Complementarities between organizational changes, RD activity and technological cooperation for the French manufacturing firms

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Abstract

This article analyzes the determinants of the French companies' innovation activity while highlighting the importance and the complementarities of the organizational and technological practices'impact. Our results suggest on one hand, that the product or process innovation is determined by the internal and external attributes of the company (size, demand pull and technological class). On the other hand, the complementarities tests between the technological (R&D activity and technological partnership) and organizational practices showed that these strategies are interconnected and that they have complementary effects which call for their simultaneous adoption. Accordingly, to be able to benefit completely from the positive effect of the partnership and the R&D efforts on innovation, they must be accompanied by certain organizational practices related to a good skills management and the implementation of an organizational architecture facilitating the knowledge creation and sharing.

Key words: innovation, complementarities, technological and organizational competencies.

JEL classification: O32, L23, C25.

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1 Introduction

The famous sentence of Solow "We see computers everywhere but in the productivity statistics" engendered numerous research works related to the effect which exercises the technological progress on productivity and the companies' performance generally. Some of them emphasized the necessity that the technological innovations, to be effective, are accompanied with organizational changes (Brynjfolsson and Hitt, 2000; Bresnahan, Brynjolfsson and Hitt, 2002; Greenan and Mairesse, 2004; Galia and Legros, 2005; Mohnen and Roller, 2005).

These works highlighted the necessity of considering complementarity between the technological skills and the organizational architecture when studying the innovation activity besides the classical company's characteristics (size, export level, R&D investment, use of advanced technologies) or its environmental characteristics (intensity of the competition, regional context) (Lundvall, 1997; Baldwin and al, 2000; Crepon, Duguet and Mairesse, 2000).

However, very few empirical studies were realized to determine the adoption of the new organizational structures effect on the intensification of the companies'innovation capacity. Our paper joins in this field of research by investigating more exactly about the determinants of the innovation activity while highlighting the importance and the complementarity of the organizational and technological skills impacts in the knowledge creation and the stimulation of product and processes innovation.

For that purpose, we present first of all a literature review concerning the sources of creation and broadcasting of the innovation skills. Secondly, we study the relations of interdependence and complementarities between organizational changes and knowledge management on one hand and R&D activity and technological cooperation on the other hand.

2 Literature review

Although the innovation literature is very plentiful, the study of the factors determining the process of innovation skills' creation and distribution still an opened question. In this section, we present the existing works studying the impact of company's internal and external characteristics, the effects of new organizational practices and knowledge management systems, and the consequences of technological cooperation and R&D on the development of the innovation competencies.

2.1 Effects of the company's internal and external characteristics

Many works confirmed the Schumpeter's hypothesis stipulating that big companies or industries where the competition is less lively are more convenient to the innovation

(Baldwin and al., 2000; Crepon, Duguet and Mairesse, 1998, 2000). According to these studies, the company's characteristics such as its size, group membership or business sector determine its innovation intensity. Besides these determinants, there are others related to the company's environment. Crepon, Duguet and Mairesse (1998, 2000) made the distinction between the demand pull and the technology push to classify the firm's external characteristics influencing simultaneously the innovation. According to the first conception, the consumers' needs are at the origin of the new product and process development.

Then, the customer services and the early anticipation of the market growth would stimulate innovation. According to the second, the appropriate dynamics of technology would incite to develop new products. So, the commitment in an innovation activity can be determined by the demand conditions and the the technology's characteristics appropriate for the company's industry. Besides these internal and external characteristics, other factors favor the launch of the company in an innovation activity.

2.2 The inter-firms technological cooperation

Several authors showed that the motivation factor the most quoted by firms during the commitment in a cooperation relation is the acquisition or creation of new resources (Hamel, 1991; Quelin, 1996). Other works specified that the companies' engagement in a cooperation relation is related to three attributes: the combination and the complementarity of the tacit competencies (Segretin, 2003), their acquisition and exchange without an irreversible commitment (Karray, 2003; Segretin, 2003) and the value creation by the increase of the firm flexibility in front of its environmental changes (Doz, 1992).

Despite the abundance of the studies made on the inter-firms cooperation, the literature analyzing the interaction between the specific competencies of each partner and the organizational changes operated to create new resources and skills remains very restricted. However, the success of the cooperation relations especially in R&D is conditioned by the identification of the competencies types created in common and the most adapted organizational forms to the development of new skills (Mothe and Quelin, 1997).

So, the inter-firms cooperation is seen as a means to acquire and to absorb the resources or the skills of partner companies. It can involve a pooling of knowledge and complementary information or the development of a learning process (Prahalad and Hamel, 1994). So, these relations allow the stimulation of the company's learning and innovation (Cohen and Levinthal, 2002 ; Karray, 2003) thanks to its "absorption capacity". Thus, the engagement of the company in a cooperation relation increases its competencies to innovate. As a supplement to the cooperation, the launch of the company in an R&D activity is considered in the majority of the empirical studies as a very important source of the technological competencies development.

2.3 Effect of the research and development activities

The R&D activities are presented in the literature as the most traditional determinants of the companies' innovative capacity (for a synthesis, confer Mairesse and al. (1996)). In fact, the R&D investments constitute the main mechanism of the technological skills development (Crepon, Duguet and Mairesse, 1998; 2000). These skills are established thanks to a learning process based on the technical resources and firm's research department effort. So, the skills have not only a cognitive dimension, they also have a technological dimension. Padmore and Gibson (1998) insist on the importance of the technological competencies stemming from the R&D activities (with regard to the organizational skills) in the explanation of the firm's innovative capacity.

Besides, Lamari and al.(2001) showed that companies practicing an R&D activity have more chance than the other companies to innovate in product and in process. So, they conclude that the learning by the intramural R&D has a considerable impact on the innovation. Indeed, the internal effort undertaken by the R&D teams has for objective to deal and to find the suitable reactions to two information types. The first type includes the technological information which the company can acquire from its environment, thanks to the acquisition of new equipments and new technologies of information and communication. In that case, the effort of the R&D teams consists in transforming this information into new knowledge. The distribution of this knowledge within the company develops new technological skills stimulating its innovation capacity.
The second type of information is related to the various problems that the company can meet such as the technical failures of the production methods, the need of a differentiation strategy to confront the competition, etc. The teams' effort consists then in finding remedies for these problems and these solutions can engender product and process innovations.
Therefore, R&D activities and investments act significantly and positively on innovation. Besides these traditional determinants, new studies showed the importance of the new organizational practices and knowledge management systems' roles.

2.4 Effect of the organizational changes and the knowledge management systems

More and more companies are adopting new organizational practices such as supply chain management systems, business re-engineering, order production, quality management systems, training systems, etc. These organizational changes imply firstly new knowledge management systems allowing the improvement of the use or the exchange of information, knowledge or skills within the company, or the collection and dealing with outside information. Secondly, they call a new responsibilities and decision power distribution among the employees favoring teamwork, decentralization, integration or empowerment of company's various services.

In fact, the organizational architecture modernization acts on the company's competencies through the application of a good problem resolution methods and techniques set requiring an active cooperation and interaction between all the internal and external organization's partners. The organizational changes can be applied to all the process or product life cycle phases and extended in all the firm's departments. The adoption of these practices by an organization stimulates the individual creativity by supplying the context to create and exchange knowledge. Since, organizational skills are envisaged as an accumulation of individual skills, the implementation of such a system is then presented as a factor accelerating and improving the knowledge creation in a firm.

As an example, Winter (1995) considers the implementation of a quality system as an organizational innovation which allows to assemble and use a dispersed individual knowledge. So, several authors demonstrated that the engineering and production systems constitute an innovation resource as important as the R&D activities considered a long time as the only innovation determinants (Dosi and Teece, 1998; Coriat and Weinstein, 2002). Thus the innovation management becomes an essential component of the global management system, particularly for technology based firms (Galia and Legros, 2005; Mohnen and Roller, 2005). This concept includes a variety of elements such as the intellectual property management, the training supports, the change management and especially the Knowledge management. Thus, the new organizational practices and the knowledge management systems have an important effect on the innovation capacity.

Therefore, basing on the previous empirical works, we built our research hypotheses concerning the various factors contributing to the creation and development of the skills to innovate in product and in process. Nevertheless, the knowledge requires coordination modalities favoring the capacity of its acquisition and use. So, it is very important to study the interdependencies between the companies' technological and organizational competencies.

2.5 Complementarity between the technological skills and the organizational changes

Many authors defend the idea according to which the innovation is the result of a coupling phenomenon between technique and market operating in an interactive way (Dosi and Teece, 1998). Thus, considered as process, innovation cannot be done by the only Schumpeterian entrepreneur (Mustar and al., 1994). It is more produced by collectives who capitalize many other collectives' work (Callon, 1994).

In addition to its existing technological knowledge capital, the company's innovation capacity is favored by the accumulation process of new skills through the learning phenomenon. Product innovation requires that innovative companies prepare adequate organizational and technological infrastructures. They must also well control the production logistics and expect suitable marketing efforts. The works of Baldwin and al. (2000) and Giessel and Boekholt (2005) have shown that the importance attached by small and medium firms to a wide range of skills ranging from marketing to human resources promotes significantly the innovation intensity. The focus is on creating and saving intellectual property rights such as copyrights, patents, trademarks, design rights and other factors as determinants such as skills, qualifications, innovation management, expertise, and networking.

Consequently, technological competencies, to be efficient, must be accompanied by organizational changes associated with a good knowledge management (Brynjfolsson and Hitt, 2000; Bresnahan, Brynjolfsson and Hitt, 2002; Greenan and Mairesse, 2004). These studies showed the need to take into account the complementarities between technological skills and organizational architecture when studying the innovation activity. This leads us to consider that the positive impact of technological skills on innovation is enhanced if they are accompanied by organizational skills and appropriate knowledge management.

After an analysis of the innovation literature and the different factors contributing to competencies development, we present in following an econometric study done on a French companies' sample in order to test our research hypotheses [1]

3 Empirical study

In order to validate empirically our study of the innovation determinants, we used data from the Community Innovation Survey (CIS) conducted in 2006 on a sample of 5179 French industrial firms with 20 employees or more. We begin by identifying the variables that affect the probability to innovate in product and process, and then analyze the potential complementary relationships between the technological and organizational skills.

3.1 Variables identification

Based on the literature, we used the following company's internal and external attributes as explanatory variables for both innovation types: product innovation (goods and services) and process innovation (production processes, logistics, supply and distribution methods, support activities):

- Dde_pull: Demand pull: In the CIS 2006 questionnaire there is no direct measurement of this variable. To measure it, we have approximated this factor by the sum of items (Cronbach's alpha =0.8457) relative to market information sources (suppliers, customers, competitors, consultants or private laboratories) (Arvantis, 2008; Mairesse and Mohnen, 2010).

- The classification of manufacturing industries into high, medium-high, medium-low and low technology was determined by ranking the industries according to the 2003 OECD edition of science, Industry and technology dashboard. This classification will allow us to approximate the effect of technology push on innovation (Mairesse and Mohnen, 2010).

- Size: Log of the employees' number in 2006.

- Gpe(Group Membership): binary variable indicating whether the firm belongs to a group.

1. In a study of Tunisian companies we obtained similar results although less perspicuous (Hajjem, Ayadi, Garrouste, 2011)

– Barriers to change: the sum of items (Cronbach's alpha = 0.8546): lack of qualified personnel, lack of information on technology, lack of market information, difficulty in finding partners...

– Coop (technological cooperation) binary variable that takes the value 1 if the company has reached at least a technological partnership, 0 otherwise.

– RDI_Activity (internal R& D activity): binary variable indicating whether the company has adopted an intramural R& D in the last three years.

– Org_chg (Organizational Change): binary variable that takes the value 1 if the firm adopts new practices in the production mode (management system, supply chain, business re-engineering, lean production, quality management system, training system, etc. ..) or knowledge management systems, new or significantly improved (to improve the use and exchange of information , knowledge or skills inside and outside of the company) or a significant change in the work organization (new responsibilities / decision-making power among employees ,teamwork, decentralization, various company's departments integration and automation ,etc. . .).

We will use these variables to determine which influence the product and process innovation probabilities and study the interdependence of technological and organizational competencies.

3.2 The determinants of the innovation probability for French firms

Given the dichotomous nature of our dependent variables, we used probit models to explain the occurrence probability of each innovation type. But before doing the estimation, it is necessary to test the exogeneity of the organizational change variable. In fact, in a conceptual point of view, the adoption of these practices by an organization was presented as a factor accelerating and enhancing individual creativity by providing a context likely to create and share knowledge. However, the company's adoption of this policy may be confused with the process innovation. Thus, to ensure the absence of correlation between this variable and the error term (Greene and Zhang, 2003), we have instrumented it by group membership and change barriers under the assumption that these two factors determine the firm decision to modernize its organizational architecture. In the following table, we present for each innovation type, the estimation result of the two-stage probit models with instrumental variables, the Wald test of exogeneity and the Sargan test of instruments validity (overidentifying):

Table 1: Estimation of the two-stage probit models with instrumental variables

variables	**inn_pdt**		**inn_pcd**	
	Coef	Z	Coef	Z
Dde_pull	0.13	4.21***	0.18	6.44***
Size	0.07	2.23**	0.07	2.45***
high_tech	-0.47	-0.86	0.20	0.40
medhi_tech	0.13	0.47	0.24	0.90
medlow_tech	0.61	2.06**	-0.16	-0.68
low-tech	-0.51	-1.66*	-0.24	-0.95
RD_activities	1.36	12.30***	0.79	7.88***
Coop	0.28	3.46***	0.27	3.74***
Org_chge	1.09	1.35	.19	0.27
Cons	-0.81	-0.74	-1.86	-10.14***
Wald test of exogeneity	1.55		0.52	
Sargan test of overidentifying	1.969		0.101	

significance level: * 10% ** 5% *** 1%.

Our results show that the two Wald statistics are not significant, so we can not reject the hypothesis of org_chge variable's exogeneity in both models. Moreover, our instrumental variables (group membership and barriers to change) are valid since the Sargan test statistics of over-identifying instruments are insignificant. These results assure the absence of this variable's endogeneity problem in both equations. So, we take simple probit models to explain the probability adoption of each innovation type. The results of these estimates are presented in the following table:

Table 2: Estimation of the simple Probit models

variables	inn_pdt		inn_pcd	
	Coef	Z	Coef	Z
Dde_pull	0.17	18.17***	0.16	4.21***
Size	0.10	5.00***	0.05	2.98***
high_tech	-0.38	-0.73	0.15	0.32
medhi_tech	0.11	0.41	0.25	0.96
medlow_tech	0.56	1.95**	-0.13	-0.58
low_tech	-0.51	-1.88*	-0.22	-0.87
RD_activities	1.47	25.94***	0.73	13.38***
Coop	0.35	6.01***	0.24	4.49***
Org_chge	0.11	2.20**	0.71	15.23**
Cons	-2.21	21.13***	-1.97	-20.87***
LR chi2	3799.62***		2837.79***	
Pseudo R^2	0.5371		0.4057	

significance level: * 10% ** 5% *** 1%.

The pseudo R^2 of our two models explaining the product and process innovation probability are medium with respective levels of 0.53 and 0.40. In addition, the models are globally significant at the 1% level. These results show that the models chosen are suitable to the data used in this study. Regressions revealed that both innovation types are not explained in the same way:

3.2.1 Role of the company's internal and external characteristics

Like several previous empirical studies (Crepon, Duguet and Mairesse, 1998, 2000, Ayadi, Rahmouni and Yildizoglu, 2007), our results show that the company's innovative capacity depend on its intrinsic characteristics and the context in which it operates. Indeed, the Schumpeterian hypothesis that large firms are more innovative than small ones is confirmed since the coefficient of the variable size measured by the logarithm of the employees' number in 2006 is significantly positive (1%) in the two innovation type equations. Thus, the larger the company is, the more likely it innovates in products and processes to take advantage of scale economies and to maintain its market share. Hence, the hypothesis of the positive effect of firm size on its ability to innovate is validated.

Regarding the firm's external characteristics, we find that the variable demand pull has positive and highly significant coefficients in both equations. We can therefore confirm the hypothesis that this factor stimulates the product and process innovation. In fact, the environmental changes create permanent changes in market conditions and customer needs. So, to maintain their competitive positions and enter new markets, companies are obliged to extend their product ranges and to improve their production methods. However, our results show that the effect of technological intensity seems very mixed. In fact, we find that membership to high technology industries has no significant effect on both innovation types. Medium-low technology industries are more product innovative. While low-technology industries have a significantly negative impact on the product innovation probability. In summary, this study suggests that technology push affects more product innovation than process innovation but does not allow us to conclude about the sign of this effect.

So we showed that product and process innovations are influenced by the company's internal and external attributes including its size and the demand pull. It remains to analyze the effect of technological and organizational practices.

3.2.2 Role of technology practices and organizational changes

In this section we will examine the effect of research and development, technology cooperation and organizational changes on the product and process innovation probability. We note the importance of the R&D activity effect on innovation. In fact, the coefficient of this variable is significantly (1%) positive in both regressions. It is clear that the effort undertaken by the firm's internal research units is the primary mechanism for the technological skills development (Crepon, Duguet and Mairesse, 1998, 2000). Then, this contributes to the creation of new knowledge allowing the production of new products and / or the adoption of new production methods. The work, experiments, investigations and discussions are activities conducted by the R&D teams and are the main sources of increase in the firm's knowledge stock. However, their sharing and effective communications are conditioned by the interaction and involvement of all the firm's internal and external partners. All these findings lead us to accept our hypothesis about the positive impact of the R&D activity on innovation.

We also note that the coefficient of technological cooperation is significantly positive for both innovation types. This result suggests that the technology partnership have contributed to French companies innovation or significant improvement of their products and their processes through the adoption of their partners' new technological skills. As pointed out by Cohen and Levinthal (1990), Prahalad and Hamel (1994) and Karray (2003), these relationships allow companies sharing knowledge and information or the development of a learning process related to their absorptive capacity. Thus, the company's commitment in a cooperative relationship significantly increases the innovation probability.

If we now examine the adoption of new organizational knowledge management practices' effect, we find that this factor has a coefficient of 0.11, positive and significant at 1% on the product innovation probability and of 0.71 (significant at 1%) on the probability of process innovation. This result is consistent with the literature (Dosi & Teece, 1998; Coriat and Weinstein, 2002; Galia and Legros, 2005, Mohnen and Roller, 2005). Indeed, we recall that this variable was constructed from the following items: adoption of new practices for the production mode (supply chain management system, business re-engineering, lean production, quality management system , training system) or implementation of knowledge management systems new or improved significantly (to improve the use or exchange of information, knowledge or skills inside or outside the company) or a significant change in the work organization (new division of responsibilities / decision-making power among employees, teamwork, decentralization, empowerment and integration of different company's services). All these factors promote change in the firm's production methods and organizational architecture and also the knowledge creation and sharing in favor of product and process innovation. Thus, our hypothesis concerning the positive effect of organizational changes on innovation is supported.

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3.3 Complementarities between organizational and technological practices

The complementarity between two variables or two strategies exists if "doing more of one increases the yields obtained by doing more of another" (Milgrom and Roberts, 1990, 1995, Holmstrom and Milgrom, 1994). The marginal return of an activity is an increasing function of the other activities' level.

3.3.1 Complementarity conditions

In the case of discrete decision variables, the notion of complementarity refers to the notion of super-modularity of an objective function (Topkis, 1978). A function is called super-modular if all pairs of its arguments are complementary.

Definition: Consider two strategies x_1 and x_2 such that $x_i = 1$ if i is the strategy adopted, 0 if not. The function $Y = f(x_1, x_2, , x_n)$ is called super-modular and x_1, x_2 are complementary if and only if:

$$f(x_1+1, x_2+1, ..., x_n) - f(x_1, x_2+1, ..., x_n) \geq f(x_1+1, x_2, ..., x_n) - f(x_1, x_2, ..., x_n) \quad (1)$$

Alternatively, equation (1) can be written as follows:

$$f(x_1+1, x_2+1, ..., x_n) + f(x_1, x_2, ..., x_n) \geq f(x_1+1, x_2, ..., x_n) + f(x_1, x_2+1, ..., x_n) \quad (2)$$

With strict inequality for at least one of the values $x_1, x_2, ..., x_n$.

It suffices to verify the complementarity for all possible strategies combinations independently of other variables or strategies. Here we want to explore the complementarity of the organizational changes effect with the R&D activity and technological cooperation effects on innovation. All these variables are dichotomous; the set of all possible combinations of the three strategies (organizational changes, technological cooperation, and R&D activity) is given by:

$$E = \{000, 100, 010, 001, 110, 101, 011, 111\}$$

If we use the super-modularity definition and to test the complementarity of each variables pair, the number of constraints to check is: $2^{(k-2)} \sum_{i=1}^{k-1} i$, k is the number of strategies. Since we have three strategies, we have to test six constraints. Similarly, our dependent variables are dichotomous; therefore the functions to be analyzed are the conditional probabilities of product or process innovation (Choi et al, 2008). The super-modularity condition in (2) can be written then as follows:

$$\begin{aligned} &P(y = 1 \setminus x_1 + 1, x_2 + 1, ..., x_n) + P(y = 1 \setminus x_1, x_2, ..., x_n) \geq \\ &\quad P(y = 1 \setminus x_1 + 1, x_2, ..., x_n) + P(y = 1 \setminus x_1, x_2 + 1, ..., x_n) \end{aligned} \quad (3)$$

This condition states that the probability of product or process innovation due to the simultaneous adoption of both strategies is greater than the sum of the probabilities obtained when each of the two practices is adopted separately. We define a complementarity index (Choi et al, 2008) (CI) to determine the level of the combined effect of each strategy pair on the innovation probability compared to the effect of each of them taken separately.

$$CI = \frac{P(y = 1 \setminus x_1 + 1, x_2 + 1, ..., x_n) + P(y = 1 \setminus x_1, x_2, ..., x_n)}{P(y = 1 \setminus x_1 + 1, x_2, ..., x_n) + P(y = 1 \setminus x_1, x_2 + 1, ..., x_n)} \tag{4}$$

With:$P(y = 1 \setminus x_1 + 1, x_2, ..., x_n) + P(y = 1 \setminus x_1, x_2 + 1, ..., x_n) \neq 0$.

The complementarity test consists in comparing the CI to 1. The complementarity between two strategies x_1 and x_2 requires firstly that $P(Y = 1 \setminus x_1 + 1, x_2 + 1, ..., x_n)$ is greater than $P(Y = 1 \setminus x_1, x_2 + 1, ..., x_n)$

3.3.2 Complementary tests and results

We will first compare the marginal effect of each of the strategies implemented separately with the marginal effect of their simultaneous adoption with other strategies. For this, we calculate firstly, the predicted probability of each innovation type ($P(Y = 1 \setminus X = \overline{X})$ for a median firm (Fontana and Nesta, 2009). This probability is obtained by using the median values for continuous variables (demand pull and size) and the mean values for dichotomous variables (technology class, R&D activity, technology cooperation and organizational change). Secondly, we calculate the change in the predicted probability of both innovation types due to a change in the value of technological and organizational significant variables (RD_activity (x_1), tech_coop (x_2) and org_chg (x_3) from 0 to 1, all other variables held at their median or average value. Thirdly, we calculate the complementarity indexes as defined in (4). For example the CI between x_1 and x_2 is given by:

$$CI = \frac{P(y = 1 \setminus x_1 = 1, x_2 = 1, x_3, \overline{z}) + P(y = 1 \setminus x_1 = 0, x_2 = 0, x_3, \overline{z})}{P(y = 1 \setminus x_1 = 1, x_2 = 0, x_3, \overline{z}) + P(y = 1 \setminus x_1 = 0, x_2 = 0, x_3, \overline{z})}$$

With $x_3 = \{1, 2\}$ and $\overline{z}$ the vector of explanatory variables held at their mean or median values, other than $x_1, x_2 and x_3$ .Thus, for each pair of variable, we will have two CI: an index for each value of the third practice (for the couple $x_1 \setminus x_2$, we will have IC_1 for $x_3 = 0$ and IC_2 for $x_3 = 1$). The results are presented in the following table:

Table 3: Complementarity tests between R & D activity,technological partnership and organizational changes

pred pro $P(y=1 \setminus x)$		**product inn**	**process inn**
Median Firm		0.296	0.284
$(x_1=0, x_2=0, x_3=0, \overline{z})$		0.082	0.084
Absolute Change		-0.214	-0.200
$(x_1=1, x_2=0, x_3=0, \overline{z})$		0.536	0.261
Absolute Change		0.454	0.177
$(x_1=0, x_2=1, , x_3=0, \overline{z})$		0.149	0.127
Absolute Change		0.067	0.043
$(x_1=0, x_2=0, x_3=1, \overline{z})$		0.101	0.253
Absolute Change		0.019	0.169
$(x_1=1, x_2=1, x_3=0, \overline{z})$		0.670	0.345
Absolute Change		0.588	0.261
$(x_1=1, x_2=0, x_3=1, \overline{z})$		0.582	0.529
Absolute Change		0.500	0.445
$(x_1=0, x_2=1, x_3=1, \overline{z})$		0.1786	0.336
Absolute Change		0.096	0.252
$(x_1=1, x_2=1, x_3=1, \overline{z})$		0.712	0.624
Absolute Change		0.630	0.540
	CI 1	1.098	1.103
R&D\Coop	CI 2	1.069	1.691
	Result	Complementarity	Complementarity
	CI 3	1.181	1.193
R&D\Org_chg	CI 4	1.014	1.103
	Result	Complementarity	Complementarity
	CI 5	1.038	1.103
Coop\Org_chg	CI 6	0.996	1.011
	Result	Complementarity	Complementarity

From the marginal effects table, the probability that a median firm innovates in product is 29% and in process is 28%. These probabilities decrease, respectively, by 72.33% (0.21 points) and 70.42% (0.20 points) if the company does not adopt any of the three strategies (R&D activities, partnership and organizational change). This is a very significant reduction in the innovation probability which suggests the importance of these strategies effects on innovation. A company that does not adopt any of these three strategies has a little chance to innovate in product or process.

Compared to this reference, if this same company decides to launch a R&D activity, its probability to innovate in product increases of 0.45 and in process of 0.17 point. The technology cooperation adoption only increases the probability to innovate in product of 0.06 point and in process of 0.04 point. Similarly, the marginal return on the innovation probability of an organizational change compared to the baseline state is of 0.01 point for product innovation and of 0.17 for process innovation. All these changes tend to prove the positive effect of these three strategies on the innovative capacity of French companies.

Now we analyze the results of the simultaneous adoption of these strategies each pair. We note that a simultaneous adoption of R&D and partnership raises the probability of technological innovation in product and process, respectively, by 0.58 and 0.28 point. This result suggests that the marginal return of a coupling between these two strategies is more important than the adoption of each practice separately. In addition, complementarity indexes between these two strategies (CI_1 and CI_2) are greater than 1. We can deduce that these two strategies have complementary effects on product and process innovation since the adoption of one increases the marginal return of the other adoption. Thus, the exploitation of new technological capabilities from partnership relations requires an internal effort of assimilation and absorption undertaken by the R & D teams. This activity is necessary to internalize the knowledge flow and use it for product innovation or significantly improving production methods. This is consistent with findings of Cohen and Levinthal (1990) or Karray (2003).

If the reference firm starts simultaneously a R&D activity and a modernization of organizational practices, the innovation probability increases by 0.5 point for product and 0.44 point for process. This means that innovation is more favored by the simultaneous adoption of both strategies then by adopting each strategy separately. This result stands for complementary or positive interaction between the R&D effort and organizational change for both innovation types. It is clear that the integration of new organizational policies in the company's strategic decisions opens the door to new ideas and opportunities to improve working methods and production. This information flow when it is integrated in the discussions, seminars and experiences of the R&D teams generates likely product and process innovations. Conversely, the R&D effort facilitates corporate consistency with the requirements of the new organizational architecture by reducing the gap between results and objectives. This result is confirmed by the values of CI_3 and CI_4 greater than 1.

Similarly, we see an increase in the product innovation probability following the company's commitment in a technological partnership of 0.09 point and 0.25 point for process innovation probability as a result of coupling between this policy and an organizational innovation strategy. Thus, the partnership will further promote the innovation probability if it is accompanied by a production flexibility, through the involvement of internal and external partners in the firm's objectives and organizational flexibility facilitating the change adaptation. Correspondingly, the new organizational practices adoption stimulates more innovation if it is accompanied by a technology cooperation which enables the acquisition of new skills and increasing the company's absorptive capacity. The complementarity indexes between these two practices (CI_5 and CI_6) are greater than 1. Therefore, it appears that there is a complementary relationship between the technological cooperation effect and the organizational innovations of knowledge management effect on product and process innovations.

4 Conclusions

The objective of this research was primarily to determine the factors that promote the innovation probability for French companies. After constructing our variables and making the necessary endogeneity tests, our results from the probit regressions suggest that the product or process innovation probability is determined by the company's intrinsic characteristics and those of its environment including its size and the demand pull (Crepon, Duguet and Mairesse, 1998, 2000, Ayadi, Yildizoglu and Rahmouni, 2007).

Similarly, the R&D activity acts positively and significantly on the two innovation types. In fact, the effort undertaken by the firm's internal research units is the primary mechanism for the development of technological skills (Crepon, Duguet and Mairesse, 1998, 2000). This strategy helps to the new knowledge creation, to the production of new products and / or the adoption of new production methods.

Our results also suggest that the technology partnership have encouraged French companies to innovation or significant improvement of their production through the internalization their partners' new technological skills (Cohen and Levinthal, 1990, Prahalad and Hamel, 1994; Karray, 2003).

In addition, the adoption of new organizational strategies for knowledge management contributes significantly to the development of innovation competencies. Indeed, this strategy promotes the firm's production methods and organizational architecture changes and the knowledge creation and sharing stimulating innovation particularly in process.

Secondly, to determine the possible interdependence and complementarity relationship between technological (R&D activity and technological partnership) and organizational (knowledge management) practices, we tested the complementarity conditions for each pair of strategies such as defined by Topkis (1978) and Milgrom & Roberts (1990, 1995). This study of the three strategies' marginal returns on the innovation probability has enabled us to show that they are interrelated and have complementary effects that require their simultaneous rather than separate adoption.

Thus, in order to benefit fully from the positive effect of the partnership and the R&D efforts on innovation, they must be accompanied by certain organizational practices related to a good skills management and the development of an organizational architecture promoting the knowledge creation and sharing and that is flexible to change. However, we must emphasize the not taking into account the time component necessary for the proper understanding of the accumulation process of innovation competencies. This opens the way for other further researches.

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