The organizational practices of innovation and the performances of firms : an empirical investigation

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Abstract:

On a weighted sample of more than 1500 firms from the French manufacturing industries, we explore the relation between individual organizational practices dedicated to innovation and the output of the process. 16 different organizational practices are identified dealing with the constraints or objective applied to employees. The belonging to a national and foreign group is also considered. Controlling for numerous variables usually included in econometric regressions at the individual level, the estimations are conducted on four different variables measuring performances: radical innovation, patent deposit, encountered failure, global innovation (process, product, commercial and design). The main finding is that the organization of innovation, for a firm within a sector, with a given innovative effort and public support, has often a significant impact on the productivity of innovation. The results give consistency to previous investigations trying to identify the organization "best practices" for innovation. However, this investigation underline the bias of the previous results that do not investigate the possible complementarities among the individual organizational practices. Clusters of organizational practices explain the main part of the model whereas a marginal change in the practices seems to have a small effect on the level of the innovation output.

Keywords: innovation, technology, organization, integration, incentives, learning, Probit, generalized Tobit

JEL classification: L2, O3

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1 Introduction

Many theoretical works emphasize the impact of new internal organizational practices on performances of firms. From a theoretical point of view many works try to explain the complexity of incentive schemes or more broadly to explain the internal structure of organization. Several contributions on multitasking deals with the endogenous capacities of firms to implement sophisticated contracts with complex provisions (Milgrom & Roberts, 1994). This literature give several interesting empirical studies that confirm the place of incentives in the performances of firms (See Prendergast, 1999). An even more recent stream of the literature tries to investigate through empirical models the place of organizational practices and their complementarities. Focused on human management practices, on new information technologies, the studies give tangible evidences that relations or even complementarities among the individual organizational practices exists[1].

However, the literature does not handle the specific and narrower problem of innovation and focuses on technology. In this way the literature fail to explain the dynamic relationship between the internal organizational practices and the build specific assets or inimitable competencies that are at the core of competitive advantage. Indeed, the investigations deal with firms that are not especially innovative: the use of new information technologies can be linked to organizational change and some better productivity, often at the shop floor level, managed without endogenous technological change or endogenous innovation.

On this issue of the organization of innovation, few predictive theoretical results are available. Even many theoretical and empirical results are available on the place of external organization (cooperation, networking…), little is said on the internal side of the organization of innovation. Surprisingly, the evolutionary economics says nothing on the subject and the main results belongs to the agent theory (See, Hölmstrom, 1989; Aghion & Tirole, 1995; Cockburn *et al.*, 1999). The core idea is that incentives limiting shirking are important to achieve better efforts and raise the innovation productivity. The literature suggests also that innovation needs specific and complex provisions on innovative output (Hölmstrom,1989). These inquiries give interesting insights into the innovative firms but fail to explain the global internal organizational strategies of firms including dimensions as training or knowledge integration.

This paper is an empirical investigation trying to find new empirical evidences of the place of individual organizational practices (IOP thereafter) on innovation productivity. The availability of a new large data set dedicated to innovation competencies matching innovation performances data from the second community innovation survey (CIS2) allows us to measure the contribution of individual organizational practices dedicated to innovation to the performance of innovative firms. Based on a weighted sample of more than 1500 firms from a multi-industry questionnaire, representing the 10 750 innovative firms of the manufacturing industries (minus the energy industry) such an empirical investigation is also a means to corroborate previous results. Thus, the methodological framework for the empirical study is standard: the specification of the innovation equation is similar to the literature based on a production or innovation function linking organizational practices and performances at the firm level.

The paper proceeds as follows: section 2 reviews the previous empirical results whereas the data and variables are presented in section 3. Section 4 presents the econometric modeling and results. The results are discussed in Section 5. A final section concludes.

2 Previous empirical results

At the empirical level, several evidences have been accumulated for a long time. The economics of innovation have indeed steadily focused on the internal organization at the empirical level. Even if the works are heterogeneous in their purpose, theoretical background, method and samples, we suggest that the literature on individual organizational practices toward innovation can be classified into five overlapping categories: specialization, communication, integration, monitoring and leadership.

A first set of studies deals with the *specialization, the pervasiveness and the allocation of R&D* within firms and groups. The degree of specialization in the production of scientific and technological knowledge varies with the size and the activities of firms (Kleinknecht et al., 1991; Santarelli & Sterlacchini, 1990). Intra-group or intra-firm R&D externalities exist (Klette, 1996; Adams & Jaffe, 1996) and maybe can be endogenously managed through organizational practices. Several empirical studies underline also the organizational strategies within multinational firms (Pearce & Singh, 1992; Florida, 1997; Gassmann & Von Zedtwitz, 1999).

A second set of works considers a firm as an *information network*. On a large empirical survey, Kusunoki et al. (1998) find that the communication (between groups and inter-functional groups) has one of the most significant, regular, and positive effect on innovativeness. Several previous works underlined the crucial role of informal communication networks (Allen, 1977; and also Clark & Fujimoto, 1991). More interesting, Hansen (1999) make a distinction on the links between the 41 divisions among a single multinational electronics company where weak ties are assumed to have a positive effect on completion time of 120 product innovation projects. In this setting, tie weakness has a positive effect when the transferred knowledge is codified, whereas the effect becomes negative when complex knowledge is involved.

A third step deals with the *integration process* with empirical mitigated results. A better cross-functional coordination and a better planning and coordination of the R&D process seem to induce innovative success in the electronic industry (Maidique et Zirger, 1985; Freeman, 1982). More

[1] For different empirical considerations, see Athey & Stern (1998), Becker & Huselid (1998), Greenan & Mairesse, (1999),

precisely, the significant impact of the belonging of researcher(s) to the board of directors of firms is expected[2] (Rothwell, 1974). However in the later studies, the job rotation or other horizontal schemes are found to be a good means to integrate communication as well as learning between specialized functions (Clark and Fujimoto, 1991; Wheelwright & Clark, 1992; Brown & Einsenhardt, 1995, Iansiti & Clark, 1994; Eisenhardt & Tabrizi, 1995). The robustness of the findings is mitigated by several results: in the Japanese sectors of electronics and biotechnology, Kenney & Florida (1994) find a mixed impact of team work and emphasize the role of job rotation. At the same time, Henderson & Cockburn (1994), converging with Pisano (1994) or Mansfield & Wagner (1975), find a positive but non-significant effect of integration on performances in the pharmaceutical industry at the international level. At last, the integration practices are not systematically significant when the output measurement changes (Kusunoki et al., 1998).

As for integration rules, differences can be found between *incentives* in American and Japanese innovative firms (Quinn & Rivoli, 1991). Incentives are however a fourth organizational dimension that is to be distinguished from the question of integration of innovation. Statistical studies lead here to scattered results. Henderson & Cockburn (1994) or Cockburn et al. (1999) deal also with the monitoring of innovation activities through the existence of an significant incentive to publish academic papers or to focus on patent filing. Dedicated rewards for schedule seem however to have a poor impact on development time in the computer industry (Einsenhardt & Tabrizi, 1995). The characteristics of the influent incentives scheme vary with the size of firms (Hönig & Martin, 1993) whereas Zenger (1994) discuses and find econometric evidence that SMEs have a better efficiency of incentives than large firms.

Last, not far from these investigations, a last dimension mixes *hierarchy,* leadership and key human factors in the innovative organization. The sophisticated Sappho project clarifies the impact of managerial factors as power and responsibility of the firm's innovator whereas Allen (1977) insists on the role of internal 'gatekeepers' to assimilate external knowledge and lead projects. Iansiti (1995) shows the impact on performances (productivity and project duration) of experts that are leaders in projects. At the same time, Heisenhardt & Tabrizi (1995) indicate that the power of the project leader (a dummy) is positively but barely significant when the sample is restricted to the personal computer and peripheral products. The investigations join several works on the place of star scientists in biotechnology (see Darby et al., 1999). In Cockburn et al. (1998) a dictator who controls the allocation of resources is introduced. Following the literature on the Japanese firm, the projects with dictators are assumed to be less productive by limiting the ability to exchange information across the firm. The explanatory variable is indeed found significantly and negatively correlated with the propensity to file patents or important patents.

Ichniowski et al. (1997), McDuffie (1995).

2 even if it does not find a significant impact of the share of researchers in the board of directors

The previous results can be summarized in three points. First, internal organizational practices have some influence on the ability of firm to achieve innovation.

Second, the internal organization of innovation has several dimensions that should be taken into account at the same time: the impact of one IOP on performance has to be estimated, all other IOP holding constant. Here, we know few works considering several individual organizational practices (in Heisenhardt & Tabrizi, 1995; Kusunoki et al., 1998) or different aspects of a same type of mechanism (in Iansiti & Clark, 1994;Cockburn & al., 1999). The scarcity of sample data is one major cause of the few number.

Third, these results can be considered from a methodological point of view. The results seem to be unstable between industries or vary with the output measurement. Many other difficulties can be underlined: a cross section analysis do not really deals with organizational change and fails to capture the evolution of organization of innovation within a firm. This argument is common to most of the empirical studies on organizational change at the firm level even if few papers use such longitudinal data (e.g. Caroli & Van Reenen, 1999) or capture the evolutions with a questionnaire distinguishing two organizational states for two different period (Greenan & Mairesse, 1999). Needless to say that measurement errors occurs when qualitative evolutions are not certified by a interview (as in Ichniowsky, 1997) leading to a large confusing variance (Huselid & Becker, 1996).

3 Sample and variables

3.1 Data sources

This paper matches two different datasets combining information on organization of the innovation process and its outcome, at the firm level.

3.1.1 The competency survey

The main dataset we use in this paper is the competency survey available from the statistical service from the French Ministry of Industry. Launched in 1997, this non-mandatory survey sampled 5,000 firms over 19 persons of the entire manufacturing industries. The questionnaire was developed in a multidisciplinary way to grasp the competencies to innovate (See Foray and Mairesse, 1999). The enterprise answered to the detention of 9 large class of competencies that give 73 answers embedded in several heterogeneous organizational practices. Even unusual and lengthy, covering three years (1994-1996), the response rate was 83%. This high response rate lead the SESSI to not investigate the non-respondent considering that (as demonstrated in the CIS1 survey) the possible biases seems to be small.

The analysis of competencies can be made at the aggregated level, identifying strengths and weaknesses of firms and sectors (See François & Favre, 1998). Now, a competency is often relying on different organizational practices as well as an organizational practice can be devoted to different competencies. Focusing on the internal organizational practices that manage such capabilities of firms, four questions are especially investigated here out of nine categories of capabilities in the French questionnaire.

The first one deals with the capacity for firms to insert innovation into a global strategy (Set C1). A second strand of question gathers the following, the forecasting and the actions on firm's markets (Set C2). Following the literature on cooperation as well on the absorptive capacity, a third set of question deals with the capabilities to absorb external knowledge (questions C5). A set on the financing of innovation as well as on the sale of innovation are also included at the end of the questionnaire (respectively questions pooled in C8 and C9).

Four remaining categories are of particular interest since they includes items on the organizational practices dedicated to the production of knowledge within the firm : Thus a first pool of question deals with the development of innovation (Question C3) A second related pool of items deals with the production of knowledge whereas a third set (called C7) is more oriented toward the human management practices. Even if the questions on appropriation (set C6) deals with the management of the environment of firms, several items can be sustained to characterize the internal routines applied to the different competencies maintained by workers.

Thus among the different competencies declared by a firm, the questionnaire is able to give information on several more precise practices that are implemented for innovation (See Table 1). However, a distinction can be made between "macro-organizational" practices made at the level of the entire firm and practices that are implemented at a more micro-organizational level: the last practices are not systematic, more often applied at the individual level or on groups or teams (e.g. item C6L10), and more closely related to the effort of individuals implicated in the innovation process. The organization of innovation is thus a set of practices implemented at the different level of a firm.

A problem is that the respondent is supposed to have a sharp view of the different used organizational practices. An employer can have a partial view of the specific rules implemented at a decentralized level of the firm as well as a employee can ignore the organizational practices implemented elsewhere or some routines ruling its unit.

A major problem issued here is the difficulties to measure competencies. The French survey is pioneer and encountered several difficulties. For example, several questions give few informations because they implied a positive answer. Several questions are loose measurement of practices because the rules behind the question are common practices or are considered as if. A second possible error is to ask interesting question where the answer is institutionally bounded. The assessment of individual needs for training is quite obvious since a significant part of turnover is legally dedicated to worker's training. A third issues concern an identification problem since the answer to the question is no more related to the restricted problem of innovation. For example, "Do you assess the ability to team work?" is an interesting but noisy question since team work is required within the different activities of a firm. Even if the whole questionnaire tries to select the practice toward innovation, some answers are wider than the narrower problem. To overcome these difficulties, we proceed to the deletion of the cited question in the paper. Even if other questions can also be concerned at a lower level (C4L7, C7L7), we keep them in the following analysis.

Table 1 : Questionnaire on competencies (and frequencies on weighted sample)

VARIABLES		Yes
Competencies N°3	***Innovation Development Practices***	
C3L5	Do you encourage mobility between departments toward innovation?	56,49
Competencies N°4	***Knowledge production practices***	
C4L3	During individual assessment, do you reward originality and the own creativity?	58,15
C4L4	Do you agree to workers doing creative but non-directly productive activities?	64,84
C4L5	Do you reward original ideas when they are accepted?	51,49
C4L6	Do you justify refusals	61,66
C4L7	Do you share the common pool of knowledge?	70,23
C4L9	Do you assess the individual participation to the knowledge production?	24,3
Competencies N°6	***IPR management practices***	
C6L9	Do you make people aware that their knowledge is strategic and confidential	59,34
C6L10	Do you monitor the communication on strategic knowledge	40,69
C6L11	Do you motivate specifically people with strategic knowledge (wage, career)?	46,47
Competencies N°7	***Human Management Practices***	
C7L2	Do you assess the ability to innovate when personal is hiring	51,74
C7L4	Do you make transparent the assessment and the reward of the bests?	35,39
C7L5	Do you make transparent the mobility rules?	40,51
C7L7	Do you induce workers to demand or to choose an appropriate training?	64,06
C7L9	Do you evaluate the return of training on innovation?	30,89
C7L10	Do you reward training that is useful to the firm?	31,92

3.1.2 The innovation survey (CIS2)

The community innovation survey for France (CIS2), launched in 1997, is our second important source on technological innovation. This survey is non-mandatory and has an 85% response rate. It gives a reliable image of the behavior of the whole firm over 19 workers from the manufacturing industries. As in the previous survey, the covered period is 1994-1996, coping with more traditional questions, this survey is a complementary source of information on the output, or resources dedicated to innovation. The information on R&D, on turnover made on innovative products, the propensity to patent innovation are included in the survey as well as information on the nature of the innovative process and output.

The matching of the two different samples gives us a sample of more than 1 500 innovative firms where organizational practices are observable. Even if the size of the sample is much larger than in previous studies, the final sub-sample is biased toward large firms. Deleting several R&D firms, a final working sample of 1 541 manufacturing firms is constructed. Once weighted[3], the used sample stands for the 10 750 French innovative firms in the manufacturing industries out from 22 000 firms. This restricted sample allows us to match on one side the organizational practices used to improve the productivity of innovation and the other side, which is the result of the innovation process.

4 Individual organization practices and performances

4.1 Econometric model and variables

The different organizational practices are considered as a direct tool to get a higher output of the innovative process. Based on the works cited above, the level of innovation performance IOutput is defined as follows:

$IOutput_i = f(IOP_i, GROUP_i, CV_i)$ *(eq 1)*

The innovation function f explains the level of the innovative output IOutput by three sets of independent variables. A first set CV are the standard Control Variables than can be found in the traditional empirical studies on innovation performance (Crépon et al., 1999). GROUP is a set of exogenous organizational variables that influence the other independent variables as well as the output level. The set of variable can be considered as an organizational variable even if they cannot be easily endogenously manipulated. At last, IOP gathers all the Individual Organizational Practices introduced to manage the human resources devoted to innovation. The independent variables are defined as well as the dependent variables with the induced econometric problems.

4.1.1 The independent variables

The belonging to a group is supposed to have a positive influence on the ability of a firm to invest in R&D, whatever the nationality of the group. The effect of GROUP is thus separated into the belonging to a foreign group (FORGROUP) seems to be more mitigated than the membership of a native group (FRGROUP). As presented before, in some cases the affiliated company will produce knowledge as well and as far as native firms whereas some group in other industries may be a simpler matter of transfer. The expected difference between the estimated coefficient of FRGROUP and FORGROUP can be positive or negative ($\hat{b}_1 - \hat{b}_2 > 0$ *or* $\hat{b}_1 - \hat{b}_2 < 0$?). The opposition between globalized and localized research activities can be however addressed since in the equation, the foreign groups are maybe assumed to be less intensive in innovative activities than their French counterparts.

Beside the organizational variable sets, the first control variable measures the effort of a firm toward innovation is the investment made. The raised Internal R&D available for 1996, is the better proxy

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3 Weights are computed here at the three digit level of the NACE (the French NAF114) using 7 strata for size (number of employees).

available here[4]. The fact that this variable is a flow and not a stock is not of great importance as suggest several previous works using R&D. Since, we want to control for the size effect introducing LNUMBER (Number of employees in log) and that multicollinearity arise if we introduce R&D expenditures beside, we choose an equivalent control through the introduction of INTENS (in log) define as the ratio of internal R&D by sales[5].

One additional control variables are considered to take into account the environment of firm. Many papers insist on the role of the environment as a determinant of the organizations. The paper deals with the institutional framework that has direct and indirect effects. The innovation survey points out if yes or not the firm received every R&D or innovation subsidies or loans (but the R&D tax credit). This binary variable (PUBLIC) is supposed positively related to innovation productivity. This control variable is also introduced in the second equation since the level of resources supposed to be indirectly influenced by the different public actions toward R&D and innovation.

The public subsidies PUBLIC (as a dummy) are also considered as positive effect on the innovative output. In a naïve way, the projects are supposed risky and several are not undertaken by firm without a public support. But, of course, the public subsidies can foster the probability to innovate or to be a radical innovator and, at the same time be negatively correlated with the level of the innovative success since projects with lower rate of return are therefore sustained.

At last, a fixed effect at the industry level (13 dummies plus the intercept) can be added, even if more sophisticated indicators as the technological opportunities would be more interesting (See Crépon et al., 1999).

The used separation between internal and external organization should lead us to give an equal attention on both sides of the organization and to control for the two dimensions in our regressions. As already mentioned in the introduction, many works are already available on the causes and impacts of cooperation or networking. Few works already include both sides of organization of innovation (See Iansiti, 1995, Iansiti & Clark, 1994; Iansiti, 1997; Cockburn and Henderson, 1998). Here, such a building block is not considered even if one can consider the internal investments, especially in R&D, and related rules, are also a proxy of the capacity of assimilation or integration of the external environment (Cohen & Levinthal, 1989).

4.1.2 The dependent variables

From the CIS2 source, we use three binary variables characterizing the innovation output (IOutput in (eq 2)). The first indicator is the more standard among the literature. PATENT is 1 if the firm declares that at least one patent was filed during the three previous years. About one third of the innovative

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4 The internal R&D costs are raised using a (third) survey on R&D that is launched annually by the Ministry of Higher Education and Research. Even if Innovative Costs are measured in the CIS survey, the use of the variable is delayed to a better understanding of its quality.

5 We replace the value 0 by 1 in the ratio to get the logarithm. We have thus to add one dummy when the raised R&D is null (NORD=1).

firms is in such a case. The value is 0 otherwise. Often, a firm innovates in the four different types of asked innovation (product, process, marketing, and design). Here the variable COMP standing for comprehensive innovation is 1, for 19% of the innovative firms whereas for, the three other quarters, the variable is null otherwise. Last, even innovative firms can innovate later than planned or have several innovation projects that have failed or have been postponed. NOFAIL is 1 when innovative firm (26% only are in this case) does not even meet a failure or a delay during the 1994-1996 period; 0 otherwise.

Each time, the performances are supposed to be a latent variable PATENT*, COMP*, NOFAIL* where the outcome are not observed. The observation is restricted to binary observed only when the latent variable is upper than 0. The univariate probit model for a binary outcome is $y_i^* = \varpi' x_i + e_i$, where y is the different cited left hand side variables[6]

$$\begin{cases} y_i = 1 \text{ if } y_i^* > 0 \\ y_i = 0 \text{ if } y_i^* \leq 0 \end{cases}$$

This probit estimation is no longer interesting when the innovative turnover is available. This amount is measured only when the firm is product inventive as well as radical innovator (first to the market). In this case, a first step is the decision to launch a radical innovation (46% of firms); a second step is the success of this new product measured by the innovative turnover[7]. In this case, a simple tobit model estimate is also biased. Thus a generalized tobit model with two latent variables is used for this last output variable. A first equation is a selection mechanism reflecting the decision where the radical product innovation turnover, y* is positive. A second equation, is a mere classical regression model where the level of the left hand side variable is the radical innovation turnover z* that is not fully observable. Here, the important point is that the value of innovation turnover is only observed when the firm is leading the market or tried to be so (radical innovator with no turnover).

$$\begin{cases} y_i^* = v' x_i + e_i \\ z_i^* = w' v_i + u_i \end{cases}$$

where x_i and v_i are the vectors of the exogenous variables for the first and second equation, ϖ and ω are the associated parameters and e_i and u_i the related residuals. The amount of innovative turnover is observed only when there is a respectively positive level of radical turnover. We have no reason here to distinguish the explanatory variables ϖ and ω that are supposed to be the same in the two equations. This model is estimated by the maximum likelihood[8].

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6 The McKelvey and Zavoina's R² (noted ZM R²) is the most accurate estimate among the different Pseudo R² measures for binary dependent variables (See, Veall & Zimmermann, 1996). The ratio is computed for each probit estimate (Following Veall and Zimmermann (1996, p 248), the LIMDEP routine is modified to fit the right definition of McKelvey and Zavoina).

7 The 46% is not surprising if one consider that 33% of innovative firms file at least one patent that can considered as another proxy of radical innovation. Furthermore, this frequency do not implicate that the demand exists and many radical products can generate no turnover. This is the case for 55% of radical innovators in the (non weighted) sample. The null turnover can also considered as a quick answer of firms with very low innovative turnover. In this case, the second equation can be considered as observable beyond a threshold.

8 The joint normality of the disturbances in the two equation is assumed to be:

The heterogeneity of indicators of performances is common to all applied econometrics dealing with performances[9]. This heterogeneity is however an interesting means to test the robustness of different organizational practices and the regularity of their organizational design, taken as a whole. However, the comparison between estimations remains difficult: beyond the econometric difficulties related to the non-linearity of the model, the organizational practices can be dedicated to a single organizational objective. For instance, the radical innovation can be managed by special rules. The declared rules are maybe not adequate for another objective as PATENT or COMP.

Thus, the final estimated econometric model coming from equation (eq 1) becomes:

$$\mathrm{IO}utput_{\mathrm{i}} = a_0 + \sum_{j=1}^{16} a_j IOP_{ji} + b_1\ FrGroup_i + b_2\ ForGroup_i +$$

$$g_1\ INTENS_i + g_2 NORD_i + l_1 LNUMBER + l_2 PUBLIC + \sum_{k=1}^{13} z_k IND_{ki} + e_i \qquad \textit{(eq 2)}$$

With IOutput= PATENT or RADIC or COMP or NOFAIL

This econometric model do not imply that the different implemented practices are more efficient. One practice can indeed be reported as implemented even if its impact on innovation is negative. For example, this would be the case if adjustment costs do exist and give inertia to an organizational change or, as emphasized by the evolutionist theory, a practice can be locked in and still be implemented even if sub-optimal. At last, as mentioned by agent theory, a provision can be manipulate or turned out and do not lead to better performances or further, can lead to counter-effects if the incentives are base on observable output that is not at the core of the monitored activity (Prendergast, 1999).

A not yet mentioned problem could be the possible endogeneity of explanatory variables. Patents can be used as an observable outcome of individuals for the principal. Thus this left-hand side can be integrated through the different provisions related to the identified incentive schemes. At last, the ability of firms to keep an interaction between organizational rules and performances is time consuming. The different rules implemented by firms are selected through time and abandoned if they do not give satisfaction even if an organization has to implement a coherent set of rules where non-optimal rules can last and This dimension is hard to consider with the available proxies.

Measuring the impact of IOP on innovative performances, two strategies are implemented to test the impact of IOP on performances. The first one introduces the different practices one by one. Thus 16

$$\begin{pmatrix} e_i \\ u_i \end{pmatrix} \xrightarrow{iid} N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} s_1^2 & r s_1 s_2 \\ r s_1 s_2 & s_2^2 \end{pmatrix} \right)$$

where ρ is the correlation between the standard errors of e and u. See Heckman, (1979).

regressions are run for each endogenous variable. The results are close to the different cited paper that examines a single IOP. The idea is thus to test the robustness of the previous results.
A second more comprehensive model with all the organizational practices is then estimated. This allows us to mitigate the results when asymptotic standard errors are high. The joint significance of vectors is tested through the linear combination of the parameters. This joint test allows us to grasp effects of variables that are no more significant when additional variables are included in the estimating equation. This strategy is also close to several surveyed studies that introduce different IOP at the same time.

4.2 Regression results

4.2.1 Control variables

Among control variables, the structure of the capital through the impact of FrGROUP and ForGROUP is another introduced organizational variable that is steadily significantly correlated to the level of radical innovative turnover. Thus, holding all variables as industry or size constant, a group seems to be more likely to have a higher productivity in innovation. This positive effect is significant for ForGroup as well as in the national case (FrGroup). Relatively to independent firms, French or foreign groups are likely to sell, *ceteris paribus*, much more radical innovations[10]. On the other output indicators, the group dimension is however not significant.
Other control variables are properly correlated with the expected signs. The intensity of R&D is broadly positively correlated to the ability to launch a radical product and to sale it (model (1c) and (1c')). The opposite sign of the added dummy (NORD) stress the central place of this activity in the innovation. Holding all variables constants, a firm with a positive R&D is likely to make about 90% higher sale[11]. On patent, the expected positive sign is found whereas the parameter is not significant on COMP and NOFAIL. On COMP, the result is not surprising since the R&D costs do not control for complementary resources involved in an global innovative activity. On NOFAIL, the independent variable is not significant but a negative sign is found. The negative sign can be justified: either R&D intensive firms are involved in a more numerous projects, or R&D intensive firms manage the same number of projects but these are more complex or riskier than those with low R&D intensive firms.

9 See Hansen & Wernerfelt (1989), Nickell (1995), Geroski (1998)

10 Relatively to independent firms, the magnitude of the effects are: 100 $(e^{(0.506-\frac{0.202^2}{2})}-1)$= 62% and 100 $(e^{(0.620-\frac{0.210^2}{2})}-1)$= 82% respectively for FRGroup and FORGroup. The difference between the last two estimated parameters is however not significantly different from 0 (Wald is $\chi^2(1) = 0.37$).

11 $100(e^{(-2.376-\frac{0.386^2}{2})}-1)$ =92%

More standard is the positive result on the size measured here as the number of employees (log). The larger a firm is, the higher is the probability to innovate quickly, comprehensively, radically with a patent registration. The elasticity between the number of employees and the level of sales of radical product innovation is significantly higher than 1 (see (1c')). This result means that, even if, as we have seen above, some constant return to scale are found on R&D investments, large innovative firms have a higher share of their turnover occupied by radical products. The interpretation of this original result is not simple since the sources of this increasing return can be assigned to an organizational effectiveness (endogenous or exogenous) that lead to a larger part of radical projects or a better quality of conducted projects as well as a more external argument where large firms have an easier access to the different (international) market and their opportunities (Barlet, et al., 1998).

The more risqué are projects and the more public support is available. The public variable is thus also negatively correlated with the output proxy NOFAIL and the level of radical turnover. Different interpretations can be given to this negative sign: one can argue that public support is dedicated to firms with a low technological level. In this case, the negative sign is still significant but would be larger with no public support. A second interpretation is to say that public support is provided on risky projects and therefore the radical output is harder (and longer) to sale than another self-financed radical project. This last right hand side variable is however positively correlated with patent registration. This positive effect hide two possible effects: one is that the French R&D and innovation supports are usually elitist. The projects are thus helped when the innovation is likely to be patented. At the same time, the French SME's hardly use the patent system that is promoted by the French public institutions as an essential tool of the innovative firms. The non significant influence on COMP is one of the main difficulty usually addressed to the French national System of public support of innovation: innovation is often considered only at the scientific or technological level, dealing more with R&D than with innovation.

4.2.2 On IOP

The impact of individual practices on innovative performances are different with the output measurement as shows a vertical lecture of column (1b) to (4b) where only one IOP is introduced at the time. The ability to launch a radical product innovation is significantly raised by several implemented organizational practices: the incentives the sharing of knowledge (C4L7=1) or the mobility between departments (C3L5=1), the reward of originality (C4L3=1 and C4L5=1), the latitude left to employees (C4L4=1), and training assessment and incentives (C7L9=1 and C7L10=1) are significant (See Column 1b). At the opposite, the monitoring on technological communication (C6L10=1) or ex post rationality (C4L6) are not influential practices even if they are implemented. At the same time, the level of innovative turnover do not apparently request the same organization rules even if horizontal schemes are still significantly and positively correlated to the level of innovative turnover (Column (1b')). Transparency on mobility rules (C7L5=1) as well as screening of innovative capabilities in hiring process (C7L2=1) are positively and significantly correlated to innovative turnover whereas, individual assessment of knowledge production is no more significant as the rules on training (C7L9 and C7L10). The magnitude of the effects seems also to be large since the smaller induced effect is a rise of innovative turnover of some 26% [12].

Thus their is a capability to produce radical innovative products based on horizontal schemes, originality and training whereas the competency to sale the radical innovation rely on horizontal schemes but also on information system and hiring process.

The results on PATENT are different since originality (C4L3=1) transparency on rewards of the bests (C7L4) as well as the incentives to choose an appropriate training (C7L7) are significantly but negatively correlated to the likelihood to file at least on patent. The negative signs are puzzling. Positive and significant parameter are found for C4L5 and C6L10.

A comprehensive innovation (COMP) request also horizontal schemes (C4L7=1 and C3L5=1) but also the ability to assess individuals' production (C4L9=1) and reward her originality (C4L3=1) and monitor the communication on strategic knowledge (C6L10=1) and the individual ability to innovate when people is hired (C7L2=1).

Last, the ability to reduce failures (NOFAIL) is hardly explained by IOP. Only, the reward of accepted original ideas (C4L5=1) is significantly correlated to NOFAIL.

The large number of IOP makes synthetic interpretations hard to process. A horizontal lecture of columns ((1b) to (4b)) reveals that horizontal schemes (C3L5 and C4L7) and the managing of individuals as producer of original knowledge (C4L3 and C4L5) as producer of collective knowledge (C4L9=1) or as potential innovators (C7L2=1). At the contrary, implemented IOP as the justification of refusals (C4L6=1), information on the appropriability of knowledge (C6L9=1) or even the specific reward of people with strategic knowledge(C6L11=1) do not have any significant impact on innovative output.

A second step is to include all the variables in the same model to identify the effect of each IOP once taken into account the other practices. Test the joined hypotheses that all the IOP effects are non-significantly different from 0. The rise of the likelihood shows a better fit when the IOP are introduced. The comparison of the ZM pseudo R^2 between the raw models ((2a) to (4a)) with the global model ((2c) to (4c)) give clues on the explanatory power of the organizational variables. More precisely, the joined hypothesis is rejected for the decision to launch a radical innovative product (estimation (1c)), patent (see (2c)) and Comp(Cf. (3c))[13]. Thus, the results give support to the idea that

[12] $100(e^{0.235}-1)$ =26.5%. The coefficient has to be cautiously interpreted since available bivariate variables measuring individual organizational practices include errors. In the model, the measurement errors occurs on one variable but also on all the independent variables measuring individual organizational practices. Thus, the reliability of the estimated parameter can be weak and one can consider that an important part of the variance can be explained by the measurement errors (see on this point Huselid & Becker, 1996).

[13] The critical value for χ^2 with 16 degree of freedom is 32.0, 26.30 and 23.54 at the 1%, 5% and 10% respectively level.

the organization of innovation matters. However the nullity is not rejected for le level of radical turnover (see column (1c')) or NOFAIL (see (4c)) leading to a more mitigated result.

The comment on the estimated parameters of IOP is more difficult (models (c)). The multicollinearity between the different practices can be emphasized. This can explain the lack of significant and robust results. The simple correlation matrix between the right hand side variables shows some high correlation between the individual organizational practices toward innovation (**Table 2**).

The correlations between practices explain the different results obtained when regression of (b) type and (c) types are run. First, the individual estimation of individual practices is biased since the complementary practices are omitted in the specification. The second problem is of course that the correct specification including all the 16 individual practices leads to a multicollinearity problem and an identification problem of parameters. Thus even if regression (1b) to (4b) reveal significant parameter, they are biased. The (1c) and (1c'), (2c), (3c) and (4c) are thus supposed to show at least higher estimated standard errors and fewer significant coefficients. This case is verified for the equation (1c) compared to (1b) since from 8 significant individual practices introduced one at time out of 16 possible practices, the number of significant variable fall to only three. In the tobit part of the model, the fall is the same since from four significant individual practices influencing the amount of radical turnover, there is no remaining significant parameters in the (1c') specification. However this evolution do not occur in the (2), (3) and (4) equations where the significant variable tend to remain significant even if the introduced changes in model specification leads to unstable coefficients.

Thus, the interpretation of the different parameter is difficult. It is difficult to separate the effect from one practice from one another. In the case where parameter remain significant (with the same sign), on can however consider it as robust (e.g. C4L4 in (1c) or C4L9 in (3c)).

Table 2 : Correlation Matrix for IOP Variables

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	C3L5	1,00														
2	C4L3	0,24	1,00													
3	C4L4	0,09	0,27	1,00												
4	C4L5	0,19	0,30	0,15	1,00											
5	C4L6	0,15	0,28	0,17	0,26	1,00										
6	C4L7	0,23	0,25	0,17	0,16	0,22	1,00									
7	C4L9	0,18	0,24	0,12	0,16	0,12	0,20	1,00								
8	C6L9	0,21	0,22	0,12	0,12	0,18	0,20	0,13	1,00							
9	C6L10	0,21	0,23	0,13	0,14	0,22	0,22	0,13	0,52	1,00						
10	C6L11	0,19	0,28	0,12	0,26	0,20	0,18	0,20	0,36	0,34	1,00					
11	C7L2	0,19	0,28	0,16	0,18	0,23	0,19	0,13	0,27	0,28	0,27	1,00				
12	C7L4	0,20	0,25	0,10	0,25	0,18	0,17	0,20	0,17	0,20	0,22	0,19	1,00			
13	C7L5	0,29	0,25	0,10	0,20	0,21	0,23	0,19	0,28	0,30	0,21	0,24	0,40	1,00		
14	C7L7	0,24	0,27	0,13	0,17	0,22	0,16	0,10	0,29	0,30	0,20	0,28	0,21	0,31	1,00	
15	C7L9	0,20	0,15	0,05	0,20	0,13	0,16	0,29	0,20	0,17	0,20	0,19	0,20	0,21	0,24	1,00
16	C7L10	0,13	0,18	0,10	0,21	0,06	0,13	0,25	0,12	0,11	0,22	0,11	0,25	0,15	0,14	0,34

The present results are convenient with earlier works: individual organizational practices are often correlated with better performances; when IOP are considered at the same time, they are significantly linked with the innovative performances. However, as in earlier works, the results is mitigate when different output indicators are considered (e.g. Kusunoki et al., 1998 or Heisenhardt & Tabrizi, 1995). The obtained disappointing results cannot lead to negative conclusions on the place of IOP in innovation process. They just show the difficulty of a systematic and one way interpretation of the causal effects. But the present results show that multicollinearity is a major problem that can lead to a lack of robustness. One can go deeper on the topic of multicollinearity that can be analyzed in term of complementarities among organizational practices.

5 Complementarities and performances

Complementarities among individual organizational practices are used in theoretical literature…

5.1 Complementarities among IOP

This problem of collinearity is not however a usual one since it is supported by theoretical considerations. The bivariate correlation are all positive (**Table 2**). This general positive correlation is consistent with the literature on recent theoretical developments of contract theories where complementarities among the individual practices are the means to achieve a coherent incentive system[14]. Along this literature dedicated to work practices, national specific organizational forms are put forward or, at a more restricted level, bundles of individual organizational practices are considered. In this literature, two variants of the last question are addressed. The first considers the identification of the IOP bundles, trying to identify dominant designs. The second tries to measure the performances of the IOP clusters. Here, the theoretical framework is wide (Milgrom and Roberts, 1995 for a survey) and deals with complementarity and supermodularity definitions. Two (discrete) practices IOP_i and IOP_j (1 or 0 in a discrete framework) are considered as complements if the objective function f satisfies :

$$f(IOP_i^1, IOP_j^1,.) - f(IOP_i^0, IOP_j^1,.) \geq f(IOP_i^1, IOP_j^0,.) - f(IOP_i^0, IOP_j^0,.)$$

where f is said to be supermodular if IOP_i and IOP_j are complements for all $i \neq j$.

Doing this, firms build a coherent organizational structure where marginal changes are supposed to give little additional revenue.

At the empirical level several recent studies give evidences about these possible complementarities among organizational practices (See Ichniowski et al., 1997 ; Bresnahan et *al., 1999*). An interesting contribution of Michie & Sheehan (1999) investigates the relation between the HRM practices and innovation. Along Ichniowsky et al. methodology, they find that HRM clusters influence significantly and positively the level of R&D investment or the probability of innovating. Three limits are found in the paper. First, the complementarity is not fully examined since the marginal effect of individual organizational practice is marginal when the cluster dummies are introduced (See Ichniowsky at al., 1997). A second limit is the assumed causality: the independent variables are not dedicated to innovation considered here as a production of knowledge. The new practice at the shop floor level can have an impact on the productive performances without any link with the innovative activity; worse, some new practices at the workplace can be considered as a obstacle to innovation (e.g. kan-ban). A third limit of the paper is the loose measurement of the output of innovative process even if the sample gives information on the organizational practices for non-innovative firms. As far we know, the previously mentioned Cockburn et al.'s paper (1999) that is restricted to production and learning incentive schemes is the only known reference dedicated precisely to the organization of innovation dealing with complementarities. In their paper they find a complementarity between short-term incentives and longer-term research incentive schemes.

The complementarity literature has two methodological outcomes in our paper (See Athey & Stern, 1998): the first one concerns the interpretation of the results (1b) to (4b). Apart from a collinearity problem, each individual parameter is biased in the face of heterogeneity in the adoption of other practices. Therefore the return of IOP cannot be inferred from regression (1b) to (4b). A second consequence is on the means to come over with the problem of identification since unobserved endogenous practices are neglected. In this case, the estimation of production controlling for interaction terms is still not convenient : "the sign of correlation between the unobserved exogenous variables can either lead to a finding that complementarities don't exist when they really do; or it can lead to a finding that they are present when he variable of interest are in fact independent" (Athey & Stern, 1998, p 19). Of course several dimensions already mentioned are concerned here. The first possible source of bias relies on the neglected external organizational practices. A second possible limit is the focus on individual organizational practices omitting the more macro-structural aspects of an organization. Third, the deletion of several questions where the answer is always positively answer shows the possible influence of a core practices at the settlement the other complementary rules even if their individual direct impact would be insignificant. Fourth, the number of organizational practices leads to an increasing number of restrictions to test supermodularity.

The problems seem however lower in our paper where the endogenous variable is not the productivity of the firm but a restricted outcome that match and measure the impact of the restricted set of independent variables. To manage the econometric problem of the number of constraints, we follow a traditional and simpler methodology initiated in Ichniowsky et al. (1997) to estimate the

[14] For a survey of management literature on organizational forms and performances, see for example Mintzberg, (1981); Miller & Friesen, (1984). The last authors show that only few organizational changes can be achieved to skip from one pattern of organization to an other one.

complementarity between the individual practices: identifying organizational clusters in a first step that are introduced in the innovation function in a second step.

5.2 Identifying Organizational Clusters

There are 16 identified individual organizational practices in our paper. Thus, if the organizational design is considered as a vector of discrete practices {0,1}, there is 2^{16}= 65536 distinct possible combinations or systems of organizational practices. All the combinations of individual organizational practices are not of course observed in our sample. The advantage of cluster analysis is that it does not introduce any *a priori* constraints in the analysis whereas the construction of indexes would assume such relation. Even if one can loose a possible easier interpretation of the results, this method seems to be adequate for a first investigation. The most common combinations are taken out of the 2^{16} possibilities. A cluster analysis on the firms is conducted taking into account the their similarity based on the 16 IOP. Three clusters are found (See Table 3). We refer thereafter to the organizational clusters as Cluster of Organizational Practice (COP thereafter). The three COP are presented from the less organized to the more organized cluster.

Table 3: Proportion of firms with individual practices within three clusters of organizational practices (COP) (Weighted sample)

	All	COP 1	COP 2	COP 3
		Ad hoc	Mixed	Organized
Unweighted sample	N=1541	342	733	466
Weighted sample	N=10750	0,30	0,43	0,28
C3L5C1	0,56	0,31	0,56[a]	0,82
C4L3C1	0,60	0,20	0,67	0,93
C4L4C1	0,68	0,44	0,80	0,77
C4L5C1	0,53	0,18	0,59	0,82
C4L6C1	0,64	0,28	0,78	0,79
C4L7C1	0,72	0,49	0,73[a]	0,95
C4L9C1	0,25	0,09	0,08	0,66
C6L9C1	0,61	0,29	0,68	0,85
C6L10C1	0,43	0,16	0,44[a]	0,70
C6L11C1	0,49	0,17	0,51	0,80
C7L2C1	0,54	0,19	0,63	0,78
C7L4C1	0,35	0,11	0,28	0,71
C7L5C1	0,40	0,14	0,35	0,77
C7L7C1	0,65	0,27	0,75	0,91
C7L9C1	0,32	0,07	0,20	0,75
C7L10C1	0,33	0,14	0,22	0,70

[a] Cluster mean does not differ significantly ($p<0.01$) from sample mean

COP1 is the cluster involving no or few rules managing innovation. In this case, firms tend to have no rule settled: no work teams, no reward, no training, no autonomy, no transparency. This type of organization does not involve a lack of innovation capability. In a complex environment and fluctuant markets, a firm can refuse to be locked in on organizational to avoid important switching costs. At the contrary, a lack of organizational rules dedicated to innovation can be found in firms with rare innovations or low innovations competencies. At last, small firms may not need any specific rules to coordinate their innovative activities. Descriptive statistics tell us that the 3200 firms belonging to COP1 are significantly[15] low intensive in R&D, small (20-49 p), independent, and significantly more frequent in the clothing, textiles, wood and paper products, metal products and machinery.

Second, COP3 is the polar case with a high likelihood to implement all the different organizational practices at the same time. In this COP, firms are more numerous in medium size as (100-200 persons or 500-1000 range) whereas there is no significantly more large firm (more than 1000 or than 2000) than in the whole sample. Firms affiliate to foreign groups are more frequent in this COP as firms with intensive R&D. Industrial electrical equipment, furniture, printing electric and electric components are industries where firms with COP3 structure are likely to belong.

A last, COP2 is an intermediate case where firms are likely to implement only 8 practices out of the 16 identified. About 4600 firms belonging to COP2 are more likely to implement an IPR strategy (C6L9=1, C6L10=1), inducing appropriate training (C7L7) and hiring innovative people (C7L2=1). A particular attention is given to the production of knowledge (C4L3 to C4L6) even if the share of the knowledge among workers is not especially implemented (C4L7=1) as the assessment of individual contributes to the collective production (C4L9=1). People are at last aware of the strategic importance of their knowledge (C6L9=1) and are especially rewarded for it (C6L11=1). However, those firms are more likely to implement less frequently human management practices. Here, decisions on reward as well as on mobility are not transparent (respectively C7L4=0 and C7L5=0); training in this organizational mode is not monitored even if it is induced (C7L9=0 and C7L10=0).

43% of innovative firms belongs to this type of organizational cluster. COP2 is more likely to be adopted by non independent firms, between 100 and 1000 persons with little R&D. COP2 Firms are more likely to belong to the following industries: mineral products, pharmaceutical industry, car industry, electric and electronic components, as well as chemical and rubber industries.

5.3 Clusters of Organizational Practices and innovative performances

Using the above results, the issue of the impact of coherent organizational clusters on performances can be considered. Thus, they are supposed to reduce the problem of collinearity and be significantly correlated with performances. More precisely, complementarity between organizational practices dedicated to innovation implies that the magnitude of the effects of organizational clusters is larger than the sum of the marginal effects from implementing each practice[16]. Following Ichniowsky et *al*. (1997), two econometric strategies are developed to get evidences on the complementarities between the individual organizational practices. First, the estimation of the individual practices is reconsidered once introduced two dummies for organizational clusters (regression (1d) to (4d)). The impact of the

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[15] For each comment made on IOP included in one COP, the comment is base on differences that are significant at the 1% level.

parameter is therefore expected non-significantly different from 0. A second complementary regression including dummies organizational clusters and all the individual practices at the same time is run. The dummies can be considered here as a joint test of interaction terms among individual practices. If the organizational clusters dummies add no explanatory power to the model (c), the assumption of complementarity is thus weaken.

Introducing dummies in model (1b) to (4b) for two out of the three organizational clusters previously identified (COP^1 is the reference). Equation 2 thus becomes:

$$\mathrm{IO}utput_{\mathrm{i}} = a_0 + \sum_{j=1}^{16} a_j IOP_{ji} + b_1\ FrGroup_i + b_2\ ForGroup_i + f_1 COP_i^2 + f_2 COP_i^3 + \qquad (eq\ 3)$$

$$g_1\ INTENS_i + g_2 NORD_i + l_1 LNUMBER + l_2 PUBLIC + \sum_{k=1}^{13} z_k IND_{ki} + e_i$$

The theory on complementarities implied that the marginal changes in the organizational practices would modify the explanatory power of the model. Thus each individual practices should be non-significant. Comparing the 16 separate innovation productivity model in column (.d) with those in column (.b), show that the effects of an individual organizational practice in models without dummies for organizational clusters disappear once the cluster dummies included. Comparing the 16 models included in (1d) to (1b), we see those four parameters out of eight turn to be non significantly different from zero. The introduction of COP instrumental variables is not sufficient however to rise enough the standard errors of the other four independent variables that are significant in (1b) even if the probability of being non different from zero rise (even if it is small for C7L10). The introduction of cluster dummies induces a similar effect in the Tobit part of the estimation since the four significant parameters estimated in (1b') are not significant any more in (1d'). The same effects are reported for the models gathered in (2d) and (3d) comparing to respectively (2b) and (3b).

Thus this comparison give confirms that individual practices without control for cluster organizational practices are biased by the omission of other complementary organizational practices. This result explain that the effects of individual practices cannot be identified and the poor results of column (1c) to (4c). Introducing cluster dummies in the 16 model of column (1b) to (4b) modify substantially the impact of each individual practice. C4L3, C7L4 and C7L7 are indeed no more significant on PATENT whereas C4L3, C4L7, C6L10 are concerned when Comprehensive (COMP) innovation is regressed. Furthermore, the introduction on COP effects vanishes all the previously significant negative (and thus puzzling) coefficients. The results remain very poor on the last endogenous variable since the introduction of cluster dummies does not change of the only practice.

These results suggest that the cluster effects may dominate the individual effects. However the cluster effects are not always different from 0. This problem occurs especially in the Tobit part of model (1). A second limit of our results is that, even if a Wald test do confirms that cluster effects are significant,

[16] There is no assumption on the hierarchy of clusters. Each one is considered here as a coherent and productive organization.

the individual parameter are not all significant. COP3 is thus often the only significant on RADIC (in the Logit part) and COMP. At the contrary, on NOFAIL, the COP2 variable is significantly different from COP1. A third point is that the parameters of COP2 and COP3 are significant but negative when PATENT is regressed. The result is not inconsistent with the theory on complementarities but is at the opposite of traditional views linking R&D or innovation to dedicated organizations. The set of organizational practices coherent with the first cluster (COP^1) lead thus to a higher likelihood to patent whereas, holding all things equal, a firm that use most of coherent organizational practices are more likely to file patent.

A second complementary regression including dummies organizational clusters and all the individual practices at the same time is also run[17]. Despite the still present multicollinearity problem that limit the ability to separate the individual effects from clustering effects, a Wald test on joined hypothesis can be implemented and keep its accuracy.

Table 4: Testing the significance of COP dummies in the different global model.

	RADIC	RADIC	PATENT	COMP	NOFAIL
	Probit	Tobit	Probit	Probit	Probit
H_o:? $\varphi_? = \varphi_2 = 0$	(1e)	(1e')	(2e)	(3e)	(4e)
Wald $\chi^2_{[2]}$	5.67*	1.34	9,46***	3,32	1,89

In this case, the dummies can be considered here as a joint test of interaction terms among individual practices. If the organizational clusters dummies add no explanatory power to the model (c), the assumption of complementarity is thus weaken. The results of the second strategy including COP in (1b) to (4b) are mitigated (see Table 4). If the Wald test ($\chi^2_{[2]}$=5.67) is significantly different from 0 in the probit part of model (1), the Wald test on the tobit part do not reject the hypothesis that organizational clusters add no explanatory power to the model ($\chi^2_{[2]}$=1.34). Such a result is also found on COMP and NOFAIL equation (respectively (3e) and (4e)). The cluster dummies are significantly and jointly ($\chi^2_{[2]}$=9.46) different from 0 when the dependant variable is PATENT[18]. The mixed results are consistent with previous results (see Ichniowski et al., 1997). Several arguments (measurement errors, heterogeneity of output measurement) can be once more provided to explain such irregular results. One can also consider with Becker & Huselid (1998) that the firm level is associated with even more limited results than plant level studies.

Despite this last point, the set of regressions gives serious clues on the influence of clustered organizational practices dedicated to innovation on the innovation productivity. This result is sensitive to the choice of output measurement. The complementarities among individual practices are supported by the positive general positive bivariate correlation. Econometric regressions show that a change in

[17] The columns are not reported in the tables.

[18] The critical value for χ^2 with 2 degree of freedom is at the 1% level is 9.21 and 5.99 at the 5% , 4.61 at the 10%

one organizational practice tend to have little effect on innovation productivity; giving further evidence on the reality of organizational complementarities.

6 Conclusion

A firm organizes innovation through several endogenous organizational practices. Among them rules implemented at the individual level manage the workers involved in the innovation process. This paper provides evidences on the productivity effects of such organizational practices. This paper shows in a multi-industry framework on a weighted sample at the firm level, that the level of the innovative output is influenced by the different implemented rules. This result is consistent with previous results done on firms within an industry or on a more restricted sample. This general conclusion that underline that the usual retained specification of innovation function forget internal organization as a relevant factor. Beyond, the precise picture of the best practices are harder to define. Multicollinearity is encountered as a consequence of complementarity between the different implemented organizational practices. Therefore, evidences are found that support the idea that innovative firms tend to cluster their organizational practices. The results are mixed as in previous studies dedicated to work practices at the shop floor level or studies giving attention to the various definitions of innovation performances. The results show the difficulty to study only one side of complex organizations.

This first investigation can be improved in several ways. Different information already available at the firm and industry level can improve the estimated model: first, the environment is poorly considered here whereas different theoretical development underline the central place of environment on the organizational form. Second, other variables are also critical to consider: technological opportunity and appropriation variables are highly correlated to the equation (1’) even if the impact on outcome seems to be more mitigated (Crépon et al., 1998). Third, the R&D costs are a proxy of innovative costs even if innovative costs are often badly reported. A raised innovative cost, based on the raised R&D budget thanks to a third survey (the annual survey on R&D launched by the French ministry of research), would give us more clues on the robustness of some results. Fourth, a introduction of the relational capital could be added considering the different links usually developed by innovative firms. This dimension seems to be most important considering that the external endogenous organizational practices are unobserved organizational practice that introduces bias in our results.

Two other further steps will be addressed in a following paper. The first one is to reduce the number of IOP aiming to be able to have a more understandable result of parameter. The construction of indexes will give an *a priori* aggregation of IOP (as in Greenan & Mairesse, 1999 or Bresnahan et al, 1999). In this case, the test for complementarity will be easier since closer to the definition of complementarity. A second investigation would be to test the idea that specific organizational practices are necessary for the innovation activity. As many authors emphasized since Arrow, the specificity of the innovative process and output lead to singular problems and thus to singular organizational responses (See, Hölmstrom, 1989). The competency survey includes a supplementary answer for each selected item where the use of specific practices is identified.

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8 Appendix: Tables

Table 5: Radical turnover (decision and level)

		Radic	Radic	Radic	Radic	Radic	Radic	Radic	Radic
		(1a)	(1a')	(1b)	(1b')	(1c)	(1c')	(1d)	(1d')
		Probit	Tobit	Probit	Tobit	Probit	Tobit	Probit	Tobit
		Neither IOP Nor COP	Neither IOP Nor COP	Only one IO without COP	Only one IOP without COP	All IOP Without COP	All IOP Without COP	Only one IOP With COP	Only one IOP With COP
		Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff	Coeff.	Coeff.
α_1	C3L5C1			0,121*	0,294**	0,076	0,232	0,092	0,279
				(0,063)	(0,139)	(0,070)	(0,169)	(0,068)	(0,166)
α_2	C4L3C1			0,130**	0,096	0,023	-0,096	0,094	-0,010
				(0,064)	(0,153)	(0,078)	(0,201)	(0,078)	(0,198)
α_3	C4L4C1			0,194***	0,058	0,176**	-0,014	0,185**	-0,002
				(0,068)	(0,158)	(0,074)	(0,174)	(0,073)	(0,166)
α_4	C4L5C1			0,118*	0,168	0,031	0,090	0,082	0,115
				(0,062)	(0,141)	(0,072)	(0,165)	(0,072)	(0,160)
α_5	C4L6C1			0,060	0,103	-0,010	-0,012	0,018	0,027
				(0,066)	(0,160)	(0,074)	(0,187)	(0,074)	(0,184)
α_6	C4L7C1			0,121*	0,289*	0,051	0,145	0,085	0,249
				(0,070)	(0,177)	(0,078)	(0,196)	(0,075)	(0,185)
α_7	C4L9C1			0,173**	0,092	0,074	-0,076	0,154*	0,020
				(0,072)	(0,159)	(0,082)	(0,186)	(0,092)	(0,201)
α_8	C6L9C1			0,098	0,063	0,056	-0,091	0,059	-0,036
				(0,066)	(0,153)	(0,078)	(0,188)	(0,072)	(0,176)
α_9	C6L10C1			0,045	0,131	-0,042	0,076	-0,002	0,074
				(0,065)	(0,147)	(0,076)	(0,189)	(0,070)	(0,167)
α_{10}	C6L11C1			0,091	0,057	0,015	-0,075	0,045	-0,029
				(0,063)	(0,137)	(0,075)	(0,170)	(0,072)	(0,163)
α_{11}	C7L2C1			-0,041	0,250*	-0,141**	0,188	-0,111	0,223
				(0,064)	(0,145)	(0,070)	(0,175)	(0,071)	(0,172)
α_{12}	C7L4C1			0,051	0,104	-0,021	0,036	-0,011	0,044
				(0,066)	(0,144)	(0,077)	(0,159)	(0,076)	(0,165)
α_{13}	C7L5C1			0,010	0,235*	-0,090	0,127	-0,061	0,205
				(0,064)	(0,142)	(0,077)	(0,172)	(0,073)	(0,178)
α_{14}	C7L7C1			0,095	0,147	0,007	0,021	0,044	0,062
				(0,069)	(0,176)	(0,077)	(0,195)	(0,080)	(0,209)
α_{15}	C7L9C1			0,183***	0,166	0,089	0,054	0,169**	0,123
				(0,068)	(0,142)	(0,080)	(0,162)	(0,084)	(0,164)
α_{16}	C7L10C1			0,240***	0,102	0,187**	-0,016	0,243***	0,032
				(0,067)	(0,145)	(0,076)	(0,165)	(0,077)	(0,172)
φ_1	SOP2							Yes	Yes
φ_2	SOP3							Yes	Yes
β_1	FRGROUP	-0,117	0,517***	Yes	Yes	-0,082	0,506**	Yes	Yes
		(0,085)	(0,192)			(0,086)	(0,202)		
β_2	FORGROUP	-0,130	0,619***	Yes	Yes	-0,121	0,620***	Yes	Yes
		(0,094)	(0,204)			(0,096)	(0,210)		
γ_1	INTRDN	0,125***	0,360***	Yes	Yes	0,121***	0,329***	Yes	Yes
		(0,029)	(0,052)			(0,030)	(0,057)		
γ_2	NORD	-1,230***	-2,555***	Yes	Yes	-1,209***	-2,376***	Yes	Yes
		(0,155)	(0,354)			(0,161)	(0,386)		
λ_1	LNUMBER	0,094***	1,697***	Yes	Yes	0,108***	1,656***	Yes	Yes
		(0,035)	(0,075)			(0,036)	(0,083)		
λ_2	PUBLIC	-0.055	-0,373**	Yes	Yes	-0,056	-0,347**	Yes	Yes
		(0.080)	(0,162)			(0,082)	(0,169)		
H_0: $\alpha_{.1}=\alpha_{.16}=0$	Wald : $\chi^2(16)$					30.32**	10.14		
H_0: $\varphi_1=\varphi_2=0$	Wald : $\chi^2_{[2]}$								
H_0: $\beta_1=\beta_2=0$	Wald : $\chi^2_{[2]}$	2.65	10.43***			1.81	9.68***		
H_0: $\zeta_1=\ldots=\zeta_{13}=0$	Wald : $\chi^2(13)$	14.13	15.36			17.10	14.65		
σ	ρ	1,381***	0,626***			1,339***	0,586***		
		(0,126)	(0,222)			(0,128)	(0,256)		
Log-L		-1957,4				-1935.837			

The parameter are calculated at the sample mean, the marginal effects are not reported
Weighted sample of 1541 innovative firms
*: 10% level; ** 5% level; *** 1% level
All regressions with 13 industry dummies

Table 6: PATENT (0 or 1)

		PATENT	PATENT	PATENT	PATENT
		Probit (2a)	Probit (2b)	Probit (2c)	Probit (2d)
		Neither IOP nor COP	Only one IOP Without COP	All IOP Without COP	Only one IOP With COP
	Variable	Parameter	Parameter	Parameter	Parameter
α_1	C3L5		-0,095	-0,078	0,010
			(0,077)	(0,087)	(0,080)
α_2	C4L3		-0,163**	-0,134	0,010
			(0,078)	(0,094)	(0,091)
α_3	C4L4		-0,117	0,018	-0,019
			(0,082)	(0,088)	(0,084)
α_4	C4L5		0,130*	0,252***	0,181**
			(0,075)	(0,086)	(0,081)
α_5	C4L6		-0,077	-0,041	-0,031
			(0,078)	(0,088)	(0,088)
α_6	C4L7		-0,118	-0,085	0,013
			(0,084)	(0,097)	(0,090)
α_7	C4L9		-0,034	0,012	0,063
			(0,088)	(0,100)	(0,108)
α_8	C6L9		0,077	0,118	0,169*
			(0,079)	(0,097)	(0,091)
α_9	C6L10		0,145*	0,214**	0,173**
			(0,078)	(0,092)	(0,084)
α_{10}	C6L11		-0,12	-0,182*	0,022
			(0,076)	(0,094)	(0,084)
α_{11}	C7L2		-0,034	0,018	0,013
			(0,076)	(0,088)	(0,086)
α_{12}	C7L4		-0,177**	-0,180*	-0,137
			(0,081)	(0,097)	(0,085)
α_{13}	C7L5		-0,036	0,057	-0,065
			(0,077)	(0,090)	(0,085)
α_{14}	C7L7		-0,023***	-0,263***	-0,010
			(0,081)	(0,098)	(0,102)
α_{15}	C7L9		0,032	0,088	0,072
			(0,080)	(0,096)	(0,095)
α_{16}	C7L10		0,016	0,048	-0,016
			(0,079)	(0,092)	(0,093)
φ_1	SOP2				Yes
φ_2	SOP3				Yes
β_1	FRGROUP	-0,138	Yes	-0,136	Yes
		(0,102)		(0,107)	
β_2	FORGROUP	-0,092	Yes	-0,074	Yes
		(0,115)		(0,118)	
γ_1	INTRDN	0,223***	Yes	0,220***	Yes
		(0,032)		(0,034)	
γ_2	NORD	-1,735***	Yes	-1,753***	Yes
		(0,176)		(0,184)	
λ_1	LNUMBER	0,382***	Yes	0,400***	Yes
		(0,044)		(0,047)	
λ_2	PUBLIC	0,407***	Yes	0,403***	Yes
		(0,407)		(0,093)	
H_0: $\alpha_{.1}=\alpha_{.16}=0$	Wald : $\chi^2(16)$			41,03***	
H_0: $\varphi_1=\varphi_2=0$	Wald : $\chi^2_{[2]}$				
H_0: $\beta_1=\beta_2=0$	Wald : $\chi^2_{[2]}$	1,88		1,74	
H_0: $\zeta_1=\ldots=\zeta_{13}=0$	Wald : $\chi^2(13)$	31,93***		27,75***	
Log-L		-789,7		-770,7	
ZM R^2		0,43		0,45	

The parameter are calculated at the sample mean, the marginal effects are not reported
Weighted sample of 1541 innovative firms
*: 10% level; ** 5% level; *** 1% level
All regressions with 13 industry dummies

Table 7: COMP

		COMP	COMP	COMP	COMP
		Probit (3a)	Probit (3b)	Probit (3c)	Probit (3d)
	Variable	Neither IOP nor COP Parameter	Only one IOP Without COP Parameter	All IOP Without COP Parameter	Only one IOP With COP Parameter
α_1	C3L5		0,197**	0,190*	0,208***
			(0,080)	(0,090)	(0,082)
α_2	C4L3		0,152*	0,06	0,120
			(0,081)	(0,099)	(0,092)
α_3	C4L4		0,077	0,001	0,073
			(0,084)	(0,090)	(0,083)
α_4	C4L5		0,00009	-0,074	-0,026
			(0,078)	(0,091)	(0,081)
α_5	C4L6		0,042	-0,041	0,072
			(0,081)	(0,098)	(0,088)
α_6	C4L7		0,173**	0,09	-0,020
			(0,088)	(0,099)	(0,090)
α_7	C4L9		0,340***	0,368***	0,339***
			(0,089)	(0,109)	(0,104)
α_8	C6L9		0,112	0,069	0,014
			(0,082)	(0,098)	(0,091)
α_9	C6L10		0,180**	0,191**	0,025
			(0,081)	(0,097)	(0,086)
α_{10}	C6L11		-0,1	-0,335***	-0,034
			(0,082)	(0,104)	(0,083)
α_{11}	C7L2		0,210**	0,227**	0,157*
			(0,083)	(0,092)	(0,086)
α_{12}	C7L4		-0,021	-0,042	-0,035
			(0,081)	(0,099)	(0,084)
α_{13}	C7L5		-0,093	-0,267***	-0,133
			(0,081)	(0,099)	(0,085)
α_{14}	C7L7		0,14	0,081	0,055
			(0,087)	(0,099)	(0,103)
α_{15}	C7L9		0,084	-0,105	0,093
			(0,086)	(0,106)	(0,093)
α_{16}	C7L10		0,114	0,103	0,033
			(0,084)	(0,101)	(0,092)
φ_1	SOP2				Yes
φ_2	SOP3				Yes
β_1	FRGROUP	0,072	Yes	0,06	Yes
		(0,104)		(0,108)	
β_2	FORGROUP	-0,107	Yes	-0,175	Yes
		(0,124)		(0,131)	
γ_1	INTRDN	0,058	Yes	0,042	Yes
		(0,038)		(0,041)	
γ_2	NORD	-0,167	Yes	-0,045	Yes
		(0,199)		(0,215)	
λ_1	LNUMBER	0,167***	Yes	0,176***	Yes
		(0,041)		(0,044)	
λ_2	PUBLIC	0,114	Yes	0,105	Yes
		(0,100)		(0,108)	
H_0: $\alpha_{.1}=\alpha_{.16}=0$	Wald : $\chi^2(16)$			45,27***	
H_0: $\varphi_1=\varphi_2=0$	Wald : $\chi^2_{[2]}$				
H_0: $\beta_1=\beta_2=0$	Wald : $\chi^2_{[2]}$	2,36		3,68	
H_0: $\zeta_1=\ldots=\zeta_{13}=0$	Wald : $\chi^2(13)$	42,11***		40,00***	
Log-L		-719		-693,4	
ZM R^2		0,12		0,18	

The parameter are calculated at the sample mean, the marginal effects are not reported
Weighted sample of 1541 innovative firms
*: 10% level; ** 5% level; *** 1% level
All regressions with 13 industry dummies

Table 8: NOFAIL

		NOFAIL	NOFAIL	NOFAIL	NOFAIL
	Variable	Probit	Probit	Probit	Probit
		(4a)	(4b)	(4c)	(4d)
	Variable	Neither IOP nor COP Parameter	Only one IOP Without COP Parameter	All IOP Without COP Parameter	Only one IOP with COP Parameter
α_1	C3L5		-0,009 (0,072)	-0,037 (0,080)	-0,038 (0,082)
α_2	C4L3		0,092 (0,076)	0,093 (0,090)	-0,012 (0,093)
α_3	C4L4		0,058 (0,081)	0,031 (0,087)	0,111 (0,087)
α_4	C4L5		0,185** (0,073)	0,212** (0,083)	0,187** (0,084)
α_5	C4L6		0,026 (0,075)	-0,049 (0,087)	-0,067 (0,089)
α_6	C4L7		0,038 (0,080)	0,035 (0,089)	0,001 (0,092)
α_7	C4L9		-0,077 (0,084)	-0,119 (0,094)	-0,149 (0,108)
α_8	C6L9		-0,086 (0,076)	-0,147 (0,090)	-0,142 (0,090)
α_9	C6L10		0,032 (0,076)	0,061 (0,090)	-0,026 (0,087)
α_{10}	C6L11		0,073 (0,075)	0,101 (0,088)	-0,001 (0,085)
α_{11}	C7L2		-0,058 (0,075)	-0,116 (0,081)	-0,109 (0,086)
α_{12}	C7L4		-0,011 (0,076)	-0,033 (0,091)	0,040 (0,087)
α_{13}	C7L5		-0,055 (0,075)	-0,053 (0,089)	-0,061 (0,087)
α_{14}	C7L7		0,096 (0,081)	0,098 (0,095)	0,015 (0,103)
α_{15}	C7L9		0,024 (0,078)	0,05 (0,093)	-0,083 (0,097)
α_{16}	C7L10		-0,057 (0,076)	-0,126 (0,089)	0,049 (0,093)
φ_1	SOP2				Yes
φ_2	SOP3				Yes
β_1	FRGROUP	0,011 (0,098)	Yes	0,012 (0,100)	Yes
β_2	FORGROUP	-0,011 (0,113)	Yes	-0,032 (0,117)	Yes
γ_1	INTRDN	-0,024 (0,034)	Yes	-0,025 (0,036)	Yes
γ_2	NORD	0,541*** (0,181)	Yes	0,548*** (0,190)	Yes
λ_1	LNUMBER	-0,057 (0,044)	Yes	-0,051 (0,045)	Yes
λ_2	PUBLIC	-0,15 (0,097)	Yes	-0,154 (0,098)	Yes
H_0: $\alpha_{.1}=\alpha_{.16}=0$	Wald : $\chi^2(16)$			19,21	
H_0: $\varphi_1=\varphi_2=0$	Wald : $\chi^2_{[2]}$				
H_0: $\beta_1=\beta_2=0$	Wald : $\chi^2_{[2]}$	0,04		0,14	
H_0: $\zeta_1=\ldots=\zeta_{13}=0$	Wald : $\chi^2(13)$	30,66***		27,89***	
Log-L		-841,1		-831,3	
ZM R^2		0,09		0,11	

The parameter are calculated at the sample mean, the marginal effects are not reported
Weighted sample of 1541 innovative firms
*: 10% level; ** 5% level; *** 1% level
All regressions with 13 industry dummies