Innovation, what innovation? A comparison between product, process and organizational innovation

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Abstract: This article compares and contrasts three types of innovations, namely: product innovation, process innovation and organizational innovation. From similarities and differences between these three types, implications for the theory and practice of innovation management are inferred. Most of these implications seem to be generic, i.e. generally applicable whatever the type of innovation and organization involved. Surprisingly few implications are contingent in that they are linked to the characteristics of the innovation involved.

Keywords: Innovation; process model; innovation roles; organizational arrangements; contingencies.

Reference to this paper should be made as follows: Boer, H. and During, W.E. (2001) 'Innovation, what innovation? A comparison between product, process and organizational innovation', *Int. J. Technology Management*, Vol. 22, Nos. 1/2/3, pp.83–107.

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1 Introduction

The present paper compares and contrasts findings from three empirical studies in which the authors have been involved, namely studies into:

- Product innovation, mainly in small and medium sized enterprises (SME) representing a wide range of Dutch industrial sectors (e.g. [1]).
- Process innovation, particularly the implementation of flexible manufacturing systems (FMS) in Dutch, UK and Belgian assembly companies (e.g. [2]).

- Organizational innovation; in this case the implementation of TQM in a wide range of Dutch industries (e.g. [3]).

The central question in this paper is: *what are the similarities and differences between the three types of innovations, how can these similarities and differences be explained, and which of the explanations are generic* (i.e. independent of innovation and context) *and which ones are contingent* (innovation or context dependent)? In order to be able to answer this question, we developed a process-based contingency model of innovation that would allow us to describe, analyse and explain how and why innovations develop and either become successes or failures (cf. [4–7]).

The paper is structured as follows. First, the term innovation is defined. Then, based on a wide range of innovation, organization and decision-making theories, six propositions are formulated. These propositions are the cornerstones of the innovation model described next. Subsequently, the three studies are introduced and their results described and analysed. The paper concludes with implications of the research for the theory, management and research of innovation.

2 Innovation

Innovation is the creation of a new product-market-technology-organization-combination (PMTO-combination [8]). This definition suggests that there are three key elements:

- Innovation is a process and should be managed as such. Key activities in innovation management are: goal formulation, designing and organizing the process, monitoring progress and, if necessary, adjusting the goals, the process and/or its organization.
- The result is at least one new element in the company's PMTO-combinations. Product innovation, for example, involves the development, production and commercialization of new products and may require the development of new process technology or market segments. Technological innovation, i.e. the in-house development of new process technology, or the adoption and implementation of technology developed elsewhere, usually also requires organizational adaptation, but need not be linked to new product or new market development.
- The extent to which the innovation is new may range from incremental, small step innovation, through synthetic innovation, i.e. the creative recombination of existing techniques, ideas or methods, to discontinuous, radical, quantum-leap innovation (see e.g.[9]). Another aspect regards the subject to whom the innovation is new. This may range from new to the world, a country/society or an industry, a company or an individual. In the present paper, new means: new, somewhere on the continuum, to the company involved.

3 Six propositions on innovation

The process-based contingency model of innovation presented in the next section is derived from six propositions that are based on various innovation, organization and decision-making theories.

3.1 Proposition 1

The effective management of innovation requires the 'innovation manager' [10] to have

- *a goal or, at least, some mechanism to evaluate progress made,*
- *a model of the innovation process,*
- *information on the actual environment and state of the innovation process,*
- *qualitatively and quantitatively sufficiently adequate interventions to redesign the process, its organization and/or environment or, if need be, goals (cf. Ashby's law of requisite variety [11]), and*
- *sufficient information processing capacity to predict or, at least, evaluate the effects of interventions made or considered.*

Derived from the control theory of organizations, these so-called 'prerequisites for effective control' [12] are well accepted, though often implicitly so, in the management of more routine activities, such as manufacturing or assembly processes. Innovation, by contrast, has always been, and often still is, regarded as something so uncertain that the best a company can do is put sufficient resources into it and then hope for the best. We believe that companies can do better than that, and that a thorough understanding of the typical characteristics of innovative activity provides the basis for the effective management of innovation. This article concentrates on (2) the required model and (5) the information processing capacity required to perform innovation processes successfully.

Many publications on intra-firm innovation and innovation diffusion alike do take in some model of the innovation process. Usually, however, the purpose of that is not so much to discuss the innovation (diffusion) process itself, but rather to provide a basis for examining:

- Factors of success, delay and failure [13–16],
- Context-process linkages [17–21],
- The role of key individuals, i.e. so-called innovation roles [22–26], or
- Factors explaining diffusion and adoption rates [27–28].

Empirical research aimed at capturing what is actually going on during innovation processes is relatively recent but increasing [1,4,6,7,29]. Incorporating theories referred to above, particularly those on context-process linkages and innovation roles, as well as other theories discussed later in this section, the model proposed in section 4 is the result of process research [1–2].

3.2 Proposition 2

Innovation processes are characterized by certain levels of uncertainty, complexity, and diversity, and interdependence. The success of innovation depends on the extent to which the 'innovation manager' is able to fit the organization of the process to the demands created by these characteristics.

The relatively easiest processes, from an organizability point of view, are routine, i.e. low variety and high analysability processes [30]. Unfortunately, innovation processes are the opposite of that. The process characteristics most frequently mentioned in the literature are:

1 *Uncertainty*: the extent to which individuals, groups or organizations are informed about the future (e.g. [31]).

2 *Complexity* (analysability): the difficulty with which the work can be understood [32]. Most innovation processes comprise a mixture of fairly simple to extremely difficult activities.

3 *Diversity*: the variety of the work that needs to be done [32], in terms of the number of competencies needed to perform the innovation process.

4 *Interdependence*: the extent to which (groups of) people depend on each other for their functioning [33].

There are several different strategies to provide the innovation process with the information processing capacity required to cope with high levels of uncertainty, complexity, diversity and interdependence. Well-known examples include:

- Goal setting and deployment, to reduce uncertainty.
- Innovation roles (see below), to cover the diversity and complexity of the process.
- Lateral linkages (e.g. project teams) to facilitate communication between interdependent functions and to increase information processing capacity in order that these functions are better able to cope with uncertainty.
- Slack resources (knowledge, time, budget) to reduce the amount of information that must be processed and to allow for (trial and error) learning.
- Information and communication technology, especially in spatially dispersed innovation activities.

Failure to implement a suitable set of strategies may well explain the failure or delay of so many efforts to innovate.

3.3 Proposition 3

The organizational conditions most conducive to earlier stages (initiation, adoption) of technological innovation are low centralization, low formalization and high professionalism. The opposite conditions – high centralization, high formalization and low professionalism, are more appropriate during later stages (implementation) of the innovation process.

The organizational conditions conducive to organizational innovation are high centralization, high formalization and low professionalism.

The various process characteristics usually change in the course of the process, thus requiring the 'innovation manager' dynamically to adapt the organization of the innovation process to the actual characteristics of the process.

Research into the relationships between organization and innovation started with Burns and Stalker [17], who found that organic structures are better able to deal with innovative situations than are mechanistic structures. This conclusion started a stream of research aimed at identifying relevant organizational characteristics and explaining their influence on the innovation process. The three most important characteristics seem to be:

- Centralization: the degree to which the right to make decisions is concentrated.
- Formalization: the extent to which the organization uses rules and procedures to prescribe behaviour, by specifying who is to perform which tasks, how and when.
- Professionalism: the proportion of specialist employees of the organization.

Research has shown that the organizational conditions most conducive to earlier stages (initiation, adoption) of innovation are low centralization, low formalization and high professionalism. The opposite conditions – high centralization, high formalization and low professionalism, are more appropriate during later stages (implementation) of the innovation process [5,18–20]. Daft [21] made a noteworthy comment on this rather generally accepted proposition. He concluded that low formalization, low centralization and high professionalism are suited to the initiation and adoption of technical (i.e. product and process) innovations. The opposite conditions facilitate administrative (i.e. organizational) innovation. The explanation would be the organizational setting of the key players in these types of innovations: high levels of formalization and centralization, and a relatively low level of professionalism for 'administrators'; a relatively high level of professionalism and low levels of formalization and centralization for technical experts.

3.4 Proposition 4

The better:

1 the match between the people involved in the innovation process and the role(s) they are to play in the process, and

2 the timing of their implementation,

the greater the likelihood of success.

Innovation is an essentially human activity rather than that of hardware or even software technologies. In the literature a wide range of so-called innovation roles have been identified [22–26]:

- idea generator
- entrepreneur or champion
- sponsor or coach
- project leader
- gatekeeper

In addition, During [1] has identified, and shown the importance of:

- problem owner
- problem solver
- scout
- ambassador
- reorganizer
- integrator

Actually [2], each of the innovation roles represents a combination of:

- *Intellectual or cognitive attributes*: knowledge, experience, skills, and intelligence.
- *Behavioural attributes*: attitude, personality, values, personal objectives.
- *Position*: responsibility, power base.

According to Roberts and Fusfeld [25],

> "the importance of each critical function varies with the development stage of the project. Initially, idea generation is crucial. Later, entrepreneurial skill and commitment are needed to develop the concept into a viable activity. Once a project is established, good leadership is needed to guide its progress. (…) Thus, the absence of a function at a time it is potentially important is a serious weakness, regardless of whether or not the role had been fulfilled at an earlier, less crucial time".

This finding reinforces the need for dynamic management of the innovation process. Furthermore,

> "(1) some roles, e.g. idea generating, frequently need to be fulfilled by more than one person in a project team in order to be successful; (and) (2) some individuals occasionally fulfil more than one critical function …".

Common combinations are the pairings of the gatekeeper and the idea generator, the entrepreneur and the project leader, and the sponsor and any of the other roles (see also e.g. [23–24]). In the next section more details of these roles can be found, in particular the way the various roles are linked to the constituent activities of the innovation process (see Table 1).

Table 1 The innovation roles, their main characteristics and their function in the innovation process

Role	*Attributes*	*Functions in*		
		Problem solving	*Internal diffusion*	*Organizational adaptation*
	Operational Roles	X		
gatekeeper	Collects and channels information about important changes in the internal and external environment			
scout	Surveys a specified, yet unexplored field by collecting specific information	X		
idea generator	Analyses or synthesizes information about markets, technologies, approaches or procedures, from which are generated ideas for solving the innovation problem	X		X

Table 1 The innovation roles, their main characteristics and their function in the innovation process (continued)

Role	*Attributes*	*Functions in*		
		Problem solving	*Internal diffusion*	*Organizational adaptation*
problem solver	Solves the PMTO-aspects of the innovation; usually this role involves various people, specialized in product development, marketing or production engineering or in the case of organizational innovation, with an HRM or managerial background (see also the re-organizer below)	X		X
	Managerial and supportive roles			
problem owner	Perceives a gap between the actual and the desired situation which is wide enough for him to start corrective action; a crucial role but difficult to implement deliberately	X		
champion	Recognizes, proposes, pushes and demonstrates a new idea for formal management approval, using his position and enthusiasm	X	X	X
project leader	Plans and co-ordinates the various sets of activities and people/role occupants; is involved in and committed to moving an idea into practice; focused on decision making; interested in a broad range of disciplines	X	X	X
integrator	Balances attention paid to different innovation problems; his authority is possibly based on a fairly high hierarchical position	X		
coach	Guides and develops less experienced people in their critical roles; is able to support and protect the innovation process through his tenure and position	X		
ambassador	An approachable and personable communicator who disseminates the innovation within the organization, by communicating problems, ideas, solutions between the problem solver(s) and other people in the organization		X	
reorganizer	A (possibly high-ranking) person who initiates and realizes the organization of the innovation process and pulls the ropes if significant organizational adaptation is required as part of the innovation itself			X

3.5 Proposition 5

The adopter's perception of the innovation characteristics identified by Rogers [27] will affect the way the adopter will, at least initially, organize the innovation process. The five characteristics of innovations identified by Rogers [27] are:

- *Relative advantage*: the degree to which the innovation is perceived as better than the idea it supersedes.
- *Compatibility*: the degree to which the innovation is perceived as being consistent with existing values, past experiences, and needs of potential adopters.
- *Complexity*: the degree to which the innovation is perceived as difficult to understand and use.
- *Trialability or divisibility*: the degree to which the innovation may be experimented with on a limited basis.
- *Observability:* the degree to which the results of the innovation are visible to others.

These characteristics, as perceived by potential adopters, not only explain adoption rates [27] but also affect the way the adopter will, at least initially, organize the innovation process.

3.6 Proposition 6

Innovation is a highly uncertain and complex process, usually consisting of a wide range of interdependent activities. Therefore, innovation processes usually require the involvement of several different people,

- *whose rationality is bounded;*
- *who are not perfectly informed;*
- *whose information processing capacity is limited;*
- *who may not be entirely suited to their role in the process nor available each and every time their contribution is needed;*
- *whose own goals, preferences, personalities and intellect will affect their behaviour and attitude towards the innovation (process), and*
- *who will therefore not always (be able to) appreciate the real characteristics of the innovation and/or the innovation process, and/or to translate that into what is required for the innovation process to become a success.*

Dynamic matching, timing, easier said than done. The difficulty comes from the fact that there is not something like the monolithic '*innovator economicus*' (cf. the *homo economicus* with whom Simon, back in 1945, has once and for all finished; see [34]). Innovation is performed, supported and managed by people of flesh and blood, whose rationality is bounded, who have their own goals and preferences, whose information processing capacity is limited and who cannot be perfectly informed. Furthermore, innovation processes do not take place in a vacuum. Hence, all kinds of dynamic circumstances will affect the process in terms of events taking place and ways in which people collaborate. Consequently, a considerable a part of the process will consist of a search for goals, activities, ways of organizing the process, finding adequate people, valid and useful information and other resources.

3.7 Summary

The six propositions suggest that the success of innovation processes depends on the fit between:

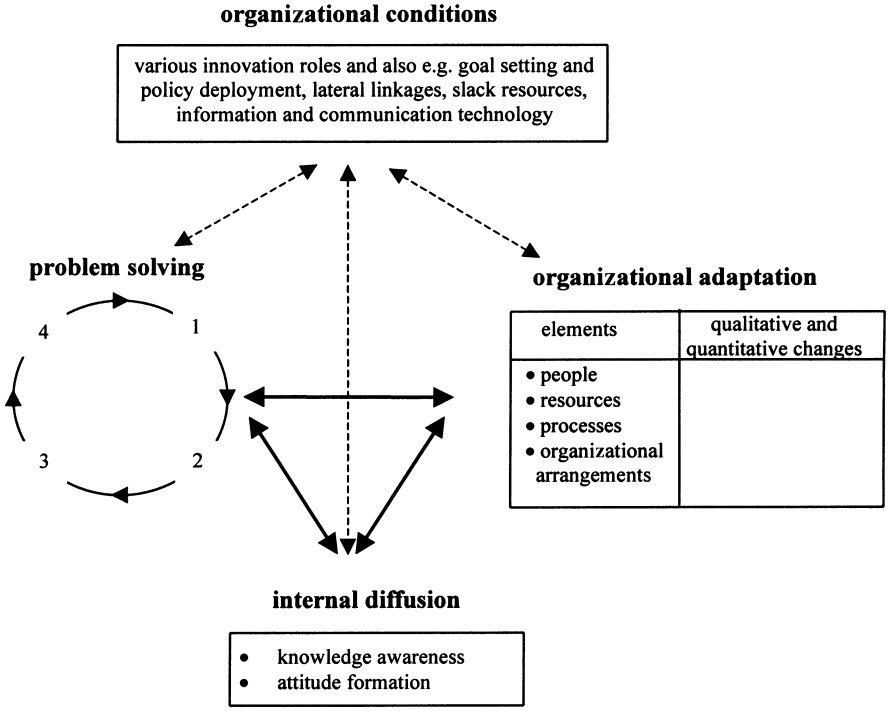
- the *required* characteristics of both the people conducting the process (prop. 4) and the way their contribution is organized (prop. 2), which are derived from the characteristics (prop. 2) and the dynamics (prop. 3) of the process, and the type (prop. 3) of innovation involved, and
- the actual characteristics of the people involved (prop. 6), their perception of the innovation (prop. 5) and the innovation process (props. 2 and 3), and the way these perceptions are effected in the organization of the process (props. 2 and 4).

This 'hypothesis' provided the basis for the development of the innovation model described next.

4 A process-based contingency model of innovation

The innovation model proposed by During (see [1–2]) combines his own empirical findings with several of the theories referred to in the previous section. The core of the model is that the successful realization of a new PMTO-combination requires a balance between the characteristics of the process, the people involved in the process and the organization of the process (see Figure 1).

Figure 1 A process-based contingency model of innovation



4.1 The constituent processes

In the course of an innovation process three categories of activity can be distinguished: problem solving, internal diffusion and organizational adaptation. The description of these categories as separate processes is not meant to suggest that they should be conducted and organized separately but, rather, to draw attention to the importance of each of these activities for the innovation process to become a success.

- Problem solving. Recognizing that innovation is essentially a learning process, the core of the model is a quasi-cyclical process of problem solving. Based on Kolb's experiential learning model [35], the process has been modelled as follows. Triggered by the recognition of a need or an opportunity to innovate, the innovation problem is defined or redefined, ideas for possible solutions are generated, information is collected, analysed and evaluated during (1) the *creative stage*. Next, during (2) the *selection stage*, sufficiently promising ideas are selected for further elaboration. Alternative solutions are specified, priorities and evaluation criteria are set and, based on that, the alternatives are evaluated and selected. During (3) the *design stage*, concrete possibilities are elaborated, principal solutions designed, and operational specifications determined. Finally, during (4) the *application stage*, the innovation is tested in practice or with the help of a model and then implemented, or implemented without any testing.
- Internal diffusion (cf. [7,27]) is the ongoing process of communication and information processing that acts as the 'glue' tying together the other activities. Its two ever-recurrent stages are:
  - Knowledge awareness; through communication with other people, both within and outside the organization, (information on) problems, ideas and opportunities are transferred.
  - Attitude formation, involves the digestion of information and leads to a positive or negative attitude towards the problem, idea or opportunity, which may then be communicated to other people, and so on and so forth.
- Organizational adaptation. Many product and, especially, process innovations fail because of what has been called organizational lag [36]. Often the success of these types of innovations depends as much on organizational adaptation as on the new product or process itself. Broadly speaking, two kinds of organizational adaptation may be required. The first category is part of the innovation itself, involving, for example, the implementation of new processes or equipment for the production, marketing, or distribution of the new product. Or, in the case of process innovation, adaptations may be required in the operational, maintenance or operations management processes, in order to be able to achieve the most effective use of the new technology. The second type of organizational adaptation relates to the organization (i.e. innovation roles and organizational arrangements) of the innovation process itself.

4.2 The organization of the innovation process

There are two main categories of organizational conditions conducive to the success of innovation: innovation roles and organizational arrangements, respectively:

- *Innovation roles*. In order for the innovation process to take place at all, people are required to perform, support and manage the process. Based on the literature

[22–26] and previous research [1–2] by the authors, a number of innovation roles can be identified (see Table 1). The various roles provide the process with the required knowledge, skills, attitudes and power.

- *Organizational arrangements*. Various strategies may provide the innovation process with the direction and information processing capacity needed to cope with the uncertainty, complexity, diversity and interdependence of the process. Clear and well-communicated *goals* serve to direct the contribution of the various people involved. *Slack resources* in terms of knowledge and skills, time and budget reduce the information processing needs. *Communication and information technology* enable the quick communication and processing of formal information. For communicating richer information integration strategies such as all kinds of *lateral linkages* can be used, ranging from face to face communication, through for example colocation and role combination, to teamwork. As to the latter, one could think of temporary functional groups, comprising the idea generator, problem solver and scout, to resolve specialist problems, and a core team, for the duration of the process, comprising the project leader, integrator, ambassador and possibly also the coach and the reorganizer. The role of the core team would be to plan, organize and co-ordinate the process, and to enhance the communication between the functional groups and between the innovation group and other parties [2].

Whatever the roles and strategies adopted, the resulting organization must be flexible, to cope with the uncertainty and dynamics of the process; smart, to deal with complex problems; multi-functional, to cover all the diversity; and sufficiently integrated in order to handle all the interdependence between the activities to be performed.

4.3 Requirements for successful innovation

The main requirements for successful innovation are:

- Balanced attention to each of the constituent processes. This balance depends on the type of innovation involved and may need to change in the course of the process.
- A fit between the characteristics of the innovation process and the people/roles and organizational arrangements required to perform, support and manage the process.

These conditions are no guarantee of success. If, however, they are not met or insufficiently met, bottlenecks will occur leading to delay or even failure. Whether the requirements are met depends on:

- The perceived characteristics of the innovation (in terms of Rogers' five factors [27]: relative advantage, compatibility, complexity, trialability and observability).
- The appreciation of the characteristics of the process itself.
- The extent to which appropriate role occupants can be found at the time they are needed.
- The extent to which the appropriate organizational arrangements can be implemented at all, given the characteristics of the standing organization.

The next section describes, in necessarily aggregate form, the main results of previous studies into product, process and organizational innovation in which the authors have been actively involved.

5 Results of field research into product, process and organizational innovation

5.1 Methodology

The research reported here is based on three major studies into product, process and organizational innovation, respectively. Table 2 summarizes the key characteristics of the three studies. Each of the studies investigated:

- The innovation problem, goals and motives.
- The innovation process.
- The organization/management of the process.
- Bottlenecks encountered.
- The effectiveness of the process.

This section describes the motives in starting the innovation and the main bottlenecks encountered. In the next section these bottlenecks are analysed.

Table 2 Key characteristics of the product, process and organizational innovation studies

	Product innovation	*Process innovation*	*Organizational innovation*
core ingredient	new products	FMS	TQM
sample size	30	7	2/98
type of research	in-depth longitudinal case studies and survey	in-depth longitudinal case studies	2 in-depth case interview-based survey in a sample of 98 companies
methods	participatory observations, interviews	observations, interviews, document studies	interviews
average number of interviewees per company	5	8	3
functions of interviewees	general management, product design, purchasing, marketing/sales	general management, product design, process planning, scheduling, manufacturing, quality management, maintenance	General management, product design, purchasing, manufacturing, marketing/sales, quality management
type of company	ranging from capital equipment to consumer products	assembly of complex products (engines, machinery)	cases: plastics and food; survey: measuring (20%), electrical (11%), transportation equipment (9%); printing companies (9%), metal products (16%)
company size	5-500 employees	400-800 employees	10-4000 employees
country	The Netherlands	The Netherlands, Belgium, UK	The Netherlands

5.2 Motives for starting, and bottlenecks encountered during, the three types of innovation

5.2.1 Product innovation

In most cases the main *motive* for starting the innovation process was the need to develop (a) new product(s), often driven by the demands of just one customer, or the desire to penetrate new markets by developing new products or adapting existing products.

The main bottlenecks encountered during the *problem-solving* process were:

- Vague and implicit innovation goals and product specifications.
- Insufficient attention to the commercialization of the innovation.
- Irregular participation of marketing/sales in the mostly cross-functional innovation teams.
- Tendency to (try to) innovate 'right first time' rather than to allow for failures, improvement and learning during the process.
- Insufficient integration of the various stages of the *problem-solving* process. Together with high pressure exercised by day-to-day operations, this led to delays and loss of motivation.

Furthermore, relatively few people were involved or informed of progress made, who was to take part in the team at a later stage, who could provide useful information or whose (future) functioning would be affected by the innovation. Limited *internal diffusion* had two consequences:

- Most companies were really small, so innovation was not a full-time job for any of the team members. Insufficient communication easily led to loss of momentum and delay or even failure. Little use was made of formal mechanisms to keep the process going.
- Moving from one stage of the problem solving process to the next was more difficult if that stage required the involvement of skills or competencies not yet present in the innovation team.

Typical bottlenecks related to the process of organizational adaptation involved:

- It was often difficult to find and accept new distribution channels (if these were required).
- The dominant orientation towards day-to-day operations was difficult to combine with innovation and difficult to change.
- Change of know-how, i.e. internal learning or acquiring knowledge developed elsewhere, was difficult.
- Resistance to, and even fear of, introducing procedures in the development process.

In *summary*, the companies tended to concentrate on the development of the new product and to neglect the production and, particularly, the marketside of the new product. Alignment of the constituent processes and stages therein was generally insufficient. There was too little communication of the innovation goals and progress made to other

people than those actually involved in the innovation process. The organizational adaptations required for the innovation process to evolve successfully did not receive sufficient attention, if they were recognized at all.

5.2.2 Process innovation

The main *motives* for adopting FMS were reduced delivery lead time, lower operational costs (man hours, stock holding) and increased flexibility (both internally – reduced set-up times and smaller batches to reduce manufacturing lead time; and externally – product flexibility). The choice for FMS to improve external flexibility and reduce lead-time was usually driven by market(ing) demands. In some cases this was combined with the launch of a new generation of products. In other cases FMS was selected to replace technically obsolete equipment. In any case, efficiency improvements were required to justify the investment in this relatively expensive technology.

The main bottlenecks related to the *problem-solving* process can be categorized as follows:

- Most companies perceived the innovation as a technical problem. The organizational prerequisites for the successful use of FMS were underestimated if taken into account at all.
- Consequently, manufacturing engineers or process planners dominated the innovation teams.
- In one or two cases, the supplier's limited experience with complex CNC-based systems and/or with managing a network of second tier suppliers led to a delay of more than one year.

At first glance, *internal diffusion* did not pose any particular problems. Actually, however, internal diffusion appears to be very problematic, not so much because of what did happen, but rather due to what did *not* happen. Manufacturing engineers and management dominated the innovation process. Involvement of, and communication with, other functions such as maintenance, scheduling, and quality control, whose functioning would require considerable adaptation in order for the FMS to function optimally (see [2]), was limited or in some cases even virtually non-existent. This provides one of the main reasons for the delayed business success of the new technology.

In addition to sometimes considerable technical problems occurring during the problem solving process, lack of *organizational adaptation* led to serious trouble in most companies. Due to:

- the perception of the innovation as a mainly technical problem,
- the fact that the innovation cannot really be tried before the implementation of the system, and
- insufficient involvement of other functions as mentioned before,

the majority of the companies discovered only after the implementation of FMS that they had to make sometimes radical organizational adaptations. It took some companies another six months up to more than two years in order not only to prove technical success but also to achieve the business success pursued.

In *summary*, the technical aspects of the innovation (were paid) most attention. Organizational prerequisites were largely neglected before the implementation of the system. A major reason for this may well be the companies' lack of experience with this type of innovation and the consequences that this should have for the organization and management of the innovation process.

5.2.3 Organizational innovation

Compared to the product and process innovations discussed here, TQM is by far the longest innovation in terms of the time elapsed between start and finish. Even worse: it is questionable if TQM is ever finished at all if one takes one of its key principles, Continuous Improvement, into account.

The main *motives* for adopting TQM were quality demands put upon the company by the marketplace or even just one customer. A relatively small number of companies mentioned internal motivators such as a high scrap rate or increased employee motivation as a prime motive.

The main bottlenecks related to the *problem-solving* process were:

- Implicit and vague goals such as: 'We need to improve our performance in the marketplace', or, quite the reverse, very concrete but partial goals such as the writing of a Quality Handbook.
- No or insufficient involvement of other people than the ones initially involved in the process, especially those who had to work with new quality methods, procedures, equipment and tools.
- Many companies tended to rush *problem-solving*, not to consider alternatives and to implement a solution without proper evaluation.

Given the character of TQM, surprisingly little attention was paid to *internal diffusion*. Lack of information and communication led to incomprehension and resistance, especially among middle managers and the shop floor. Factors that played an important role here included:

- Insufficient information on TQM: what is TQM, why and how is the concept going to be implemented, how is TQM going to affect the company's people, processes and structure?
- Training and education were usually limited, and largely restricted to the shop-floor.
- The works council and in some cases even the second management level, i.e. those directly reporting to the board of directors, were insufficiently involved in the adoption decision.
- In some cases, management did not really back the concept but felt that they were forced to implement it in order to satisfy market or customer demands. This was clearly reflected in their attitude and goal setting behaviour.
- The organization was not sufficiently informed about results achieved, such as reduced scrap or improved communication and work climate.

Sufficient attention was paid to formal aspects of organizational adaptation, such as putting tasks, work instructions, responsibilities and authorities on paper. In some cases

the emphasis was rather put on the implementation of new equipment, e.g. measuring and calibration tools. The need also to train people was generally neglected or restricted to the shop-floor. In contrast, culture-related issues were underexposed. In the many cases in which the present (bureaucratic) culture did not fit with the TQM requirements, a lengthy, sometimes painful process was needed in order, for example, to change the dominant leadership style in the company.

In summary, most companies overemphasized problem solving. Organizational adaptation was one-sided and oriented too much towards formal aspects (structure and tools, rather than culture and leadership). Internal diffusion was badly neglected.

6 Analysis

All companies involved in the research had considerable trouble achieving the innovation goals set at the outset. The factors explaining that seem to fall into five broad categories:

- Attention actually paid to the three constituent processes.
- Perceived characteristics of the three types of innovation.
- Experience obtained with previous innovations.
- Organizational context of the innovation process.
- The trial-point of innovations.

6.1 Insufficient and unbalanced attention for the three constituent processes

Table 3 compares the effort the companies actually put into the three processes and the attention they should, with hindsight, have paid to these activities, in order to reduce or even prevent the bottlenecks described in the previous section. It appears that there is a considerable gap between what the companies *thought* was required for successful innovation and what was actually needed.

Table 3 Attention paid to, *versus* the actual importance of, the three constituent processes

	Product innovation		*Process innovation*		*Organizational innovation*	
	attention given	attention required	attention given	attention required	attention given	attention required
problem solving	+	++	++	++	+	+
internal diffusion	–	+	–	+	–	++
organizational adaptation	0	+	0	++	0	+

++ very important + important 0 moderately important – hardly important -- not important

6.2 Perceived characteristics of the innovation

Why is it that the companies underestimated the need to pay sufficient and balanced attention to the constituent processes? One major reason seems to be their initial perception of the innovation itself. Table 4 compares the companies' appreciation of the

five innovation characteristics identified by Rogers [27] with the actual values of these characteristics. As the discussion below will show, failure to understand the real characteristics of innovations may have serious consequences.

Table 4 The perceived and actual value of the relative advantage, complexity, compatibility, trialability/divisibility and observability of product, process and organizational innovation

	Product innovation		*Process innovation*		*Organizational innovation*	
	perceived value	actual value	perceived value	actual value	perceived value	Actual value
relative advantage	+	+/–	+	–*	0	+/–
complexity	0	+	0	+	0	+
compatability	+	+/–	+	+/–	+	+/–
trialability/divisibility	+	0	+	0	0	–
observability	+	+/–	+	–	0	–

+ high 0 moderate – low +/– differs from case to case.
* The actual relative advantage may be high if all required reorganization is realized.

Product innovation

Most companies seem to have overestimated the *relative advantage* of the innovation. In particular the profitability of the envisaged product appeared much lower than expected, in most cases. The required organizational adaptations (production process and, particularly, distribution channels) were largely neglected and only found out to be important at, often, too late a stage. Consequently, the *complexity* of the innovation was underestimated; i.e. product innovation in many cases involved much more than innovating the P in the PMTO-combination. *Compatibility* only posed problems if the new product was intended to provide the company with access to a new market segment. *Trialability* tended to be overestimated, but this does not explain many of the bottlenecks encountered. Neither does the *observability* of the innovation, which often increased dramatically once a detailed design or prototype was available.

So, the perceived relative advantage, complexity and compatibility of product innovation seem to explain most of the bottlenecks, especially in companies that had to implement considerable adaptations to their organization (new production process, new distribution channels, entering a new market segment). Usually the reorganization required for that was badly underestimated. The consequences: underexposure of the organizational adaptation process and communication with other functions (internal diffusion), in particular manufacturing, and marketing and sales.

Process innovation

Expressed in terms of efficiency, flexibility and/or speed, the perceived *relative advantage* of FMS technology was high in all cases. Most companies, however, had a lot of trouble achieving these benefits. Presenting a radical departure from the companies' present technology, the organizational *compatibility* of the FMS was low. Overcoming this organizational gap usually requires quite some effort, but FMS adopters do not really

have a choice if they want to achieve the performance goals pursued. The majority of the companies grossly underestimated the reorganization required. Related to that is the *complexity* of the innovation. The implementation of a successful FMS, in terms of both technical and business success, requires an integrated techno-organizational innovation rather than just the implementation of a new piece of equipment. This is much more complex than most companies expected. In process innovation, *trialability* seems high but is low. It is not difficult to break down the project into relatively independent work packages, or to test the different subsystems of the FMS. However, technical success can only be shown after installation of the whole system, while business success can only be proven after completion of all the reorganization required. The *observability* of this type of innovation is high and low at the same time. Once the operator training programs start, obsolete machine tools are removed, the foundations are excavated, and services (e.g. electrical and hydraulic leads, coolant system) are installed, it is very clear that something is going to happen. At the same time, however, the reorganization required in management (process planning, quality control, scheduling) and maintenance (tool and equipment) processes are much less visible.

In all but two cases, the companies hardly worried about the compatibility of the FMS and, consequently, failed to appreciate that their adoption decision actually entailed a complex and integrated techno-organizational innovation. As a result, they did not pay sufficient attention to organizational adaptation. Due to the relatively low *trialability* and *observability* of the innovation, it appeared only after installation of the FMS that the system performed dramatically poorer than expected. Consequently, it took those companies much more time (six months up to two years) and effort (radical organizational change) than anticipated to achieve the advantages pursued. One company, which implemented two FMSs, was much more successful than the others. The main reason: previous experience, which helped them to assess the innovation much more accurately.

Organizational innovation

In the case of TQM, the *relative advantage* pursued was improved responsiveness to customer demands, higher product quality and/or lower cost. The extent to which these goals were realized differed greatly between the companies studied. Requiring fundamental organizational (especially culture) and managerial (e.g. a change from supervision to leadership) changes, the *complexity* of this type of innovation is usually high. The *compatibility* of TQM is highly dependent on the culture of the organization. Requiring hardly visible, cultural rather than structural, organizational arrangements, the *observability* of TQM is low and remains low, especially if the effects of TQM are not measured, as was the case in most companies. This type of innovation, even if it is conducted 'according to the book', is the one with the longest lead time. Therefore, the implementation of TQM must be broken down into subprojects and stages. Yet, the *trialability* of TQM is low, as trying the effects of TQM on a small scale is actually inherently impossible.

Most companies underestimated the complexity of TQM and did not pay sufficient attention to increasing the observability of the innovation by demonstrating results achieved. Though differing from company to company, the compatibility of TQM does not explain much of the success of the innovation process. Compared with other types of innovation TQM takes a long time to implement and essentially this process never

finishes. It is therefore important to keep the process going and to put a lot of effort into demonstrating the innovation. Internal diffusion, badly neglected by most companies, should therefore be regarded as the core activity in this type of innovation.

Conclusion

Irrespective of the innovation involved, the perceived characteristics of the innovation explain a lot of the attention given to problem-solving, internal diffusion and organizational adaptation, respectively. The gap between perception and reality explains most of the bottlenecks encountered during the innovation process. The next question is how can this rather general and innovation-independent misperception of the innovation be explained? It appears that the main reason is (lack of) experience with previous innovations.

6.3 Experience with previous innovations

Product innovation

All companies involved in the product innovation research had sufficient experience with customizing products to customer demands. The, often implicit, learning from that led to some preferred approach to the management of innovation. However, this approach is not necessarily suitable for more radical innovation, especially when new production processes and/or new distribution channels are needed in order to be able to enter new market segments.

Process innovation

Complex innovations such as the introduction of FMS are infrequent and the differences with investment in less advanced equipment are so great that the implementation should be managed as an innovation process. Most companies failed to discover this need soon enough, and with the trial-point (see below) lying so far ahead, there was no indication whatsoever that the one-sided technical approach adopted would lead to problems.

Organizational innovation

With the companies having even less experience with the massive reorganization required to achieve TQM, the goals they set for the innovation were rarely clear at the outset, and more often than not they simply did not know how to organize and manage the innovation. Consequently, the process was rather unstructured. Interventions were haphazard and then the more formal aspects of TQM (quality tools and procedures) were emphasized. The result: a ‘paper tiger’ rather than a company living the TQM philosophy. The length of the innovation process did not add to a more effective and sustained development in the right direction.

Innovating is one thing, learning from it another. Some of the FMS adopters were relatively innovative companies, in terms of product innovation. Yet most of them really suffered during the innovation process and, especially, after the implementation of the new system. Apparently, successful product innovation practices were not disseminated to other functions, including those related to manufacturing. The most successful FMS

adopter had quite some experience with similar innovations, such as the implementation of CAD/CAM systems, JIT and also TQM (!). This suggests that companies should pay more attention to disseminating successful practices to other parts of the organization not directly involved in the innovation process. Yet, "when this project is finished, I will be transferred to another plant and take up a new job. A lot of what we learnt will be lost to this plant when I am gone", sighed the project leader of that successful FMS adopter.

6.4 Contextual influences on the organization of the innovation process

Most companies appeared to rely on their standing organization, rather than to implement suitable organizational arrangements such as the ones mentioned in section 4. Also, only some, but in none of the cases all, of the innovation roles were fulfilled and then mostly only partially so. Roles, such as the project leader or the problem solver, could be recognized in most cases. Important but much less 'technical' roles such as those of the ambassador, the reorganizer or the champion, were scarcely implemented and then insufficiently so. This had obvious consequences for the innovation processes, in terms of the bottlenecks encountered.

We are not entirely sure whether the companies were unable to implement suitable arrangements or to find people who could play the various innovation roles but there are strong indications that they simply did not even try to. We believe that the companies' (lack of) experience with similar innovations, rather than their organizational structure, played a decisive role here. All companies could have relatively easily set up an appropriate innovation organization. Even purely functional bureaucracies can implement a temporary structure to come closer to what is required for successful innovation. Our analyses suggest that it was not lack of will but lack of recognition that made the companies organize the innovation process as they did.

6.5 The trial-point of innovation

So, previous experience explains the initial perception of innovations and if an activity is not recognized as an innovation process it will not be organized as such either. Why is it then that it took so many companies so long to recognize that they had, albeit unwillingly, made a fundamental mistake when attempting to perform the process basically without any organizational adaptation? The answer: the so-called trial-point of innovation. Especially when the innovation cannot be observed or tried until there is a prototype product or until the new technology is installed, the company barely receives any signal that something will go wrong.

Perhaps the best example of this is process innovation. It is relatively easy to test parts of the system at the supplier's site, but testing the whole system can only take place after installation at the customer's site. And then only *technical success* is measured. The new technology's *business success*, in terms of the efficiency and flexibility pursued, strongly depends on organizational adaptation. If this has been insufficient, achieving business success may take much longer, depending on the responsiveness of the adopter. Here, organizational characteristics seem to play a much more important role than during the initial stages of the process. Some companies found out very quickly what they had to do in order to get the system 'off the ground'. It took other, more bureaucratic companies months of unsuccessful fire-fighting before they learnt that a more thorough and an actual innovation process-type of approach was needed in order really to get the system up and

running. Only then, top management (!) got involved and started to organize the organizational adaptation and internal diffusion processes required for that, playing roles such as the ambassador, integrator and reorganizer themselves.

7 Consequences and lessons for theory and practice

There are some interesting similarities and differences between product, process and organizational innovation. The main *similarities* are:

- Unbalanced attention to the three constituent processes. In all three types of innovation the emphasis was on problem-solving. Less or no attention was paid to organizational adaptation. Internal diffusion was usually neglected.
- Most companies did not take sufficient time to complete the problem-solving cycle. They tended to stop the process on implementation of the solution. At the same time, however, this was also the stage at which most problems first became evident.
- Usually, the range of functions involved in the innovation process was too limited.
- In none of the cases were the innovation roles sufficiently fulfilled at the time one would expect them to be most effective.
- The companies were too optimistic as to the relative advantage, complexity and compatibility of the innovation. Also, the trialability/divisibility and observability of the innovation were lower than expected (although these expectations are usually very implicit).

Experience with previous innovations and, through that, the initial perception of the innovation problem explain most of these symptoms. Organizational context seems to play a less important role, at least at the outset of the process. Later on, smaller, more flexible organizations are better able than the bigger, more bureaucratic ones quickly to respond once bottlenecks really begin to show and to organize the organizational adaptation and internal diffusion neglected before.

7.1 Differences

The differences between product, process and organizational innovation processes are surprisingly few and appear to be strongly related to the type of innovation developed or adopted. The most important one is that organizational innovation seems to require much more internal diffusion than does product innovation, with process innovation lying somewhere in between. TQM is essentially a company-wide concept. In particular, the required cultural change is not easy to achieve, requires deep-rooted acceptance and, thus, a lot of communication throughout the company and cannot therefore be restricted to just one or two functions. Furthermore, implementing TQM is a very protracted process, easily taking ten years or so, and problematic in terms of trialability and observability. It is therefore not easy to keep the process going and attention focussed.

Process innovation also requires the involvement of several different functions whose competence is needed during the process or whose functioning will be affected by the new technology. Compared to organizational innovation, the effects of process

innovation are visible much sooner. On the other hand, lack of technical success or, worse, business success, may come very costly for the company.

7.2 Managerial implications

It is not the purpose of the present article to paint a bleak picture of the companies involved in the research and of the way they tackled the innovation problem and process. After all, we are talking about innovation, something companies have no or only limited experience with. Yet, some lessons can be inferred that may help companies prevent or reduce innovation bottlenecks. Some of these lessons are well-known, others are less obvious:

- Innovation requires top management commitment and, especially, involvement. This is much more than just stating how important is (the) innovation and making go/no go decisions. Usually, top management are the only ones able to resource the process adequately and to pull down the walls between functional departments, which is needed to prevent or reduce the many bottlenecks that are due to lack of internal diffusion and organizational adaptation. A major spin-off of such an approach is increased knowledge of how to tackle innovation.
- Successful innovation requires a careful balance between top-down strategic drive and bottom-up emergent creativity. Innovative activity should be based on a carefully designed and continuously updated corporate strategy and the market and operations strategies derived from that. At the same time, companies should foster unintended creativity and allow for trial and error learning.
- What this balance looks like depends on the type of innovation adopted. A top-down 'blue-print' strategy seems to be better suited to process innovations although even here there must be room for incremental steps and learning during the process and, in particular, also after that (Continuous Improvement). An indirect, incremental approach seems to be more appropriate for the management of protracted organizational innovations such as the implementation of TQM and other concepts that are loaded with cultural change and learning new practices. Here again, however, some top-down direction is advisable as well, in particular as regards the formulation of the (longer-term) innovation goals and the contours of the concept.
- Trial and error *learning* is not for free: it takes time and costs money. Companies should allow for that by deliberately building sufficient financial and time slack into the process. It is more efficient to spend time and money on learning than to accept an innovation that does not perform as intended.
- Innovation requires much more than technical skills (e.g. the problem solver), but also considerable social and managerial skills (e.g. the project leader), a favourable attitude (enthusiasm – e.g. the champion, approachability – e.g. the ambassador) and occasionally also some formal or informal power (e.g. the coach). It is difficult enough to 'design' the right combination of these virtues. A probably bigger problem is that the HRM function in most companies tends to focus too much on technical knowledge and skills, rather than on selecting people on the basis of their potential as role 'players'. Companies that really wish to become more successful innovators should therefore transform their *HRM strategy* and practices and pay

much more attention to the skills required to be able successfully to contribute to innovative activity.

- Companies should invest more in intra-process internal diffusion and also in disseminating successful practices to other parts of the organization not directly involved in the innovation process. Although perhaps not directly applicable or even trivial, lessons learnt during other types of innovation processes can be very helpful.

7.3 Further research

The process-based contingency model of innovation is a useful tool for describing, analysing and understanding various types of innovation processes conducted by a wide range of companies in terms of size and product. Yet, it cannot be concluded that the model is applicable to all kinds of innovation or companies. It cannot, for example, simply be concluded that TQM is representative of organizational innovation. Similarly, the companies involved in the product innovation research were mostly SMEs and this will have biased the findings as to the way in which these companies approached the innovation process. So further testing of the model is required.

Furthermore, it is not clear whether the model is useful for understanding less radical innovations, or multiple innovation processes conducted simultaneously. An interesting question combining these areas is the present interest in incremental innovations such as Continuous Improvement which, amongst others, involves several different but small, often barely visible, innovations conducted simultaneously in various parts of the organization.

Finally, further research is needed into the fit between the innovation process characteristics (uncertainty, complexity, diversity and interdependence) and the organization of the process. In the studies presented in this article, we found that complexity, diversity and also interdependence increased dramatically *after* the companies found out that they were actually dealing with an innovation process. Also, contrary to what is usually assumed, uncertainty did not drop during the process, but only when the business success of the innovations was proven. The question is: did we actually measure these *process characteristics* or perhaps rather the *quality of the organization* performing the process? This question also calls for further research on innovation.

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