effectively these problems are faced, and the worse the problem tends to become". As such, a defensiveness strategy should be negatively related to learning orientation. *A contrario*, those who integrate knowledge exploration and exploitation without regards to organizational boundaries have the most risky knowledge

strategy. This form should outperform their rivals who do not engage in such integration [40].

Hypothesis 3: Organizational learning is negatively related to a defensive strategy.

Hypothesis 4: Organizational learning is positively related to a riskiness strategy.

Regarding the environment, we decided to focus on the perceived threat to survival caused by the environment. Companies developing organizational learning should be less feared by the environment because have tools and processes to understand it better than the other companies.

Hypothesis 5: Organizational learning is negatively related to the perceived threat of survival caused by the environment.

Finally, regarding the influence of age on the general model, because of the development of core rigidities [22] and competency traps, aging should not be related to organizational learning and to innovation.

Hypothesis 6a: Age is negatively related to organizational learning.

Hypothesis 6b: Age is negatively related to innovation.

5. Methods

5.1 Sample

The questionnaire was built by using previous conceptual and empirical researches in the field and pre-tested with peers in the fields of strategic management and knowledge management.

The data were collected by mail on a sample of 1000 companies whose names were gathered from the Hoovers directory of companies in 1999. 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 answers rate is in line with other studies dealing with small and medium-sized companies. The companies studied were incorporated on average on 1982. 50.9 % of the companies are privately owned, 45.4 % are public, while the remaining 3.7% are subsidiaries of other companies. 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 %. Of the responding companies, 68.2% consider their target market is a niche market.

5.2 Operationalization of the Variables and Validation of the Constructs

The development of any science needs a valid measurement of the theoretical constructs. 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 [30]. Our constructs were built using sets of perceptual questions (7-points Likert scales) answered by the CEOs or company presidents. The questions are available on request. Following Venkatraman and Grant [36], the study's constructs were evaluated to establish their unidimensionality, convergent validity, reliability and discriminant validity (Table 1). Unidimensionality and convergent validity is assessed using a confirmatory factor analysis (CFA). They are several indexes to estimate CFA [20]. Following several authors [20][3], 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. Finally, discriminant validity between measures of different dimensions of the same construct or between measures of different constructs can be assessed by comparing two CFA measurement models: one where the correlation between the two latent variables are set free and one where the correlation is constrained to 1, pretending that the two latent variables have the same measurement set. The Chi-square difference between the two models should be statistically significant. Age (in years) and Environment threat (Likert scale) were assessed with single measures. Items used to measure the main constructs are presented in Appendix A. All the items and intermediary results are available on request. Results are presented in Table 1.

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
Defensiveness	4	.72	.145	.998	.992
Riskiness	4	.67	.483	1	1
Innovation	4	.84	.05	.997	.986
Financial performance	4	.77	.75	1	1

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 using the method described above (Table2). It shows satisfactory results between the five different constructs used.

Finally, age was measured as the number of years since the company's creation.

Table 2 - Testing Discriminant Validity

Construct	Defensive-ness	Riskiness	Innovation	Financial perf.
Org. Learning	14.1**	6.3*	5.34*	11.2***
Defensive-ness	-	20.6***	18.2***	19.6***
Riskiness	-	-	4.37*	17.4***
Innovation	-	-	-	56.9*

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

6. Results

For H1 to H4, 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 [20]. 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.

Table 3 - Results of the Models Testing

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
H3: Defensiveness • Org. Learning	51.03**	.992	.986	.09	.297*	.088
H4: Riskiness • Org. Learning	38.6†	.996	.993	.067	.515***	.266

† p<.1, * p<.05, ** p<.01, *** p<.001

From a statistical point of view, results (Table 3) suggest several comments. Chi-squares statistics for H3 do not achieve satisfactory results and are questionable for H2

and H4. Nevertheless, because of its sensitivity and the impossibility to interpret it in a standardized way, several authors [39][14] suggest to use the other goodness-of-fit statistics and to use the chi-square statistic mainly for model comparison. As such, fit results are adequate for H1, H2 and H4 and are questionable regarding H3. Concerning the loadings, they are important and significant for H1, H2 and H4 and low for H3. Furthermore, H3 does not achieve a high R² (.088). In term of contribution, organizational learning influence financial performance in a small proportion (R²=.095) and strongly influence innovation performance (R²=.362). Regarding the strategic posture, riskiness influences organizational learning (R²=.266). H1, H2 and H4 are validated and H3 is not validated.

Regarding H5, a model (Figure 2) was tested to assess the influence of the environment's threat on organizational learning and innovation performance. Main statistical results are reported in table 4.

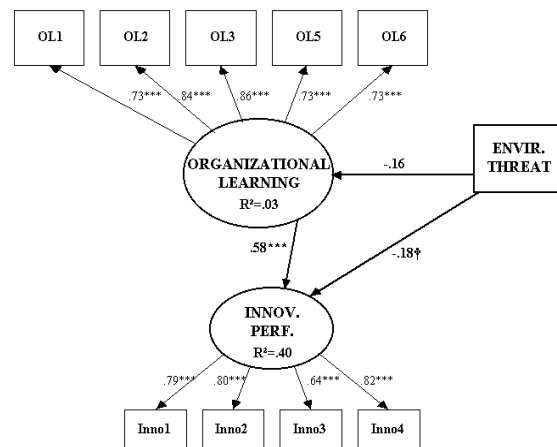


Figure 2 - Path Model Including Environment's Threat (Ovals represent latent variables. Statistics are standardized regression coefficients)

† p<.1, * p<.05, ** p<.01, *** p<.001

Table 4 - Organizational Learning, Innovation and Environment threat

χ^2	60.13**
CFI	.992
NNFI	.987
RMSEA	.087
Loading Org.Learning•Innovation	.58***
Loading Envir. Threat • Org. Learning	-.16
Loading Envir. Threat •Innovation	-.18†
R ² Org.Learning	.03
R ² Innovation Perf.	.40
R ² difference (Innov.Perf.) with H2	.0338

† p<.1, * p<.05, ** p<.01, *** p<.001

Results of the fit statistics are not fully satisfactory regarding chi-square statistic (p<.01) and RMSEA (.087) but are good in term of CFI (.992) and NNFI (.987). Environment's threat is negatively and significantly related to innovation performance. Furthermore, a R² difference of only 3.4 % is found in term of explaining power of learning orientation on innovation performance compared to the model without the environment's threat, suggesting a slightly low influence. H5 is not fully validated.

Finally, regarding H6, a model similar to figure 4 is built by replacing environment threat by the age of the companies (in years) (Table 5).

Table 5 - Organizational Learning, Innovation and Age

χ^2	43.6
CFI	.997
NNFI	.995
RMSEA	.054
Loading Org.Learning•Innovation	.54***
Loading Age • Org.Learning	-.25*
Loading Age•Innovation	-.24**
R ² Org.Learning	.06
R ² Innov. Perf.	.411
R ² difference (Innov.Perf.) with H2	.049

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

The model explained data well. As for environment's threat, age is negatively and significantly related to innovation performance and to organizational learning. In term of explaining power, a R² improvement of 4.9% is found for innovation performance and a R² of 6% for organizational learning. If age is not the main constituent,

it reasonably influences both organizational learning and innovation performance. H6a and H6b are validated.

7. Discussion

Organizational learning is a complex phenomenon and this paper gives a first insight into it. In this study, constructs are proposed and statistically validated. In term of results, as hypothesized in the literature, the presence of organizational learning processes strongly influence innovation performance. Incorporating new knowledge and using it in the firm leads to more innovation. The assumptions made in the theoretical literature for the last decade and originally validated by case studies analysis find here an other validation.

Besides these general results, a first insight on the strategic factors influencing organizational learning shows that the strategic orientation of the company has an effect on it. If nothing can be concluded in this study regarding defensiveness strategy, if we could primarily relate learning processes to prudent organization, the results show that riskiness is associated to organizational learning. Furthermore, in term of organizations, the type of sclerosis pointed out by Leonard-Barton [22] for aging companies which do not engage into organizational learning is found for high-tech small firms studied.

Regarding external factors, the threat caused by the environment is not statistically influencing organizational learning and has a moderated (and negative) influence on innovation. For these two factors (age and environment's threat), the low explaining power suggests that other variables, yet to determine, are in play.

7.1 Implications for Managers

This paper is directly useful for managers in the sense that it reinforces the existing literature advocating for the development of organizational processes in high-tech small firms. 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 learning processes, and the entire process has side-effects on innovation performance. As such, years after years, firms must be careful to let organizational learning processes at an operational level remain high. Furthermore, a riskiness strategy shall reinforce these processes.

Finally, for firms operating in a threatening environment, nothing can be derived yet from the statistical results.

7.2 Limitations and Further Research

This 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 carefully interpret the causal models. 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. Only a small portion of the possible internal and external variables were tested in this paper and 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. 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.

8. 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 this database and also replicating the same constructs in other contexts. 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.

9. References

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APPENDIX Constructs Measurements

Organizational Learning Company's ability to:	Mean	S.D.
Comprehend innovations developed by other companies	5.53	1.26
Adopt innovations developed by other companies	4.88	1.20
Combine innovations created by other companies with those developed within our company	5.12	1.16
Implement technologies developed by other companies	4.77	1.26
Use technologies (ideas) that were developed internally to create new products, goods or services	5.63	1.16

All items are rated on a 7-point Likert-scale (1= Totally disagree ; 7= Totally agree).

Innovation Performance	Mean	S.D.
Product Innovation	5.34	1.37
Adoption of new product technologies	5.25	1.15
Adoption of new process technologies	4.93	1.35
Transforming R&D results into products	5.11	1.37

Evaluation of the company's performance over the past three years compared to the major competitors (1= Much worse; 7= Much better)

Financial Performance	Mean	S.D.
Sales growth	4.85	1.51
Benefits	4.77	1.18
Return on Sales	4.72	1.23
Return on investment	4.73	1.44

Evaluation of the company's performance over the past three years compared to the major competitors (1= Much worse; 7= Much better)