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The Uncertainty of Innovation: A Systematic Review of the Literature

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Abstract

Innovation is defined as a process that is fraught with uncertainty. This article's aim is to diminish lack of knowledge of the factors that create uncertainty in innovation processes. The basic thrust of the present argument is that the potential value integral to innovation may or may not be materialized in the future. Given that the future entails uncertainty, it is reasonable to expect that uncertainty is inherent in every innovation process. Uncertainty results from the fact that, on the one hand, events in the future do not follow the course of past events, and, on the other, knowledge of the future is always incomplete. Using a systematic approach to reviewing the literature, eight factors which create uncertainty in processes of innovation were identified, namely: technological uncertainty, market uncertainty, regulatory/institutional uncertainty, social/political uncertainty, acceptance/legitimacy uncertainty, *managerial uncertainty*, timing uncertainty, and consequence uncertainty.

Keywords: Innovation, Uncertainty, Literature review

1. Introduction

"Innovation is an hypothesis, whose truth cannot be established with certainty" (Paul Hurst, 1982).

Uncertainty has been a rather frequent theme in organizational studies over the past decades (e.g. March & Simon 1958; Allen 1977; Galbraith 1977; Hofstede 1980, 2001; Shane 1995; Beckman et al. 2004). There is strong agreement, for example, that decisions in organizations are made in a state of uncertainty. Due to a lack of comprehensive, unambiguous, consistent and stable set of values, to a lack of perfect and complete information, and to constraints imposed by historicity, most, if not all, decisions in organizations are made in uncertainty (Hurst 1982).

Presumably, the same also holds true for innovation. An innovation is an idea, practice or object that is perceived as new by the entity adopting it (Rogers 2003). The concept of innovation implies the idea that something is added to something else that already exists, or that something that exists is given up. The argument is that adding and/or taking away are ways to improve a state of affairs. Despite positive connotations associated with the concept of 'innovation', it should be noted that the potential value integral to innovation may or may not be realised in the future. Given that the future entails uncertainty, it is reasonable to postulate that *uncertainty is inherent in innovation process*. Innovation processes consist of, and require, action to be taken under conditions of uncertainty. Innovation is a process of muddling through (Rehn & Lindahl 2011), where one steps into the unknown (Hurst 1982). Uncertainty results from the fact that, on the one hand, events in the future do not follow the course of past events, and, on the other, knowledge of the future is always incomplete.

It is not a surprise that uncertainty has become popular as a theme among innovation research scholars. A great deal of work has been done in order to understand how uncertainty affects organizational innovation processes (e.g. Tushman 1978; Souder & Moenaert 1992; Gales & Mansour-Cole 1995; Damanpour 1996; Tatikonda & Rosenthal 2000; Rogers 2003; York & Venkatraman 2010). However, a deficiency in previous research has meant that uncertainty has primarily been seen as an 'independent variable' – a factor that produces specific effects. Research interest has focused on these effects and, particularly, their managerial implications (e.g. Damanpour 1991; Martin 1994; Osborne 1996; Johannessen et al. 1999; McDermott & O'Connor 2002; Thamhain 2003; Linder et al. 2003; Rose-Anderssen et al. 2005; Välikangas & Gibbert 2005; van Looy et al. 2005; Ortt & Smits 2006; Bernasconi et al. 2006; McAdam et al. 2007; Xu et al. 2007; York & Venkatraman 2010; Hall et al. 2011). If the previous research included factors that create uncertainty, the categorization of the factors has been fairly broad. Freeman (1982), for example, has categorized innovation uncertainty falling into technical, market and political/economic uncertainty. Parallelly Freeman and Soete (1997) and Bessant (2008) have found three sources of uncertainty in innovation process. Freeman and Soete (1997) have distinguished technological, commercial and organizational uncertainties, whereas Bessant (2008) has argued that uncertainty arises within technological, market and regulatory environments. Souder and Moenaert (1992) have offered a rather more accurate categorization. They have identified four sources of innovation uncertainty, which are consumer, technological, competitive and resource uncertainty. In addition to

technological and market uncertainties, Cantarello et al. (2011) have identified behavioral uncertainty. Nonetheless, it seems that there is a lack of research that focuses *exclusively* and *in detail* on the factors that produce uncertainty in innovation processes.

The objective of this article is to increase the understanding of factors that create uncertainty in innovation processes. *Using a systematic method to review the literature, different kinds of uncertainty* related to innovation are explored, categorized, and discussed. Throwing light onto the 'hidden' side of innovation – i.e. uncertainty – is important for at least two reasons. Firstly, due to the pro-innovation bias of innovation research (cf. Rogers 2003), focusing on the uncertainty associated with innovation processes is valuable in an intellectual sense. Although innovation uncertainty has been touched upon, and discussed, in earlier studies, there is a distinct lack of research systematically bringing together findings and categorizing various sources of uncertainty. Secondly, increasing knowledge about uncertainty in the process of innovation might also provide innovation practitioners with new insights. A more comprehensive understanding of the various sources of uncertainty offers practitioners the opportunity to improve their innovation management activities. Although uncertainty is by nature inherent in innovation processes (and probably cannot be avoided), it may be assumed that practitioners, who are aware of various sources of uncertainty and its possible manifestations, are better off compared to those who deny or do not act upon uncertainty. Therefore, in addition to making a scientific contribution, the findings of this systematic literature review may be used to improve innovative performance in organizations.

This article is organized as follows. In Section 2, the scope of the research is explained. In Section 3, the design of the research project is described and some general features of the reviewed studies are presented. In Section 4, the result of the literature review is presented and discussed. Finally, conclusions drawn are detailed and avenues for further research are suggested in Section 5.

2. Innovation and Uncertainty

2.1 Innovation as a process

One of the most common discussions associated with the definition of innovation deals with whether innovation is a process or a discrete event (Cooper 1998). In this article, innovation is defined as an idea, practice or object perceived by its adopter to be new and an improvement. This definition implies three assumptions: firstly, an idea, practice or object which is not adopted is not innovation at all. To be regarded as an innovation, an idea must be implemented. Secondly, the 'novelty' of innovation is context-specific and depends on an adopter's experience. What seems routine in some contexts may in other contexts be seen as innovation. Thirdly, while innovation implies change, not all change involves innovation since "not everything that an organization adopts is perceived as new" (Zaltman et al. 1973). Innovation involves deliberate and planned organizational activities, which, however, may paradoxically have positive or negative outcomes.

Defining innovation as intended "novelty in action" (cf. Altshuler & Zegans 1997) implicitly contains the idea that innovation is a process, which consists of various stages from initiation to implementation (cf. Rogers 2003). Initiation refers to identifying problems, evaluating alternatives, whereas implementation refers to deciding between alternatives and putting

innovation to use. Processes of initiation and implementation have obvious similarities with Joseph Schumpeters's (1911, 1941) ideas of seeing and doing 'things' differently (see also e.g. Brown 1997). For Schumpeter, seeing and doing things differently was the force required for long-term economic growth. Seeing and doing things differently – i.e. innovation – creates and destroys existing structures causing continuous economic and social progress. Schumpeter called this process of continuous progress 'creative destruction'. In creative destruction the existing power derived from previous technological, organizational, regulatory and economic paradigms is replaced by new forms engendered by innovation.

The expression 'creative destruction' – understood as seeing and doing things differently – implies that innovation is a specific form of change process. Innovation is about change because it represents discontinuity or a break with the past (cf. Drucker 1985; Bessant 2003). At the heart of this change process is an organization's ability to manage the translation of new ideas into new forms of action. In order to be considered as an innovation that has an economic or social contribution to offer, an invention has to be moved from 'the laboratory' into production and disseminated to other parties beyond its discoverers (Garcia & Calantone 2002). However, it is important to note that creative destruction is neither a linear nor a causal process (cf. Smits 2002) where the old is merely replaced by the new – it is a process of success and failure. Adapting Foster (2010), it can be argued that in complex, ever-changing societies, innovators cannot make rational choices because of the uncertainty that they face. Therefore, in 'creative destruction' failing innovators are just as important as successful ones (Foster 2010).

The processual nature of innovation has been contemplated from different points of views in the literature on innovation. From the process perspective, innovation is typically seen as an interplay between events and people in which actions at each stage of the process influence events in subsequent stages, which determine whether the innovation process will continue or not (e.g. Cooper 1998; Smits 2002). Utterback and Abernathy (1975), for example, have described innovation as an iterative process, where "a basic idea underlying the innovation is developed over time in a predictable manner with initial emphasis on product performance, then emphasis on product variety and later emphasis on product standardization and costs". Utterback and Abernathy (1975) have emphasized that innovations do not only occur during developmental phases but may also occur during dissemination at which time innovations undergo continual improvement. Adapting Aldrich (2001), Sotarauta and Srinivas (2006) have conceptualized as an evolutionary process the development of an invention into an innovation and its further dissemination beyond its inventors. The evolution of innovation consists of four generic processes: variation, selection, retention and struggle. Variation refers to any intentional or unintentional departure from routine. Variations manifest themselves as new ideas, of which some will be selected and others eliminated. The selection of new ideas is determined by the interplay between organizational competencies and environmental factors. Retention means the preservation or duplication of selected ideas with the result that they are repeated in the future. Struggle arises due to scarcity of resources within organizations and between them in a given environment. Rogers (2003), in turn, has offered a five stage model of the innovation process. Rogers's (2003) model consists of the following stages: agenda-setting, matching, redefining/restructuring, clarifying, and routinizing. At the

stage of agenda-setting, the organization perceives there to be a problem that may create a need for innovation. Matching refers to aligning a problem associated with the organization's agenda with an innovation. In the redefining/restructuring stage, the innovation is modified and re-invented to suit the organization. Clarifying means the detailed definition of the relationship between the organization and the innovation. Finally, at the routinizing stage, the innovation becomes an ongoing element in the organization's everyday life. As mentioned, Rogers's model can be summed up in initiatory activities and those associated with the implementation of the innovation (see also Zaltman et al. 1973).

Regardless of whether innovation is defined as a catalyst within the creative destruction process, as a process of seeing and doing things differently, as an evolutionary process or as a process of initiation and implementation, from the point of view presented in this article the most interesting thing is the uncertainty inherent in those processes.

2.2 The nature of 'uncertainty' in innovation process

One of the earliest definitions of uncertainty was put forward by Frank Knight. In his seminal work, Knight (1921) distinguished between 'risk', defined as a measurable unknown to which probabilities can be assigned, and 'uncertainty', which are risks, to which such probabilities cannot be assigned. However, despite the popularity of the theme of uncertainty in organizational studies, there is no agreement on the conceptualization of the concept itself (Gales & Mansour-Cole 1995). Galbraith (1977), for example, has ironically stated that "a great deal of uncertainty exists about the concept of uncertainty". Galbraith (1977) himself defines uncertainty in respect of the information that one requires to act. For Galbraith (1977) uncertainty means "the gap between the amount of information required to perform the task and the amount of information already possessed by the organization". Paralelly, Brashers (2001) claim that uncertainty exists when "details of situations are ambiguous and complex; when information is unavailable or consistent; and when people feel insecure about their own knowledge or the state of knowledge in general". Defining uncertainty as a situation where there is a lack of information also implies the notion that uncertainty can be reduced by increasing the available amount of information (cf. Galbraith 1977; Daft & Lengel 1986). This kind of thinking resonates with Ellsberg's (1961) concept of 'known uncertainty'. Known uncertainty refers to situations where key variable and outcome probabilities are known but their factual values remain unclear. In a state of known uncertainty different possible outcomes are amenable to probabilistic analysis (cf. Bullen et al. 2006; York & Venkatraman 2010).

A more problematic situation occurs when not only the factual values but the existence at all of variables and outcomes is unknown. In a state of 'unknown uncertainty' (Ellsberg 1961) there exists a "lack of clarity of cause-effect relationships, lack of agreement among involved parties and the difficulty of identifying appropriate sources of information" (Gales & Mansour-Cole 1995). Unknown uncertainty arises from the existence and conflicting interpretations (cf. Daft & Lengel 1986). In contrast with 'known uncertainty', which can be reduced by conducting probabilistic analysis, 'unknown uncertainty' is a situation where such calculations cannot be made (cf. Bullen et al. 2006). According to Reddy (1996) uncertainty involves "a vision of the future as so fundamentally and radically indeterminate as to

preclude probabilistic analysis". Unknown uncertainty manifests itself as ignorance in the face of novel and fundamentally unpredictable events (Sartorius 2006). For Teubal (2002) unpredictable events represent 'fundamental uncertainty' which exists because not all events can be translated into 'states of nature' and their corresponding probabilities. Similarly Spash (2002) has written about 'strong uncertainty', by which he refers to situations where "not only are we unable to predict the consequences of events, we are unable to determine which events will lead to future change".

Whether 'known' or 'unknown', uncertainty is typically characterized as a state which causes dissatisfaction within organizations. The reason for that is obvious: individuals and organizations simply feel dissatisfaction because they do not know how to proceed in an uncertain situation. There is strong desire for certainty and a tendency to deny uncertainty. Due to the negative consequences (real or perceived) of uncertainty, people typically prefer to avoid it. Hofstede (1980, 2001), for example, has argued that uncertainty avoidance is one of the basic dimensions of national culture (see also *Kalliny & Hausman* 2007; Kaasa & Vadi 2010). Uncertainty avoidance, together with another cultural variable termed 'power distance', is seen to explain the different approaches to risk involving projects, such as corporate venturing in different countries (Venkataraman et al. 1993). Uncertainty avoidance is also implicitly present within the context of organizational change. Change presents individuals with new and confusing situations which threaten the status quo and trigger resistance from those who feel dissatisfied by the new arrangement (e.g. Kotter & Schlesinger 1979; Agboola & Salawu 2011). Uncertainty avoidance as a form of change resistance may yield to organizational inertia (cf. Hannan & Freeman 1984; Wong-MingJi & Millette 2002).

Nonetheless, despite possible detrimental effects caused by uncertainty, within the context of innovation uncertainty also carries positive, or at least neutral, meanings. Johnson (2001), for example, has linked uncertainty and entrepreneurship. Johnson (2001) portrays the tolerance of uncertainty and ambiguity as a necessary condition for making things happen. Similarly Gerwin and Tarondeau (1982), Souder and Monaert (1995), van Riel et al. (2004) have conceptualized the adoption and implementation of innovation as processes of coping with uncertainty. They see innovation as an information-processing activity aimed at uncertainty reduction. Hanft and Korper (1980) and Rogers (2003) have offered a more optimistic view of uncertainty. According to Hanft and Korper (1980) uncertainty may actually improve decisions, because it can help to achieve agreement when "honest differences in fact and values might otherwise lead to intransigence". Rogers (2003), in turn, has emphasized the fact that technological innovation "is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome". It has been also argued that uncertainty-accepting societies are more innovative (Venkataraman 1993; Shane 1995). Finally, taking an evolutionary approach, uncertainty is seen as a necessary condition of innovation (e.g. Foster 2010). In a state of uncertainty people have different and often conflicting beliefs which can result in many mistakes and errors. However, mistakes and errors are crucial, because they can be eliminated and replaced by better beliefs in a process of competitive selection. Thus, "errors and mistakes are not a bad thing; they are a necessary part of the process that generates economic growth" (Foster 2010).

While some issues related to innovation may be construed as 'known uncertainty' or 'risk', such as the increase in production capacity resulting from new technology, this article considers *innovation as a process to inherently involve 'unknown uncertainty'*. Despite the consensus among researchers, for example, that new technology plays an important role in many innovations (e.g. Rogers 2003; Bernasconi et al. 2006), it is impossible to predict what effects technology will have, because these effects are dependent on unknowable actions taken in the future. Therefore, this article argues that actors in the innovation process must act under conditions of unknown uncertainty that arise not only from incomplete information, but also from ambiguous and equivocal information about innovation. Furthermore, while acknowledging the potential 'positive' ripple that may ensue from uncertainty (cf. Foster 2010), this article focuses on the 'negative' effects of uncertainty. The reason for that is practical: an overwhelming majority of the reviewed literature has perceived uncertainty to be detrimental to, or problematic for, innovation.

3. Research design

The methodology used in this article is a systematic review of the literature. A systematic literature review is a trustworthy, rigorous and auditable methodology for evaluating and interpreting previous research relevant to a particular phenomenon of interest. Since single studies can at best only contribute one piece of an enormous puzzle, the value of a systematic review is that it combines discrete pieces and creates a coherent overview (e.g., Cooper 1984; Mulrow 1994; Kitchenham & Charters 2007). By performing a systematic literature review, this article integrates existing information and provides a theoretically founded framework for understanding various aspects of uncertainty in innovation processes.

According to Alderson et al. (2004), two steps are particularly important for a systematic literature review, which are, setting 1) the inclusion criteria, and 2) the strategy for locating and selecting the studies for potential inclusion.

3.1 The inclusion criteria

Three inclusion criteria were used as a guide for selecting and assessing the studies for potential inclusion. To be included in the systematic review, a study had to:

1. be a theoretical, conceptual or empirical study focusing on uncertainty of innovation. There were no restrictions on types of innovation, i.e. innovation could be incremental or radical, as well as service or product-related. "Focusing on the uncertainty of innovation" refers to the fact that studies mentioning only the word 'uncertainty' without discussing it were not included;

2. include the keywords 'innovation' and 'uncertainty' (or its synonyms; see subsection 3.2) in its title or abstract;

3. be published as an article in a peer-review scientific journal, or be an article or book, referred to in such peer-review articles.

Although the role of inclusion criteria is to help limit the selection bias, reduce chance effects and hence enhance the legitimacy of the literature review (cf. Landry et al. 2006), it should be noted that if inclusion criteria are used too 'blindly', such a literature review may fail to uncover the complexity of uncertainty in innovation. In order to avoid this, this literature

review includes several studies which did not meet the inclusion criteria in point 2, but were interpreted as significant, nonetheless, in respect of the research objective.

3.2 Search process and studies selection

The literature review was conducted in four phases (Fig. 1). While the author of this paper is responsible for its contents, the review process (search and selection of articles) was conducted in cooperation with a research colleague.[1]

In the first phase, a computerized search was carried out by using multiple keywords in the following databases: *ABI Inform ProQuest, Academic Search Elite (EBSCO), Elsevier Science Direct,* and *Emerald*. The four databases include a great number of scientific journals which focus on innovation. Without any confining criteria, the number of articles which included concepts of 'innovation' and 'uncertainty' was as high as 239,843 on 1 February 2011. In order to create a reasonable, but still valid, population of studies, the search was confined only to articles which were published in peer-review scientific journals. This choice is in line with the rationale behind the systematic literature review methodology: the accuracy and reliability of the review can be enhanced by focusing on studies of good quality (Mulrow 1994). However, the number of peer-reviewed articles touching on innovation uncertainty still numbered 61,120. In order to reduce the number of articles, the search process was further limited by using Boolean search operators. The term 'innovation' was rated important where it had been included in the title of an article. The term 'innovation' was connected to the term 'uncertainty' (when it was included in the title or in the abstract of an article) by the Boolean search operator 'AND'. The search combination 'innovation' AND 'uncertainty' yielded 487 articles when conducted in February 2011.

In the second phase, the search was diversified to include synonyms of 'uncertainty'. The sensitivity and precision of search terms is crucial for the validity and reliability of a systematic literature review (Ganann et al. 2010). The synonyms selected were 'complexity', 'instability', 'ambiguity' and 'confusion'. The selection of synonyms was based on several ad-hoc queries to databases. Queries indicated that the words 'complexity', 'instability', 'ambiguity' and 'confusion' were used in pretty much the same manner as the word 'uncertainty'. The search combination 'innovation' (title) AND 'complexity' (title/abstract) OR 'instability' OR (title/abstract) OR 'ambiguity' (title/abstract) OR 'confusion' (title/abstract) yielded 588 articles. The total number of articles which met the selection criteria was thus 1,075.

In the third phase, the abstracts of these 1,075 articles were briefly read. In the majority of the articles where uncertainty (or a synonym of uncertainty) was mentioned, it was not used to describe the nature of the innovation process, but it was just a word like any other. This allowed for the exclusion of 951 papers which did not meet the inclusion criteria in point 1. Eliminating those articles that only mentioned uncertainty (or its synonym) of innovation but did not specifically focus on it reduced the number of articles to a total of 124.

In the fourth phase, all 124 articles were read in full and assessed by the author and his research colleague according to the inclusion criteria. During the reading process it became

[1] This colleague worked as a research assistant on the Virtu project, as part of which this review of the literature was undertaken. See www.virtuproject.fi.

obvious that articles found in the first and second phases included important references to articles which did not meet the inclusion criteria no. 2. Those articles which were judged as important from the point of view of the research problematic were included in the review process. Furthermore, some articles which were first selected on the basis of abstracts were rejected due to their minor significance. It was also realized that limiting searches only to four databases meant that articles that are not listed in these databases will not be found. Therefore, a complementary source for the literature was employed. The total number of articles under review for this study was 101.

In the end, despite using the inclusion criteria and expanding the search process beyond four databases, it is highly probable that other studies exist which some other researcher may have included in his/her review. This could not be avoided, because the data extraction described above required interpretation, which, in turn, depended on the prior experience of the researchers involved. However, it should be emphasized that the selection of studies was done by the author and his research colleague alone. This procedure will have significantly improved the search and selection process and reduced the threat of systematic errors.

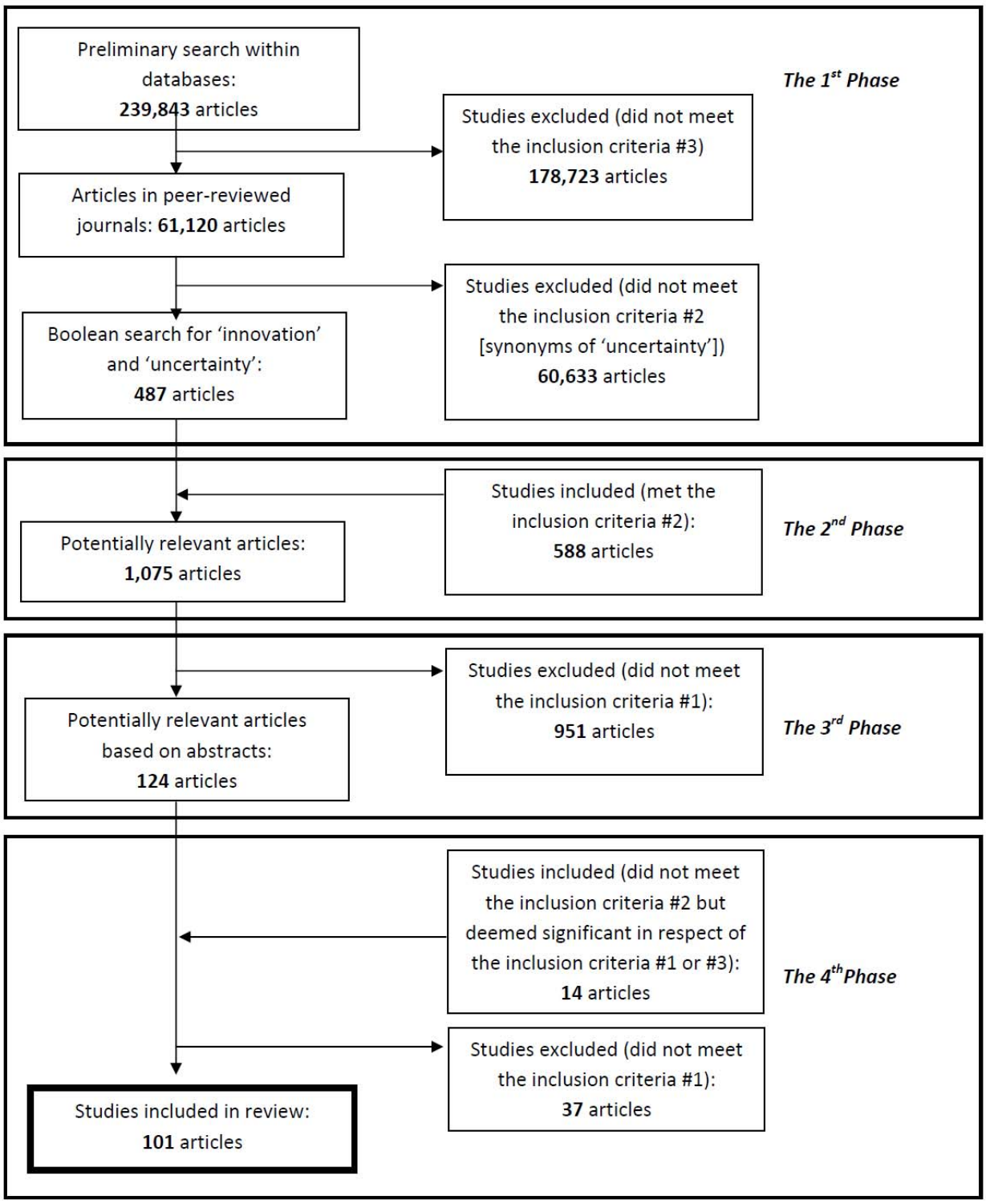

Figure 1. The systematic review flow diagram

3.3 Analysis of selected studies

Due to the heterogeneity of the studies reviewed in terms of the date of publication,

methodology and theoretical framework, a meta-analysis (i.e. employing statistical and econometric procedures for synthesizing findings and analyzing data, Transfield et al. 2003), was not appropriate for this review. The analysis conducted was descriptive by nature. The innovation literature, as mentioned in the introduction, includes several classifications of uncertainty in relation to innovation. However, for the purposes of this paper, these earlier classifications were considered to be too broad or fragmented to capture the myriad forms of uncertainty in the innovation process. Therefore, in order to provide an accurate and coherent categorization of the uncertainty of innovation, selected papers were analyzed in two phases.

In the first phase of analysis, articles were analyzed in terms of their subject matter and type of innovation, their theoretical framework, their methodology, and the sources of uncertainty. The objective of this phase was, on the one hand, to ensure that studies were relevant to the purpose of this paper, and, on the other hand, to compose an extensive list of sources of uncertainty in the innovation process as mentioned in articles (Table 1). Articles were labeled with as many factors of uncertainty as were identified in them. The first phase was conducted independently by the author and his research colleague.

The second phase of analysis consisted of reducing and combining the sources of uncertainty. After several combining and restructuring cycles undertaken with the help of mind mapping and earlier classifications identified in reviewed literature, the eight-factor classification of uncertainty in innovation processes was compiled by the author. The author verified the classifications with his research colleague and borderline cases were discussed. The eight factors are 1) technological uncertainty, 2) market uncertainty, 3) regulatory/institutional uncertainty, 4) social/political uncertainty, 5) acceptance/legitimacy uncertainty, 6) managerial uncertainty, 7) timing uncertainty, and 8) consequence uncertainty. The factors creating uncertainty in innovation processes are discussed in detail in section 4.

Table 1. The various sources of uncertainty in innovation as identified in selected papers.

Technological uncertainty	Technical uncertainty	Market uncertainty
Commercial uncertainty	Competitive uncertainty	Consumer uncertainty
Environmental uncertainty	Regulatory uncertainty	Legal uncertainty
Societal uncertainty	Political uncertainty	Economic uncertainty
Organizational uncertainty	Resource uncertainty	Decision-making uncertainty
Acceptance uncertainty	Task uncertainty	Behavioral uncertainty

3.4 Some general features of the reviewed studies

Before detailed discussion, some general features of the reviewed literature are presented here. Dividing reviewed studies into ten-year periods has been done in order to demonstrate the increase in research relating to uncertainty of innovation. In the 1970s there was only one study which met the inclusion criteria. In the 1980s the number of studies increased to six peer-reviewed articles. In the 1990s, the inclusion criteria were met by 14 studies. The remaining studies reviewed, 80 in total, were published in the 2000s. Methodologically speaking, the studies reviewed included conceptual and theoretical works (n=36), model

constructions (n=11), surveys (n=15) and empirical case studies (n=39). Since the search was not confined to any particular fields of innovation, reviewed studies were found to have been published in journals covering diverse field of expertise. The total number of journals was 74 of which 52 had an impact factor identified by Thomson ISI. Table 2 shows the distribution of articles listed by the journal in which they appeared together with the impact factor of that journal.

Table 2. Distribution of articles by journal title and journals' impact factors.

Journal Title	Number	Impact Factor[2]
Academy of Management Journal	1	5,25
Academy of Management Perspectives	1	1,19
Academy of Management Review	1	7,87
Appetite	1	2,44
BMC Health Services Research	1	1,72
British Journal of Sociology	1	1,70
Business Strategy and the Environment,	1	-
Common Market Law Review	1	0,92
Computers in Biology and Medicine	1	1,11
Creativity and Innovation Management	1	-
Economics Letters	1	0,45
Economics of Innovation and New Technology	1	-
Educational Administration Quarterly	1	1,22
Endeavour	1	0,25
Energy Policy	1	2,61
Entrepreneurship and Regional Development	1	1,35
European Journal of Innovation Management	3	-
European Management Journal	1	-
European Journal of Operational Research	1	2,52
European Planning Studies	1	0,65
Harvard Business Review	1	1,66
Health Policy	1	1,39
Industrial and Commercial Training	1	-
Information Economics and Policy	1	0,71
Information Processing & Management	1	1,64
Innovation: Management, policy & practice	3	-
International Economic Review	1	1,52
International Journal of Educational Development	1	0,98
International Journal of Emerging Technologies and Society	1	-
International Journal of Entrepreneurial Behaviour & Research	1	-
International Journal of Industrial Organization	2	0,73
International Journal of Managing Projects in Business	1	-

[2] Latest Thomson ISI impact factor of the journal rounded up to two decimals. Impact factors were extracted from the website of each journal.

International Journal of Public Opinion Research	1	0,64
International Journal of Public Sector Management	1	-
International Journal of Research in Marketing	1	1,37
International Journal of Technology Management	2	0,52
International Journal of Technology Management Sustainable Development	1	-
International Studies of Management & Organization	1	-
Journal of Business Venturing	1	2,15
Journal of Economic Dynamics & Control	1	1,12
Journal of Economic Issues	1	0,70
Journal of Emerging Technologies in Accounting	1	-
Journal of Engineering Technology Management	2	0,74
Journal of Intellectual Capital	1	-
Journal of Management Studies	1	3,82
Journal of Marketing	1	3,78
Journal of Operations Management	1	5,09
Journal of Product Innovation Management	5	2,08
Journal of Public Administration Research and Theory	1	2,08
Journal of Small Business Management	2	1,19
Journal of Systems Management	1	-
Journal of the Association for Information Systems	1	2,22
Management Decision	4	0,62
Management Research Review	1	-
MIT Sloan Management Review	2	1,10
New Genetics and Society	1	1,04
Organization Studies	1	1,45
Oxford Economic Papers	1	0,71
Research Policy	3	2,51
Research Technology Management	1	0,7
R&D Management	3	0,93
Science, Technology & Human Values	1	2,21
Small Business Economics	1	1,56
Social Science & Medicine	1	2,74
Strategy & Leadership	1	-
Technological Forecasting & Social Change	2	2,03
Technology in Society	1	-
Technovation	5	2,99
The Innovation Journal: The Public Sector Innovation Journal	2	-
The Leadership Quarterly	1	2,91
The TQM Magazine	1	-
Value in Health	1	3,03
World Futures	1	-

The theoretical frameworks of the reviewed studies cover a wide range of approaches. As far as this article is concerned, they may be divided into two groups, those studies that consider

innovation uncertainty as an explainable dependent variable, and those that consider it to be a variable independent of any other phenomenon. Examples of the studies which fall into the first category include studies which focus on the organizational challenges of managing innovation (e.g., R&D project management, change management, network management), whereas the latter category includes studies which focus on uncertain effects (e.g., organizational performance, market acceptance) generated by innovation. The literature reviewed included studies focusing on one form of uncertainty only, as well as studies discussing several forms of uncertainty in relation to innovation. Although the purpose of this paper is not to present a statistical analysis of the studies, it is informative to look at the distribution of factors of uncertainty. The review shows that the two most common sources of uncertainty are technological uncertainty (in 27 studies) and market uncertainty (in 24 studies). The other six factors discussed are as follows: regulatory/institutional uncertainty (in 16 studies), social/political uncertainty (in 16 studies), acceptance/legitimacy uncertainty (in 19 studies), managerial uncertainty (in 18 studies), timing uncertainty (in 16 studies), and consequence uncertainty (in 19 studies).

4. Results and discussion: eight factors which create uncertainty in the innovation process

Table 3 lists the selected papers in alphabetical order together with their subject area/the purpose of the study, theoretical framework/approach, methodology, and the source of uncertainty (1-8). The eight factors are discussed in detail in subsections 4.1-4.8.

Table 3. Selected papers. (Details of the selected studies can be found in the bibliography.)

Article	**Subject area/ Purpose of the study**	**Theoretical framework/ approach**	**Methodology**	**Source of uncertainty** 1=technological uncertainty 2=market uncertainty 3=regulatory/institutional uncertainty 4=social/political uncertainty 5=acceptance/legitimacy uncertainty 6=managerial uncertainty 7=timing uncertainty 8=consequence uncertainty
Adam (2000)	To demonstrate the pertinence of the timescape of (GM food) innovation	Socio-environmental theory	Conceptual analysis	7
Aldrich & Fionel (1994)	To examine the strategies that can be used in pursuit of the legitimacy of innovation	Organizational legitimacy; industry creation	Conceptual analysis	5
Allen (1982)	To analyze technological dissemination of innovation	Innovation dissemination	Model construction	1
Arias (1995)	To explore how networks simultaneously promote and block	Social network theory	Conceptual analysis	4

	innovation			
Arnold et al. (2007)	To explore the unintended consequences of Sarbanes-Oxley on technology innovation	Structural inertia theory	Cross-sectional case study	8
Artto et al. (2008)	To provide a critical analysis of prior project management literature addressing different context-specific strategies of innovation projects	Project management	Review of the literature	5
Banerjee & Chatterjee (2010)	To evaluate the impact of piracy on innovation in the presence of technological and market uncertainty	Piracy in innovation	Model construction	1,2
Bessant (2008)	To understand the challenges of innovation capabilities	Discontinuous innovation	Multiple case study	1,2,3
Bhatta (2003)	To analyze the notion of risk in innovation in the public sector	New public management; risk management	Conceptual analysis	6
Bonifati (2010)	To examine the relevance of some concepts of complexity theory in the context of innovation	Complexity theory	Conceptual analysis; review of the literature	2,4,8
Buddelmyer et al. (2010)	To deepen understanding of the role innovation plays in determining company survival by highlighting the role of the degree of uncertainty	Company survival; competitive advantage	Survey; model construction	1,2,3
Cantarello et al. (2011)	To analyze the role of uncertainty in new product development processes	Governance modes in NPD processes	Multiple case study	1,2,4,7
Carbonell & Rodriguez (2006)	To investigate the impact of innovation speed on managerial perceptions of positional advantage and new product performance	Competitive advantage	Survey	1,2
Castellaci et al. (2005)	To explore main strands and to identify neglected topics and methodological challenges of innovation research	An interdisciplinary approach	Conceptual analysis; review of the literature	8
Chen (2005)	To provide a community-based framework to explain the collective actions that overcome uncertainty in innovation	Safety and cost management; knowledge insufficiency; collective action framework	Historical case study	4
Cornford et al. (2010)	To analyze the processes by which technology comes to play a role as an active agent within the collective	Science and technology studies; actor network theory	Case study	4
Corrocher & Zirulia (2010)	To analyze the pricing strategies of mobile communications operators	Innovation-based approach to firms' pricing	Theoretical hypotheses and descriptive	2

	and examine the role of demand characteristics in the development of new tariff plans	strategies	statistics	
Cooper (1998)	To build a multidimensional model which encourages practitioners and academics to treat innovations as they exist	Multidimensional approach for innovation	Conceptual analysis; model construction	7,8
Coughlin (2010)	To address key trade-offs in innovation	The convergence of technology and global ageing	Conceptual analysis; review of the literature	1
Degeling (2009)	To explore surgical authority, futility and innovation in medicine	Evidence-based medicine	Review of the literature	5
Demaid & Quintas (2006)	To analyze the tension between understanding knowledge creation and use, and the drive to capture processes in formal documents and systems	Formal rules and socio-economic behaviors	Multiple case study	3
Doraszelski (2004)	To analyze the distinction between technological breakthroughs and engineering refinements	Innovation adoption	Model construction	1,7
Dosi (1982)	To establish a model that accounts for both continuous changes and discontinuities in technological innovation.	Technological paradigms; technological trajectories	Model construction; conceptual analysis	1
Evan & Olk (1990)	To analyze differences in governance and administration in R&D in Japan and US.	Inter-organizational alliances in R&D	Survey	5
Fleurke & Somsen (2011)	To analyze the role of regulation in chemical risk and the stimulating of innovation	Regulatory theory	Case study	3
Foster (2010)	To identify elements that may promote necessary entrepreneurship and innovation	Theory of economic growth; productivity; creative destruction	Review of the literature; a case study	2,3,6,8
Freel (2005)	To provide evidence of the extent to which perceptions of environmental uncertainty discriminate between small firms engaged in various levels of product innovation	Environmental uncertainty	Survey	1,3,6
Gales & Mansour-Cole (1995)	To examine user involvement in innovation projects	User involvement	Survey; multiple case study	3,4,7
Geijsel et al.	To examine the conditions	Transformational	Multiple case	5

(2001)	that foster the implementation of large-scale innovation programs through the eyes of teachers	leadership; participatory decision making	study	
Gerwin & Tarondeau (1982)	To compare adoption and implementation of computer integrated manufacturing systems in different countries	Innovation adoption	Multiple case study	6,8
Giaretta (2005)	To consider whether constant product innovation is compatible with the ethical management of a business	Business ethics; organizational change	Conceptual analysis; review of the literature	7
Gibbons & Littler (1979)	To address innovation dilemmas	Organizational change; risk management	Case study	1,2,4,7
Gilbert & Cvsa (2003)	To examine the trade-off faced when a firm's channel partner has opportunities to invest in either cost reduction or quality improvement	Supply chain management	Model construction	2
Grecsek (1988)	To understand the multidimensional nature of software copyright in innovation	Copyright of innovation	Conceptual analysis	3
Guedes (2003)	To examine the extent to which government initiatives have been successful in promoting innovative activities in biotechnology both in academia and industry	Innovation network	Case study	3
Gupta & Wilemon (1996)	To explore the major changes that R&D management has undergone in recent years, the changes R&D managers expect to encounter during the next few years, and the causes of those changes	Change management	Survey	2
Halbesleben et al. (2003)	To integrate research on social aspects of time, leadership, and innovation into a competency-based model	Temporal complexity	Model construction; conceptual analysis	7
Hall & Martin (2005)	To establish an evaluation framework to address the potential unintended and unforeseen consequences of innovation, as well as its potential benefits	Stakeholder theory, innovation management; evolutionary learning	Case study	1,2,4,8
Hall et al.	To explore technological,	TCOS	Case study	1,2,4,5

(2011)	commercial, organizational and social uncertainties of innovation	Framework		
Hamel & Välikangas (2003)	To explore strategic resilience	Organizational strategy	Conceptual analysis	2,6
Hanft & Korper (1981)	To discuss uncertainty in federal policy and innovation	Public policy	Case study	4
Harris & Woolley (2009)	To establish a framework that addresses problems managers face in the early stages of defining an innovative project	Cognitive mapping	Action research; model construction	1,2
Hartz & Jürgen (2009)	To explore the different ways in which early economic data can inform public health policy decisions on new medical technologies	Economic evaluation	Review of the literature	7
Harvey & Novisevic (2001)	To develop a decision framework based on the notion of social time	Decision making	Conceptual analysis; model construction	7
Heiskanen et al. (2007)	To present the argument that educating consumers may not solve all problems, and may sometimes even address the wrong question	Radical innovation; consumers´ acceptance and resistance	Multiple case study	3
Hjorth (2004)	To develop a number of related 'spatial concepts' intended to describe entrepreneurship as 'creation and use of space for play/innovation'	Management; entrepreneurship; spatiality	Case study	6,7
Hoppe & Ozdenoren (2005)	To offer a new theoretical framework to examine the role of intermediaries between creators and users of new inventions	Innovation intermediary	Model construction	8
Hurst (1982)	To explore the possibility of explaining innovations by means of an evolutionary model	An evolutionary theory	Conceptual analysis; review of the literature	4,5
Johannessen et al. (2011)	To describe a conceptual model and an associated set of managerial and organizing implications for the innovation-led company	Performance management; knowledge economy	Multiple case study	5
Jun & Weare (2010)	To examine the institutional motivations underlying innovation	Institutional motivations; innovation dissemination	Survey	4
Kickul & Gundry (2002)	To propose and test an entrepreneurial process model that examines the	Entrepreneurship ; strategic orientation;	Survey	5

	interrelationships between a small firm owner's personality, strategic orientation, and innovation	innovation process		
Koch (2004)	To understand innovation networks as the interplay between stable and dynamic elements	Technology studies; sociology of organizations; management studies	Multiple case study	4
Koen et al. (2010)	To understand how companies manage dilemmas that they face in pursuit of business-model innovations	Business model dilemmas	Multiple case study	6
Lambooy (2005)	To explore what innovation theory teaches us about policies enhancing the development of creative and innovative regions	Theories of innovation; regional innovation system	Conceptual analysis; review of the literature	3,8
Lehoux et al. (2009)	To explore public involvement in health innovation	Science, technology and society perspective	Conceptual analysis	5
Leifer et al. (2001)	To understand factors related to successful radical innovation implementation	Radical innovation	Multiple case study	1,2,6
Li et al. (2008)	To interpret exploration and exploitation in the literature on technological innovation	Exploration and exploitation	Review of the literature	6
Lowe (1995)	To understand the role of social processes in entrepreneurial innovation	Social processes	Case study	3
Macdonald & Jinliang (1994)	To understand timeliness in industrial innovation	New product innovation; emerging markets; business life cycle; timeliness of innovation	Conceptual analysis; review of the literature	6,7
Mallett (2007)	To explain social acceptance of renewable energy innovations	Innovation dissemination	Case study	5
McDermott & O'Connor (2002)	To explore the process of radical new product development from a strategic perspective	Radical innovation; strategic management	Multiple case study	2
Mitleton-Kelly (2006)	To explore the creation of new order	Complexity theory	Case study	6,8
Muller & Välikangas (2005)	To offer guidelines for developing a customized suite of **innovation** metrics	Metrics for innovation	Conceptual analysis	2,6
Naranjo-Gil (2009)	To examine organizational and environmental factors that may explain the	Public organization; environmental	Survey	2

	adoption of innovations in public sector organizations	uncertainty		
Narvekar & Jain (2006)	To understand the technological innovation process	Intellectual capital	Cross-disciplinary survey of the literature	1
Nieto (2004)	To establish consistent ground for technological innovation management	Technology; technological innovation process	Conceptual analysis; review of the literature	1
Numata et al. (2010)	To propose a new clinical development system to stimulate medical device development in Japan	Medical device innovation; research and development policy	Case study	3
Ortt & Smits (2006)	To describe trends in innovation management	Innovation management; innovation system	Review of the literature	1,2,4,5,6
Osborne (1996)	To describe and evaluate the management of innovation within a local voluntary agency in Britain	Innovation management; public organization	Case study	6
Ozaki (2011)	To investigate what encourages consumers to adopt a green electricity tariff	Innovation adoption	Case study; survey	5
Parsons (2006)	To argue that innovations aimed at improving the efficiency of the public sector seriously risk making it dangerously fragile at a time when it needs to become more adaptable	Public organization; risk; learning	Conceptual analysis; review of the literature	6
Peters et al. (2007)	To analyze the influence of cultural factors on sense-making of food biotechnology and the resulting public attitudes in the USA and Germany	Trust; sense-making	Survey	8
Porzsolt et al. (2009)	To propose a strategy and new structures to standardize the description of health care innovations	Health care innovation; assessment of innovations	Conceptual analysis; model construction	7
Potts (2009)	To argue that the innovation deficit in government and public sector services can be explained as an unintended consequence of the concerted public sector drive toward the elimination of waste through efficiency, accountability and transparency	An economic evolution; risk; public organization	Conceptual analysis	6
Rappert & Brown (2000)	To explore how diverse actors attempt to manage innovation in health	Genetic diagnostics; telemedicine	Case study	5

	technology development			
van Riel et al. (2004)	To explore internal innovation success factors	High technology service innovation; decision-making	Survey	4,8
Robertson & Gatignon (1986)	To suggest that the supply-side competitive environment affects the dissemination of new technology	Technology dissemination	Conceptual analysis; review of the literature	8
Roffe (1999)	To examine and analyze the strategic planning issues involved in starting and developing training innovation	Strategic planning; training innovation	Conceptual analysis; model construction	7,8
Ronteltap et al. (2007)	To establish a new conceptual framework for the consumer acceptance of technology-based food innovations	Food innovation; innovation dissemination and adoption; consumer acceptance	Conceptual analysis; model construction	5,8
Rose-Andersen et al. (2005)	To demonstrate how complex systems provide an overall conceptual framework for thinking about innovation	Complex systems thinking	Multiple case study	2
Schilling (2002)	To model the technology selection process	Learning; timing; network externalities	Multiple case study; survey	7
Schlich (2007)	To examine the renegotiations of power and responsibility associated with the introduction of innovation	Medical innovation; power	Conceptual analysis; review of the literature	5
Scranton (2007)	To describe the nature of dynamics of innovation	Complexity; dynamic innovation; design	Case study	1
Shenhar et al. (1995)	To establish a two dimensional taxonomy for the classification of products and innovation	Technological uncertainty; system scope	Multiple case study; model construction	1
Sinha (2001)	To provide a rationale for international joint venture formation	Joint ventures; imitative innovation	Conceptual analysis	3
Smits (2002)	To analyze changes in three major developments (i.e. structural changes in our economy, the broadening of decision-making processes and the emergence of the network society, and changes in the knowledge infrastructure) within the context of innovation processes	Structural change of economy; network society; knowledge infrastructure	Conceptual analysis; review of the literature	2

Souder & Moenaert (1992)	To develop a contingency framework which shows the effect and determinants of interfunctional information transfer in R&D	Technological innovation; interdependency of organizational functions	Conceptual analysis; model construction	1,2,6,7
Sveiby et al. (2009)	To study research on unintended undesirable consequences of innovation	Innovation dissemination	Review of the literature	8
Swink (2000)	To assess the direct contributions of design integration and top management support to several dimensions of NPD performance, and identify potential moderating influences of technological innovativeness on these direct effects	New product development	Survey	1
Tatikonda & Montoya-Weiss (2001)	To establish conceptual framework which characterize relationships among organizational process factors, product development capabilities, critical uncertainties, and operational/market performance in product development projects	A resource-based view of the firm; organizational information-processing	Survey	1,2
Thamhain (2003)	To explore the principle factors that influence innovation-based performance of R&D teams	Team performance; innovation management	Multiple case study	6
Tidd & Bodley (2002)	To review and to examine the range of formal tools and techniques available to support new product development processes.	New product development	Survey	1
Veryzer (1998)	To provide a better understanding of managerial practices associated with discontinuous innovation	Discontinuous innovation; new product development	Multiple case study	1
Verhees & Meulenberg (2004)	To develop a model of the combined effect of market orientation and innovativeness on product innovation and company performance	Small firms; new product development	Model construction	5
Vermeulen et al. (2007)	To explore the role of the government and the impact of policies on market construction and innovation	Institutional theory; governmental policy	Case study	3
Välikangas & Gibbert (2005)	To explore the role of constraints as enablers of innovation	Boundary-setting strategies	Conceptual analysis	1
Waelbrock (2003)	To show that when innovations are used as	Complexity	Model construction	8

	factors of production, entrepreneurs do not take into account the fact that their innovations increase the complexity of the production process			
Walton et al. (2002)	To offer a model for the bias found in willingness-to-pay valuations against new treatments	Health care innovation; willingness-to-pay evaluation	Model construction	8
Wilson (1997)	To review the literature on information behavior	Information behavior	Review of the literature	5
Xu (2011)	To explore how an entrepreneur's diversity of social capital influences the characteristics of his/her cognitive model	Social capital; cognitive model	Survey	5
York & Venkatraman (2010)	To offer a framework which relates the fundamental drivers of entrepreneurship and environmental degradation	Environmental action; entrepreneurship	Conceptual analysis	1,3,4,8

4.1 Technological uncertainty

The relationship between technology and innovation is close. A main thrust of innovation research has focused on technology-based innovations. Rogers (2003), for example, has emphasized that most of the new ideas, the dissemination of which has been analyzed, are technological innovations. The relationship is so close that words 'innovation' and 'technology' are typically used as synonyms.

Adapting Rogers (2003), technology can be widely defined to include both the technical tools and the knowledge needed to use the tools. Based on the reviewed literature, both aspects of technology can also be seen as sources of uncertainty. The technological innovation process is full of uncertainties and ambiguities (Narvekar & Jain 2006). According to Harris and Woolley (2009) innovators encounter technological uncertainty, both in terms of product specification (i.e. technical tools) and production processes (i.e. knowledge). When it comes to product specification, the innovation's technical feasibility, usefulness, functionality or quality is at least partly unknown (Allen 1982; Leifer et al. 2001; Hall & Martin 2005; Buddelmyer et al. 2010; Hall et al. 2011). The uncertainty related to product specification is dependent on the novelty of the technology *(*Swink 2000; Tatikonda & Montoya-Weiss 2001; Tidd & Bodley 2002; Nieto 2004; Carbonell & Rodrı´guez-Escudero 2009). Shenhar et al. (1995) have defined four types of innovations based on the degree of technology novelty. The types are low technological uncertainty innovations, medium technological uncertainty innovations, high technological uncertainty innovations, and super-high technological uncertainty innovations. The last two cases at least can be seen as examples of fundamental technological change that "requires the transition from one technology paradigm to another and, therefore, is not only less likely to occur and but also associated with higher uncertainty than innovation along a given trajectory" (Dosi 1982).

Production processes refer here to a diverse collection of processes, techniques and knowledge used to produce products and services. New technologies not only require new technical skills but also new business models in which those technical capabilities become valuable (Välikangas & Gibbert 2005). Technology causes uncertainty in respect of the skills and knowledge required to succeed in using new technology (e.g. Veryzer 1998; Nieto 2004; Ortt & Smits 2006; Carbonell & Rodrı´guez-Escudero 2009; Cantarello et al. 2011). Ortt and Smits (2006) have eloquently stated that "technology does not offer itself as ready-made packages, but more as opportunities". Similarly, Coughlin (2010) has pointed out that technology has a 'Janus face' implying both new solutions as well as new problems. Due to the interdependency between technology and necessary organizational capabilities, it seems that 'technology is equivoque', by which Weick (2001) means that "while technologies always had stochastic events, the unique twist in the new technologies is that the uncertainties are permanent rather than transient". In other words, the relevance of past practice for new technology becomes increasingly uncertain (Scranton 2007).

In summary, the technological uncertainty in innovation arises due to a lack of knowledge of the details of new technology or due to a lack of knowledge required to use new technology.

4.2 Market uncertainty

Innovation without a market is has no value. The idea of innovation implies that it is invented and implemented in order to meet the needs (real or perceived) of the market. A market environment for innovation consists of the needs of customers, the actions of competitors, and the prices of substitutive commodities. A great uncertainty exists concerning future market conditions (e.g. Foster 2010) and includes "the disruptive effects of emerging technologies, empowered customers, new market entrants, shorter product life cycles, geopolitical instability, and market globalization" (Muller & Välikangas 2005).

The reviewed literature shows that market-based uncertainty can be classified into three categories. The first and most important source of uncertainty is customers. The uncertainty regarding the demand for the innovation, the unknown behavior of customers and unclear customer needs were recognized as the main sources of uncertainty caused by customers (e.g. Souder & Moenaert 1992; Leifer et al. 2001; Tatikonda & Montoya-Weiss 2001; Gilbert & Cvsa 2003; Freel 2005; Hall & Martin 2005; Rose-Anderssen et al. 2005; Carbonell & Rodriguez 2006; Naranjo-Gil 2009; Corrocher & Zirulia 2010; Cantarello et al. 2011). It is particularly challenging to estimate what consumers might want in the future (Harris & Woolley 2009). Gupta and Wilemon (1996) and Smits (2002) have written about growing market fragmentation, which occurs due to meeting the needs that result from the changing demographics, values, expectations and behaviors of consumers. Similarly, York and Venkatraman (2010) have stated that customers' changing opinions concerning environmental issues may increase uncertainty for organizations as they cannot predict how environmentally-friendly innovations will be rewarded by consumers and markets. According to Hamel and Välikangas (2003), this results in the accelerated migration of power from producers to consumers.

Secondly, market uncertainty manifests itself as a lack of knowledge about the behavior of

competitors. The logic of innovation is based on the idea that an organization does thing differently from its competitors. However, doing things differently is difficult because organization cannot know with any certainty what its competitors' intentions might be (e.g. Souder & Moenaert 1992; McDermott & O'Connor 2002; Naranjo-Gil 2009; Banerjee & Chatterjee 2010). This kind of uncertainty typically results from the globalization and liberalization of markets (Ortt & Smits 2006).

Thirdly, even if it is minor in scope, a source of market-based uncertainty is the price development associated with competing products and services. Gibbons and Littler (1979) have found that difficulty in predicting prices of raw materials needed for substitutive commodities may cause uncertainty in the innovation process. Uncertainty arises because price development is dependent on many factors associated with demand and supply of raw materials, predictions for which are impossible.

In summary, the market uncertainty in innovation exists, on the one hand, due to unforeseeable changes in relations between firms and customers and, on the other hand, due to unforeseeable changes in relations between competitors from which new markets emerge.

4.3 Regulatory/institutional uncertainty

While agreeing with the argument of York and Venkatraman (2010), which states that "the issue of resolving our current crisis is not one of regulation, but of innovation and motivation", it is supposed that regulations and institutions play an important role in innovations. Lambooy (2005) and Foster (2010), for example, have pointed out that entrepreneurial firms need institutional arrangements that facilitate their innovation efforts. Uncertainty-related innovation can be reduced by means of institutional arrangements (Lambooy 2005; Foster 2010; see also Hayek 1973). On the other hand, regulations and institutional arrangements can be seen as obstacles to innovation and as a source of uncertainty. Vermeulen et al. (2007) have pointed out that complexity of institutional arrangements may block the dissemination of innovation and constrain change. Similarly, Guedes (2003) has found that instability in government funding of innovation can lead to weakness in the innovation network. Some authors have stated that uncertainty related to regulations and institutional arrangements can also be seen as good for innovation. Lowe (1995), for example, has found that an unclear regulatory environment creates fields of opportunity in which "the entrepreneur can create his own rules".

By definition, a regulatory and institutional environment for innovation consists of laws and regulations that have been developed in order to constrain and enable innovation activities. Constraining regulations are needed, for example, to ensure that the innovation does not pose a threat to the citizen or society as a whole. Constraining regulations are typical in issues related to the environment or health. Enabling regulations refer to legislation that supports the innovation processes. These are, for example, intellectual property rights that support and promote the fair and equitable sharing of benefits that arise from the development of a given innovation.

Despite the good intentions behind regulations, however, it seems that they may have detrimental side effects for innovation processes. The reviewed literature reveals that changes

– actual or perceived – in regulations and institutional arrangements were seen as factors that increase environmental complexity and turbulence, which, in turn, creates uncertainty in innovation processes (e.g. Gales & Mansous-Cole 1995; Sinha 2001; Freel 2005; & Quintas 2006; Sartorius 2006; Bessant 2008; York & Venkatraman 2010).

The main reason for uncertainty is a lack of clear understanding of how certain regulations affect a given innovation process. Fleurke and Somsen (2011), for example, have found that in the fields of biotechnology, nanotechnology and synthetic biology innovation is discouraged by a time-consuming and costly notification procedure. Regulatory quandaries create uncertainty and complexity. At its worst, the result might be precautionary regulation which amounts to significantly more than the management of risk associated with scientific uncertainty, but which also hampers innovation (Fleurke & Somsen 2011). Foster (2010), in turn, has identified a different kind of problem related to the relationship between regulation and innovation. According to Foster (2010), measures to promote innovation can be challenging for a government because they "require an understanding of emergent industries that a public sector administrator may not have". Instead of supportive regulations for innovation, uncertainty inherent in emergent issues may yield regulations that facilitate routine business improvements and processes. Numata et al. (2010) have also analyzed the relationship between the regulatory environment and innovation. They have argued that the Japanese regulatory environment has caused a high level of uncertainty leading to stagnation in the development of medical innovations. Heiskanen et al. (2007) have achieved similar research results concerning the dissemination of innovation. According to them, intelligent packaging has been only slowly disseminated within Europe, at least partly due to uncertainties about legislation.

One specific form of uncertainty embedded within the innovation process relates to the issue of whether the developed concept qualifies for intellectual property protection, such as a patent or trade mark (Buddelmyer et al. 2010). Uncertainty regarding copyright is typical in the field of software development. Grecsek (1988), for example, has stated that most confusion relates to the question of what constitutes the idea (which cannot be protected) and what constitutes the expression of that idea (which can be protected). If the innovator is not convinced that his/her effort can be protected by copyright he/she feels uncertainty, and innovation may be stifled. Similarly Allarakhia and Wensley (2005) have found that biotechnological innovations may be hampered due to uncertainty in relation to intellectual property rights. They point out that it is not clear whether existing patent law allows a researcher who has discovered an innovation to be awarded a patent for it.

Based on the literature, it can be concluded that the more unknown the domain (e.g. consequences and technology) of the innovation, the more ambiguous are the regulations and, hence, the more uncertainty is felt by innovators.

4.4 Social/political uncertainty

It has been argued that innovations do not occur in isolation, but developed and disseminated in interfaces between different stakeholders (e.g. Hurst 1982; Rogers 2003; Pettigrew & Massini 2003; Johansson 2004). The role of interaction is particularly emphasized in

systemic innovation, which refers to development activities that involve a change in multiple interdependent components (Jaspers 2009). Interaction is needed for developing new ideas and also for implementing them as new practices.

Even thought interaction can be seen as a generic feature of innovation, it is important to note that interaction is also a significant source of uncertainty. This is because interaction is a process whereby the diversity of interests among members of an organization is revealed. With interaction the social and political aspects of innovation become visible. Cooperation between, and the risk of opportunism on behalf of, the partners involved in innovation increases uncertainty (Cantarello et al. 2011). For Arias (1995), Sartorius (2006) and Ortt & Smits (2006), the result is the 'fundamental uncertainty' that arises from the wide variety and high complexity of interactions between different actors with their own interests. Bonifati (2010) is thinking along the same lines when he writes about 'ontological uncertainty'. By ontological uncertainty he refers to complex qualitative changes in the relationship between producers, sellers and users, from which new patterns of interaction emerge. This emergent nature of innovation makes prediction impossible. Hall and Martin (2005) have also emphasized the uncertainty faced by innovators due to their inability to predict the potential harmful or disruptive side effects of innovation for the stakeholders.

Adapting Latour (1987), Cornford et al. (2010) have eloquently touched upon the problem of interaction uncertainty in respect of innovation. They write that "central to this activity [innovation] is the attempt to stabilize an idea or concept – that is to produce a fact – as an accommodation of various interests, and to do this in a way that it can be returned to the world reinforced and made more powerful" (Cornford et al. 2010). Koch (2004) and Gales & Mansour-Cole (1995) describe the situation as a paradox. In seeking to reduce uncertainty, the actors engage in relationships with others that in and of themselves lead to social and political uncertainties. Innovation has the potential to disrupt power structures and work routines within an organization (e.g. Gibbons & Littler 1979; Chen 2005; Jun & Weare 2010).

Most decisions relating to the development of innovation take place subject to high levels of uncertainty (van Riel et al. 2004). Although decisions can be improved with better information, they are always influenced by political and value judgments (Hanft & Korper 1981). Therefore, adaptation of innovation may be difficult to achieve, and will be beholden to internal politics (e.g. York & Venkatraman 2010). In addition, while political and social uncertainty may cause conflict in the short term (e.g. Hurst 1982), uncertainty may lead to cognitive inertia in organizations (Porac & Thomas 1990) and produce over-conservatism in the longer term (cf. Mack 1971) – "a bias toward routine ways of solving problems, toward doing nothing" (Hanft & Korper 1981).

In summary, social and political uncertainty can result from a diversity of interests among stakeholders and a power struggle between the stakeholders.

4.5 Acceptance/legitimacy uncertainty

Innovation not only disrupts the social order of an organization, but it may also create cognitive dissonance for individuals within the organization (cf. Wilson 1997). Therefore, the producers of innovation should be interested in their acceptance and legitimacy (e.g. Ortt &

Smits 2006; Ronteltap et al. 2007).

Aldrich and Fionel (1994) have introduced the notion of cognitive and socio-political legitimacy of innovation (see also Hall et al. 2011). Cognitive legitimacy refers to the knowledge base that is needed in using innovation. Without relevant knowledge and experience related to innovation, the potential user suffers, and the innovation loses its legitimacy. Socio-political legitimacy, in turn, refers to an individual's values and an organization's norms and culture. Innovation loses its socio-political legitimacy if it contradicts a user's 'world view'. In other words, individuals feel uncertain if an innovation is inconsistent with their current thinking (Hurst 1982).

The reviewed literature included several studies that discuss acceptance and legitimacy uncertainty of innovation. Kickul and Gundry (2002), Verhees and Meulenberg (2004) and Xu (2011), for example, have found that the creation of the structures and processes that facilitate innovation is based on an individual's cognitive models. Similarly, Johannessen et al. (2011) have stressed the importance of an innovator's tacit knowledge in arguing that low level of experience may increase the ambiguity surrounding innovation activities. The literature also reveals that socio-political legitimacy plays an important role in innovation. Rappert and Brown (2000), Geijsel et al. (2001), Mallett (2007), Schlich (2007), Degeling (2009), and Lehoux et al. (2009), among others, have found that innovation perceived as a threat by individuals or collectives (e.g. professions or interest groups) causes uncertainty in regard to whether it should be accepted or rejected. Similarly, Evan and Olk (1990) and Artto et al. (2008) have pointed out that any innovation is susceptible to high degrees of uncertainty due to people's unique interests and fear of compromising their proprietary interest, as well as difficulty in transferring and exploiting R&D results in member organizations.

The acceptance of innovation is dependent on the individual´s existing world view, which, in turn, reflects their identity, values and norms (cf. Ozaki 2011). Latour (1987 in Moensted 2006), has touched upon the legitimacy of innovation in asking what ultimately legitimates the innovation. Is it that people will be convinced once the innovation works, or is it that the innovation will work when all relevant people are convinced?

Based on the literature, it can be seen in summary that the cognitive legitimacy of innovation is uncertain when necessary skills and knowledge contradict the existing skills and knowledge possessed by users. On the other hand, the socio-political legitimacy of innovation is uncertain when that innovation threatens an individual's basic values and/or an organization's norms.

4.6 Managerial uncertainty

Innovation is a transformational process (e.g. Gerwin & Tarondeau 1982), which challenges rational management models (e.g. Thamhain 2003; Mitleton-Kelly 2006; Foster 2010). Instead of planning, it is said that innovation requires intuition – the novel insight into problems that does not directly result from a rational and structured thought process. Innovation is dealing with novelty within an organization (cf. Macdonald & Jinliang 1994). This also means that innovation always functions as a certain kind of disruptive behavior within an organization. Rehn (2011), for example, writes about 'dangerous ideas', by which

he refers to thinking that questions the conventional and is provocative. Similarly, Hjorth (2004) has argued for the importance of "playing with the ideas" that challenge existing organizational routines. Hamel and Välikangas (2003) argue along the same lines when they claim that innovation flourishes when organizations become resilient. For Hamel and Välikangas (2003) resilience means the capacity for continuous reconstruction of organizational values, processes and behaviors that systematically favor perpetuation over innovation. Since innovation refers both to thinking differently and unconventionally, and to experimenting and implementing new ideas, it is understandable that innovation is a process which implicitly implies risk and the possibility of failure. Exploring the new is more risky than exploiting the existing situation (cf. Li et al. 2008).

The reviewed literature shows that the risk inherent in innovation and the possibility of failure are the most important factors in creating uncertainty in the managing of innovation. Uncertainty arises from a lack of knowledge regarding the effectiveness of management activities which may be used for supporting innovation behavior in risky situations where a fear of failure exists. Managing innovation differs from managing routine tasks. Routine tasks imply predictability, standardization and stability, whereas innovation requires autonomy, unprogrammed tasks, and risk-taking. The literature reveals that there are managerial uncertainties associated with changing the members of an R&D project team, required resources and competencies, managing relationships with the rest of the organization and co-operation with partners (e.g. Souder & Moenaert 1992; Osborne 1996; Leifer et al. 2001; Muller & Välikangas 2005; Freel 2005; Hall & Martin 2005; Mitleton-Kelly 2006; Koen et al. 2010). Koen et al. (2010), for example, have pointed out that traditional tools used to manage risk are fundamentally flawed in innovation projects because the unknowns associated with innovation, by their very nature, are unpredictable. Similarly Muller and Välikangas (2005) have stressed that there is lack of requisite metrics to make informed decisions in innovation projects. According to them, innovation management is "somewhat of a black art". Osborne (1996) and Mitleton-Kelly (2006), among others, in their turn, have stressed the complexity of innovation embedded in inter-organizational contexts. Mitleton-Kelly (2006) points out that rethinking existing norms of behavior and ways of working have emerged in interaction between different actors. For Mitleton-Kelly (2006) it is this interaction which means "moving into a zone of discomfort and uncertainty".

Innovation necessitates initiative, which in turn can lead to the situation termed by Shaw (2002) as the paradox of "being in charge but not in control". This paradox is also a significant source of uncertainty. Innovation necessitates initiative, which, in turn, brings with it the risk of failure. Bhatta (2003), Parsons (2006) and Potts (2009), among others, have suggested that risk and failure are fundamental catalysts for innovation. It has also been said that "innovation is not a matter of optimizing, but a process of trial and error" (Ortt & Smits 2006). While commonly recognized wisdom argues that innovation flourishes in an environment where risk-taking is encouraged and failures are tolerated, it should be noted, however, in the light of reviewed literature, that 'design for failure' (cf. Parson 2006) may be a project that increases – not reduces – uncertainty. In the words of Thurmond and Kunak (1988 in Macdonald & Jinliang 1994), the change required by novelty may lead the organization towards failure more surely and more decisively than any failure in the market.

In summary, the managerial uncertainty in innovation manifests itself as a fear of failure and as a lack of the tools required to manage the risk inherent in innovation processes.

4.7 Timing uncertainty

Timing is an important part of management. Global competition, which manifests itself as rapid speed of change, requires timely actions. Macdonald and Jianling (1994), for example, have emphasized the fact that due to short-lived product life cycles, the speed-to-market has become a critical success factor for organizations. Jalonen and Lönnqvist (2009), in turn, have demanded predictive business – a management perspective by which they refer to the early recognition of business opportunities and threats and to agile reaction to changes in the business environment.

Time is also definitely of great significance in innovation. It is an implicit element of the definition of innovation. Innovation refers to new ideas which have been implemented. As noted before, the novelty of innovation depends on the context. It means that the idea, practice or object seen as novel at some point and in some place may fail to be accorded the status of innovation at other time and in some other place. However, despite the subjectivity of such novelty, innovation researchers unanimously acknowledge that timing is a crucial driver for successful innovation (e.g. Macdonald & Jianling 1994; Schilling 2002; Halbesleben et al. 2003). Dumaine (1989), for example, has suggested that time affects profitability more than budget does. Time has also been considered important for reasons of competitive advantage (e.g. Macdonald & Jinliang 1994; Cooper 1998). Cooper (1998) has identified the 'innovation imperative' by which she refers to situations where organizations are obliged to innovate concurrently. In other words, competing through innovation is not a one-time event. Adapting Agamben (1999), Hjorth (2004) has referred to time as an period "when a possibility to actualize an imagined creation is practiced in concrete social relation […] making use of what is postulated/constructed as a freedom to act in the words 'I can' ". Although rapidity of innovation has been seen typically as an advantage for organizations, some authors have also praised slowness. Giaretta (2005), for example, has pointed out that in a state of complex and uncertain innovation, the fear of being "left behind" may blind organizations to see things differently. Based on the above discussion, it can be argued that timing is critical for innovation, albeit not an easy task.

The classical dilemma is to innovate early, but not too early (Macdonald & Jinliang 1994). Therefore, it is important that a new product launch is executed in step with product promotion and avoids conflict with other events in the market (Macdonald & Jinliang 1994). The innovation literature describes three kinds of time-related uncertainties. The first one relates to the fact that knowledge increases as time passes. In other words, the earlier the entry, the more uncertainty there is (cf. Macdonald & Jinliang 1994). Gibbons and Littler (1979), Roffe (1999), Doraszelski (2004), Porzsolt et al. (2009), and Hartz and Jürgen (2009), for example, have suggested that organizations experience an incentive to delay or postpone the adoption of an innovation because of the difficulty in finding the optimal timing for an investment decision. This kind of reasoning resonates with the commonly held truth that the most important decisions, with the greatest implications, are made in the early stages of the innovation process, before all relevant information is available (Moensted 2006). The early

stages of the innovation process are uncertain due to the “high perceived variability and low perceived analyzability" of the tasks in question (Souder & Moenaert 1992). As the process progresses and more information is made available, variability will decrease and analyzability will increase (Souder & Moenaert 1992).

Secondly, time-related uncertainty reveals itself in the later phases of an innovation project. Gibbons & Littler (1979), Gales & Mansour-Cole (1995) and Cantarello et al. (2011) have found that uncertainty may persist or even increase as innovation projects progress. Gales and Mansour-Cole (1995) argue that while uncertainty may be high in the early phases of an innovation project, uncertainty is unproblematic by nature. This is because only a limited number of individuals are involved in resolving uncertainty in the early phases of an innovation project. As an innovation project progress and reaches full-scale production, more individuals are involved. This creates the uncertainty that Gales and Mansour-Cole (1995) call problematic.

Thirdly, Halbesleben et al. (2003), have introduced the notion of ‘temporal complexity’. Instead of arguing against the importance of timing in innovation at such, they suggest that time should be seen as a multi-dimensional social construct with wide variability. Denying the idea that people “living at the same time live in the same time” (see Jacques 1982) and adapting the notion of the ‘temporal timescape’ (Adam 2000; Harvey & Novisevic 2001), Halbesleben et al. (2003) point out that in order to understand the role of time in innovation processes, it is crucial to specify various time-related components. They suggest that at least timeframe, tempo, temporality, synchronization, sequence, simultaneity, anticipated and emerging gaps and pauses, time personality, and timelessness should be seen as relevant time-related components. Instead of seeing time in terms of clock time, which can be measured unambiguously, innovators face timing uncertainty caused by temporal complexity.

In summary, the timing uncertainty in innovation results from a lack of information in the early phases of innovation, from the ambiguity of information in the late phases of innovation or from temporal complexity faced by innovators.

4.8 Consequence uncertainty

Innovation is required to contribute both to short and long-term results. However, the consequences of innovation cause uncertainty because they cannot be predicted in advance. Lambooy (2005) has argued that despite the perceived usefulness of innovations, they are not always supported because processes and outcomes are unpredictable. Uncertainty exists because the relationships between necessary inputs and possible outputs cannot be exactly determined (e.g. Roffe 1999; Castellacci et al. 2005; Foster 2010). It has also been found that the intangibility of the end product creates uncertainty and substantially complicates innovation decision-making (van Riel et al. 2004). Especially uncertain is the assessment of the long-term consequences of innovation (Gerwin & Tarondeau 1982; Robertson & Gatignon 1986; Cooper 1998).

Rogers (2003) and Sveiby et al. (2009) have applied a taxonomy that consists of three dichotomies in the consequences of innovation: direct vs. indirect, desirable vs. undesirable, and anticipated vs. unanticipated consequences. Consequences are direct when they trigger an

immediate response to an innovation, whereas indirect consequences are the second-order results of direct consequences. Desirable consequences refer to functional and undesirable ones to the dysfunctional effects of an innovation within a social system. Anticipated consequences are the intended and recognized effects of an innovation, while unanticipated consequences refer to its unintended and unrecognized effects.

All three dichotomies are represented in the reviewed literature. A negative complexity externality may be mentioned as a typical example of the indirect consequences of innovation (Waelbroeck 2003). For Waelbroeck (2003) this refers to the increasing complexity of production processes due to innovation. The notion of negative complexity externality may also be taken more broadly, to include the perpetual novelty which arises from the interaction and connectivity of elements in a given innovative context (Mitleton-Kelly 2006; Bonifati 2010; Foster 2010). Connectivity of elements and perpetual novelty make the prediction of consequences of innovation impossible. According to Bonifati (2010) prediction is impossible "not only because agents are unable to decide which among some set of well-defined consequences will happen as a result of [innovation] actions they contemplate taking, but also because some of the very subjects, objects, and criteria of value with which these consequences of their possible actions would have to be expressed simply do not exist at the historical moment in which agents must act".

The reviewed literature shows that there are also innovations with undesirable consequences. Hanft and Korper (1980), for example, have noticed that many innovations persist in the field of health technology even if it has become evident that they are of marginal utility, are outmoded or even harmful. In addition to planned outcomes, detrimental side-effects of innovation may exist that might paradoxically become obstacles to renewal. Hanft and Korper (1980) have found that *s*ocietal side effects, in terms of the use of scarce resources, may outweigh the benefits of an innovation. Similarly, Gerwin and Tarondeau (1982), Walton et al. (2002), Hoppe and Ozdenoren (2005) and Portzsolt et al. (2009) have found out that the benefits of innovation remain often, if not undesirable, at least obscure.

Besides indirect and undesirable consequences, many scholars have identified unanticipated or unintended consequences of innovation. Peters et al. (2007) and Ronteltap et al. (2007), for example, have reported that innovations like food biotechnology can have a wide range of unintended, delayed and, in some cases, even fatal consequences. York and Venkatraman (2010) have found that many innovations that aim to protect the environment may have unanticipated and negative consequences. Sartorius (2006) argues in the same vein by stressing that it is impossible to predict the sustainability engendered by specific innovations in the longer term. Arnold et al. (2007) have examined the relationship of legislation and innovation. They found that legal innovation (i.e. Sarbanes-Oxley Act of 2002) may have many unintended consequences which affect production cycle times, information technology investment, supply chain performance, and ultimately, market competitiveness. Similarly, Hall and Martin (2005) have reported unintended consequences associated with innovation in the context of genetically modified organisms (GMO).

Based on the reviewed literature, it can be argued that promises of a better tomorrow are uncertain, because in addition to direct, desirable and anticipated consequences, innovations

may have indirect, undesirable and unanticipated consequences. Even thought the majority of the literature is focused on detrimental indirect and unanticipated consequences, it is important to note that indirect and unanticipated yet also positive consequences may increase uncertainty.

5. Conclusions

The reviewed literature confirms that uncertainty is inherent in the innovation process. Innovation is an organizational activity that is fraught with high level of uncertainty. Based on the systematic review of 101 articles, this paper argues that uncertainty can be classified into eight categories which are technological uncertainty, market uncertainty, regulatory/institutional uncertainty, social/political uncertainty, acceptance/legitimacy uncertainty, managerial uncertainty, timing uncertainty and consequence uncertainty. The factors of uncertainty and their manifestations are presented in table 4.

Table 4. Factors of uncertainty and their manifestations in innovation processes.

Uncertainty factor	**Manifestation of uncertainty**
Technological uncertainty	-due to the novelty of technology its details are unknown -uncertainty regarding knowledge required to use new technology
Market uncertainty	-unclear customer needs -lack of knowledge about the behavior of competitors -difficulties in predicting the price development of raw materials and competing products and services
Regulatory/institutional uncertainty	-ambiguous regulatory and institutional environment
Social/political uncertainty	-diversity of interests among stakeholders of innovation processes -power struggle
Acceptance/legitimacy uncertainty	-necessary skills and knowledge contradict existing skills and knowledge possessed by perceived users of innovation -innovation threatens individual's basic values and/or organization's norms
Managerial uncertainty	-fear of failure -lack of requisite tools to manage risk inherent in innovation process
Timing uncertainty	-lack of information in the early phases of innovation -ambiguity of information in the late phases of innovation -temporal complexity
Consequence uncertainty	-indirect consequences -undesirable consequences -unintended consequences

Although this article covers an extensive array of studies, it should be noted that its classifications are not indisputable. Although technological and market uncertainties seem to have an established status, the categorization is challenging because many of the factors are linked to one another. Interdependencies between uncertainty factors are implicitly derived from the very nature of the innovation process. Just as an example, innovation processes can be seen as iterative processes comprising the technological development of an invention combined with the market introduction of that invention to end-users by means of adoption and dissemination (Garcia & Calantone 2002). In other words, innovation processes require action under conditions of technological, market and legitimacy/acceptance uncertainty. Interdependencies between factors were either 'confirmative' or 'non-confirmative'. As an example of confirmative interdependency, the relationship between timing and the consequences of innovation may be mentioned. The uncertainty concerning the consequences of innovation is highly dependent on time – i.e. the more time progresses, the more certain the consequences of the innovation become. The relationship between the acceptance/legitimacy of innovation and innovation management may serve as an example of non-confirmative interdependency: the more acceptable and legitimate the innovation becomes, the less uncertainty arises due to fear of failure. Furthermore, it should be noted that some identified uncertainties are derivative by nature. It can be claimed, for example, that market and consequential uncertainties are not obviously related to uncertainty in the innovation process itself. While acknowledging the problematic regarding the derivative nature of some uncertainties, this article argues that derivative uncertainties are also relevant because they affect, even if indirectly, organizational innovation processes.

It should also be noted that due to interdependencies between factors, the proposed classifications include several categories that could be united into a single umbrella category. For example, the category of environmental uncertainty could include the categories of technical, market and regulatory/institutional uncertainty. Similarly, managerial uncertainty could include social/political uncertainty. In addition, in defining innovation loosely as a process of seeing and doing things differently, this article has not touched upon the possible differences between incremental and radical innovations.

However, despite the shortcomings mentioned above, it can be argued that this article is important both in a practical and a scientific sense. From the management point of view, the results of the systematic review of the literature can be used to identify and avoid possible bottlenecks in organizational innovation processes. This could mean, for example, that in a case where there is uncertainty concerning acceptance/legitimacy of technological innovation, there is now an awareness that managers should strive to ensure that stakeholders in the orbit of innovation should be given not only technical details of innovation but also the opportunity to discharge their concerns regarding the consequences of innovation. This article also provides information for policy makers. The article suggests, for example, that innovation may be fostered by addressing uncertainty related to the regulatory/institutional environment of innovation. From a scientific point of view, the article fills the research gap concerning issues that may relate to the failure of an innovation (cf. Rogers 2003). Hence, the article may be seen as valuable in an intellectual sense, because it rectifies the pro-innovation bias of

innovation research. Increasing the understanding of uncertainty in respect of innovation perhaps might eventually also complicate current notions associated with successful innovation (cf. Rehn & Lindahl 2011). Nonetheless, the 'hidden' side of innovation is certainly worthy of further research. One possible avenue for further research would be to identify whether uncertainty manifests itself fundamentally differently in incremental innovations compared to radical ones. Other interesting research might be to assess whether uncertainty factors manifest themselves differently at different stages of the innovation process. Finally, because this article is limited in considering uncertainty as negative for an organization's innovation process, it would also be worthwhile, both intellectually and practically, to examine the potential positive effects of uncertainty.

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