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A knowledge-based system to diagnose the innovation process in industrial firms

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Abstract

In this paper, we assume that managers are unfamiliar with the research concerning product innovation management because this research is not presented in a way that allows for comprehension and knowledge transfer. We therefore designed a knowledge-based system aimed at improving the intelligibility of the product innovation process and synthesising heterogeneous knowledge from different research fields by means of systemic modelling. Furthermore, the 'DIAPASON' system (a diagnosis tool of innovation process) is described and the results of the implementation of this pilot system in four industrial firms are presented. Finally, we discuss the need for further research to improve our understanding of complex organisational processes using knowledge modelling .

Keywords

Innovation management, process, knowledge-based system, diagnosis, systemic modelling, knowledge transfer, organisational learning.

1 INTRODUCTION

It has become obvious that innovation or new product development has to be encouraged to keep firms competitive in complex and fast changing environments. For the last twenty years, management research has provided a wide range of recommendations to improve innovation management. However, firms still make the same mistakes in their new product programs (Cooper, 1983). One reason why firms find it difficult to act on research findings is that failure or success has been reported on a variable-by-variable basis, whereas managers tend to think in terms of global models (Cooper, 1983 ; Van de Ven, 1986). Barclay (1992) observed that most research results concerning innovation management are on the whole unknown to managers and that they are not available in a clear and understandable format.

As Brown et al. (1989) point out : '*The results of research in the area of innovation were never really synthesised to the point where managerially useful insights were developed*'

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We assume that the lack of intelligibility of the innovation process for both researchers and managers is related to :

- The breadth of domains or fields of expertise involved in the management of the innovation process,
- The ambiguity or complexity of this process which is closely linked to the specific characteristics of each firm and to the individual behaviour and perceptions of each actor involved in the process (Akrich and al.1988, Crozier 1977).

Therefore, the aim of this article is to explain how we tried to articulate knowledge of innovation management in a theoretical model that we implemented through a knowledge-based system.

We have focused this research on 'incremental product innovations', in medium size industrial firms. The model was developed and applied to the stages of the process generally called 'pre-project phases' (from strategy formulation to product specification).

The choice of incremental innovations as opposed to technical breakthroughs can be justified by the importance of incremental innovations and their relative 'manageability' (Drucker, 1985). This choice can also avoid problems of confidentiality during the field implementation of the system.

This research focuses on the strategic phases of the process because of the impact of strategic choices on the overall project performance (Cooper, 1984). In addition, the decision making processes involved in these phases are plagued by uncertainty and equivocality. (Daft and Lengel, 1986). Moreover, recent approaches like Business Process Reengineering (Champy, 1995) do not sufficiently take into account the strategic aspects of firms' development and the innovation process.

This research is the basis of a PhD (Chanal, 1995) and implements a research methodology developed in the team of Professor Lesca (Chanal and Lesca, 1995) to improve our understanding of complex processes through knowledge modelling and use of knowledge-based systems prototypes.

This article first examines the specificity of knowledge modelling in the case of a **complex process** such as innovation management and presents a theoretical framework adapted to complexity and referring to the systemic paradigm. We then discuss the 'philosophy' of the knowledge-based system DIAPASON (Diagnosis of Innovation Management) : it is not really a decision support system nor an expert-system but rather a 'knowledge-based decision support system' (KBDSS) designed to improve the intelligibility of complex situations for all the actors of the process. The DIAPASON system is then described and its level of complexity assessed using the framework presented by Meyer and Curley (1991) The main effects of the implementation of the system in four industrial firms are then discussed, along with concluding remarks and suggestions about further research to design knowledge-based systems that may be used for organisational diagnosis purposes.

2 A THEORETICAL FRAMEWORK TO MODEL COMPLEX SYSTEMS

2.1 Characteristics of the innovation process

Definition

We define a process as '*a system of organised activities occurring in time and aimed at an objective*'. For example the innovation process transforms a technology from concept to commercialisation.

Efforts to model process knowledge have to take into account the **time dimension** (particularly how information and communication flows structure the different activities throughout the system), and also the **different actors** of the process. This knowledge is difficult to model as it tightly depends on the specific situation of each firm : '*Every innovation typically involves a different blend of processes. The way in which these processes are combined and blended is the art of managing innovation. To complicate matters further, there are perhaps as many different ways to manage innovations as there are different innovations*' (Souder, 1987).

A decision making process

Many models of the innovation process are based on a sequential representation of activities, from the idea of a new product to its launching on the market. For this research, we decided to study the process stages from strategy formulation to product design which are both the more strategic and the less structured activities.

We can notice a similarity between these 'pre-project phases' and the Simon decision-making model : The idea generation phase would be the **intelligence phase**, the feasibility study and concept definition would be the **design phase**, and the project evaluation would be the **choice phase** of Simon decision-making model (Simon, 1982).

Most problems occurring in the innovation management in the early stages of the process are therefore **decision-making problems**. This assumption is consistent with many observations of the main problems encountered in the management of innovation (Gobeli and Brown 1993, Van de Ven 1986).

This 'decision dimension' of the innovation process leads us to think of a 'decision support system' to help actors of the process.

A complex, transversal process involving heterogeneous knowledge

The innovation process is often described as a complex system with uncertainty and risk taking (Akrich et al.1988, Foster 1986). If we admit that expert knowledge of innovation management has been widely covered by research publications, the question is how to transfer this knowledge from academics to managers. Useful scientific knowledge to improve innovation management can be found in different domains : strategy, marketing, finance, project organisation, information systems, engineering, product design and also cognitive sciences, organisational learning, psychology.

This 'transversal dimension' of the innovation process leads us to try to articulate existing knowledge from different domains into a consistent model.

A collective process
The innovation process involves many actors inside and outside the organisation. An alternative theory to the determinist diffusion model of innovation (Rogers and Shoemaker, 1971) appears to be a constructivist approach in which we take into consideration specific interests of the different 'stakeholders' of the project (Crozier 1977 , Akrich et al.1988, Mason and Mitroff 1981). We must therefore take into account contextual knowledge (objectives of the project, rationality of different actors, type of environment) to understand the meaning of the innovation activities. It seems also necessary to create a collective representation of what is going on in the process to identify areas of conflict and contradiction.

The 'collective' dimension of the innovation process leads us to take into account the perceptions and motivations of different actors of the process to create a common representation of the situation.

2.2 A theoretical framework to model complex systems

Le Moigne (1990) has developed a method to improve the intelligibility of complex systems : 'systemic modelling'. This method is based on the system analysis involving the study of information flows and the memory process, the decision-making process, and the coordination mechanisms. We applied the systemic modelling principles of Le Moigne to a theoretical model of the innovation process including a sequential and a systemic dimension.

In effect, each of the 150 rules we could draw from the literature analysis, fit into a matrix (phase of the process / systemic analysis). The third dimension of the cube (strategic dimension) will guide the data gathering in firms as we interview different actors of the process. See Figure 1.

3 IMPROVING THE INTELLIGIBILITY OF A COMPLEX PROCESS

3.1 Knowledge-based decision support systems (KBDSS)

For Borch and Hartvigsen (1991), knowledge-based systems provide the benefits of both expert-systems (ES) and decision support systems (DSS). The authors give the following definitions of DSS and ES :

'A decision support system is a coherent system of computer-based technology. It is used by managers as an aid to their decision making in semi-structured decision tasks and focus on supporting rather than replacing managerial judgements'

'An expert system is a computer program using expert knowledge to attain high levels of performance in a narrow problem area. Expert systems can offer decision makers important support for dealing with the domain of their decision.'

Owens and Philippakis (1995) go a step further by referring to the concept of knowledge-based decision support system (KBDSS) which provides both new modelling and analysis capabilities to the decision maker. **In that sense our system can be assimilated to a KBDSS.**

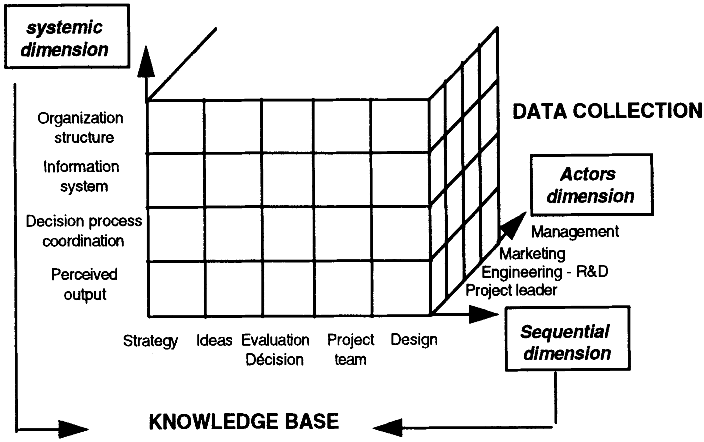

Figure 1 A theoretical model of the innovation process.

3.2 Computer-based systems for strategic processes

We focus here on some experiments of decision support systems to help strategic decision-making and try to outline the specificity of strategic problems. These experiments are applied to strategic planning (Borch and Hartvigsen 1991, Tanguy 1992). The first research concludes that '*one of the fundamental problems is the lack of understanding of the cognitive processes of management in ill-structured areas*'.

Tanguy (1992) tries to model the strategic planning process by focusing on the following questions :

- How to represent complex interactions in the decision-making process
- How to rapidly evaluate financial consequences of strategic options
- How to lead the firm to adopt a coherent strategy with each manager being aware of his own responsibility in the whole process.

These questions led the author to suggest some principles of strategic decision supporting :

- Planning consists of putting the firm into a situation of **organisational learning**
- The decision support system is also a **communication tool** and a simulation tool, and helps managers to identify areas of conflict and to simulate different options.

The experience of knowledge-based systems developed in the team of Professor Lesca in Grenoble (France) to improve our understanding of complex processes such as organisational learning (Picq, 1991), competitive intelligence (Schuler, 1994), and more recently, innovation process (Chanal, 1995) have contributed to a research methodology for management science using knowledge-based systems. They are designed to **provide a representation tool and a basis for a collective discussion.** The actors are often not able to formulate clearly what is wrong with the management of the process, and if they can, they usually do not agree about the origin of problems or about how to solve them (Chanal and Lesca, 1995).

This 'communication' and 'collective' dimension of the system is consistent with the Souder's analysis (1987) of decision models for evaluating innovation projects : '*It does not seem to matter so much what specific types of models are used. The process is more important. Any model that opens communication and moves the organisation toward an* *honest and open discussion of its options and its strategic technical plans is an effective model.'*

Some of these knowledge-based systems for strategic decisions are more 'DSS-like' as they require little knowledge but focus on the firm's situation (Choffray and Lilien 1982, Borch and Hartvigsen 1991, Tanguy 1992), whereas other systems are more 'ES-like' as they include a broad knowledge-base. This is the case of our system since its level of knowledge complexity is rather high as we will see later.

3.3 A diagnostic approach

Nonaka (1990) argues that most research work on innovation refers to a *'problem solving or information processing'* paradigm. However in real world practice, as he says, problems do not present themselves to the practitioner as givens. They must be constructed from the materials of problematic situations which are uncertain. We have therefore to move from a problem solving model to **a problem generating or information creating model.**

This is the core of the philosophy of the system : although it is based on a large domain knowledge about innovation management, it is aimed at comparing a theoretical model to real life situations. This confrontation consists in a 'mirror' approach as it is widely used in psycho-sociology (Ortsman, 1992). In this framework, the system provides a representation of a specific situation as it is perceived by the different actors of the process.

This representation is not supposed to reflect the 'truth' or the 'reality' but simply to generate new questions and to encourage discussion of the process.

4 THE DIAPASON SYSTEM

4.1 High knowledge complexity and low technical complexity

Before we present Diapason in greater detail, we will assess the complexity of the system, to enable specialists of KBS to compare this system to others with which they are more familiar.

To measure the complexity of this system, we used the framework for classifying the complexity of knowledge-based systems developed by Meyer and Curley (1991). According to this framework, our system presents a high level of knowledge complexity and a low level of technical complexity. The scores for each variable of Meyer and Curley's framework are presented in Table 1.

The final score obtained for the Diapason system is 82 for knowledge complexity and 35 for technological complexity. Note that the classification of 50 systems done by Meyer and Curley using this method results in a mean for knowledge complexity of 57 (with a minimum of 33 and a maximum of 100) and a mean for the technology dimension of 49 (with a minimum of 30 and a maximum of 80).

Table 1 Scoring the Diapason system's complexity using the framework of Meyer and Curley (1991)

Variable	*Definition by Meyer and Curley*	*Assessment for Diapason*	*Score (scale)*
	DEFINING KNOWLEDGE COMPLEXITY		
Breadth of domain	Number of specific fields of expertise	More than 2 : IS, strategy, marketing etc.	3 *(1-3)*
Depth of domain	Education and work experience of experts	Use of scientific research only	3 *(1-3)*
Rate of change of domains	Degree to which the underlying disciplines are changing	Moderate rate of change but new approaches like BPR	2 *(1-3)*
Domain penetration	Degree to which the system captures the full scope of domains	The system is quite general	3 *(1-5)*
System output	Comprehensiveness of system output	Outputs : problem diagnosis + recommended actions	2 *(1-4)*
Breadth of information inputs	Number of different information inputs in the system	4-5 actors of the process are interviewed	3 *(1-3)*
Ambiguity of information inputs	Is additional interpretation required ?	The system requires a mediator to interpret users' perceptions	3 *(1-3)*
	DEFINING TECHNOLOGY COMPLEXITY		
Diversity of platforms	Number of different computer architectures and O.S.	Developed with Toolbook on a PC (windows)	1 *(1-3)*
Diversity of technology	Type of other technologies included in the system : graphics, spreadsheets, imaging, voice	The system includes text and a graphic representation of the situation	2 *(1-6)*
Database intensity	Size of the underlying reference database	Less than 1 Mb	1 *(1-3)*
Network intensity	Use of networking for accessing other databases or applications	Stand-alone system	1 *(1-3)*
Scope of KB programming effort	Degree of difficulty in the encoding of the KB	Less than 500 rules	1 *(1-3)*
Diversity of information sources	Number of information sources	3 to 4 people interviewed for each stage of the process	2 *(1-3)*
Diffusion of the expert system	Number and diversity of users	The system is still a prototype : only one user	1 *(1-3)*
Systems integration effort	Degree of programming effort to integrate the system with existing IS	Not a factor	1 *(1-5)*

Our system is thus placed in the 'knowledge intensive systems' quadrant described by the authors as follows: '*These systems often span multiple complex domains and resolve uncertainty in the information inputs used by the expert system in its reasoning process to make decisions. They are technologically uncomplex and tend to operate on single hardware platforms utilising small databases*'.

4.2 Description of the system

DIAPASON has been developed with the 'Toolbook' hypertext software. It does not use an inference engine which means that all answer combinations (about 500) are pre-analysed and stored in the knowledge-base. The hypertext technique allows us to adapt the questions to the specific situation of the firm. For example, if the firm uses 'value analysis' or QFD method for product design, the system will ask complementary questions about the conditions under which this method is used. We will first describe the knowledge-base and then the main functions of the system.

The knowledge-base

The knowledge-base is made of 150 elements of knowledge (rules) and about 500 units of explanation drawn from scientific management research.

To model this knowledge, we were not in the situation to interview the experts of the domain. Therefore, we sometimes had to choose between contradictory knowledge such as the role of the 'gatekeeper' in the organisations. Some authors say that the gatekeeper plays a key-role in innovative organisations (Roberts and Fusfeld, 1981), others argue that a gatekeeper's role should not be too formal because managers tend to look themselves for the information they need (Macdonald and Williams, 1993), while others suggest an alternative structure to gatekeepers which is a network of information gathering involving all team members (Davis and Wilkof, 1988). It is not always easy to draw a unique rule from different knowledge but by doing this **we underline the contradictions or ill-structured elements of knowledge in the literature**, which in itself is a scientific contribution.

Each rule fit into one cell of the theoretical matrix (systemic dimension / sequential dimension). For example one set of rules deals with R&D-Marketing relationships during the idea generation phase (communication should be frequent and relatively informal, dealing with themes such as new technical possibilities, changes in customer needs, competitors ' strategies). This set of rules takes place in the cell 'coordination / idea generation phase' and leads to specific questions such as :

• *How would you define the communication between R&D and marketing departments during the idea generation phase :*

rather frequent	***rather non frequent***
rather formal	***rather non formal***

• *Do the members of technical and marketing teams often communicate about the following themes :*

New technical possibilities	***yes***	***no***
Changes in customer needs	***yes***	***no***
Competitors' strategies	***yes***	***no***

Data collection concerning the innovation process in industrial firms

Data collection on each firm's situation is done with interactive questionnaires. We decided to limit the required answer to a simple alternative like 'rather yes' or 'rather no' as we aim to get a subjective perception of the actors about the process and not to measure a variable precisely. Different managers involved in the innovation process are interviewed to generate a comprehensive diagnosis.

Data processing and weighting of rules to interpret the answers

Weighting rules and rating the different answers in order to produce a relevant representation of the situation proved difficult. To do this, we adapted an empirical and incremental approach, testing the system with artificial and extreme situations to check if the weights were coherent. We also used most of the theoretical knowledge. For example, if a rule says that, during the ' idea generation phase', understanding of customer needs is more crucial than technical information, we will rate 'market information' higher than 'technical information'.

Display of a synthetic diagnosis for each phase of the process

For each phase of the process, the interviewed manager has to answer about 30 questions with the help of the consultant or the researcher. At the end of the session, the system displays a synthetic chart with main strengths and weaknesses for each systemic dimension of the model. See Table 2.

Explanations and advice

Borch and Hartvigsen (1991) say that, for knowledge-based systems, '*a critical factor is the quality and applicability of the system explanations*'. As our system is designed to be a basis for discussion about problems and ways to handle them, the explanations of the system feedback have to be as explicit as possible. Therefore, the user can ask for complementary explanations and suggestions by clicking on each cell of the chart (either positive or negative). The comments and advice form a basis for discussion with the manager. For example, in one firm, one of the system's recommendation was to improve interfunctional mobility. The manager's comment was that he agreed with this advice but that he faced real difficulties such as training or incentive problems, to implement this mobility.

Interpretation of perception differences (collective diagnosis)

We assumed that the interpretation of differences of perception among the participants would provide a richer and more comprehensive representation of the process. This would be a useful function of the software, but which we had no time to implement in the system and that we processed manually. However it has been technically evaluated in the context of a group decision support system software which is 'Groupsystem'

Table 2 An example of display of diagnosis for one phase of the process

Phase of idea generation	*OK*	*Could progress*	*Priority efforts*
Organisation			
Rules, values, style of management	■		
Structure of the firm	■		
Managing human resources			■
Information system			
Business intelligence		■	
Marketing information			■
Technological information	■		
Memory and storage of information		■	
Decision making process			
Objectives setting	■		
Creativity, idea generation methods	■		
Internal communication		■	
Perceived output of idea generation	■		

5 IMPLEMENTATION OF THE SYSTEM

5.1 Experimentation protocol

This diagnosis system has been implemented in four medium size industrial firms (500 to 1000 employees). Three of them manufacture electronic products and the fourth is a software firm. We have focused on 'incremental' innovation projects significant enough to justify a project-team organisation.

In each firm, about five managers (general manager, marketing manager, R&D manager, engineering manager, and project leader) were interviewed, during two sessions of about two hours each. After the individual interviews, we synthesised all the results and organised a final meeting during which main issues were discussed with all the participants.

5.2 Evaluation of the benefits of the system

Contribution of the knowledge-base

The knowledge-base contributes to identify problems that managers may not have otherwise considered. For example, in one firm, we identified the fact that the production manager was involved too late in the process to evaluate the product design before it moved to the development phase. If we had analysed the formal procedures in this firm, we would have thought that the engineering department was involved at the right time.

The wide range of themes studied in the base appears to be necessary. Although the three industrial firms are quite similar (size, types of products, environment), they encounter different problems in the management of the innovation process. One has difficulties organising project teams. The second one is well organised in terms of project management but lacks creativity to identify new projects.

The third one has a solid technical background and many new product ideas but shows signs of marketing weakness that hamper understanding of customer needs for product design.

Benefits of the systemic approach

The systemic articulation of concepts enables the identification of different aspects of a generic problem. For example, in one firm, the marketing-R&D relationships seemed to be satisfactory, however we did notice some problem areas : the time of project evaluation was too long ; it was difficult for the various departments to find an agreement about product design ; some managers were not satisfied with the organisation of the project team. All these issues are in fact different consequences of a generic problem which is the lack of authority and competence of the marketing department in the new product development process.

The systemic approach also helps to better understand information feedback during the process and shows the need for anticipation at each stage.

Legitimacy of the system for the industrial users

The complementary explanations that come with the synthetic chart are a good basis for discussion and also lead the participants to be more confident with the 'expertise' of the system. Even if they do not always agree with the suggestions, they can understand why the system is reaching certain conclusions and can easily argue for or against the analysis of the situation. Nevertheless, this system could not be used by the end-users without the mediation of a researcher or a consultant because the outputs of the system require some additional 'human' interpretation.

The diagnostic output

The main interest of this diagnostic tool lies in an immediate, structured and argumentative feedback of the innovation process. Strengths and weaknesses are classified to enable the managers to focus on the more crucial issues.

Generally, participants find that the time invested in the diagnosis process is relatively small compared with the accuracy of recommendations. This would tend to support the assumption of a better efficiency of the diagnosis with such a knowledge-system.

As far as the validity of restitution is concerned, we can say that the system has never produced incoherent feedback for the users and that the weighting procedure seems on the whole to correspond to the actors' perception of the situation. Nevertheless, the users expressed the need for some adjustments of the system to better adapt to the specific characteristics of their firm such as : nature of relationships with suppliers or with clients, customisation of products, use of methods like value analysis in the design process.

5.3 Additional features and research directions

The implementation of a diagnosis system in four firms gives us some insights into further research or system development that could be interesting for other organisational diagnosis.

As far as the knowledge-base itself is concerned, the participants suggested future improvements such as : having more advise to implement progress actions or more detailed explanations about different methods like creativity or value analysis. This kind of development is technically feasible with the hypertext approach.

Managers tend to find the system 'too general' and not enough adapted to their particular situation. This remark raises two questions. One is related to the 'learning capacity' of the system, which should take into consideration variables describing the firm and its environment. This aspect also refers to the necessity of 'knowledge refinement' defined as :'*The generation, testing, and possible alteration of rules in an existing knowledge-base, in an attempt to improve the system's performance*' (Owens and Philippakis, 1995).

The second question is related to the interest and feasibility of developing specialised knowledge-bases adapted to a certain type of firm or industrial sector. The different situations we could observe in relatively similar firms in the electronics sector tend to show that too narrow a specialisation of the knowledge-base would not be relevant.

Some developments can be suggested for the system itself. The first one is the use of the system directly with a group of managers, using GDSS technologies. We think that a collective diagnosis would have a different purpose to that of a diagnosis based on individual interviews. During individual interviews, managers tend to make confidential comments that they would not express in a group. A group session would be more useful for a group of managers to rapidly identify the main issues in the innovation process.

The second direction of development is related to the use of scales in the answers to differentiate between 'definitely yes', 'rather yes ' , or 'it depends' . But even if such a development is technically feasible, the domain knowledge related to innovation management will perhaps not be sufficient to interpret all the combinations of answers if there is more than two modes.

6 CONCLUSION

This article has presented an overview of the use of a knowledge-based system in four industrial firms, the goal being to diagnose the innovation process in order to give the different managers involved in new product development some advice to improve organisational structures, information flows and communication.

By formalising academic knowledge related to the innovation process in a knowledge-based system, we have tried to contribute to a better understanding of the innovation process and to knowledge transfer from research to business. The observations made with the Diapason system outline the importance of using a knowledge-base covering a large spectrum of organisational problems that may occur in the management of innovation. Moreover, the methodology of diagnosis consisting in individual interviews followed by a group meeting appears to be very interesting to elaborate a common vision of the innovation process and consequently a better understanding of the group decision-making process in the context of product innovation. This collective dimension of the diagnosis could be reinforced with the development of a 'group decision support system'.

7 REFERENCES

Akrich M., Callon M. and Latour B. (1988) A quoi tient le succès des innovations. Premier épisode : l'art de l'intéressement. *Annales des Mines*, **June**, 4-17.

Barclay I.(1992) The new product development process. Part 1 : past evidence and future practical application. *R&D Management*, **22, 3**, 255-63.

Barclay I.(1992) The new product development process. Part 2 : improving the process of new product development. *R&D Management*, **22, 4**, 307-17.

Borch O. and Hartvigsen G. (1991) Knowledge-based systems for strategic market planning in small firms. *Decision Support Systems*, 7, 145-57.

Brown W. and Karagozoglu N. (1989) A systems model of technological innovation. *IEEE Transactions on Engineering Management*, **36, 1**, 11-6.

Champy J. (1995) *Reengineering Management : the mandate for new leadership*. Harpercollins Publishers, New-York.

Chanal V. (1995) *Le management de l'innovation de produit industriel : mise en oeuvre d'une démarche de diagnostic pour améliorer notre compréhension du processus.* Th. doct. : Sci. de Gest. : Grenoble 2, ESA.

Chanal V. and Lesca H. (1995) *Méthodologie de recherche : vers une ingénierie de la recherche en gestion.*, Publications du CERAG, ESA, Université Grenoble 2, **95-10**.

Choffray J.M. and Lilien G. (1982) Designor : a decision support procedure for industrial product design. *Journal of Business Research*, **10**, 185-97.

Cooper R.(1983) A process model for industrial new product management . *IEEE Transactions on engineering management*, **EM-30, 1**, 2-11.

Cooper R. (1984) The strategy-performance link in product innovation. *R&D Management*, **14, 4** , 247-59.

Crozier M. et Friedberg Erhard (1977) *L'acteur et le système*. Seuil, Paris.

Daft R. and Lengel R. (1986) Organizational information requirements, media richness and structural design. *Management Science* ,**32, 5**, 554-71.

Davis P. and Wilkof M. (1988) Scientific and technical information transfer for high technology : keeping the figure in its ground. *R&D Management*, **18, 1**, 45-58.

Drucker P. (1985) *Innovation and entrepreneurship*. Heinemann, London.

Foster R. (1986) *Innovation, the attacker's advantage*. Summit Books, New-York.

Gobeli D. and Brown D. (1993) Improving the process of product innovation. *Research Technology Management*, **March**, 38-44.

Le Moigne J.L. (1990) *La modélisation des systèmes complexes*. Dunod, Paris.

Meyer M. and Curley K. (1991) An applied framework for classifying the complexity of knowledge-based systems. *MIS Quarterly*, **Dec**, 455-72.

Macdonald S. and Williams C. (1993) Beyond the boundary : an information perspective on the role of the gatekeeper in the organization. *Journal of Product Innovation Management*, **10, 5**, 417-27.

Mason R.O. and Mitroff I. (1981) *Challenging strategic planning assumptions*. Wiley, New-York.

Nonaka I. (1990) Redundant, overlapping organization : a japanese approach to managing the innovation process. *California Management Review*, **Spring**, 27-38.

Ortsman (1992) Peut-on changer l'organisation du travail et la culture de l'entreprise ? *Revue Française de Gestion*, **mars-avril-mai**, 5-17.

Owens H. and Philippakis A. (1995) Inductive consistency in knowledge-based decision support systems. *Decision Support Systems*, **13**, 167-81.

Picq T. (1991) *La maîtrise de la complexité par le développement de l'intelligence de l'organisation*. Th. doct. : Sci. de Gest. : Grenoble 2, ESA.

Roberts E. and Fusfeld A. (1981) Staffing the innovative technology-based organization. - *Sloan Management Review*, **Spring**, 19-33.

Rogers E. and Shoemaker F. (1971) *Communication of innovations*. 2nd ed. The Free Press, New-York.

Schuler M.(1994) *Genèse d'un outil informatique pour l'apprentissage et la mise en oeuvre de la veille stratégique*. Th. doct. : Sci. de Gest. : Grenoble 2, ESA.

Simon H. A (1982) *Models of bounded rationality*. The MIT Press.

Souder W. (1987) *Managing new product innovation*. Lexington Books, Lexington.

Tanguy H.(1992) Planification stratégique : pour un usage " rético-rhétorique " des modèles. *Annales des Mines*. **Sept**, 19-29.

Van de Ven A. (1986) Central problems in the management of innovation. *Management Science*, **32, 5**, 590-607.

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