Technological and Organizational Tools for Knowledge Management: In Search of Configurations

Mariano Corso
Antonella Martini
Luisa Pellegrini
Emilio Paolucci

ABSTRACT. Knowledge Management (KM) is becoming a growing concern in management research and practice because of its role in determining firm innovation capability and in enhancing working life quality of knowledge workers. This requires, even for Small and Medium Enterprises (SMEs) the creation of a sustainable work organization in terms of configuration of organizational and Information and Communication Technology (ICT) tools. With a particular emphasis in the area of Product Innovation (PI) and on the basis of a survey on 127 Italian SMEs, this paper aims at analysing the emergent technological and organizational approaches to managing knowledge in the PI process. Three different KM Configurations emerge: the 'technical', the 'relational' and the 'advanced' approach.

1. Introduction

Knowledge Management (KM) is a new way of thinking of the organization and sharing of the intellectual and creative resources of a firm. It consists of the systematic effort of finding, organizing and giving access to the organizational intellectual capital and of feeding a culture of continuous learning and knowledge sharing so that the organizational activities can be based on existing knowledge (Daft, 1997). KM is becoming a growing concern in management research and practice; the fundamental reasons which underlie this growing interest are two. First of all, knowledge now plays and will continue an important role in the future in determining a firm's capability to innovate and hence, its long-run effectiveness and survival. Secondly, a growing percentage of the total work force is composed of knowledge workers asking for new and more adequate organizational forms and supporting tools. Proper Knowledge Management, in particular, becomes fundamental to prevent the pressures of work intensification and time-to-market compression from producing, on the one side, low capabilities to learn and capitalize experience, and, on the other, worker stress and burnout.

The managerial challenge is real: it consists of creating a sustainable work organization – a configuration of organizational and Information & Communication Technology (ICT) tools – which enables both continuous innovation and the enhancement of working life quality.

This theme is today deeply perceived by high intensity knowledge organizations, but will soon become fundamental even for a growing part of European firms, and in particular for Small and Medium Enterprises (SMEs). While in most cases, as a matter of fact, European SMEs still compete on efficiency and flexibility in manufacturing and delivering existing and relatively stable products and processes, this strategy will hardly be viable in the near future in the face of competition of low cost companies from developing countries. In

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Mariano Corso
Antonella Martini
Luisa Pellegrini
Department of Electrical Systems and Automation
Faculty of Engineering
University of Pisa
Via Diotisalvi 2
56126 Pisa – Italy
E-mail: mariano.corso@dsea.unipi.it
E-mail: antonella.martini@dsea.unipi.it
E-mail: luisa.pellegrini@dsea.unipi.it

Emilio Paolucci
Department of Operation and Business Management
Faculty of Engineering
Polytechnic of Turin
Corso Duca degli Abruzzi, 24
10129 Torino – Italy
E-mail: paolucci@athena.polito.it

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order to survive in the global economy, European SMEs will rather have to rely on their own ability to improve products and processes, providing customers with value-adding innovations and learning capabilities. This entails developing and exploiting tools in order to manage knowledge in a more and more complex network of relationships inside and outside their boundaries.

New ICT and organizational tools can play a key role in this process. By providing quick and easy access to external sources of knowledge and new and more intense communication channels with partner organizations, ICT can erase traditional constraints on SMEs innovation ability, while leveraging their flexibility and responsiveness. Attention from ICT practitioners is therefore progressively shifting from the use and the effects of ICT tools for increasing efficiency, to their role in fostering inter-functional and inter-organizational integration, with a strong accent on Knowledge Management. In the area of Product Innovation (PI), in particular, the use of Web based applications, and other tools such as Product Data Management (PDM), Virtual Prototyping, Computer Aided Design (CAD), are expected to substantially reshape the overall KM process (Baba and Nobeoka, 1998; Thomke, 1998; Thomke et al., 1998).

Organisational tools provide SMEs with levers which support the processes of knowledge capture and dissemination. Such levers refer to two kinds of vehicles which embody knowledge (Bartezzaghi et al., 1997): people (Hansen et al., 1999; Takeuchi and Nonaka, 1986) transferring knowledge both inside and outside organizational boundaries, eventually supported by an effective management of systemic feedback, and databases supporting the transfer of past experience to future projects.

Despite the alleged competitive role played by both organizational and technological tools in supporting KM, literature has scarcely investigated problems connected with the integration of ICT and organizational tools.

This article presents results obtained in the second step of an exploratory research project which combines the comparative case study methodology, in the first step, and the survey methodology, in the second. In the first step, the nature of the investigated phenomenon and the substantial lack of models co-located our analysis in the pre-paradigmatic phase of theory development, suggesting the application of methodologies based on the case analysis. The aim of this second step is to analyse the emerging configurations of technological and organizational choices to manage knowledge in order to contribute to the formulation of a clear and verifiable theory. Evidence is based on a survey of a random sample of 127 SMEs localised in Northern and Central Italy.

The paper is articulated into five sections including the Introduction. In section two, the state of the art of literature on KM is presented, with particular reference to the area of PI. The third section describes the methodology adopted in the empirical study. Section four discusses results from the field studies. Finally, in section five, suggestions for further research undertakings are provided.

2. Knowledge management in product innovation

The great importance assumed by PI has imposed a radical change in the organisation and management of the New Product Development (NPD) projects. Accordingly, management literature evolved from a 'relay race' approach to a cognitive approach which considers NPD as a knowledge-intensive activity (Brown and Eisenhardt, 1997). The roots of cognitive perspective can be found in the Resource-Based View (Ricardo, 1817; Penrose, 1955): '*a resource based theory of the firm thus entails a knowledge-based perspective*' (Conner and Prahalad, 1996, p. 477), as knowledge leads to a set of capabilities enhancing survival and growth chances (Kogut and Zander, 1992). The Resource-Based View considers the firm as a set of resources whose accumulation and use over time, through innovation processes, explain the dynamics of competitive advantage acquisition and exploitation (Wernerfelt, 1984; Rumelt, 1984; Barney, 1991; Peteraf, 1993; Collis and Montgomery, 1995). More in particular, the Resource-Based View puts in evidence how the exclusive possession of resources – the inputs the firm owns or controls (Amit and Schoemaker, 1993) – originates rents, as resources are not uniformly distributed among firms and are characterized by mobility barriers. The combination of resources creates distinctive competencies, which allow the firm to reach positions of competitive advantage with respect to competitors. The competitive advantage sustainability depends on resource combination and characteristics, with particular reference to the aspects of value (the ability to size opportunities or thwart competitive threats), scarcity (the unavailability for competitors in the industry), the imperfect possibility of imitation (the resource can be sustained for long periods without competitors replicating or acquiring it), and the lack of substitutes (the lack of strategic equivalents) (Collis and Montgomery, 1995). Accordingly, because of its characteristics of tacitness, inimitability and immobility, knowledge is a major source of competitive advantage (Pan and Scarbrough, 1998).

The cognitive perspective in Product Innovation requires companies to become more effective in managing knowledge, overcoming space, time and organisational barriers, mostly due to the separation between knowledge source and the locus where knowledge itself is potentially used (Bartezzaghi et al., 1997; Clark and Wheelwright, 1993). Overcoming those barriers that may hinder synergy and learning is the essence of KM.

We can briefly review literature on KM in PI, tracking how it evolved towards systemic management of knowledge along two main dimensions (Corso et al., 2001a): (i) the scope of the knowledge creating PI system, and (ii) the emphasis in the knowledge process. The first dimension indicates the degree to which contributions progressively enlarge the boundaries of the PI process, evolving from knowledge integration among NPD phases within the same project, to knowledge integration among different PI projects over time and, finally, to knowledge integration with partners outside the traditional boundaries of product development. The second dimension, instead, deals with the level at which contributions consider the overall KM process: from mere attention to knowledge sharing, to knowledge codification and storing for reuse and, finally, to the overall process of knowledge creation and management (Figure 1).

In the early 1980s, *Concurrent Engineering* (CE) was considered the new paradigm for NPD as it replaces phased program planning with the joint participation of different functional groups in the PI process (Nonaka, 1990; Joice, 1986). But, as the main emphasis is on the speed of a specific innovation process, knowledge is socialised in tacit and contextual forms, with limited emphasis on its codification, abstraction and generalisation

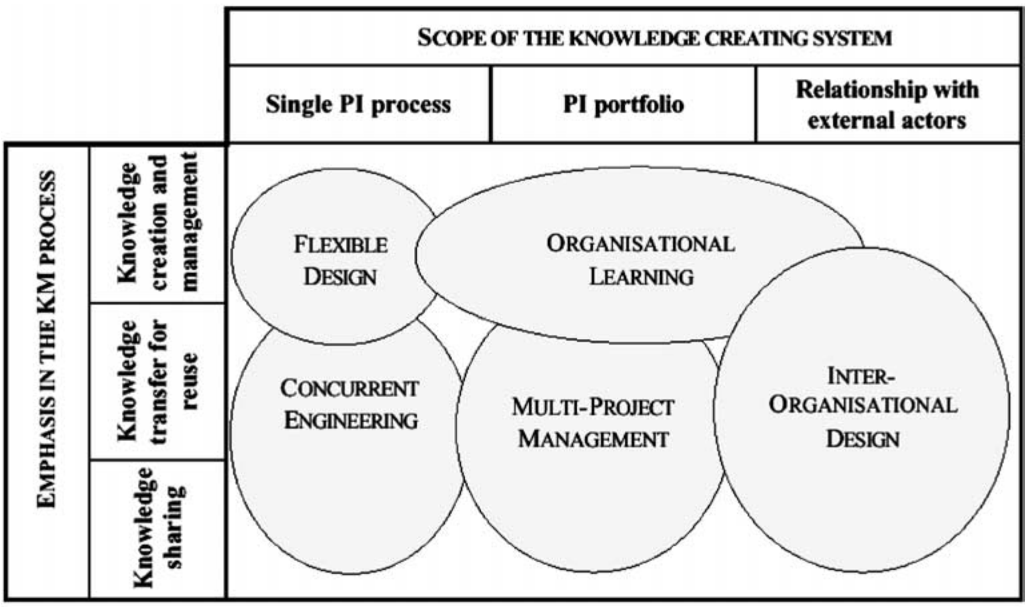

Figure 1. Knowledge Management in Product Innovation – an interpretative review.

to foster future innovation. Furthermore, CE keeps a rigid separation between product concept generation and product development (Dougherty, 1990, 1992; Iansiti, 1995), as it implies the joint participation of cross-functional often co-located groups in the execution of these separate and sequential sets of activities. But in turbulent environments, the necessity to react to new information during project evolution, originated the *Flexible Design* (Iansiti, 1995; MacCormack and Iansiti, 1997; Verganti et al., 1998) where the 'concept freeze milestone' (that is the time period at which the concept cannot be ever modified) moves as close as possible to market introduction. The overlap between the concept development and the implementation phases means, in KM terms, the fostering of rapid learning loops in NPD.

In the late 1980s, *Multi-Project Management* (MPM) highlighted the long-term limits of CE as that approach potentially isolates each innovation process from the rest of the organisation. Success depends even more on both fostering commonality and reuse of design solutions over time and shifting attention to project families (Wheelwright and Clark, 1992; Wheelwright and Sasser, 1989; Sanderson and Uzumeri, 1995). This means focusing on product architecture (Henderson and Clark, 1990), devoting more attention to the management of sets of related projects and avoiding inefficiencies connected with individual projects 'micromanagement' (Cusumano and Nobeoka, 1992). More exactly, MPM doesn't concern the management of the interdependencies among concurrent projects sharing common resources (Speranza and Vercellis, 1993) , but of the interdependencies connected with knowledge transfer between projects over time (Czajkowski and Jones, 1986; Clark and Fujimoto, 1991; De Maio et al., 1994).

Analysing interdependencies, some authors focus on the actual *object* of the interaction (Nonaka, 1991; Itami, 1987) distinguishing between interactions related to the exchange of tangible technological solutions (e.g. parts, components), of codified knowledge (patents, processes and formulas) and of noncodified know how, generally person-embodied. Others focus on the *scope* of the interaction, distinguishing between component level and architectural level (Henderson and Clark, 1990). A third, and last, group of contributions focuses on the *approach in the transfer process*, that can either be reactive – when solutions and knowledge from past projects are *ex post* retrieved and reused – or proactive – when solutions are deliberately developed for future use, often projects not previously planned (De Maio et al., 1994). Many authors show how traditional reactive policies based on the carryover of parts and subsystems are intrinsically limited and may also be detrimental to innovation (Clark and Fujimoto, 1991; Witter et al., 1994). Excellent companies rather use proactive policies where *ex-ante* efforts are made to predict characteristics and features of new parts and subsystems to suit future applications. Depending on the architectural or component knowledge embodied in the solutions, these proactive polices are named "product platforms" or "shelf innovation" (Hayes et al., 1988; Wheelwright and Sasser, 1989; Wheelwright and Clark, 1992; Meyer and Utterback, 1993; Sanderson and Uzumeri, 1995).

Proposed in the 1990's, *Organisational Learning* (OL) emphasised the dynamic of knowledge creation and transfer over time: while MPM focuses on knowledge embodied in design solutions, OL emphasises the transfer of knowledge also in tacit form or its embedding into processes and organisational routines (Nonaka, 1991; Nonaka and Takeuchi, 1995). Also, while MPM considers knowledge reapplication as an automatic process, OL emphasises how knowledge learning and reuse may face barriers at organisational and individual levels, asking for management support (Bartezzaghi et al., 1997; Nonaka, 1991; Senge, 1990; von Hippel and Tyre, 1995; Imai et al., 1985; Arora and Gambardella, 1994; Hedlund, 1994).

Most contributions, however, share the assumption that PI is the outcome of NPD projects over time, hence, implicitly considering downstream phases only as sources of information for feeding next generation product development, or even constraints to be anticipated during development (Clark and Fujimoto, 1991). Some contributions, on the contrary, highlight the necessity to extend the innovative efforts to the overall product lifecycle (Itami, 1987; Bessant et al., 1994; Caffyn, 1997; Bartezzaghi et al., 1999; Corso, 2001).

Starting from the CE concept of inter-functional team, *Inter-organizational Design* (IOD) recently emerged, further expanding the PI process scope outside the R&D traditional boundaries. External complexity, in fact, hinders the single firm from the chance to managing the knowledge system supporting the whole PI process. In particular a first sub-stream stresses the importance of designing new roles within R&D, such as *gatekeepers*, to bridge to the external environment (Allen, 1997; Katz and Tushman, 1981; Ancona and Caldwell, 1990). A second sub-stream focuses on the direct and early involvement of external actors in inter-organizational groups (Clark and Fujimoto, 1991; Imai et al., 1985; Katz, 1982). Finally, others investigate the specific relationships the firm builds with actors belonging to the supply chain (vertical agreements) (Clark and Fujimoto, 1991; Imai et al., 1985; von Hippel, 1976, 1977, 1978, 1988; Cusumano and Takeishi, 1991; Dyer, 1996; Edwards and Samimi, 1997; Takeuchi and Nonaka, 1986; Nonaka, 1990), with competitors (horizontal agreements) (Clark and Fujimoto, 1991) and with complementary firms and institutions (cross agreements) (von Hippel, 1988; Teece, 1986; Lundvall, 1988; Lee, 1996).

For SMEs the challenge consists of dramatically enhancing their ability to provide customers with superior innovation and service capabilities. This implies the ability to create and manage knowledge, also leveraging on external sources of knowledge (top-right part of Figure 1). Organizational tools together with new emerging technologies, with particular reference to internet applications, can play a key role in this process, as they provide quick and easy access to external sources of knowledge and new and more intense communication channels both within the firm and with partner organizations. Notwithstanding this fact, the managerial literature has completely disregarded the present and potential role of both organizational and ICT tools in KM within SMEs, so ignoring their specific needs in terms of organizational and technological support to manage knowledge. On this subject, the empirical research is scarce too (Corso et al., 2000; 2001b). Hence we see the need of empirical research investigating the ICT and organizational tools supporting KM in PI within SMEs and how they cluster in consistent configurations.

3. Research methodology

3.1. *The investigation framework*

The research investigation framework (Figure 2) presents three groups of variables and their relationships: Contingencies, KM Configurations and KM Behaviours.

More exactly, Contingencies are exogenous to the model and conceptualise how some industry (e.g. environment turbulence) and firm-specific variables (size, position in the supply chain, different aspects of product complexity, etc.) can influence the choice of the technological and organizational tools – the Levers – which support the KM process in New Product Development.

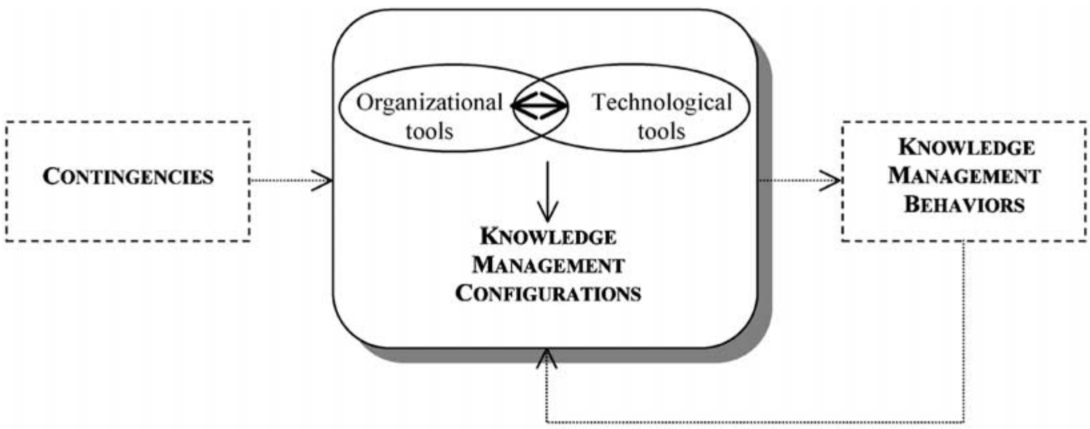

Figure 2. The investigation framework.

Knowledge Management Configurations identify the set of Levers SMEs adopt in order to transfer and consolidate knowledge. More exactly, knowledge transfer focuses on the flow of knowledge within and outside the organizational boundaries of the firm, while knowledge consolidation represents the efforts organizations perform to capture and consolidate knowledge for future retrievals.

The choice of the Levers, made accordingly to Contingencies, produce effects in terms of KM Behaviours which are, at the organizational level, the combination of behaviours of individuals and groups concerning the creation, diffusion, consolidation and application of knowledge (e.g. individuals abstract knowledge from experience and generalize it for new applications or make explicit and communicate acquired knowledge, etc). In fact, management can encourage certain Behaviours by the implementation of the Levers which, according to Contingencies, drive people for example to experimentation, integration in the PI process or articulation of acquired knowledge.

The relationship connecting the last two groups of variables is not one way: if in the short run KM Levers can have a relevant impact on organizational Behaviours, in the long run, KM Behaviours tend to affect the choice and use of ICT technologies as well as the selection of the most appropriate organizational tools (KM Configurations).

This paper focuses on Levers and on how they cluster in consistent KM Configurations. To represent this fact, in Figure 2, relationships connecting KM Configurations with the other two groups of variables are simply traced with broken lines.

Two basic Lever types have been identified: the organizational type and the technological one.

The organizational Levers refer to eight variables, that is to eight vehicles capturing and disseminating knowledge: (1) traditional communication tools between the R&D department members, with particular reference to interpersonal relationships and paper documents; (2) internal meetings for the transfer of design solutions emerging from past projects; (3) advanced communication tools, particularly e-mail and file sharing on internal networks to support communication within the technical office and with the other departments; (4) project teams involving members from other departments or customer/suppliers; (5) databases for design solutions (DB – See glossary of engineering terms); (6) people connecting the firm with the external environment, (7) interaction with customers and, finally, (8) interaction with suppliers. These variables can be classified according to two dimensions (Table I): (i) the level of codification of the Levers, that is the possibility to articulate and, hence, embody knowledge in concrete and tangible representations (Clark and Wheelwright, 1993) such as documents and software (Kogut and Zander, 1995), and (ii) the degree of opening toward the external environment (Corso et al., 2001b).

Technological levers can be classified into two groups: the specific ICTs adopted in the NPD

TABLE I
Organizational Levers classification

Degree of opening	Level of codification	
	Articulated/explicit levers	Tacit levers
Internal	– Paper documents (1) – Meetings (2) – Advanced communication tools (3) – Databases for design solutions (5)	– Interpersonal relationships (1) – Project teams (4)
External		– Project teams (4) – Gate keepers (6) – Interaction with customers and suppliers (7, 8)

process and the tools supporting integration among organizational units and external actors.

Referring to the first aspect – ICT tools adopted for the NPD process – we analyse several technologies: computer aided engineering (CAE), computer-aided manufacturing (CAM), product-data management (PDM) and two-dimensional computer-aided design (2D CAD) for internal use (e.g. design, management of the bill of materials and integration with CAM) (See glossary for further explanation of these terms).

With respect to the second group – ICT tools supporting integration – the degree of 'opening' toward the other departments and the external environment is also investigated: networks represent the meeting locus where knowledge transfer takes place with very low costs and times. In this way, we investigated the presence of internal networks (intra-Nets), which connect different departments inside organizational borders or within a group, the external networks (inter-Nets) connecting different actors along the supply chain and 2D CAD for interacting with customers and suppliers. We also include three-dimensional computer-aided design (3D CAD), defined further in the glossary, as one of the tools supporting integration rather than as a tool adopted in the NPD process because we found in our earlier work that especially with customers, SMEs usually adopt 3D in order to support technological coordination (Corso et al., 2001b, 2000).

3.2. *The empirical research*

This study was carried out on 127 SMEs in Northern (Piedmont and Lombardy) and Central (Tuscany) Italy, operating in the mechanical, electronic, plastic and chemical industries. The methodological approach is the survey, in particular because of the possibility to validate obtained data and to generalize results.

The 1997 KOMPASS data-base, a compendium of the most important Italian firms, provided the population for firm names. Two criteria drove the random selection of the sample:

– small and medium size, in terms of employees – from 35 up to 350 – and turnover – between 2.5 and 60 millions Euro;
– manufacturing firms belonging to the mechanical, electronic, plastic and chemical industries, because of the importance of such sectors in the Italian economic system, both in terms of firm number and turnover amount on the Italian GDP.

In Lombardy 535 SMEs were contacted; of these, 61 firms (11.4%) returned the questionnaire, but only 55 were returned complete. In Piedmont, 600 firms were contacted, with a 12.16% response rate (73 firms), but only 51 SMEs were complete. In Tuscany 139 SMEs were contacted: 21 of them returned the questionnaire (15.11%), completely filled in. Table II summarizes population and sample characteristics in terms of distribution per geographical area and industry.

After a first telephone contact and a preliminary discussion with managers regarding research project aims, selected SMEs were invited to fill in the questionnaire published on the Web. A message was sent to the interviewees with the link to the research project Web page containing a

TABLE II
Population and sample characteristics

Industries	Population (%)			Sample							
	Lombardy	Piedmont	Tuscany	Lombardy		Piedmont		Tuscany		Total	
				N.	%	N.	%	N.	%	N.	%
Mechanical	46.00	76.00	30.30	24	43.63	36	70.58	5	22.73	65	51.18
Electronic	23.00	17.17	27.40	11	20.00	12	23.53	8	36.36	31	24.41
Plastic	17.00	1.00	23.10	13	23.63	1	1.96	5	22.73	19	14.96
Chemical	14.00	5.83	19.20	7	12.74	2	3.93	3	18.18	12	9.45
Total	100.00	100.00	100.00	55	100.00	51	100.00	21	100.00	127	100.00

description of the research aims, instructions for completing the survey, the researchers' telephone for further explanations/assistance and the questionnaire itself, in html version.

SMEs could respond to the questionnaire directly online. Data were automatically transferred to a database, and then checked for reliability by the researchers. In comparison with traditional survey tools, the use of the Internet allowed advantages both for the interviewers – rapidity in receiving filled-in questionnaires and processing data – and the interviewees – rapidity in the completion and forwarding phase. Furthermore, by participating in our research, involved SMEs obtained feedback in terms of suggestions concerning the appropriate use of levers for KM.

For those firms, however, not having an internet access, or not willing to use it, the questionnaire was sent by fax. In order to reduce fill-in time, the questionnaire tackled only comparative scale answers (ordinal scales in which respondents have to choose the answer with the highest priority), multiple choice answers, interval data (for example numerical scales, in which, for each answer, firms are asked to select an answer ranging from 1 to 4) and relative data. Non-comparative scales or open questions were used only for quantitative information or when there was not any ambiguity in the answer or it was not possible to fix *à priori* alternatives or intervals. Moreover, the html format of the questionnaire provided tighter control over how the survey was completed.

The questionnaire, which contains 87 questions, is structured into five sections: (1) general information regarding SMEs in order to characterise each firm for its size, dispersion and competitive context; (2) the manufacturing system: its complexity, the innovations recently introduced, the relationships with customers and suppliers; (3) the product: its complexity and the innovations introduced (4) the NPD organisation; (5) the use of ICT tools within SMEs and, in particular, the use of computer based technologies for NPD, with a strong emphasis on 2D and 3D CAD, CAM, CAE, PDM, intra-Nets and inter-Nets.

Cluster analysis was adopted in order to identify coherent classes of behaviour (KM Configurations), starting from the full list of variables (the Levers). We used K-means clustering (i.e. non-hierarchical technique) because of the insight gained in the first stage of our research project (Hair et al., 1987). In this previous stage, the use of a multiple-case study methodology with semi-structured interviews, and the selection of an interest based sample, although introducing statistical limitations, allowed researchers to gain a broader understanding of the research issue. In this stage the use of the K-means clustering method avoid the risk of poor explanations that could derive from cluster analysis in pure survey approaches.

4. Research results

Cluster analysis divided SMEs into three groups (Table III), which represent the emerging ICT and organizational approaches to KM in Product Innovation. It should be kept in mind that only the Levers which are distinctive were included in the clustering process, while the others have not been considered because of their very high diffusion rate (intra-Net, paper documents and interpersonal relationships were in use in almost all the SMEs), or very low one (PDM and meetings were very scarcely adopted).

The first cluster, $KM_{Technical}$, encompasses 23 firms, which adopted what we called the 'Technical Approach'. On the organizational side, for internal knowledge transfer, these firms rely greatly on advanced communications tools (e-mail and file sharing) while project teams are not used much. Unlike other clusters, there are almost no interactions with external actors, particularly with both customers and suppliers (just 4.3%). On the technological side, 3D CAD and internal 2D CAD are quite widespread.

The 47 SMEs belonging to the second cluster, $KM_{Relational}$, have adopted a KM Configuration characterized by a very high interaction with actors along the supply chain (especially with customers) and the lowest diffusion degree of ICT tools, with the exception of e-mail and file sharing (76.6%) for internal transfer. Also for inter-company relations, these firms mainly rely on traditional mechanisms rather than on technological tools. For these reasons the KM configuration adopted by this cluster is referred to as 'relational'.

Finally, cluster $KM_{Advanced}$, comprising of 48

TABLE III
Clusters of KM configurations[a]

Analyzed variables	Cluster $KM_{Technical}$		Cluster $KM_{Relational}$		Cluster $KM_{Advanced}$	
	SMEs N.	%	SMEs N.	%	SMEs N.	%
Organizational tools						
Project teams	6	26.1	19	40.4	24	50.0
DB for design solutions	11	47.8	14	29.8	31	64.6
Advanced communication tools	19	82.6	36	76.6	32	66.7
Interaction with customers	0	0.0	47	100.0	46	95.8
Interaction with suppliers	1	4.3	45	95.7	47	97.9
Gate keepers	7	30.4	35	74.5	35	72.9
Technological tools						
2D CAD for internal use	12	52.2	10	21.3	39	81.2
2D CAD for external use	10	43.5	11	23.4	21	43.7
3D CAD	14	60.9	9	19.1	43	89.6
CAE	7	30.4	4	8.5	10	20.8
CAM	9	39.1	2	4.3	21	43.7
InterNet	10	43.5	12	25.6	23	47.9
SMEs (N. and %) per cluster[b]	23	19.5	47	39.8	48	40.7

[a] Table should be read in the vertical sense: for each cluster, the values in the first column represent the number of SMEs, belonging to that cluster, with the specific variable, while the values in the second column represent the % of SMEs with the specific variable, respect to the total number of SMEs in the cluster.
[b] 9 missing.

enterprises, is characterized by a high diffusion degree of both the organizational and technological tools. Knowledge is managed and shared inside the company mainly by means of advanced tools, project teams and DB for design solution. In contrast with the previous cluster, the interactions with external actors along the supply chain greatly rely on computer networks, 3D and 2D CAD for the articulation of the knowledge to and from partners. What distinguishes cluster $KM_{Advanced}$ from cluster $KM_{Relational}$ is also the strongest effort in codifying, storing and reusing knowledge.

While in all clusters SMEs use advanced communication tools for internal knowledge transfer, the use of internal ICT tools (internal 2D CAD, CAE, CAM) and DB is associated with the codification effort, which is greater in $KM_{Advanced}$, followed by $KM_{Technical}$. In addition, while these latter clusters also adopt external ICT tools for knowledge transfer along the supply chain, $KM_{Relational}$ does not support its high external interaction degree with any technological tools.

Future research developments will be dedicated to the identification of the drivers (for example product characteristics), which affect the choice between the alternative KM Configurations.

5. Conclusions and future developments

While confirming a general gap in the adoption of ICT tools by SMEs, this paper shows how this latter cannot be ascribed only to generic considerations concerning cultural lags.[1] Pattern of ICT adoption should rather be analysed in the frame of the wider Knowledge Management system that also includes organizational tools and management practices. In particular, if compared to larger enterprises, SMEs tend to place more emphasis on management of knowledge in tacit forms.

This paper has identified the different lever combinations that SMEs adopt and the related KM Configurations. Three distinct configurations emerge: the ‘technical’, the ‘relational’ and the ‘advanced’ approach.

These are the first results of a research, still in progress, which is investigating the long-term effects of new ICT and organizational tools on KM and, hence, on SMEs performances. These results lay the basis for future research developments in order to understand:

– if and what Contingencies drive the selection of the previously identified KM approaches;
– if the KM approaches adopted by the three clusters have an evolutive nature;
– if the three KM Configurations allow the achievement of different types of performances.

Glossary

– CAE (Computer-aided engineering) is the set of applications for the analysis of physical characteristics of a virtual object (i.e. thermal properties, mechanic resistance and vibrations, etc.).
– CAM (computer-aided manufacturing) is the set of tools for the control of a production line, automated by means of a computer containing instructions regarding the manufacturing process.
– DB (databases) for design solutions are vehicles that store knowledge and support the transfer of past experiences to future projects.
– PDM (Product data management) is an integrated system of applications for storing, transferring and retrieving the information which are necessary to design, manufacture and maintain the product.
– 3D CAD (three-dimensional computer aided design) offers important advantages in terms of: (1) clear and immediate understanding of the way the product is evolving – hence, the anticipation of possible incoherencies and manufacturing/assembling problems, (2) support to concurrent engineering, allowing the simultaneous work of designers and the interaction of different departments.

Note

[1] Cultural lag consists of a non-comprehension of a phenomenon, in this case ICT benefits (Rullani, E. and S. Micelli, 1998).

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