Methods for modeling and supporting innovation processes in SMEs

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Abstract

Purpose – Sets out to investigate business modeling techniques (BMTs) which can be used to support and improve innovation processes within small and medium-sized enterprises (SMEs).

Design/methodology/approach – Based on a literature review, different analysis perspectives on innovation processes are identified and discussed, and some firm needs and problems are pointed out. The importance of BMTs to firms is further tested by an empirical study whose initial results are reported. Finally, by matching problems and techniques characterized by the same ontology, the BMTs most suitable to address SME needs are identified and their role within the innovation process discussed.

Findings – The main result of the paper is the identification of the problems facing SMEs in innovation processes and the possible support offered by BMTs. Though methods and models alone do not assure the success in the innovation development process (IDP), they are enabling factors and can support the creation of strategies, reasoning, insights and communication.

Originality/value – The adoption of such BMTs, facilitating the codification of the characteristics of the IDP, might be particularly useful in those environments where, due to the lack of specialized resources, it is difficult to structure all of the information related to the innovation process and to exploit the related benefits and opportunities

Keywords Innovation, Modelling, Small to medium-sized enterprises, Italy

Paper type Case study

Introduction

An innovation is a product, service, or process that is new or perceived as new by its developers (Van de Ven, 1986). Some processes (e.g. new product development) are essential to develop innovations within companies. This paper discusses the use of modeling techniques to support innovation processes. We argue that techniques for process modeling and analysis, which we refer to collectively as business modeling techniques (BMTs), can be used to support and improve innovation processes. Such techniques are commonly used in many fields, e.g. for information system development. In these fields, the importance of such techniques is broadly recognized and benefits of their use have been shown empirically in the literature (Maylor, 2001; Wheelwright and Clark, 1992). However, BMTs have often been considered inappropriate for processes such as new product development (NPD) that are highly unstructured and characterized by difficult-to-forecast activities linked by reciprocal rather then sequential dependencies. Nevertheless, interest in modeling techniques to support innovation is rapidly increasing, though as yet, few modeling

European Journal of Innovation Management
Vol. 8 No. 1, 2005
pp. 120-137

1460-1060
DOI 10.1108/14601060510578619

techniques have been proposed to support innovation processes (Presley *et al.* 2000). We suggest that there may be BMTs that are appropriate to support such processes (e.g., design rationale techniques or cognitive mapping). By providing models of the innovation process, BMTs can support the identification of problems and the assessment of alternative modes to perform the process. Moreover, by their adoption organizations can learn how they innovate and improve the process.

We specifically focus on BMTs to support the innovation development process (IDP) within small and medium-sized enterprises (SMEs). The importance SMEs play for economic development is widely recognized in the literature and their role as innovators is indisputable (Rothwell and Zegveld 1982). Nevertheless, there are few studies to support the management of innovation within SMEs (Hoffman *et al.*, 1998, March-Chordà *et al.*, 2002, Motwani *et al.*, 2000) and little attention has been devoted to how innovation is pursued or how to support it (project management techniques and quality function deployment are among the few supporting tools to be considered). Furthermore, a lack of specialized resources to effectively manage IDPs makes it difficult for such firms to identify suitable methods and adopt them.

The research question this paper addresses are which BMTs can be used to support and improve IDPs in SMEs. Addressing this question requires the assessment of the specific characteristics of IDP within SMEs, the analysis of existing BMTs and a study of their effectiveness in modelling such a process. In particular, based on a review of the analysis perspectives on IDP and some theoretical and empirical insights, SMEs' specific needs and problems are assessed and BMTs to support such needs are identified. For each technique the role and IDP phase they can be adopted are also discussed. Finally, some conclusions and future research lines are drawn.

Insights on innovation processes: seven perspectives for analysis

IDPs are complex, knowledge-intensive and often not *ex-ante* defined or definable. Characteristics of innovation processes have been deeply investigated in the literature (detailed reviews on this issue are proposed in Gopalakrishnan and Damanpour , 1997; Slappendel, 1996; Tang, 1998; and Wolfe, 1994), though most studies focuses on a few aspects, such as information management, creativity, management and organization etc. In order to present a complete picture of IDP, in this section different analysis perspectives are reviewed and discussed. Within each perspective a brief description of the most significant studies and research approaches is also proposed. Note that the proposed perspectives describe the same process: an IDP is simultaneously a sequence of tasks, a political process, a cognitive process etc. But recognition of different analysis perspectives is useful for identifying problems and needs that arise within firms and assessing suitable supporting techniques.

Sequence of tasks

IDP can be described as the set of tasks aimed at the creation of a new product/process. Several studies have identified stages and tasks necessary (but not sufficient) to the development of successful innovations (Cooper, 1983, 1994; Cooper and Kleinschimdt, 1986; Saren, 1984). For example, Wolfe (1994) classifies two generations of models, namely stage models and process-based models (which are in particular referred to NPD). In both cases, normative models are more common (Saren, 1984). Case studies and quantitative analysis have also been developed to study tasks and

interdependences among them so as to identify suitable management techniques (e.g., concurrent engineering and project management), suggest the appointment of some specific organizational roles (e.g., gatekeeper or innovation champion) and define general models for project design (Koput, 1997, Van de Ven and Poole, 1990). As reported in Table I (2nd column), the main problems studied within this research track are associated with IDP design (task definition and decision-making power allocation), coordination (identification and management of interdependencies among tasks so as to guarantee an effective management of the whole process) and control (definition of milestones and control tools).

Decisions that evolve over time

The IDP can be described as the set of decisions made during its design and execution (Marples, 1961; Mintzberg *et al.*, 1976; Thomke *et al.*, 1998; Wheelwright and Clark, 1992). An IDP is triggered by the decision to create a new object. The creation requires consideration of alternative options, each requiring the identification and solution of some technical and organizational problems. Different options must thus be rated and ranked based on some criteria (feasibility, cost, time etc.). Problem solving is complicated because these criteria are often uncertain (not all the information necessary to rate options is available) and ambiguous (information can be misunderstood, priorities and criteria to be adopted to rate options are not clear or well defined). Although at a macro-level of analysis an innovation requires the solution to new problems, some tasks and decisions (at a micro-level of analysis) repeat over time. For this reason it is important to keep trace of the adopted decision-making criteria. As reported in Table I, the main problems studied in this research area are those associated to the analysis of the decision-making rationale (e.g., difficulties in problem solving, problem setting and retrieval of the adopted criteria). Some general process models, factors and variables to be considered during innovation development are also discussed in the literature.

Strategic process

The strategic role of innovation processes within firms has been stressed in several studies (e.g. Utterback, 1994). Innovation is the main source of competitive advantage for many organizations. Studies developed based on this perspective propose models to develop innovation strategies that are coherent with market needs, the overall firm strategy, and the technologies and resources a firm can use (Clark and Wheelwright, 1994; Tushman and Moore, 1982; Utterback, 1994). Other studies suggest market time and entry modes (Abernathy and Clark, 1985; Abernathy and Utterback, 1978). Strategy development is complicated by the existence of targets that vary over time mainly due to environmental changes. As reported in Table I, major problems in this research area are the definition of an innovation strategy (e.g. the kind of innovation to develop, variables to take into account etc.)

Political process

Innovation processes may have a political dimension. Some scholars have studied and stressed the symbolical relevance and the political difficulties new projects may encounter (Kidder, 1981). Management of attention, creation of a good currency, internal conflict management and resistance to change are considered as crucial

Table I. Innovation process perspective of analysis: problems and needs within SMEs

Analysis perspective	Main problems	Hypothesis: SMEs crucial problems
Sequence of tasks	Task definition; management and control; role assignment; management of the part-whole relationship	Procedure neglect; responsibility avoidance; lack of process control; management deficiencies
Decisions that evolve over time	Problem framing and problem solving; storing/retrieval decisions associated to past projects and their rationale	Problem framing and problem solving; lack of a structured organizational memory
Strategic process	Strategy development and communication	Lack of a strategic vision (short-term vision)
Political process	Management of attention; creation of a good currency; change management; conflict management	Change management; conflict management
Interpretative process	Communication among departments due to the development of different thought world	Communication among departments due to the development of different thought world
Creative process	Creativity and motivation; blame culture	Blame culture
Communication and information flow	Lack of structured communication (internal and external to the firm); NIH syndrome; loss of architectural knowledge; selection of supporting technologies	Lack of structured communication (internal and external to the firm)

problems in innovation development (Van de Ven, 1986). As reported in Table I, to address such problems, the development of agreements among those who are involved in the process and the creation of common perspectives and vision are necessary.

Interpretative process

Innovation processes have a cognitive and interpretative dimension. Studies in this research area deal with the analysis of the involved actors, cognitive characteristics and the way they interpret their role and the roles of other participants (Dougherty, 1992; Heller, 2000). For example, Dougherty (1992) observed that departments often interpret process goals and operative approaches from different "thought worlds", making inter-departments communication and collaboration hard. Organizational routines also make innovation processes more complex. To address cognitive problems it is necessary to consider cultural factors (e.g. the use of methodologies to support the identification of different perspectives as a required condition to define agreements).

Creative process

IDP is a creative process (Slappendel, 1996; Tang 1998). Creativity is the ability to develop new ideas or products based on observed patterns and relationships. Studies, developed in this research area, mostly by psychologists, demonstrated that creativity can be stimulated and fostered. In particular domain-knowledge and motivations are considered as the main contributors to creativity whereas the existence of a blame culture can hinder it (Amabile, 1983).

Communication and information flow

IDP is an information and communication-intensive process. Studies within this research area have investigated the properties of the exchanged information, roles (internal or external to the firm) among which such information should be exchanged and the characteristics of the information networks (Eppinger, 2001; Morelli *et al.*, 1995; Tushman, 1979). Recording information flows can be useful to identify lack of internal or external connections so as to preserve architectural knowledge, i.e. knowledge related to the parts that constitute the innovation-object (Henderson and Clark, 1990). Organizational routines can make people forget architectural knowledge or develop syndromes such as the not invented here (NIH) syndrome, preventing the recognition of the value of external information and knowledge (Katz and Allen, 1982).

The impact of the problems described above may differ based on the context of the IDP. In particular, the lack of specialized resources and financial sources can make these problems more critical within SMEs. In the next section, we consider the problems of SMEs in more detail.

Innovation development within SMEs: problems and needs

A major topic in the innovation literature is the importance of SMEs for innovation. Studies have shown that SMEs contributed to the main innovations of the twentieth century (Oakey, et al., 1988; Rothwell and Zegveld, 1982; Rothwell, 1994).

SMEs have some advantages because of their size. Many are flexible and have strong relationships with customers, enabling rapid response to technical and market shifts. Small firms usually have good internal communications and many have a dynamic and entrepreneurial management style (Rothwell, 1994). As well, some

studies suggest that the average capability of technical people is higher in small firms and that innovations in these firms can be less expensive (Cooper, 1964). SMEs usually explore new technical spaces. In summary, innovation in small firms can be (more) efficient and effective (Vossen, 1998).

On the other hand, many SMEs are not innovative at all. Researchers have stressed the differences between a limited number of very innovative small firms and a large number of non-innovative firms (Acs and Yeung, 1999; Hadjimanolis and Dickson, 2000) Many obstacles to innovation in SMEs are also stressed in the literature. The lack of financial resources, inadequacy of management and marketing, lack of skilled workers, weakness in external information and linkages, and difficulty in coping with government regulations are factors that limit their competitiveness (Buijs, 1987; Freel, 2000; Rothwell, 1994). SMEs may be unable to exploit new products because of the limited organizational and marketing capabilities. Other studies discuss cultural barriers to innovation, such as reluctance to change, tendency to ignore procedure, focus on short-term requirements, lack of strategic vision and the diffusion of a blame culture (Filson and Lewis, 2000; Freel, 2000). SMEs' main problems are due particularly to the scarce attention devoted to organizational and managerial problems especially in the field of innovation (Cobbenhagen, 1999).

Table I lists problems that are relevant within SMEs, classified according to the perspective of analysis from which they are usually studied. For example, the tendency to ignore procedures (which are often not codified), not to assume responsibility, the absence of process monitoring activities and a poor management are problems mainly stressed in the studies that interpret the innovation process as a sequence of tasks. Issues related to problem framing and problem solving (mainly due to the absence of technology watch and technology search roles) and the lack of structured organizational memory are mentioned as significant problems in the studies that interpret the innovation process as a flow of decisions. A major problem is also considered the lack of a strategic vision to drive the innovation development. Such problems strongly compromise the success of IDP within SMEs. On the contrary, less crucial for SMEs are problems identified in the studies that interpret the innovation process as a political process (because of the low number of employees and the entrepreneur power), as am interpretative process (again due to the low number of employees who often have more roles) and as a communication and information flow. Problems associated to the creative perspective, such as the existence of a blame culture, depend on the skills and capabilities of the entrepreneur, so they are not common to all firms.

A field study: some initial results

In this section, we present some initial results of a field study carried out on a sample of 19 SMEs that work in the Puglia region (Italy). The study was designed to investigate needs and problems within Italian SMEs in order to properly design a questionnaire to submit to a significant sample of Italian firms in a future study and to provide an initial test for the hypotheses (problems considered as relevant) proposed in the paper.

Sample selection

The authors started with a list of approximately 100 firms. All the selected firms were SMEs as defined by the European Commission Recommendation published in the EU

Official Journal No. L 107 (30/4/96). Different industrial sectors were included so as to not bias the final results. The sample includes firms in the textile, mechanical, agricultural and food, and furniture sector. Such sectors are the most significant in the considered region (and indeed in all of Italy). Firms were initially contacted by phone and asked if they would be willing to participate; 19 firms agreed, and they form the sample for this study. The firms in the sample have between seven and 150 employees (an average of 46) and an average annual turnover of €1.75-18 m (an average of €7 m).

Method

Firms that agreed to take part in the interview were visited in person. Each interview has lasted about an hour and was conducted with the top manager (usually the owner of the firm) or one of the responsible persons for the IDP. A questionnaire (a first draft of the questionnaire we intend to submit to the final sample of firms) was used to collect data. Interviews where organized in the following way. Initially general questions about innovation were asked, so as to understand the firm's attitude toward innovation (why innovations are developed) and the main kind of innovations. Then, we investigated the innovation process (how innovations start, departments involved, phases and activities carried out, knowledge involved and supporting techniques). The third part was devoted to the identification of problems and needs.

Results

Our first finding is that few SMEs pay much attention to innovation (reported by 7/19 interviewees). Just one firm stated that innovation represents the main competitive goal of a SME. Innovation is mainly aimed at improving the quality (16 firms) and marketing properties (12 firms) of a product. However, many firms (15) also consider innovation as a means to reduce costs and improve the production process (nine firms). They develop incremental innovation both related to the product and the process. A few radical innovations are also developed.

Most of the firms stated that innovations usually develop based on an idea of the owner-entrepreneur (13 firms) and 11 of them said that, in any case, the role of the owner is fundamental for its promotion. He/she usually defines the firm's strategy (13 firms). Innovation starts from client suggestions (ten firms), the participation at fairs and exhibitions, marketing analysis and the R&D department (nine firms). Two firms said suppliers suggested innovations while only one firm said that it developed innovation in collaboration with the university.

Technological know-how is rarely developed in house: it is mainly acquired by purchasing hardware and software technologies or by accessing external laboratories. Most of the past and future three-year investments firms identified deal with productive plants and information technologies (personal computers and software, in particular for administrative support). This contrasts the observation that many firms (eight firms) said thay have R&D and design departments and with their high reported percentage of the turnover invested in R&D (a reported average of 5 percent).

Effective intra-firm communication (18 firms) and flexibility (nine firms) are considered as main SME advantages in innovation development compared with large firms. However, most firms also stated that intra-firm communications are mostly exchanged hierarchically and in many cases there are not direct communications

among departments (five firms stated that no communications are exchanged between R&D and design or between marketing and design departments).

The lack of infrastructure and the lack of work flexibility are reported as the most serious obstacles to innovation development (according to eight and seven firms, respectively). Six firms also mentioned as important the difficulty in collecting relevant information and knowledge. Contrary to the literature, just three firms mentioned financial resources as relevant. Finally, only one firm mentioned the difficulty in finding good managers and carrying out the IDP.

Process planning and development/execution are the innovation phases recognized as important by most of the firms (nine firms), though not all of them. Just two firms mentioned a learning phase as important. Strategic planning is performed by seven firms, while nine firms stated that the strategy has never been developed. Almost all of the firms mentioned the cost-benefits analysis as one of the performed activities (16 firms). Many firms also mentioned idea generation and design and just a few also considered initial problem-solving/screening of different ideas and final assessment of the innovation results. Most of the firms stated they do not adopt structured techniques or standard procedures to monitor the market (customer needs, technological advancements and competitor performance), develop an innovation strategy or control the IDP.

The most used supporting techniques (five firms) were flowcharts. Only one firm mentioned simulation techniques. Many firms declared their interest in the techniques of the IDEF family. Most of the firms were not interested in any of the proposed supporting techniques (techniques are reported in the following section).

Finally, based on the different perspective of analysis above mentioned, we asked firms to talk about problems that usually occurred during innovation development. Interviewees generally found it hard to talk about problems. Most of them considered as frequent problems resource allocation and coordination, process monitoring, innovation strategy definition and new idea selection. Less frequent but relevant were information and communication management and collection of information and rationale related to innovation in progress. On the contrary, many firms stated that they never collected innovation-related decision rationales and developed knowledge repository. This is coherent with the fact that learning is not considered as an important innovation process phase. Only five firms said that they would need methods and techniques to support ex-ante and ex-post learning, whereas most of them said they would need techniques to support the process execution. Many of them (nine firms) stated they would not be interested in analysing a SME best practice database.

Analysis

The picture that emerges from the previous analysis shows a reactive rather than proactive attitude towards innovation by the contacted SMEs (it is important to stress that the sample is composed of the 19 firms that were interested enough to be willing to be interviewed). They are interested in innovation development, but they do not develop an innovation strategy (or even an overall strategy), do not adopt any methods to control and monitor the innovation process and do not record information and knowledge acquired during development and the rationale for it. They ignore many of the activities reported in the literature as fundamental to the development of successful innovations. Moreover, most of the firms were not able to identify problems that occur

during innovation development. They usually recognize problems that occur very rarely. They are not interested in supporting techniques, so showing cultural barriers to improving the process. They also provided some contradictory answers. For example, firms report few problems with intra-firm communication but also stress lack of communication among departments, which is quite important for IDP (such as marketing and design).

The interviews thus provide support for the identification of problems in previous section, as reported in Table I. In next section we propose a review of modelling techniques to support and improve innovation development within SMEs.

Techniques to support innovation processes

In this section models and techniques to support and improve IDPs within SMEs are examined. Some recent studies showed that innovation can be fostered and supported by the use of structured techniques (Buijs, 1987; Cardinal, 2001). To adopt them, firms would have to follow well-defined procedures and practices. Moreover, they would become more aware of some innovation issues and aspects. The techniques proposed below are indeed adopted by very innovative and successful firms (Libutti, 2000; Maylor 2001; Rinholm and Boag, 1987). Models and techniques are enabling structures (Chiesa *et al.*, 1996): their adoption represents a necessary, though not sufficient, condition to achieve success. Of course, not all innovation problems can be addressed by adopting some technique. Some problems require cultural solutions or government support (such as an increase in the work flexibility, infrastructure building, definition of gatekeeper roles among firms and universities). As a result, such aspects are not examined here.

Innovation development process: a model for SMEs

Models are tools that can support reasoning and the analysis of the world (Pidd, 1996). They can be used as "facilitators" (i.e., they facilitate the representation of different perspectives about the world and support communication and coordination), to support decision making (i.e., they allow the assessment of the consequences of a decision, so supporting the choice) and to codify knowledge and support learning.

Several BMTs can be used during IDP. To group similar BMTs, we present a simple model of an IDP, based on a review of the literature (e.g. During, 1986; Cooper and Kleinschimdt, 1986; Marquis, 1982; Tushman and Moore, 1982; Utterback, 1971; Wheelwright and Clark, 1992; Wolfe, 1994). According to this model, an IDP has three main phases (or macro-activities), namely planning (phase I), development (phase II) and learning (phase III). It is important to note that the phases are not sequentially accomplished; they are rather linked by reciprocal dependencies. As showed by the literature review and field study results, phases I and III (though crucial) are often neglected by SMEs (Rinholm and Boag, 1987).

Models for planning. We can distinguish between strategic planning (definition of the firm's strategy and policy with respect to innovation) and operative planning (design of how a project will be developed). Both cases require agreement among the functions involved in innovation development and between management and operative/technical functions, which in turn requires a common perspective and vocabulary. By making views and vocabularies explicit, models can facilitate communication and understanding of different worldviews, needs and relationships

(Dougherty, 1992). For strategic planning, models might support the communication of the owner/entrepreneur's vision (often kept tacitly) and criteria for decisions. For operative planning, models explicate assumptions and knowledge, so helping in capturing knowledge of downstream activities at earlier stages of a project (Heller, 2000). This anticipation can avoid mismatch among functions and rework, so reducing cost and time to market. Models can also support the relationships with customers, i.e. to better understand their needs and problems. The use of models for planning is particularly important for SMEs. The lack of resources (temporal, financial, and human resources) makes the planning stage critical for these firms. Planning would prevent SMEs from making technical decisions based on contingencies.

Models for development. Innovation development involves exploration of a variety of solutions, the result of which influence successive decisions in a fashion that cannot be defined *ex ante*. Even so, process models might be used to determine the possible consequences of actions and choices. The execution of a project also requires monitoring and controlling tools. Models can guide action and be used as a standard against which progress is measured (where we are, where we are going). They can represent who is doing what so as to improve the effectiveness of communications. Models can show the relationship between the parts and the whole, so that the vision is not lost when functions focus on their specific needs. Having guidelines to follow is valuable for SMEs (Zutshi *et al.*, nd) who often have technical but not managerial competencies and experiences.

Models for learning. Learning means the internalization of knowledge. Within IDP, models can support both ex-ante and ex-post learning. Ex-ante, models can be used to clarify ideas and externalize tacit knowledge. As stated in (Weick, 1979) "you don't know what you are thinking until you hear what you are saying". In this way, models provide a base for reasoning and communication. SMEs often work based on very tacit knowledge, so codification of this knowledge is a means to improve how things are done and to industrialize activities. *Ex-post* models can be used to recollect the sources of problems, problem-solving modes and best practices so as to learn from them. Though every innovation is new, elementary tasks repeat over time, so IDPs usually do not evolve in a completely unpredictable way (Westfechtel, 1999). Models can thus be used to acquire knowledge based on past experiences. Learning is a critical function rarely supported in SMEs (Rinholm and Boag, 1987). As well, models might preserve the knowledge of workers leaving the firm, a particularly pressing problem in SMEs, which have fewer employees, making the loss of even one a serious problem.

BMTs to support innovation development within SMEs

In this section we review BMTs for IDP in SMEs. We draw on the database proposed by (Kettinger *et al.*, 1997), which contains 72 techniques and supporting methodologies. The techniques are reviewed based on the perspective of analysis mentioned in the second section. To make the connection, the methods are classified according to their ontology, that is, the entities, categories or class of objects that model uses to describe the world and the relationships among those classes. We identified six main ontologies, namely, activities, states, decision criteria and decision variables, roles, concepts and data flow, that characterize BMTs. Such information is then used to identify, for each perspective, the most suitable supporting techniques, as shown in Table II.

Sequence of tasks

This perspective is a common one for BMTs as many of them represent tasks. Flowcharts, IDEF0, IDEF3 are the most common (e.g. Grover and Kettinger, 1995; Kettinger *et al.*, 1997, Presley *et al.*, 2000). Flowchart and IDEF0 represent what the process does (the activities), IDEF3 and grammatical models show the way process actors work. In particular, IDEF3 depict links among actions developed within a given scenario, defined as the organization structure, based on which it is possible to characterize the goal and define the process border line. The main advantage of these techniques is the possibility to represent different relationships among actions as well as their temporal nature (synchronous or asynchronous).

However, due to the difficulty of anticipating the specific activities to be performed and the importance of feedback loops, the creation of a fine-grained task model of the innovation process is probably impossible. On the other hand, coarse-grain models such as the stage models are likely too general to be very useful for a specific project. Still, IDPs are rarely completely new and unpredictable, so a medium-grain level might be useful both in the planning and in the execution phase (Cooper, 1983). It is thus useful to start with a medium-grain level model and to modify it during the process.

During phase I, such models can be used to model and compare different alternative strategic approaches. They can also be used to allocate resources and define gates and milestones to measure performance (Goldense, 1993). During phase II, models can help monitor and control the project. Finally, these models might provide valuable insight a-posteriori, so allowing the company to learn about the way the project was performed. For example, a task model might be recorded as the project unfolds and analyzed after the fact to identify problems and possible solutions.

Decisions over time

These aspects of an IDP can be supported by modeling techniques based on decisions and states, such as simulation models (qualitative and quantitative), decision trees, design rationale, analytical hierarchy process, Petri net, and state transition diagrams (Aalst and Hee, 1996; Lee and Lai, 1991, MacLean *et al.*, 1991, Marples, 1961). Design rationale models provide a structured and formalized framework to make and record decisions. Such models could be extremely useful in SMEs, where decisions are often made based on contingencies. The adoption of these models can force people to consider alternatives so avoiding choices determined by contingent solutions. These techniques can thus be used to structure strategic and operative planning (phase I), to support problem solving during planning and execution (phase I and II) and as knowledge repository during the learning phase (phase III).

Table II.
Perspective of analysis and related ontology

Perspective	Ontology
Sequence of tasks	Activity, states, roles
Decisions that evolve over time	Decisions, data flow, states
Strategic process	Concepts
Political process	Concepts, roles
Interpretative process	Concepts, roles
Creative process	Data flow, concepts
Communication and information flow	Data flow, roles

Strategic process

Problems associated to this perspective require techniques able to represent concepts. To support the definition of an innovation strategy the use of maps (such as marketing, engineering or manufacturing maps) and models such as the critical success factors are suggested (Wheelwright and Clark, 1992). These models can be extremely useful to SMEs, given that one of their main limits identified was the lack of strategic planning. Maps, such as cognitive maps can be used both as a guide to the definition of a strategy and also as a means to their externalization and communication (Eden and Ackermann, 1992; Fiol and Huff, 1992; Pidd, 1996). Cognitive maps are characterized by two ontologies: concepts and relationships (usually causal relationships) among them, as they are defined by those who the map refer to. Relationships are usually associated to a direction and a value (that measures the intensity of the relationship). The importance of cognitive maps for IDP is stressed in (Russell, 1999; Swan, 1995). Maps are useful to reduce problems associated to communication misunderstandings. For example, Russell (1999) proposes a cognitive map that shows concepts and relationships a SME manager associates to the issue of corporate entrepreneurship. Map development can be a useful means managers can adopt to codify their strategy and vision, to support reasoning (e.g. about the innovation policy and its coherence with the firm strategy) and communication. These techniques can thus be used both as facilitators and learning tools, mainly during the planning and learning phase (phase I and III).

Political process

Models to support this view and to address the related problems are those whose ontologies are concepts and action for agreement, such as cognitive maps, active-workflow models, and speech interaction modeling (Kettinger *et al.*, 1997; Winograd and Flores, 1986). They can be extremely helpful in providing a base for discussion as well as to formalize and clarify the way it should proceed. Agreements are based on obtainable results and require the definition of responsibilities. Metrics for performance assessment (Goldense, 1993) and role-based models such as role activity diagrams can provide useful (Huckvale and Ould, 1995). Political problems usually arise during planning (phase I) and execution (phase II). The above mentioned techniques can mainly be used as facilitators.

Interpretative process

Models to address problems related to this perspective are those whose ontologies are concept-based such as cognitive maps and IDEF5 (Grover and Kettinger, 1995). IDEF5 was designed to depict the so-called typologies (or ontologies), which are graphically represented by circles. Different ontologies are related by classification mechanisms (such as generalization, a kind of etc). Such techniques can be mainly used as facilitators. They can be particularly useful during phase I and II.

Creative process

Problems related to this perspective require cultural solutions, for this reason there are not many supporting techniques. However, some models and methods have been developed to foster creative attitude and brainstorming such as affinity diagramming, Delphi technique, and the "out of the box thinking" method (Giaglis, 1999; Kettinger

et al., 1997). Also, some studies have shown that engineers solve problems by adopting knowledge and solutions used in the past in new ways (Marples, 1961; Thomke and Fujimoto, 2000). The importance of models to collect the knowledge created during the development of a project and transfer it from one to another project is thus critical (Thomke and Fujimoto, 2000). To this aim design rationale and IDEF3 models as well as most of the earlier mentioned models can be adopted to preserve the project knowledge. Such techniques can be used as learning tools, so trying to eliminate the blame culture that is particularly dangerous during phase I and II.

Information and communication flow

To address problems related to this perspective, models that facilitate the identification of the characteristics of the information exchanged (and their main properties) as well as persons/roles among which it is exchanged can be useful. Thus, models whose ontologies are entity, information and role-based, such as data flows diagrams, IDEF1 and role active diagrams can be adopted (Albino *et al.*, 2003; Chen, 1976; Giaglis, 1999; Grover and Kettinger, 1995). Such techniques can also be also useful to select the Information and Communication Technologies to support information exchange and to improve the process (Morelli *et al.*, 1995, Tushman 1979). By recording information and communication flows such methodologies provide information that can help identifying the lack of internal and external links, so preserving architectural knowledge (Henderson and Clark, 1990). Due to routine and/or the NIH syndrome, architectural knowledge can be easily lost (Katz and Allen, 1982). These techniques are thus particularly useful during phase I and II to support process management. Also they can be useful during phase III to memorize the adopted rationale and reason about the process development.

Based on the above analysis, we argue that different BMTs can be used to support and address several needs and problems that emerge during IDP within SMEs. The analysis is also summarized in Table III, where for each of the mentioned problems (those considered as more relevant for SMEs) the most suitable BMTs, their role and process phase are reported.

Conclusions

The main result of the paper is the identification of the problems facing SMEs in innovating and possible useful supporting BMTs. Though methods and models alone do not assure the success in IDP, they are enabling factors and can support the creation of strategies, reasoning, insights and communication. The adoption of such techniques, facilitating the codification of the characteristics of the IDP might be particularly useful in those environments where, due to the lack of specialized resources, it is difficult to structure all of the information related to the innovation process and to exploit the related benefits and opportunities. Moreover, formal techniques and methods can have a didactic role. They can teach firms how to develop innovations and also make them more sensible towards innovation, so reducing their tendency to act based solely on intuitions and routine rather than structured knowledge. Among BMTs, design rationales and cognitive maps are most relevant. Design rationales can be used to structure the decision process, capture the decisions made about products and create a sort of organizational memory whereas cognitive maps can be used to

Table III. The problems/methods matrix

SMEs crucial problems	Techniques and models	Phase	Role
Procedure neglect; responsibility avoidance; lack of process control; management deficiencies	IDEF0; IDEF1, IDEF3; grammatical models; stage models; state transition diagram; role active diagram	I, II, III	Facilitator; learning support
Problem framing and problem solving; lack of a structured organizational memory	Design rationale; simulation; decision tree; state transition diagram	I, II, III	Decision-making support; learning support
Lack of a strategic vision (short-term vision)	Maps; IDEF5	I, III	Learning support; facilitator
Change management; conflict management	Active workflow diagram; role-active diagram; tools for performance measurement	I, II	Facilitator
Communication among departments due to the development of different thought world	Cognitive maps; IDEF5	I, II	Facilitator
Blame culture	Affinity diagramming; Delphi technique; “out of the box thinking” method; design rationale; IDEF3	I, II, III	Learning support
Lack of structured communication (internal and external to the firm)	IDEF1; data flow diagram; role-active diagram	I, II, III	Facilitator; learning support

capture the different interpretations held by various players in the IDP and support the strategy development.

Of course, identifying possible methods is easier than seeing them implemented. What is lacking therefore is not applicable BMT methods, but rather process-based research to identify the problems and needs SMEs encounter during innovation development. Our paper has made a start in this direction. We call for further process research on SMEs and IDP to fill this gap in the current literature. These studies could also be useful to record best practices and provide a guide to innovation, similar to the approach adopted for large firms by (Van de Ven and Poole, 1990). This knowledge could be used to create a generalized model of IDP in SMEs and a handbook such as that proposed by (Malone *et al.*, 1999). In this way SMEs could have a standard against which compare their performance as well as a repository of knowledge and a reference to guide their work.

This paper represent the first stage of a research project aimed at studying innovation development within SMEs and methods to support it. The field study we presented only refers to SMEs that work in traditional and mature markets, which mostly develop incremental innovations. However they are not representative of all the typologies of SMEs. The analysis we proposed thus needs to be extended to a larger sample of firms and to firms working in new sectors, such as information technology and biotechnology.

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