

Innovation management; a literature review of innovation process models and their implications

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Abstract

The body of innovation management literature grew considerably over the last 35 years. This led to an increasing amount of different models of innovation processes. This paper reviews 12 sources in which models of innovation processes have been proposed. While comparing both the models and their implications, additional attention is paid to several dimensions of innovation searching for patterns that assist in the practical use of the findings.

It is found is that from these models, 6 phases could be distilled. Also, from these models an extensive overview was created of 150 important activities - routines - that are increasing innovation success. In the cases these routines were not practical enough for immediate use, management tools were searched for and presented.

Furthermore, in search for information about in which situations and to what extent these routines and tools should be used, the following can be said. Some authors are recently gaining more insight in to which routines are better fit for which situations. However, the main conclusion must be that there is still very little known on this point. Also about the amount of, or extent to which, routines should be fulfilled is uncovered ground.

1. Introduction

Innovation management is an increasingly covered topic in scientific and management literature over the past 35 years (see figure 1). The reason for this interest is likely to be the realisation that innovation is of key importance for survival of an organisation. Whether it concerns firms that need to compete for market share or profit (Cooper 2005, Hamel and Prahalad 1998, Kaplan and Norton 1992) or public organisations that need improve their services (Hartley 2005, Mulgan and Albury 2003), does not matter. The need for innovation is imperative (Tidd and Bessant 2005). Or in Coopers words, "It's war: Innovate or die" (Cooper, 2005a, p. 4).

But at the same time, innovation is not easy. Innovation efforts over time gave us a multitude of failed innovation projects (See e.g. box 1 on the next page). Even huge companies that once were the forerunners and creators of whole markets have failed to stay competitive when (major technological) changes occurred (Hamel and Prahalad 1994, Utterback 1994, Christensen 1998). An organisation is so involved with - and simply used to - what they are good in (core competencies), they become trapped in it. When the environment changes (e.g. changing consumer needs, changing regulation) organisations are not able to adapt (Leonard-Barton 1992, Benner and Tushman 2000).

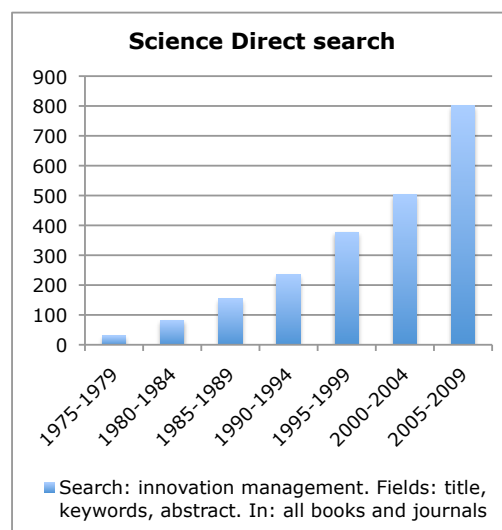


Figure 1. Number of papers and books about innovation management over the years as searched in Science Direct

1.1 Innovation

How the innovation process should be managed, depends on how you look at innovation. The definition of innovations varies across sub-fields of innovation research (see some examples in box 2).

As can be seen, innovation come in a variety of types; product or services. Second, there seems to be a debate whether innovation needs to be successful in order to call it innovation. Compare on this point for example Hartley (2006) and Jacobs and Snijders (2008). A third variation is that authors differ in including (Drucker 1985b, Jacobs and Snijders 2008) or excluding (Tidd and Bessant 2005,) the the post-launch- or commercialisation phase of the innovation process. But in all cases, innovation is not only an idea, it is also the implementation of it.

Independent of how you actually define innovation, it is good to know that the phenomenon of innovation is not new (Verloop 2004). Already in pre-historic times, mankind was able to turn ideas into realisation. Over time, countless innovations were developed, such as controlling fire (Goudsblom 1992), democracy as a form of government (Alan Dahl *et al.* 2003), railway (companies) (Freeman and Louçã 2001), the light bulb (Bright 1949) and a more recent example, the development of new medicine (Achilladelis and Antonakis 2001).

As can be seen from even this thin slice of the innovation pie, the variation among innovations is huge.

Box 2. Definitions of innovation

"Industrial innovation includes the technical, design, manufacturing, management and commercial activities involved in the marketing of a new (or improved) product or the first commercial use of a new (or improved) process or equipment" (Freeman 1982)

"Innovation is the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or service." (Drucker 1985)

"Innovation is the successful exploitation of new ideas" (UK DTI 2004)

"Successful innovation is the creation and implementation of new processes, products, services and methods of delivery which result in significant improvements in outcomes, efficiency, effectiveness or quality" (Albury 2005)

Innovation is "the successful development, implementation and use of new or structurally improved products, processes, services or organisational forms" (Hartley, 2006).

Innovation is "something new being realised with (hopefully) added value" (Jacobs and Snijders 2008).

Box 1. Innovation failures

(Tidd and Bessant 2005 pp. 37)

"In 1952 Ford engineers began working on a new car to counter the mid-size models offered by GM and Chrysler - the 'E' car. After an exhaustive search for a name involving some 20 000 suggestions the car was finally named after Edsel Ford, Henry Ford's only son. It was not a success; when the first Edsels came off the production line Ford had to spend an average of \$10 000 per car (twice the vehicle's cost) to get them roadworthy. A publicity plan was to have 75 Edsels drive out on the same day to local dealers; in the event the firm only managed to get 68 to go, whilst in another live TV slot the car failed to start. Nor were these teething troubles; by 1958 consumer indifference to the design and concern about its reputation led the company to abandon the car - at a cost of \$450 m. And 110847 Edsels."

"Whilst the Internet was seen as a seedbed for an enormous number of new ventures, the experience of the 'dot-coms' has not all been rosy. Some firms like Amazon and Yahoo! Saw their share prices surge upwards on initial flotation - but for them and many others the bubble burst. New players were ill-equipped to survive and only a handful of the original start-ups remain - but even large and established players were hit hard. For example, the giant telecommunications player BT lost 60% of its market value, whilst Marconi eventually went under."

Innovations vary along at least five dimensions; type and degree of novelty of the innovation, type and size of the organisation in which the innovation project took place and fifth, the environment/sector in which the innovation was developed.

The first dimension is innovation type. In line with several authors I distinguish product-, process- and service innovations (Luecke and Katz 2003, Albury 2005). Second, the degree of novelty is considered. Jacobs and Snijders (2008) speak of a fuzzy approach to novelty in which all innovations can be assigned along an axis from incremental to radical. Albury and Mulgan (2003) distinguish, incremental, radical and systemic innovation. In this paper, however, the clarity of the incremental - radical dimension is used.

Third, a distinction is made between innovations that took place in an private firm or in a public organisation. The comparison between these two is still not made often while it is suggested that the management of innovation in public organisations is different to that in

private firms (Hartley 2006). As a fourth dimension, the size of organisation is considered. It could be interesting to see if management techniques are different in small organisations compared to large ones. At last, the stability of environment is gauged to determine to what extent this affects the management style.

It is interesting to use these dimensions when considering innovation management models and activities as they might explain which management approaches should be used in certain situations.

1.2 *Defining and researching the innovation process*

Innovation is not new and it comes in many forms. Also, as many authors argue, it is important for organisations to innovate (Hamel and Prahalad 1998, Tidd and Bessant 2005, Mulgan and Albury 2003). Therefore, scholars and practitioners have studied how innovation can actually be managed. Hansen and Birkinshaw (2007) define innovation management as the active and conscious organisation, control and execution of activities that lead to innovation. A similar definition is used by Jacobs and Snijder (2008): the management of the innovation process.

The *innovation process* is defined as the development and selection of ideas for innovation and the transformation of these ideas into the innovation (Jacobs and Snijders 2008). To emphasise the uncertain character of this innovation process, other authors use the *innovation journey* (Van der Ven 1999). An *innovation project* is in this paper used as being the innovation process of one particular innovation. Andrew and Sirkin (2006) argue that the management of an innovation project is essentially like any other business projects, though it comes with more risk and uncertainty.

The body of literature around the topic of innovation management is relatively young. Since roughly halfway through the last century innovation became a topic of research. Before we continue, it may prove interesting to understand the cycle of theory and practise from which our current knowledge draws (figure 2).

The first step in managing innovation is to understand how the innovation process can be successfully influenced. This is pursued by empirical studies on successful companies and thereby describing how they organise innovation (e.g. Van de Ven and Poole (1990), Rothwell *et al.* (1974), Andrew *et al.* 2007).

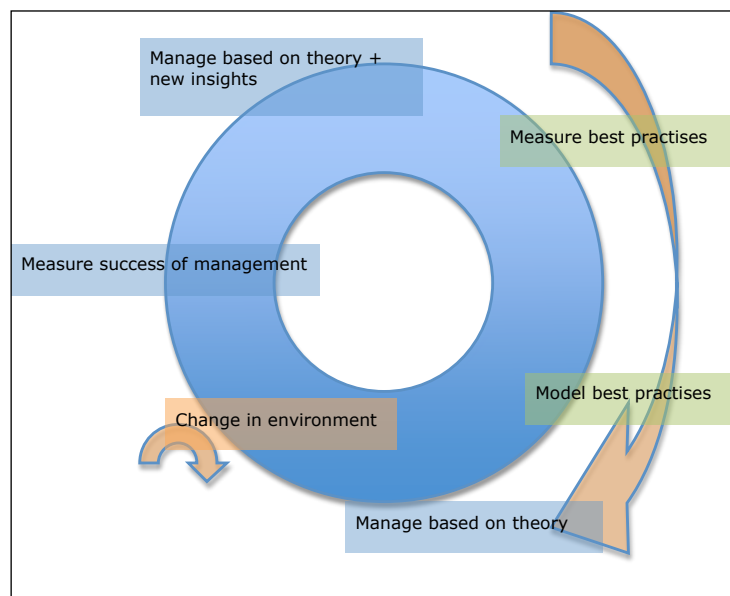


Figure 2. Cycle of research and practice. Blue indicates business; Green indicates research

Once understanding how the innovation process can be positively influenced, the next step is to make a best practise model (e.g. Cooper 1986, Rothwell 1994, Van der Ven *et al.* 1999, Tidd and Bessant 2005). Then this knowledge can be used in practise to actively manage the process. This management basically means to tweak and alter the factors to increase quality and efficiency of the innovation process and to decrease the time it takes and the chance on failure.

Good innovation research is therefore constantly moving from theory to practice and back to theory. As we will see, in the innovation models described, some are based on empirical research (or experience), and other on theory.

1.3 Aim of this paper

Research on the process of innovation over the last 35 years has provided us with a broad range of innovation process models (see e.g. Evitt 2007). The first aim of this paper is therefore to give an overview of the models of innovation processes and the contextual factors indirectly influencing the process.

Knowing how the innovation process can be theoretically and conceptually modelled is the first step, but without the implications for the management of the process, it is of little value. The second aim therefore is to extract the management implications from these models. This is essentially about which management routines and tools need to be used to stimulate the process of innovation.

The third aim is to explore the further implications of the obtained list of routines and tools.

Logically, the three research questions that guide this paper are therefore:

- 1. What innovation process models exist in literature?*
- 2. What management routines and management tools can be extracted from literature that stimulate the innovation process?*
- 3. What further implications for the practical use of innovation management routines and tools can be found in literature?*

Concerning the last aim, the paper distinguishes the dimensions of innovation as motivated above, to find out if the practical implications are different for different innovations.

1.4 Overview

To answer these research questions, this paper is simply structured as follows. In the next three chapters, respectively the three research questions will be treated. In an discussing and concluding chapter the implications are summarised and discussed.

2. Innovation process models

Models are simplified representations of reality. The variety among models about innovation management is the result of on the one hand still little consensus as to how an innovation process should look like, and on the other hand because of the purpose with which it was developed. For example, a descriptive model including a best practice in a set of technological manufacturing firms will be different to a prescriptive model about how to manage innovation in a police department.

This section does not claim to include all existing models, but it gives a broad scope of the variation that exists. The method used to search for sources is described below.

2.1 Brief historic overview

Before we dive in to the diversity of existing models, we take a step back and see at how innovation process models developed over time. The mental model that people have of innovation has not been the same over time. The main reason for this change is the change in the environment in which innovation takes place (Rothwell 1994). This is further explained in table 1, where an overview of three authors is given.

The table is largely self explicatory, but a general tendency is that the innovation management models have become more complex, more interdisciplinary, more integrated and more connected with their surroundings - more links between organisations. It is important to note however, that it is not always better to pursue a later model; all models are still used today and in the right place (Verloop 2004, Rothwell 1994, Jacobs and Snijders (2008).

Verloop (2004)	Rothwell (1994)	Jacobs and Snijders (2008)	illustrations
Trial-and-error approach (pre-historic)			Discovery of fire or discovery of America
Scientific curiosity driven model (industrial)		Entrepreneurial laboratories (about 1865)	BASF, GE, Bell Labs
	Technology Push (50s -Mid 60s)	Focus on result; introduction of project planning, coupled to business targets (about WWII)	Science discovers, technology provides, man conforms (logo of the 1932 Chicago World's Fair)
Opportunity-driven bridge-building model (post industrial)	Market Pull (Mid 60s - Early 70s)		
	The "Coupling" Model (Early 70s - Mid 80s)	Technology management in context of financial risks, strategical planning and technological roadmaps (late 80s)	Propelled by scarcity; oil crises, financial crises
	Integrated innovation process model (early 80s - early 90s)		Japanese reverse engineering and manufacturing
	Integrated, parallel, flexible and connected model (90s - now)	Emphasis on learning and interaction with the market to satisfy existing and latent market demands (mid 90s)	Huge global networking firms

Table 1. Historic overview of innovation management models

2.2 The models

It is interesting to analyse a number of characteristics when discussing the different models, to better understand the differences and similarities. First of all, to underline the broad range of background, this paper covers, the source of the model is explicated. Second, it is determined whether the model had an empirical underpinning, if it was based on prior theoretical research, or both. Also, the main type, novelty and sector of the innovation is determined.

The models are found in Management books and scientific journals. Through the help of scientific search engines in combination with searching further in references 1

There are 12 models included from various sources. This include management literature, policy papers as well as scientific handbooks (See table 2). Three of the models were developed some time ago, but have proofed so influential, that leaving them out would mean a significant hiatus in this paper (Rogers 1962, Cooper 1986, Rothwell 1994).

The other models are roughly all from the last decade and include both private (e.g. Verloop 2004, Andrew and Sirkin 2006, Van der Ven *et al.* 1999) and public models (Mulgan and Albury 2003) and authors who include both (Tidd and Bessant 2005, Hansen and Birkinshaw 2007, Jacobs and Snijder 2008, Nootboom 2001).

Some more recent authors have based their models for some parts on prior authors, but over time, more empirical studies have improved and changed the models considerably. Noteworthy authors such as Van

de Ven and Poole, have based their book *Innovation Journey* (1999) on an extensive empirical study (1990). Similarly, Rothwell (1994) based his work on earlier work by himself and colleagues of the seventies (1974). And Andrew *et al.* (2007) served as major empirical underpinning for Andrews and Sirkin book (2008).

	Source	Mainly based on	Innovation type	Incremental vs. Radical	Organisation type	Organisation size	Environment
Rogers (1962)	Book; Free Press						
Cooper and Kleinschmidt (1986)	Journal of Product Innovation Management	Recent theory and practise	Industrial manufacturing product innovation	Both, but leaning towards radical	Private	Fairly large with an own R&D department and a distinctive senior management	Considering it was just after '81-'82 recession, this was probably a period of dynamic growth
Rothwell (1994)	International Marketing Review	Prior research	Product	Not explicitly stated, but tendency to radical	Private	Fairly large	Turbulent economic environment
Van der Ven et al. (1999)	Book; Oxford University Press	Large empirical study	Product, process, services	Not explicitly stated, but tendency to radical	Private	Large	Turbulent economic environment
Nooteboom (2001)	Book; Oxford University Press	Theory	Product, process, services	All	Private and public	Large and small	Both turbulent and stable considered
Mulgan and Albury (2003)	UK Strategy Unit paper	Prior research + some case studies.	Services	All	Public	Large	Both turbulent and stable considered
Verloop (2004)	Book; Elsevier	Experience	Product, process	Radical	Private	Large	Both turbulent and stable considered
Cormican and O Sullivan (2004)	Technovation	Model based on theory, verified in practice.	Product, technology	Portfolio of different novelties	Private	Large multinationals	Mainly focused on next generation tech; turbulent
Tidd et al. (2005)	Book; Wiley and Sons	Empirical and theoretical research	Product, process, services	Both steady state as well as discontinuous innovation	Private and public	Large and small	Both turbulent and stable considered
Andrew and Sirkin (2006)	Book; Harvard Business School Press	Experience and empirical research	Product, process, services	Not very explicit, but leaning more towards radical	Private	Large	
Hansen and Birkinshaw (2007)	Article; Harvard Business Review	Based on empirical experience of the authors	Product, process, services	Not very explicit, but leaning more towards radical	Private	Large multinationals	Over a decade time; both turbulent and stable environment
Jacobs and Snijders (2008)	Book; Stichting Management Studies	Theoretical and empirical research	Product, services	Emphasise that most innovations are incremental.	Private and public	Both large and small organisations	Mainly focussed on stable times

Table 2. Characteristics of the models

The type of innovation differs considerably among the models. Most of the innovation process models are largely based on (1) radical (2) products and processes in the (3) private sector (Cooper and Kleinschmidt 1986, Cormican and O Sullivan 2004, Verloop 2004, Andrew and Sirkin 2006). But, in modern economies in which services are getting more important, other types of innovations (incremental and/or services) are considered as well (Tidd and Bessant 2005, Jacobs and Snijder 2008), though still with less attention. Also, innovation in the public sector is still less represented (Mulgan and Albury 2003).

2.3 Phases

All models distinguish certain phases, stages, components, building blocks, or main activities (See table 3). In this paper we use the word “phases”. One similarity is that they all imply - or even explicitly state - that there is some order in these phases, though not necessarily linear. As Hartley (2006) argues, stages are helpful for conceptualising the innovation process and determining where drivers and barriers can occur.

The stage-gate process, introduced by Cooper (1968), has the most distinctive and orderly phases. He more or less prescribes that the next phase can only start, if the project complied with all the requirements prior one. This is not only useful to determine if the project should proceed or not, but also to keep track of possible new occurrences during the process.

While in management, this linear approach can be clear and useful, other authors argue that it is a too simplistic view of the process (Tidd and Bessant 2005, Mulgan and Albury 2003). They also use a phased model, but acknowledge that many feedback-loops and cycles take place before proceeding through the process.

What is interesting, though, is that for example Tidd and Bessant (2005) and Jacobs and Snijder (2008) adopt the stage-gate model of Cooper in the implementation phase of their model. This means that during the first phases of idea generation and selection, the phases are less linear and have more feedback loops, while in the later phases, a more formal and rigid process is used.

Rogers (1962)	Cooper (1986)	Rothwell (1994) (3G)	Van der Ven et al. (1999)	Nooteboom (2001)	Mulgan and Albury (2003)	Verloop (2004)	Cormican and O Sullivan (2004)	Tidd and Bessant (2005)	Andrew and Sirkin (2006)	Hansen and Birkinshaw (2007)	Jacobs and Snijders (2008)
Knowledge	Scoping	Idea generation	Initiation period	New combinations	The generation of possibilities	Idea generation and crystallisation	Analyse environment and identify opportunities	Search	Idea generation	Idea generation	Variation
Persuasion							Generate innovation and investigate				
Decision	Build the business case	Research design and development		Consolidation			Plan project and select sponsor	Select	Commercialisation		(Internal) selection
							Acquire				
	Development	Prototype production	Developmental period		The trailing and prototyping of promising ideas	Development and demonstration	Prioritise project and assign teams	Execute	Realisation	Idea conversion	Realisation
	Testing and validation	Manufacturing									
		Marketing and sales									
Implementation	Launch	Marketing	Implementation / Termination Period			Investing and preparing for launch	Implement product implementation plan	Launch			(External) selection / survival
Confirmation				Generalisation							
				Differentiation	Replication and scaling up			Sustain		Idea diffusion	Multiplication
				Reciprocity							
					Analysis and learning			Learning and re-innovation			Learning

Table 3. Phases, stages, components, or main activities of the innovation process

So which phases can be observed? Below the phases of the 12 models are summarised. This is done by including a phase if more than 2 authors consider it to be a phase, stage, component, etc. The phases

defined below are going to be used throughout the paper for clearness. However, it is noted, that it is not the only way to define the phases.

All models start with some form of *idea generation* or searching for ideas for innovation. Some authors emphasise the opening up of possibilities (Nootboom 2001, Mulgan and Albury 2003, Jacobs and Snijders 2008). Van der Ven *et al.* (1999) argue that this is considered to be divergent behaviour.

The next step is for a majority of authors to narrow the options down, to make a decision, and to select which projects are pursued and which are not pursued (Rogers 1962, Nootboom 2001, Tidd and Bessant 2005, Jacobs and Snijders 2008). This *selection* should be based on both the organisational strategy and on the existing portfolio of projects to spread risks. At this point it has to be judged if the innovation is potentially lucrative enough (Andrews and Sirkin 2006) or if it is going to increase public value enough (Moore 1995).

The next step is to turn the (selected) idea into some tangible product, process or service. This sub-process is differently described by almost all authors, but words such as development (Cooper and Kleinschmidt 1986, Van der Ven *et al.* 1999 and Verloop 2004), prototyping (Mulgan and Albury 2003), manufacturing (Rothwell 1994) and realisation (Andrews and Sirkin 2006, Jacobs and Snijder 2008) are used. For clearness, in this paper we name this phase *development and testing*. Generally the innovation is tested in this phase, although some authors introduce an extra phase for this in their model. Generally this is the phase in which considerably more resources are appointed to the project. In Van der Ven *et al.* (1999) words, this is convergent behaviour.

The fourth general step is the one in which the newly developed product, process or service is going to be implemented in "the real world". This phase is called *implementation/launch*. It entails the preparing of customers and marketing activities. Most authors stop here with their innovation process.

However, some authors (Rogers 1962, Nootboom 2001, Mulgan and Albury 2003, Tidd and Bessant 2005 and Jacobs and Snijders 2008) include a *post launch* phase. This entails the sustaining and supporting of the innovation or even re-innovating it and scaling it up.

At last, Mulgan and Albury (2003), Tidd and Bessant (2005) and Jacobs and Snijders (2008), include a phase for explicit *learning*. Not only learning about the innovation itself, but also about how the innovation process went. The obvious purpose is to not make the same mistakes in a future project. Although most authors (and practitioners) recognise the importance of this phase, it is rarely done in a structured way (Tidd and Bessant 2005).

2.5 Main contextual factors

Besides these innovation phases, there are several authors that see the innovation process not in a vacuum, but include some contextual factors. Authors that explicitly treat these contextual factors are Rothwell (1994), Van der Ven (1999), Mulgan and Albury (2003), Cormican and O Sullivan (2004), Tidd and Bessant (2005) and Jacobs and Snijder (2008).

The variation in how these factors are described is larger than when considering the phases, above. To illustrate this, they range from organisational characters to societal factors, and from influenceable factors to external factors. Also, while some authors describe these factors extensively (Van der Ven *et al.* 1999, Tidd and Bessant 2005), others treat them superficially (Mulgan and Albury 2003).

Rothwell (1994) (3G)	Rothwell (1994) (5G)	Van der Ven et al. (1999)	Mulgan and Albury (2003)	Cormican and O Sullivan (2004)	Tidd and Bessant (2005)	Jacobs and Snijders (2008)
Top management commitment and visible support for innovation.	Time-based strategy (faster, more efficient product development).	institutional arrangements to legitimise, regulate, and standardise a new technology;	Skills	Strategy	The strategic context for the innovation	Strategic profile
Long-term corporate strategy with associated technology strategy.	Development focus on quality and other non-price factors.		Resources	Leadership	The innovativeness of the organisation	Implementing routines
Long-term commitment to major projects (patient money).	Emphasis on corporate flexibility and responsiveness.	public-resource endowments of basic scientific knowledge	Organisational methods	Culture and climate	The links of the organisation with its environment	Feedback about development of the innovation and learning culture
Corporate flexibility and responsiveness to change.	Customer focus at the forefront of strategy.	development of markets, consumer education, and demand	Leadership	Planning and selection		
Top management acceptance of risk.	Strategic integration with primary suppliers.	proprietary research and development, manufacturing, production, and distribution functions by private entrepreneurial firms to commercialise the innovation for profit	Cultures	Structure and performance		
Innovation-accepting, entrepreneurship-accommodating culture.	Strategies for horizontal technological collaboration.		Communication and collaboration			
	Electronic data processing strategies.					
	Policy of total quality control.					

Table 4. Main contextual components, subroutines, organisational influences, strategy elements

The factors are analysed and for as far as possible, summarised. Main components that are used are:

- Strategy (Yellow)
- Culture (Green)
- Leadership (Red)
- Organisational structure (Blue)
- Resources/Skills (Purple)
- (links with) outside the organisation (Light blue)

3 Routines and tools

Above, I have elaborated on models of innovation processes and their phases of innovation processes and about the contextual factors. Although some phases are named in an active way (e.g. search or launch), in general the models are rather abstract and descriptive. This third section is therefore about how to fill these abstract phases and contextual factors with more practical activities. These activities, being of major importance for the innovation process, are sometimes called key activities. Other authors

use the word 'routines' (Tidd and Bessant 2005 and Jacobs and Snijders 2008), because these activities are to be institutionalised into the organisation. In this paper, the word routines is used.

By providing an overview of these management routines, the second research question is answered.

3.1 *The routines*

Not all models include this step of defining these routines. An overview of the authors that do can be found in the appendix. As we can see in this table, the variation of routines and activities becomes extensive (more than 150 routines).

The way in which authors enlist them is also more diverse than with the phases. For example, while Cooper and Kleinschmidt (1986) list a relatively short set of 13 routines, Cormican and O Sullivan present an extensive checklist of 50 factors that need to be taken care of.

Under the different phases and contextual factors there are several routines that are suggested by several authors, and others by only one. There is a great variety in activities and routines. See the appendix for the complete lists. To have a better overview, the colours are referring to the type of routine as described below. For more information about specific routines, I have to direct you to the original sources, since this falls outside the scope of this paper.

For *idea generation*, four main types of routines come back. These are (1) market studies, (2) technical studies, (3) mobilising ideas from inside the organisation to generate ideas (encourage people to come up with ideas and share them; making cross-functional teams to increase interdisciplinary ideas) and (4) involving people from outside the organisation (either lead users, creative people, society in general, other countries/firms).

Considerably less routines are associated with the phase of *selection*. The main routines here are (1) to analyse the options in terms of market potential and feasibility. And then the choice is made based on the strategic direction of the company and the portfolio of existing projects or products (2).

For *developing and testing* there are many and diverse routines suggested. Examples for (0) development are cross-sectional team working, finding the best people, creating incubating places for development, concurrent working, early involvement of users, focus and commitment and its support and design tools. For testing (0) authors distinguish generally in-house testing and external testing as main activities.

Implementation and launch (0) can be implemented by using the following routines. It has to be noted that this phase does not comprise many activities related to the innovation process. In most cases it is more a logistic task. The only routines suggested are pre-launch market exploration, production start-up, focus and commitment and marketing activities.

Post-launch activities (0) are only included in a few models. The models that do include them suggest routines like assigning idea evangelists, re-development, and supporting a supportive infrastructure.

Finally, to implement *learning* (0), all authors treating this phase emphasise the need for real numbers, preferably real time, in evaluations.

Routines that can not be placed under one particular phase are related to contextual factors. However, there are several routines that could have been placed both under a phase and a contextual factor. In these cases, they are only listed under the phase classification, above.

Most of the remaining routines are placed under the following contextual factors: Strategy (0) Culture (0) Leadership (0) Organisational structure (0) (links with) outside the organisation (0) or provisions of resources (0).

Idea generation	Selection	Development and Testing	Implementation /Launch	Post-Launch	Learning
Away-days; give people time away to come up with new ideas.	SWOT analysis to determine strategic position	Operating tests: tests to check the functionality/ reliability of the product under real-life working conditions.	A detailed financial analysis, involving a return or profitability assessment.	Designate "idea evangelists"	Value Analysis
Quality Function Deployment; analyse how to deliver value to the customer	Risk Assessment Matrix	Let users try the product and let them give feedback	Trade literature, trade shows, and trade advertising but no special promotion or training for the sales force.	Organise places where professionals meet: 'collaboratives' in the health service or Talking Heads (school heads)	Brainstorming
Review of competitors' products	Portfolio management	Rapid prototyping technologies and approaches	use alpha, beta gamma versions of products		Benchmarking
Invite artists or trend-spotters	Payback period and/or break-even analysis	Try out different approaches	apply a stage-gate model		
Build cross-unit networks		Create safe havens			
Role-playing					

Table 5. An interesting grasp of available tools

3.2 Innovation management tools

As we have seen, starting with some relatively simple models, we ended up with a broad variety of routines that can help managers to incorporate the innovation process in their organisation. The tasks for managers became more practical with every step (from model to phases and contextual factors to routines), but most routines are still too abstract (for example the routine of "making a choice based on the strategic direction of the company and the portfolio of existing projects or products" or "involving others")

Therefore, some authors have proposed practical tools. These tools are the practical application of the routines in the case these routines are too abstract. Also, the same tools can be used for several routines. Brainstorming, for example, can both be an excellent tool for idea generation as well as evaluation. So can conferences and other gatherings be excellent places for idea generation but also for the diffusion of innovation (post-launch).

These tools are incorporated in the overview (for the extensive list, see the appendix). An interesting (but rather random) grasp of tools is listed in table 5 above.

4 Characteristics of innovation

Up until now the focus of this paper was on creating a broad overview of possible activities to manage the innovation process. This overview has resulted in a many routines and management tools. It is

obvious that no organisation is capable of implementing all these activities into all innovation projects. The overview also suggests that this is not necessary. This section is about the practical use of the above identified routines and tools. It will try to cover what is known about when to use which routines or tools and to what extent.

As we have seen in the introductory paragraphs of this paper, there is quite some differences between innovations. This raises the question if some routines and activities are more useful for specific innovations. For example, are selection routines different for small organisations compared to large ones? Or are implementation routines different in a rapidly changing environment compared to a more static environment? This is treated in paragraph 4.1. Afterwards, paragraph 4.2 is about the actual using of routines and tools. To what extent should they be applied?

4.1 *When to use which routines and tools?*

In the literature that was studied, only very few comments were made about which routines should be used in which situations. Generally, authors argue that not necessarily all routines should be used but an organisation is able to make a selection of the proposed routines. The proposed routines are merely an overview what has been found in practice to work well.

An exception is the book by Tidd and Bessant (2005) that proposes some routines and tools do deal with increased uncertainty when developing more radical innovations and when dealing with a dynamic climate. Box 3 shows some of these adapted routines for this situation as opposed to the normal "steady state" situation. They emphasise for example in the idea generation phase that organisations should keep an extra eye open for weak but interesting signals and keep an antennae out for early technological developments.

Another example of differentiated routines is given by Jacobs and Snijders (2008) but in this case for differences in organisation type. They distinguish two groups where the first has a significant design, R&D or innovation department and the second not. Although not the same, this is similar to the division between product versus service innovation. Their findings are first of all that the organisations *with* R&D department pay considerable more attention to structure while organisations *without* pay more attention to intuition during the innovation process. Another finding is that, while all organisations are considered to be top-innovative, the organisation fulfilled the routines differently (See box 4).

Unfortunately, no other mentionable differences were directly put forward by authors on the issue of when to use which routines or tools.

To find out if there are other patterns I have compared the models and routines that were found in literature. This could only be done by first defining what kind of innovation the authors wrote about when proposing their sets of innovation management models and routines (the result of this was already presented in table 2 in chapter 2, where the dimensions of innovation were included). Second, the

Box 3. Routines for disruptive times

Search:

- Picking up and amplifying signals
- Using multiple and alternative perspectives/scenarios
- Using a technology antennae for picking up early signals

Select:

- Legitimate challenging the dominant vision
- Develop a parallel structure or an alternative track for ideas that lie outside the mainstream

Implement:

- Building and relying more on an extensive network
- Participate in risk-sharing strategic research programmes
- Use a dual structure or separate organisation to exploit radical new ideas
- See the project as a main stream project but adopt more flexibility and entrepreneurship

Box 4. Product vs. service

Organisations from the first group (all commercial firms) scored better on the proposed routines. Significant differences were in the following three routines:

- Strategy/business model
- Re-development
- Learning from real figures

It seems that for a private organisation involved in product innovation these routines are more important than for organisations involved with services.

models and sets of routines are compared between the different pieces of literature. So for example, the literature considering product innovation (e.g. Cooper and Kleinschmidt 1986) are compared with the models and routines of literature considering service innovation (Jacobs and Snijders 2008). Similarly, models and routines about private innovation (e.g. Hansen and Birkinshaw 2007) is compared with models and routines about innovation in public organisations (Mulgan and Albury 2003).

The result is somewhat disappointing. Only few noteworthy observations could be made. And even these observations could easily be the result of chance or by other not-included factors. The reason for this is that there are only 12 sources and even more combinations possible with all 5 dimensions of innovation. Therefore, these relations cannot be analysed with any significant outcome.

Nonetheless an attempt is done. First the models are analysed of which the results are presented in table 6.

Innovation type	Novelty	Organisation type	Organisation size	Environment
<p>Product/process (10) The launch phase is the last phase</p> <p>Services (7) Less attention to the launch phase. More attention in the younger models</p>	<p>Incremental (5) Quiet a "full" model with most phases included. The younger the models, the more attention to incremental innovation.</p> <p>Radical (10) Almost all models include radical innovation.</p>	<p>Public (4) Strong emphasis on later stages and no attention to launch. Relatively little attention to public innovation.</p> <p>Private (10) Almost all models include private sector innovation</p>	<p>Large (11) All models include large organisations.</p> <p>Small (3) Considerably little attention to small organisations. No further conclusions can be drawn in the relation between the model and the organisation being small.</p>	<p>Turbulent (9) Most models are about economic times or sectors in which there is a high degree of uncertainty and thus a more turbulent environment</p> <p>Stable (9) Also, most models consider stable times. Noteworthy is that especially the later models include stable times as well.</p>

Table 6. Differences between models explained based on dimensions of innovation

Concerning the difference in *sector*, an interesting observation is that in general models that consider public sector innovation assign more attention to the later phases in the model (see table 3). This is understandable, because for a typical firm, the later phases (diffusion, sustaining) are largely business as usual.

An other observation is that the models are becoming more complete. Where in the older models the emphasis was on radical, product innovation in large firms and turbulent environments. More attention is put towards incremental and service innovation in small and public organisations in more stable environments.

Analysing the routines and tools is even more problematic. Although some differences could be observed (e.g. routines such as technological forecasting are more found in literature explicitly treating product innovation and routines such as market research are more found in literature that explicitly treats private innovation as opposed to public sector innovation), no significant results can be drawn.

4.2 Using routines and tools

While some authors argue that poor performance in one routine can be compensated by the other (Jacobs and Snijders 2008), most other authors stipulate that all routines need to be balanced and well taken care of (Tidd and Bessant 2005, Morton and Birkinshaw 2007, Cormican and O Sullivan).

An interesting contribution is how Prud'homme van Reine and Dankbaar (2009) emphasise that all routines (and especially concerning culture) should not be seen as having a linear relation with innovation success (*i.e.* more of the routine means more innovation). They argue that the relation is rather parabolic in which there has to be found a dynamic equilibrium. Also Jacobs and Snijder try to illustrate this same point with their notion of contradicting truths ("Januswijsheden"; *e.g.* organise central guidance vs. stimulate self-organisation).

In general, for many routines it is unclear to what extent the activity needs to be pursued. For example, Mulgan and Albury (2003) suggest "breaking the rules" as an activity for generating possibilities, but obviously, not all rules need to be broken for innovation. Also, sometimes the recipe for innovation can seem to be contradicting Jacobs and Snijders (2008) argue that "an open culture" is important, but at the same time advocate "focus".

6. Discussion and Conclusion

There are a couple of points of discussion before this paper can be concluded.

First of all it has to be noted that the literature search for relevant models of innovation processes has been extensive, but not very structured. With a high probability, it can be said that most relevant literature was reviewed, but a second search or expert panel need to confirm that.

Second, an extensive overview of models, routines and tools is created. This overview has kept the original terminology of the authors for authenticity. This resulted in a very rich database, but varied in terms of terminology. To make further steps with this overview, some general terminology has to be used for clearness. When this is done, the overlap and underlying differences become clearer. This will be a task for further research.

In that same line, the overview is extensive, but not very easy in its use. Some sort of database could make the information more accessible and thereby useful.

Last point of discussion is the analysis of possible differences between the sets of routines and tools when considering the various characteristics of innovations. Although some insight was acquired during the literature study, this part is still very thin. This is mainly the result of a lack of current research, but is also because this paper mainly and first of all set out to create the overview and secondary looked into this third research question. Further research might explore this terrain more thorough.

That being said, it is time to return to the research questions.

1. *What innovation process models exist in literature?*
2. *What management routines and management tools can be extracted from literature that stimulate the innovation process?*
3. *What further implications for the practical use of innovation management routines and tools can be found in literature?*

All questions have been answered in the form of tables, overviews or the appendix. Summarising, it was found that all models had some kind of phases with some order in them. Main summarising phases are: idea generation, selection, developing and prototyping, implementing/launch, post-launch and learning/evaluation.

The majority of the sources included contextual components in their model of the innovation process. These were: strategy, culture, leadership, organisational structure, resources/skills and links with outside the organisation.

Moving beyond the phases and contextual factors, more than 150 routines or activities were distilled from literature. At the same time, quite some overlap was found and for each phase or contextual some main themes were identified.

Where routines were still quite abstract, management tools were found adding to the database. These tools can be used in different phases and for satisfying different routines.

Furthermore I found that the models that are described in theory are becoming more elaborate over time. This holds first of all for the number of phases, including more and more post-launch activities. But also in terms of the types of innovations that are considered literature is becoming more complete; not only radical, technical innovations in the private sector, but also more incremental and service innovations and innovations in the public sector.

Concerning the relation between characteristics of innovation and management routines and tools the following can be said. First of all, existing literature is not explicit on which management routines and tools should be used in which situations. Two minor exceptions are the boxes 3 and 4 in section 4.

Finally a discussion remains about the extent to which routines and tools should be implemented. How much of an routine is sufficient to stimulate innovation?

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