Risks in major innovation projects, a multiple case study within a world's leading company in the fast moving consumer goods

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Abstract: This paper investigates which risks characterise radical innovation projects. In-dept case studies were carried out via interviews and a questionnaire. The risk concept applied in this study includes three dimensions: certainty, controllability and impact. Three structural or unambiguous risks were found: New product performance according to specification, reliability of suppliers and new product adoption by consumers. The incidental or ambiguous risks that were found relate to: internal organisation and project management. These results can provide guidance for project teams and innovation managers regarding issues they must seek to tick off early and issues that continuously require team and management attention.

Keywords: new product development; radical innovation; risk; case-studies; project management.

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1 Introduction

Creating radical innovations is a risky business. Revenues can be huge, but highly uncertain, while the hit rates are low and the costs of failure often very high. Yet, many companies perceive considerable pressure to engage in radical innovation efforts to gain and maintain competitive advantage (Christensen and Bower, 1996; Christensen, 1997; Chandy and Tellis, 1998; McDermott and O'Connor, 2002; Thieme et al., 2000; Wind and Mahajan, 1997).

Risks are inevitable in innovations. As an innovation strategy based on risk avoidance cannot be an option, proactive risk management is needed in which risks are identified in the early phases of product development when there is still time to influence the course of events (Cooper and More, 1976; Cooper, 1979, 1981, 1993; Wheelright and Clark, 1992). Radical and incremental innovation projects differ on different dimensions. They are different on some project dimensions: Radical innovation life-cycles are longer, more unpredictable, have more stops and starts, are more context dependent in that strategic considerations can accelerate, retard or terminate progress, and more often include cross-functional and or cross-unit teamwork. Incremental projects are more linear, predictable, encounter less resource uncertainties, and include less complex collaboration relations (Cardinal, 2001; McDermott and O'Connor, 2002; O'Connor and Ayers, 2005). Furthermore, radical and incremental innovations are different with respect to the results they are meant to realise: Radicals involve discontinuous development, with which unprecedented improvements or performance features are achieved (Leifer, 2001; Majchrzak, 2004). In addition, they also differ with respect to the basic assessment criteria applied at the start and at monitoring or review moments during the life-cycles of the various projects (Rice et al., 1998). The focus of the criteria applied to incremental projects is on the returns to the firm within a predetermined timeframe: "What will the profit impact be? How fast will it grow? How much market share can we expect?" In contrast, the key criteria regarding radical projects relate to the return of new value to the market: "What impact can this new technology have on the market? What will this new technology enable? Will this technology deliver the benefit that is needed?"

Projects of both types can wrongly be continued or terminated if the underlying differences in risks are not recognised. The present research examines which risks are associated with radical innovations and how these risks can be conceptualised and measured in a managerially and methodologically sound way. Although there is a respectable literature on risk perception, risk behaviour and risk-taking propensities, an accepted model of strategic risk-taking that recognises the contextual interplay among decision-makers, organisational processes, and market and industry factors that influence judgments of risk and strategic risk-taking is still lacking (Ruefli, 1999). There are numerous innovation management studies indicating that radical innovations are highly risky but widely accepted, however practicable measures of risk in the field of product innovation have not yet been developed.

The aim of this study is to find out which risks are associated with radical innovation projects if a risk conceptualisation is applied that specifically fits the characteristics of such projects.

The outline of the paper is as follows: First, the key concepts of radical innovation and risk are clarified and defined. Subsequently the existing literature on risks in radical innovations is reviewed. Next, the method used in the empirical research is explained. Then the results and analyses are presented and finally, in the discussion section, a reflection is given on the outcomes of the study.

2 Radical product innovations

Researchers have used different definitions of radical innovations (Ehrnberg, 1995; Green et al., 1995). Although there is consensus on what constitutes a radical innovation, the concept itself is only loosely defined (Gatignon et al., 2002). Researchers seem to agree that opposed to incremental innovations in radical innovations unprecedented improvements or performance features are achieved, representing major changes in technology that involve the discovery of new knowledge, substantial technical risk, time, and costs (Cardinal, 2001; Leifer et al., 2001; Majchrzak et al., 2004; Roussel et al., 1991). Variations on the theme often relate to researchers' wish to highlight specific major changes, for example: newness to the market including customers and trade, technological newness including materials and functions. The key words explicitly or implicitly used to characterise radicalness are: 'major changes'. These key words strongly relate to what we understand as the conceptual basis of risk in radical innovation projects. Risk involves the need to bridge a gap between required and acquired technological, business/market, and organisational knowledge and skills. In this context we define radical product innovations as: the development, production and commercialisation of products that either include one or more key technologies that are new to the firm and/or create new business value to customers. Our definition explicitly includes the development and production activities within the innovation project because unprecedented development and production challenges can considerably contribute to the risk of radical innovations.

Our study was carried out within the fast moving consumer sector where food, detergents, and cleaning products are produced. Innovations within this sector are a function of new technological and scientific – often chemical – knowledge embedded in a product. The innovativeness of such products strongly resembles the radicalness of drug innovations where the core challenges centre on molecules (Abernathy and Clark, 1985; Henderson, 1994).

3 Risks in radical innovations

There is a growing awareness of risks associated with radical innovations. A number of researchers have identified specific critical determinants of radical innovation successes related to strategic choices, organistional conditions, and team or individual capabilities. The vast majority of these studies strongly suggest that the basic conditions for achieving success in radical innovations differ from those under which incremental innovations are realised. Radical innovations seem to be the result of conscious and tenacious efforts. Companies aspiring to achieve radical innovations often must make risky leaps. In Table 1 we have summarised the results from this literature review. We were specifically interested in the competences researchers have identified as requirements for projects seeking success via radical projects.

Table 1 Summary of literature review on required competences for successfully executing radical innovation projects

Categories	*Required competences*	*Source*
Strategy	Recognised implication of architectural innovations within the industry	Henderson and Clark (1990)
Technology strategy	Right application for the technology	Balachandra et al. (2004)
	Suitable new market perspectives for new products	O'Connor and Rice (2001), Song and Montoya-Weiss (1998)
	Focus on value-for-market	O'Connor (1998)
Market strategy	In-depth knowledge about current and potential customers and stakeholders	Christensen and Bower (1996)
	Readiness to cannibalise own investments	Chandy and Tellis (1998)
Product and production	Necessary associated infrastructure to get and keep the product/service working	McIntyre (1988)
	Readiness for transition into operations	O'Connor et al. (2002)
Human capabilities	Appropriate personality traits (starters and finishers)	Stevens and Burley (2003)
	Adequate management skills and experiences	Damanpour (1991), McDermott and O'Connor (2002) and O'Connor and Ayers (2005)
	Capability to get ideas accepted within own R&D organisation	Rice et al. (2001)
Internal organisation	Protection of highly uncertain projects (e.g., via 'hubs')	Leifer et al. (2001) and Rice et al. (2001)
	Dedicated controls on input, behaviour and output (e.g., fixing stage gate, criteria for evaluation and screening)	Cardinal (2001), Rice et al. (2001) and Stevens and Burley (2003)
	Fitting project management system	Damanpour (1991)
Knowledge	Technical knowledge and expertise	Dewar and Dutton (1986)
	Readiness to reuse knowledge (e.g., via an adaptor)	Damanpour (1991) and Majchrzak et al. (2004)

4 On the concept of risk in radical product innovation

The general approach in the statistics literature is that the concept of risk reflects the variation in the distribution of possible outcomes (Arrow, 1970) and that it can be described as a function of the probability or likelihood and the impact of possible negative consequences (losses) of an activity (Kerzner, 2003). The probability is primarily estimated by extrapolation from observed relative frequencies of past similar events. The impact or costs are assessed in terms of material and/or immaterial losses. 'Good' decision-making or 'proper' risk-taking are validated against substantive accumulated data from the past.

However, there is reason to believe that this overall robust conceptualisation of risk falls short in capturing at least a number of aspects of novel, fairly unique activities or situations, as is the case in radical product innovation (Vlek and Stallen, 1981). In product innovation projects, the underlying database consists of intuitive judgements, lines of explicit reasoning, or scenarios about possible future developments of actions or situations. This *perceived level of outcome uncertainty* constitutes the first component for capturing the level of perceived risks in innovation projects.

A second distinction – according to Vlek and Hendrickx (1988) and Vlek and Cvetkovich (1989) – is between risk-taking in a static choice situation vs. in a dynamic risk-taking process. Betting on the roll of a dice or the flip of a coin are examples of static risk choices. March and Shapira (1987) report a sharp distinction made by managers between 'gambling' (where the odds are exogenously and uncontrollable) and risk-taking (where skill or information can reduce uncertainty).

> "Managers see themselves as taking risks, but only after modifying and working on the dangers so that they can be confident of success. Prior to a decision, they look for risk controlling strategies."

In a dynamic process – which is the case in any product innovation project – humanly controllable factors such as knowledge, skills and other resources may influence the anticipated risk factor. If in such a process outcomes are uncontrollable and purely occur by chance, risk is higher than in situations where the decision-maker is still able to influence, even modestly, the potential outcome (Sitkin and Pablo, 1992; Slovic et al., 1977; Song and Montoya-Weiss, 1998). The *perceived level of control*, i.e., the perceived ability to influence the course of actions within the time and resource limits of the innovation project, will consequently be used as a second component to capture the level of perceived risk.

For many years, classical decision theory onceived risk as reflecting a variation in the distribution of possible outcomes (positives as well as negatives), their likelihood, and their expected values. In the last decades, however, serious objections have been made against this conceptualisation of risk. Managerial surveys found (Baird and Thomas, 1990; Keil et al., 2000; Mao, 1970; March and Shapira, 1987) that managers typically evaluate risks as the chances of downside loss, and that managers are not inclined to equate the risk of an alternative with the variance of the probability distribution of possible outcomes that might follow the choice of the alternative. Sitkin and Pablo (1992) gave a nuance to this focus on potential loss, by stating that it is not the expected outcome itself, but the degree to which a specific outcome would be disappointing to the decision-maker or other key stakeholders that is crucial.

Studies of managers indicate that the performance and aspiration constructs found in the behavioural theory of the firm (Cyert and March, 1963) are central to managers' concepts of risk (Miller and Leiblein, 1996). Discussions of risk in the strategy literature also consistently reflect this view of risk as a failure to meet an aspired level of performance (Aaker and Jacobson, 1990; Porter, 1985). In view of these findings, we distinguish a third component to determine the level of risk of a certain issue in the innovation process: The *perceived impact on the aspired project performance*, i.e., the relative importance of the issue concerned to realise the aspired performance. In sum, given the newness and uniqueness of a particular product innovation project and its dynamic nature, we consequently distinguish three components to determine the level of risk of a certain issue in the innovation process. This implies that when diagnosing risks in the specific context of innovation activities a three-dimensional risk should be adopted. By combining these three dimensions, an issue will be defined as 'risky' if its (Keizer et al., 2002):

- *Certainty* is *low*, i.e., the probability of a satisfying solution for the innovation issue is low
- *Controllability* is *low*, i.e., the ability of the innovation team to influence the course of actions in such a way that a satisfying solution can be realised within time and resource limits of the project is small
- *Relative importance* is *high*, i.e., not obtaining a satisfying solution for the innovation issue may jeopardise the realisation of the aspired project performance.

5 Research method

Our research was carried out within one large globally operating firm in the fast moving consumer goods sector. We were able to do in-depth case studies in ongoing projects, which is almost never possible in a research project. We did eight in-depth radical innovation case studies in which we interviewed the individual members of the project teams involved. Subsequently we analysed the results via content analysis and concluded which risks are most characteristic for radical innovation projects.

On the basis of the above-mentioned stand on radical innovation, we made a first draft of a risk reference framework. This framework consisted of 12 main risk categories and 92 related risks.

The framework was a basis in the next step in the research procedure, in which the individual members and stakeholders of eight ongoing radical innovation projects were interviewed. Whether innovation projects were radical was determined via a quick scan procedure. The quick scan was designed to assess the overall technology and market change involved in innovation projects. It was used early in the life of an innovation project (feasibility phase). Using this quick scan, for each project in a project portfolio five manager members from the company's innovation review committee assessed the level of change with respect to both the product technology involved and the business creation. The managers were asked to score the projects in terms of levels of change as low, medium or high. A project was accepted as radical if it received at least one 'high' and one 'medium' score.

The aim of the interviews was to obtain an overview of the risks participants in the innovation process perceived. The formal risk assessment process was carried out, using the Risk Diagnosing Methodology (RDM) (Ganguly, 1999; Halman and Keizer, 1994). To identify potential project risks, two interviewers interviewed every member of the eight risk teams. Prior to the start of the interviews, a kick-off meeting was organised to inform the interviewees about the objectives of the interviews. In line with our risk definition, the respondents were asked to prepare themselves by thinking of issues for which the project team in general and/or the interviewee individually felt that a gap in knowledge, skills and or experiences had to be bridged. To stimulate preparation, the suggestion was made that each respondent should once again go through the project plan (with intended scope, objectives, and deadlines) and have a thorough look at the critical issues included in the risk reference framework that had been the result from the first research step. The framework served as a 'trigger-list' and encouraged interviewees to think of possible gaps that could jeopardise the success of their own projects.

All interviews followed a standard protocol. First, the interviewee was invited to clarify his or her position and relationship with the project. Next, the interviewee was asked to explain, from his or her perspective, what the project was about and to indicate, from his or her own responsibility and competence, the main gaps in knowledge, skills and/or experiences. Then, issues for the project and project team as a whole were addressed. Respondents were invited to look across functional borders. The last part of the interview concerned the risk reference framework. Respondents were asked to check whether no important gaps had been overlooked. In order to evaluate the seriousness of the identified potential risk factors for each project, the interviewees for each project team separately were then asked to give their second thought judgment in a risk questionnaire. Members of each project team individually scored (on a 1–5 point scale) each of the identified potential risk factors of their own project on the three risk dimensions:

- the level of uncertainty, e.g., the certainty that an appropriate solution for a particular technical problem could be found
- the controllability or ability to influence the course of actions within the time and resource constraints, e.g., the ability to realise a certain solution within certain time and resource constraints
- the amount at stake, or the likely impact of the identified risk factor for the overall success of the business, in general, and the innovation project in particular.

In total 114 individuals were interviewed in this phase. Each interview took approximately 90 min. These interviews within eight different projects resulted in a list of 653 different perceived risks. In Table 2 an overview is presented of the case study projects, the number of participants per project, and the number of risk issues elicited from each project. For reasons of company confidentiality we have used fictive names.

After this step had been completed we carried out a content analysis, using the procedure recommended by Kassarjian (1977), in which the results of the data gathering activities were brought together. The aim was to standardise the outcomes of the interviews from the various project teams. First, every risk issue included in the risk reference framework was given a unique code. Next, two researchers independently verified, for all 653 perceived project risks, whether a specific project risk was adequately addressed by one of the issues included in the risk reference framework.

If this was the case, the researcher gave the project risk concerned the same code as the risk issue in the framework. After this process, the researchers compared their outcomes and discussed any differences. In cases where consensus could not be reached, a third researcher with adequate knowledge in the field of innovation management served as referee and determined the final coding. The referee had to intervene in only 5% of the 653 identified perceived project risk issues. Most issues could be coded within the risk reference framework. The issues that could not be coded were discussed separately in order to determine the label under which they should be added to the framework. Finally, the framework with 12 main risk categories and 92 critical innovation issues was revised into a risk reference framework with 12 main risk categories and 142 related critical innovation issues.

Table 2 Overview of projects with number of participants and number of risk issues

Projects name	*Number of participants*	*Number of risk issues*
Sparrow	12	53
Starling	21	179
Gull	19	96
Finch	13	71
Woodpecker	15	120
Blackbird	13	51
Magpie	8	24
Rook	13	59
Total	*114*	*653*

6 Results and analysis

The successive steps of the literature review, interviews with 32 senior managers and R&D experts and in-depth case studies on risk with contributions from 114 individuals involved in the? projects resulted in a final risk reference framework consisting of 12 main risk categories and a total of 142 related critical innovation issues. The 12 risk categories are presented in Table 3. The risk reference framework reflects the multidimensional character of radical product innovation success and failure where technological, organisational, business and economic factors interact and should all be carefully considered together.

Table 4 shows, as an example, the risks that were identified in the series of interviews with the respective members and stakeholders of the eight case studies, related to one specific risk category. In accordance with our definition of risk, risks are formulated here as objectives to be realised. In this table the risks in the category ‘Manufacturing Technology risks’ are represented. If with respect to a particular project issue one or more of the respondents indicated that it would differ from earlier, comparable situations and that he or she doubted whether that gap could be bridged within the time and resources constraints, the issue was included in the list of risks for the specific project. It appears that the relative importance of the risks varied across projects. Risk regarding “product system requirements meeting quality and safety standards and adequate scale-up training for the workers involved” was perceived much more important within the projects Starling and Woodpecker than in the other projects.

Table 3 Risk reference framework: 12 risk categories with their number of connected critical innovation issues

Risk categories		*Number of connected critical innovation issues per risk category*
1	Product family and brand positioning risks	13
2	Product technology risks	11
3	Manufacturing technology risks	12
4	Intellectual property risks	7
5	Supply chain and sourcing risks	11
6	Consumer acceptance and marketing risks	16
7	Trade customer risks	10
8	Competitor risks	9
9	Commercial viability risks	17
10	Organisation and project mgmt risks	22
11	External risks	8
12	Screening and appraisal risks	6
Total number of critical innovation issues		*142*

Table 3 also makes clear that the importance of a whole risk category can vary across projects. For Starling and Woodpecker, Manufacturing Technology caused many worries, while the Magpie team, on the other hand, did not identify any important project risks within this category.

However, our analyses also showed that some detailed risks were perceived as important in projects. Issues such as "Organisation and management of the innovation project itself", "Product advantage if compared to competitive products", "Products' appealing to generally accepted values (e.g., health, safety, nature and environment)"; "Ability to communicate the new product with target consumers" and the "Ability to anticipate effectively to possible negative external reactions" were perceived as relevant in all case studies.

Table 4 Critical innovation issues connected with manufacturing technology risks

Manufacturing technology risks	*Sparrow*	*Starling*	*Gull*	*Finch*	*Wood pecker*	*Blackbird*	*Magpie*	*Rook*
Raw materials meeting technical requirements	3	–	–	–	–	1	–	–
Known and specified process steps to realise new product	–	3	–	–	–	1	–	1
Known and fully understood process conditions (temperature, energy, safety requirements, etc.)	–	2	–	1	3	2	–	–
Adequate production means (equipment and tools) available when needed	1	–	6	1	7	–	–	–

Table 4 Critical innovation issues connected with manufacturing technology risks (continued)

Manufacturing technology risks	*Sparrow*	*Starling*	*Gull*	*Finch*	*Wood pecker*	*Blackbird*	*Magpie*	*Rook*
Scale up potential according to production yield standards	–	3	1	1	5	–	–	–
Quality and safety requirements of production system (facilities and personnel)	–	9	–	–	9	–	–	–
Product packaging implications: known and feasible	–	4	1	–	2	–	–	2
Alternative options to process new intended product	–	–	–	–	–	–	–	–
Manufacturing meeting production standards	–	1	–	–	2	–	–	–
Required production capacity available when needed	–	1	–	–	1	–	–	1
Adequate production start up process	–	3	–	–	1	–	–	–
Reusability of rejects in production	–	3	–	–	–	–	–	–
Total number of manufacturing technology risks	*4*	*29*	*8*	*2*	*30*	*4*	*0*	*4*

An interesting question after the content analysis was: What are the most frequently identified risks? We ranked all risks according to the frequency each of them was identified by interviewees within the sample of our projects. The list of the ten most frequently identified risks is presented in Table 5.

Table 5 Ten most frequently identified risks

Rank	*Risk category*	*Top-10 of risk issues*	*Frequency*
1	Consumer acceptance	Communicating the new product with target consumers	26
2	Organisation and project management	Organisation and management of the project	23
3	Product technology	Stability of the product, while in storage in production plant, in shop/warehouse, during transportation or at home	22
4	Manufacturing technology	Quality and safety requirements of Production system (facilities and personnel)	18
5	Supply chain	Constant and predictable quality of supply by suppliers	16
6	External risks	Possible negative external reactions by key opinion formers or interest groups	15

Table 5 Ten most frequently identified risks (continued)

Rank	*Risk category*	*Top-10 of risk issues*	*Frequency*
7	Manufacturing technology	Adequate Production means (equipment and tools) available when needed	14
8	Product technology	New product fulfils intended functions	13
9	Commercial viability	New product meets consumer standards and demands	13
10	Consumer acceptance	New product's appeal to generally accepted values (health, safety, nature, environmental issues)	12

As summarily explained above in the Method section, after the individual interviews had been carried out the interviewees of each project team were presented a project-specific risk questionnaire. For each identified potential risk, they were asked to assess (on a 1–5 point scale) the levels of uncertainty, ability to reach a satisfactory solution within the time and resource constraints of the project, and impact of the risk factor on project success. Next, two processes are carried out on the scores. First, for every risk statement, the scores for the three evaluation parameters are summarised and expressed as a 'risk score' in accordance with the distribution of the respondents' scores over the five-point scales. Four possible outcomes can be distinguished for every evaluation parameter by using the following decision rules:

- Consensus on high risk ('+'): At least 50% of the scores are 1 or 2 on the five-point scale (1 being 'very risky'), and there are no scores of 5.
- Consensus on low risk ('0'): At least 50% of the scores are 4 or 5 on the five-point scale, and there are no scores of 1.
- Consensus on medium risk ('M'): At least 50% of the scores are 3 on the five-point scale, and there are no scores of 1 or 5.
- Lack of consensus on risk ('?') (All remaining cases): There is a wide distribution of opinions. After discussion with the interviewees, the '?' scores may be changed to one of the other three risk scores.

Next, each risk statement can be classified into a 'risk class' by examining the assigned risk scores on the evaluation parameters. RDM uses five risk classes: S = safe; L = low; M = medium; H = high; F = fatal. For example, a combination of risk scores +, +, + on a given risk would result in its being viewed as extremely risky, and not mitigating this risk would be fatal for the project (which would then be assigned a risk class of F). The combination +, 0, + can be classified as highly risky (risk class H), and the combination 0, 0, 0 can be classified as safe (risk class S).

The total number of possible risk score combinations is 64, all of which are worked out in the RDM manual (Halman and Keizer, 1994, 1997). If there is a distribution of opinions, the risk score can be represented by a range between the lowest and highest risk class that can be reached if the respondents achieve consensus. (For instance: L-M, H-F, and so on).

Across the eight projects the analysis enabled us to determine, for each of the three dimensions, those issues that respondents overall perceived as most risky. Tables 6–8 provide insight into the highest risks on the three dimensions in our specific sample of projects. Highest here means that on the respective risk dimensions they were scored higher than the mean and medium on the five-point scales that were used in the questionnaire.

Table 6 shows the main risks measured on the dimension 'level of certainty'. The lower the certainty, the higher the risk. Issues associated with the expected competitive positioning and future market prospects are among the riskiest. In the feasibility phase of a project – which was the phase in which the interviews were held – these categories are by definition the most difficult to predict.

Table 6 Radical innovation project issues that innovation professionals perceived as highly uncertain (based on a 1–5 point scale: 1 = no certainty; 2 = low level of certainty; 3 = moderate level of certainty; 4 = high level of certainty; 5 = very high level of certainty)

Risk category	*Specific risks*	*Mean* (*St.Dev.*)	*Median*
Product technology	Parity in performance compared to other products	1.67 (0.70)	2.00
Commercial viability	Clear and reliable volume estimates	2.11 (1.20)	1.50
Commercial viability	Sales perspectives being realistic	2.17 (1.17)	2.00
Supply chain	Contingency options for each of the selected suppliers	2.37 (1.12)	2.00
Intellectual property	Knowledge of relevant patent issues	2.44 (0.79)	2.00
Intellectual property	Patent crossing potential	2.56 (0.90)	3.00
Organisation and project management	Project mission and goals being clearly specified and feasible	2.57 (1.38)	2.50
Competitors	New product enabling the creation of potential barriers for competitors	2.63 (1.29)	2.00
Intellectual property	Trade mark registration potential	2.67 (1.09)	3.00
Supply chain	Appropriate contract arrangements with suppliers	2.67 (1.13)	2.50

Table 7 shows the risks on the dimension of influenceability: the issues professionals found hard to control. The lower the influenceability, the higher the risk. It is not surprising that issues like: "Possible actions from competitors" and "Acceptance of the new product in the market" are perceived as less influenceable. Yet, these are important factors for project success. The findings in Table 7 indicate that a number of issues are beyond the direct authority of the project team. Controlling issues like: "Supplier's readiness to accept modifications if required" and "Strategy to follow with respect to possible crossing of patents" will require the commitment and combined efforts of several departments within the organisation and even outside the company.

Finally, Table 8 presents the highest risks on the impact dimension. The more important bridging a particular gap in knowledge, skills and/or experience is for the eventual success of a radical innovation, the riskier the underlying issue is for the project involved.

The results give an impression of the bottom line of the radical projects in the perception of the participants. If these objectives cannot be realised, the projects cannot be successful.

Table 7 Radical innovation project issues innovation professionals perceived as minimally controllable (based on a 1–5 point scale: 1 = none; 2 = low degree of ability; 3 = moderate degree of ability; 4 = high degree of ability; 5 = very high degree of ability)

Risk category	*Specific risks*	*Mean* (*St.Dev.*)	*Median*
Supply chain	Supplier's readiness to accept modifications if required	1.83 (0.69)	2.00
Competitors	New product enabling the creation of potential barriers for competitors	2.28 (0.66)	2.50
Intellectual property	Patent crossing potential	2.27 (1.01)	2.50
Product family and brand positioning	Contribution to project portfolio	2.32 (1.17)	2.00
Competitors	Ability to foresee competitor's future challenges	2.35 (1.15)	2.00
Consumer acceptance	New Product offering easy-in-use advantages if compared to competitive products	2.61 (0.95)	2.50
External risks	Relevant environmental issues which have to be managed identified	2.61 (1.06)	3.00
Commercial viability	New Product's commercial viability due to required repeat sales	2.67 (1.07)	2.00

Table 8 Radical innovation project issues innovation professionals perceived as having the highest impact on project success (based on a 1–5 point scale: 1 = very high degree; 2 = high degree; 3 = moderate degree; 4 = low degree; 5 = none)

Risk category	*Specific risks*	*Mean* (*St.Dev.*)	*Median*
Trade customers	Communicating the product with trade customers	1.30 (0.46)	1.00
Commercial viability	Product viability due to repeat sales	1.33 (0.60)	1.00
Commercial viability	Sales perspectives being realistic	1.37 (0.58)	1.00
Consumer acceptance	Efficacy of advertising	1.40 (0.49)	1.00
Intellectual property	Availability of required external licenses	1.55 (0.66)	1.00
Product technology	Product format meeting requirements	1.57 (0.94)	1.00
Intellectual property	Knowledge of relevant patent issues	1.63 (0.70)	1.50
Supply chain	Appropriate contract arrangements with suppliers	1.66 (0.67)	2.00
Intellectual property	Dependency on third party development	1.66 (0.87)	2.00
Commercial viability	Long term market potential	1.75 (0.83)	2.00

7 Conclusions

Finally, the analysis allows us to draw some conclusions about the risks as meant in the three-dimensional risk definition applied in this paper. A distinction is made between risks that scored unanimously high across the eight projects (the unambiguous risks) on the one hand, and the risks interviewees had different opinions about (the ambiguous risks), on the other hand.

The right side of Table 9 shows the unambiguous risks across the sample of projects. In at least half of the projects these risks scored as 'high' or 'fatal'. These risks can be seen as characteristic for radical projects. On its left side the table shows the risks respondents maximally diverged on.

Table 9 makes clear that across eight different projects, from which 114 individual team members were interviewed leading to a list of 12 categories including 92 risks, only a limited number of risks can be considered as generic radical innovation project risks. In other words, even within one company where different projects will be expected to have some characteristics in common, the risks associated with these projects differ considerably.

The unambiguous risks projects relate to three basic questions:

- Will the new product perform according to specifications (balance between the product components, and functional product format)?
- Can we rely on our suppliers (quality and contract arrangements)?
- Will consumers adopt the new product (fit with standards and demands, and fit with habits and user conditions)? Within our sample of projects these issues are seen as highly risky.

The short list of ambiguous risks contains risks for which there was strong dispersion of opinion within each of the projects. Apparently these are not clear-cut risks. Some project team members perceive them as highly risky, while others see them as not risky at all. These potential risks can be seen as discussion items. They should always be thoroughly discussed within a radical innovation project team to determine the extent to which they must be taken seriously. Among these risks we find four risks relating to internal organisation and project management. None of these internal risks is found in the list of unambiguous risks. Apparently, people have different opinions about the effectiveness of their own organisation and project management from which they know the strengths and weaknesses. Together with the other ambiguous risks – contingency options, communication to the target customers – these risks relate to qualities and requirements for which it is difficult to decide whether they will be fully met during the project life-cycle.

Table 9 Ambiguous and unambiguous risks across eight radical innovation projects

Ambiguous risks		*Unambiguous risks*	
Category	*Risks*	*Category*	*Risks*
Supply and sourcing	• Contingency options for each of the selected suppliers	Product technology	• Correct balance between different product components. • Product format meets functional requirements
Consumer and marketing	• Communicate this new product with target consumers		
		Supply and sourcing	• Constant and predictable quality guaranteed • Appropriate contract arrangements with suppliers
Organisation and project management	• Roles, tasks and responsibilities well defined within the team • Team organisation and management. • Communication between members of the team. • Reliable and feasible estimation of required resources	Consumer and marketing	• Product specifications in accordance with consumer standards and demands • Product requires changes in consumer habits and/or user conditions

8 Discussion

The aim of this study was to find out which risks are associated with radical innovation projects if a risk conceptualisation is applied that specifically fits the characteristics of such projects.

Risk in radical innovation projects appears to be a complex concept. Building on insights provided by different scholars we have proposed a three-dimensional risk concept with the purpose to enable an integral view of radical innovation risks. When we applied this risk concept to our cases to identify the highest risks, we found considerable differences between the high risks on each of the three dimensions. When the three dimensions of our risk definition were combined into measures resulting in short lists of both unambiguous and ambiguous risks, the results showed that different radical projects share a number of risks, but the differences between the risk profiles of the projects appeared to be much larger than the commonalities. High risk awareness remains required. Part of the complexity of the concept in use can also be attributed to the uncertain and indistinct nature technical innovation processes have, specifically at the R&D intensive stages (Debackere, 1997).

Nevertheless, the short lists of shared high ambiguous and unambiguous risks can be a relevant bench-mark in managing radical innovation projects. The distinction between ambiguous and unambiguous risks has clear relevance to the management of radical innovations.

Across our case studies we learned that almost always the risks that members of a project team perceive as unambiguous risks are already on the project's agenda. People will easily recognise them. Moreover, the risks within this category seem to regard issues that can be quite arduous, but manageable and at a certain moment they can be ticked off. Conversely, most often the ambiguous risks are not on the agenda. Therefore, the existence of a short list of ambiguous risks probably is the most relevant outcome of this study. These risks constitute a set of issues every radical innovation team should seriously be aware of from start to finish. The organisational and project management aspects in this group can be seen as belonging to the organisational routines (Feldman, 2000; Zellmer-Bruhn, 2003). Discussing such items can help people to become aware of the conditions they tend to take for granted even if they are not productive for the result of the project. The fact that a relatively large number of organisational items are among the major risks underlines once again that the success of a radical innovation is certainly not only decided in the technological domain. Supportive organisational conditions are equally important.

We have measured the risks in the feasibility phase, when many things are still open. The unambiguous risks represent issues that must be clarified in the front end phases of the project life-cycle. The ambiguous risks require constant attention from start to end of the project life-cycle.

A limitation of our study is that it was carried out within eight projects of one company. What can be generalised from such a research design? Strictly speaking the outcomes of this study are only significant to the company in question. However, we claim that the study has further relevance due to the method we have applied. We have reconceptualised the risk concept in a way that makes it generically applicable in all radical innovation projects. Our study in this specific environment shows that the application of this generic concept elicits distinct data on ambiguous and unambiguous risks. To what extent the short lists of these risks found in our study are representative for the risks associated with ambiguous and unambiguous risks in radical innovations within the fast moving consumer industry in general and in other industries remains to be demonstrated. This study provides a basis for further explorations.

A look at the whole list of potential risks associated with radical innovation projects raises the question of to what extent these risks differ from the risks associated with new product development risks (Cooper, 1979, 1981, 1993). Maybe, after all the differences are not so dramatically big as some scholars have suggested (McDermott and O'Connor, 2002; O'Connor and Ayers, 2005; O'Connor et al., 2002). In her study of radical innovations in the pharmaceutical industry, Cardinal (2001) also draws that conclusion. Our study was not within the pharmaceutics but all the product designs in our case projects had a strong chemical basis. In every project the introduction of effective new molecular characteristics and functions played a dominant role.

Cardinal found against odds that extensive control on input, behaviour, and output, normally associated with incremental and not with radical innovations, appeared actually to be associated with radical projects. One explanation may be that R&D management tends to exercise more vigilance on radical projects than on incremental projects because they fear more damage in case of failure. Risk management can be seen as a control tool. A timely systematic recognition and discussion of risks in radical projects can be seen as encouragement to those responsible both inside and outside the project team to openly and creatively face the issues that may jeopardise the project's success. Further research should be done to find out to what extent perceived ambiguous and unambiguous risks differ between industries and companies.

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