Bachelor Assignment

"Discontinuous innovation?!"

A Systematic Literature Review about Discontinuous Innovation

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Preface

This bachelor thesis describes the result of my graduation project. With this thesis my bachelor business science will come to an end at the University of Twente, Enschede. First of all I would like to thank Rick Middel and Dries Feams for their advice and cooperation. I would like to express thanks to the people from room D201 for creating a pleasant working atmosphere. Finally I am grateful for the guidance Aaldert Tim Sattler gave me.

Management Summary

A lot is written about discontinuous innovation but there is not much consistency in the literature. The Di-lab, the university and the different organisations, wanted to get an overview of what is known about discontinuous innovation. This is important to the university, this gives a clear view of where additional research is needed. For the organisations it is important to know what they are dealing with and what is known about how to deal with discontinuous innovation. To give an overview of what has been written, this systematic literature review (SLR) gives an answer to two research questions: "*How is discontinuous innovation defined?"* and "*What is the current process of discontinuous innovation?"* Conducting the SLR, fifty relevant articles were selected. To come to a good answer of the research question, "*How is discontinuous innovation defined?",* there are three different aspects. The first aspect is to look at the *main characteristics* of discontinuous innovation and the second explanation is to look at the *output* of discontinuous innovation. The third and final aspect is *inter-linkages* between discontinuous innovation and other innovations. The *main characteristics* of discontinuous innovation are divided into: ambiguity & fuzziness, development, economics and benefit customers. The *output* of discontinuous innovation is divided into three different ways. The first output explanation is to give main *output characteristics*. The second way is to look at the output discontinuous innovation has on the *product curve* and the third and final way is to look at the output discontinuous innovation has on the *environment* and what effect the environment has on discontinuous innovation. The third explanation of discontinuous innovation is to look at the *inter-linkages* between discontinuous innovation and other innovations. These inter-linkages can be subdivided into three different ways; discontinuous innovation used as an *umbrella term*; *disruptive innovation leads to discontinuous innovation*; and *inter-linkages between discontinuous innovation and other non-continuous innovations*.

The second research question, "*What is the current process of discontinuous innovation?",* is answered by systematically structuring the information from the articles around the model of the DI-lab. The different phases of the model are; search, select, implement and control. Which are influenced by: environment, innovation strategy and innovation culture. First we have looked at the *environment* phase. There are triggers that make an environment discontinuous these are: new market emerges, new technology emerges, new political rules emerge, running out of road, change in market sentimental or behaviour, deregulation/shifts in regulatory regime, fractures along 'fault lines', unthinkable events, business model innovation, 'techno-economics paradigm' and architectural innovation. The second element is the *innovation strategy*. This can be divided into dealing with the discontinuous environment and the role of management. Together they form the organizational strategy. *Innovation culture* is the last element in the model of the DI-lab. The innovation culture determine what is accepted and what is not accepted within an organisation. Dealing with discontinuous innovation the culture needs to support among other things: entrepreneurship, autonomy, risk taking and creativeness. The three elements, environment, innovation structure and innovation culture influence the discontinuous innovation process: search, select, implement and control. The *search* phase has thirteen different strategies for looking for innovation. These thirteen stages are: sending out scouts; multiple futures; using the web; working with active users; deep diving; mobilising the mainstream; corporate venturing; corporate entrepreneurship; brokers and bridges; deliberate diversity; idea generators; and market indicators. *Selecting* a discontinuous innovation it is important to forecast how discontinuous innovations will perform, and selecting the discontinuous innovation which will probably be most successful. Formulas have been made to forecast discontinuous innovations. Different authors point out that it is important to combine quantitative and qualitative methods. The *implementation* phase is about how discontinuous innovation is implemented within the organization. Employees are the key factor in dealing with implementation. There are different uncertainties that occur in the implementation phase. Some of these uncertainties can be overcome by different management interference. Organizational structure is important in the implementation phase. Solutions for organizing for

discontinuous innovation can be the “ambidextrous organisation” or the “entrepreneurial spin-off”. The final phase, the *control* phase, is about how externally the discontinuous innovation can be controlled. The market can be divided into different phases. The different phases are innovators, early adaptors, early majority, late majority and sceptics. They all have different reactions to discontinuous innovations. Discontinuous innovation will change the behaviour of the customer, but there is a limit on which change can be reached. There is a lot known about discontinuous innovation but there are still many areas where further research is appropriated.

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1. The project

This chapter is an introduction about the project for which this systematic literature review is conducted. The background of the project is explained and the cause of why the SLR is conducted is described.

1.1 Background

In 2006 a discontinuous innovation lab (DI-lab) was started in Germany, Denmark and the UK. The reason for founding the DI-lab was that academics and companies were trying to deal with discontinuous innovation. There is a lot of indistinctness about discontinuous innovation, and because of this, the founders of the DI-lab wanted to know how they could recognize discontinuous innovation. What are the signals of discontinuous innovation and how they can be indentified and investigated? These questions were the main focus of the Innovation Lab in 2006 (https://intranet.unternehmertum.de).

The process that the DI-lab uses to describe discontinuous innovation is shown in figure 1. The process is made-up out of four stages: search, select implement and control. There are three factors influencing the process: environment, innovation strategy and innovation culture (https://intranet.unternehmertum.de).

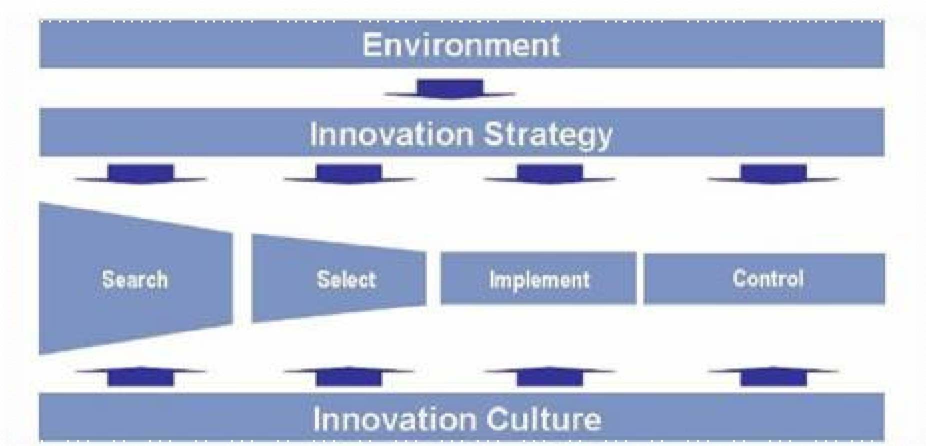

Figure 1: Discontinuous Innovation Model DI-lab (https://intranet.unternehmertum.de)

Search is about the recognition of weak signals, which gives a hint that discontinuous changes will come up. Select is the phase where firms need to evaluate and select the innovations. It is about making strategic choices. The implementation phase is about overcoming innovation barriers like the lack of competent people, non-existing project management structures or internal resistance. The last phase is control; this is the control of how the discontinuous innovation will perform (https://intranet.unternehmertum.de).

Those four phases are influenced by three different factors: environment, innovation strategy and innovation culture. The environment is the local, national and global factors who define the environment and the dynamics of an industry. Innovation strategy will be made-up by the top management. The strategy must have a fit with the needs, environment and culture of the company. The final factor is innovation culture; this is the predominating attitudes and behaviour that characterize the functioning of a group or organization (https://intranet.unternehmertum.de).

As stated earlier, the DI-lab project started in 2006 in Germany, Denmark and the UK. Now more countries are joining; France, Australia, Sweden, Norway, Finland, Italy and Switzerland.

The uniqueness of the DI-lab lies in the international framework of academics working together with companies from different countries, industries and sizes. The goal of the DI-lab is to build an international network where researchers and companies can share experiences with innovation management in an environment of discontinuity. Their aim is to collaboratively identify and explore the best practice to deal with discontinuous innovation. The first three years of the project are focused on the key questions of search, select and implement discontinuous innovations respectively. The project can be a good basis for companies to learn together about managing discontinuous innovations through sharing experiences, trying new things, reflect on what is and what is not working and looking at new ideas and models. By combining companies and researchers and make a comparison between experiences in different sectors it is possible to develop new knowledge in this research area. Once a year an international conference gives a synopsis of the results yielded in the national workshops. The aim of the DI-lab is to build an ongoing, interactive community that encourages the creation and sharing of knowledge around discontinuous innovation (www.mb.utwente.nl).
The twenty-second of February 2008 the Benelux also joined the DI-lab (www.innovation-lab.org).
In the Benelux the organization of the project is under control of the University of Hasselt, Catholic University of Leuven, Technical University of Delft and University of Twente (www.mb.utwente.nl).
The University of Twente is part of the Benelux team of the DI-lab. They are doing research and give workshops and conferences to share knowledge between researchers of the Benelux and the companies of the Benelux. The first workshop was held on the 27th of March of 2008.

1.2 The cause

The Benelux joint the DI-lab half a year ago. Together with the universities companies joint the DI-lab. Discussing together the question arose; what is discontinuous innovation? There is a lot written about discontinuous innovation. There are many articles written about discontinuous innovation but there are no consistencies in the literature about the terminology of discontinuous innovation. There are a lot of different directions in approaching discontinuous innovation. Therefore a consisted answer could not be given to this question. Organisations who joined the DI-lab wanted to get an answer about what discontinuous innovation is and how to deal with it. For the university it was important to get an overview of what is written about discontinuous innovation to get a clear overview of where more research is needed. This systematic literature review gives a clear overview and it can be starting point for further research and gives a answer to what is known about the subject.

2. Systematic literature review

In this chapter an overview is given of how this systematic literature review (SLR) is conducted. First the research questions are explained and an overview is given of how the SLR is carried out. Secondly the research strategy is explained, how non systematic information is used and which databases are utilized. The criteria for selecting articles are given and the key and free text words that are used. Finally the result of the founded articles of the SLR is given.

2.1 Research questions

As mentioned above there is no consistency in the literature about discontinuous innovation. To get more insight into the subject the following research objective and questions are formulated.

Research objective

"Conducting a systematic literature review about discontinuous innovation"

Research questions

- How is discontinuous innovation defined?
- What is the current process of discontinuous innovation?

2.2 Conducting SLR

A systematic review is a review that strives to comprehensively identify, track down and appraise all the literature on a specific topic. Systematic literature review is a fundamental scientific activity. Large quantities of information are reduced into edible pieces for digestion (Mulrow, 2003). Systematic reviews are intended to reduce uncertainty (Petticrew, 2003). Systematic review is often conducted in the health science. There are many reasons to conduct a systematic review. One of the reasons is already mentioned above, to reduce uncertainty in a specific area. There is a lot of information published that is unmanageable; systematic reviews can efficiently integrate existing information and will provide data for rational decision making. Systematic reviews can establish whether scientific findings are consistent and therefore can be generalized or whether findings vary significantly by particular subsets (Mulrow, 2003).

To conduct a systematic review you need to use explicit methods to limit bias and it will improve reliability and accuracy of conclusions (Mulrow, 2003).

The steps to conduct a systematic review are:

- Conduct the SLR with more than one person
- Define a research question
- Look for all studies reliably addressing to the research question
- Sift the studies to select relevant ones
- Assess the quality of the studies
- (Calculate results for each study (and combine them if appropriate))
- Interpret results

This general approach is followed in all systematic reviews, although the latter steps depend on finding some suitable studies (www.cochrane-net.org).

2.2.1 Research strategy

Conducting the SLR we will follow the different steps of the systematic literature review described above. First we will define the research objective and questions. These are shown in the start of this chapter. Following that, we will look for relevant studies addressing the research question. The inclusion criteria are used to make sure that all relevant articles are used and the exclusion criteria are used to make sure that only the right articles are selected. Using the inclusion and exclusion criteria key- and free text words are selected and will be used to search for relevant articles. Because a SLR needs to be conducted by more than one person to prevent subjectivity in selecting articles, the same key words will be selected by the two questions. By doing this the subjectivity will be minimized. Using the key and free text words we will select the relevant articles, the selection will be made by first selecting relevant titles, and removing the duplicates between the two different databases. Then we will select on the abstract of the article and finally on the full content of the text. To make sure all the relevant articles are reached the references will be checked to look if there are more relevant articles. We will determine the quality of the articles, to determine the quality the citation index will be used. The step to calculate the results for each study is not relevant for my research. This is the calculation of the correlation of the different articles, but because research question about discontinuous innovation is not about the correlation of the different articles, this part of the research is not relevant. At the end we will intemperate the results of the findings of the article. A comparison of the articles is made. This is done by giving an answer to the first question: *"How is discontinuous innovation defined?"* To answer this question a comparison will be made between the different explanations and approaches to define discontinuous innovation. Answering the second question; *"What is the current process of discontinuous innovation?"* the model of the DI-lab is used.

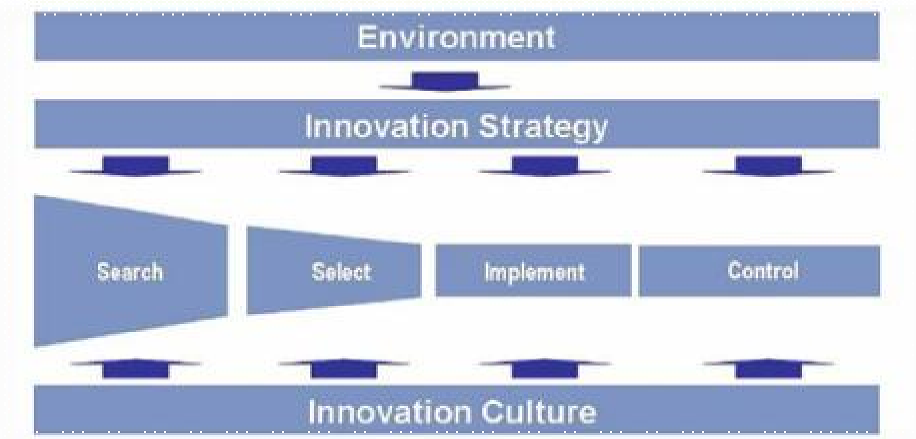

Figure 2: Discontinuous Innovation Model DI-lab (intranet.unternehmertum.de)

The information will be gathered about the different phases and the factors making the discontinuous innovation process. Information will be gathered around factor influencing discontinuous innovation: environment, strategy and culture. And information is gathered about the different phases of discontinuous innovation: search, select, implement and control.

2.2.2 Dealing with non-systematic information

Conducting a systematic literature review it is important to find all relevant literature about a subject. The information will be taken out of published articles, which can be found in databases. Information that is not published can have relevant information, but cannot be found in the databases and therefore it is not included. Discontinuous innovation is an emerging research field; as a result there is information from conferences. But this information cannot be systematically found and therefore it is also not included in the SLR. The information that is available from companies who joined the DI-lab is not incorporated in the SLR, instated it is presented in textboxes. Examples are given of how discontinuous innovation is dealt with in practice.

2.2.3 Databases

There are two databases used: Scopus and Web of Science. Scopus covers 15,000 peer-reviewed journals from more than 4,000 international publishers, including coverage of: over 1200 open access journals, 500 conference proceedings, over 600 trade publications and 200 book series. Subject areas that are covered are: life sciences >3,400 titles, health sciences > 5,300 titles, physical sciences > 5,500 titles and social sciences > 2,850 titles (www.info.scopus.com).

Web of Science consists of five databases containing information gathered from thousands of scholarly journals in the following areas of research: Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, Index Chemicus and Current Chemical Reactions (http://images.isiknowledge.com).
Science Citation Index Expanded indexes over 6,650 major journals, The Social Sciences Citation Index indexes over 1,950 journals, Arts & Humanities Citation Citation covers 1,160 journals, Current Chemical Reactions contains single- and multi-step new synthetic methods taken from leading journals and patents from 39 issuing authorities and Index Chemicus contains the structures and critical supporting data for novel organic compounds reported in leading international journals. It contains over 2.6 million compounds. Not all the available databases are relevant for business administration, but if there are related articles they can be found in the different databases.

2.2.4 Criteria

Inclusion and the exclusion criteria are used to select the articles that are found in the databases. These criteria's are guidelines for formulation the key and free text words.

Inclusion criteria

- Articles which are describing the understanding of discontinuous innovation;
- Articles which are describing current practise of discontinuous innovation;
- Articles which are describing characteristics of discontinuous innovation;
- Articles which are containing are containing descriptive or analytical models to describe innovation;
- Articles which describe exclusively discontinuous innovation

Exclusion criteria

- Articles who are not published in peer-review journals or published as a full paper in conference proceeding;

2.2.5 Key words and free text words

Conducting a systematic literature review it is important to have key words and free text words to define the systematic search. The research questions are two different questions, but to answer them the same key words are used. The guidelines for conducting SLR state that a SLR needs to be done by two persons to prevent subjectivity. The reason is that two or more persons will look at the articles making sure that there are no relevant articles missing. This SLR is done by one person, because of this there is chosen to use similar key words. The conductor needs to look at the same articles twice, minimizing the chance of subjectivity. The key- and free text words are formulate by looking in Scopus, where all key words are systematically organised. The key words that are used in relation to discontinuous innovation frequently and relating the different phases are linked to the sub-questions. With this working method connections can be made for key- and free text words that are used for finding all relevant articles.

Sub questions
"How is discontinuous innovation defined?"
Key words: Discontinuous innovation, - technology, - markets, -environment and -change
Free text words: market diffusion, new product development process, new product development management, product design, search, selection, implementation and product development

"What is the current process of discontinuous innovation?"
Key words: Discontinuous innovation, - technology, - markets, -environment and -change
Free text words: Forecasting, marketing, uncertainty, strategy, pro-active link aging and tacit knowledge

Scopus uses keywords for selecting articles, Web of Science however does not work with keywords, instate it works with “looking in topic”. Web of Science makes no differences between free texted words and key words. Therefore all the words are considered to be topic words.

2.2.6 Conducting SLR results

The process of conducting the systematic literature review for the first research question with Scopus is shown in Figure 3. Figure 4 shows the process for research question one with Web of Science. Figure 5 shows the process to get to the final amount of articles for of Scopus and Web of Science for research question one. The results of searching for articles for the second research question in Scopus are shown in Figure 6. Figure 7 shows the results for the second research question searching with Web of Science and Figure 8 shows the total used for research question two for Scopus and Web of Science.

There is a difference between the amount of hits between Scopus and Web of Science. Web of Science gives more hits. The difference in the amount of hits is caused by the fact that Web of Science does not make a difference between key- and free text words. Scopus makes a better pre-selection than Web of Science. In the final selection of articles there was no real difference between the articles finally selected by Scopus and Web of Science.

The final use of the articles for the SLR in answering question one and two were almost the same. Conducting SLR for research question one, there were three articles more found in comparison with research question two. The articles that were found are all the same except the three articles that are found in research question two. Therefore the three different articles were also used to look for relevant information for research question two. The articles that were finally used for both research questions are shown in Table 1.

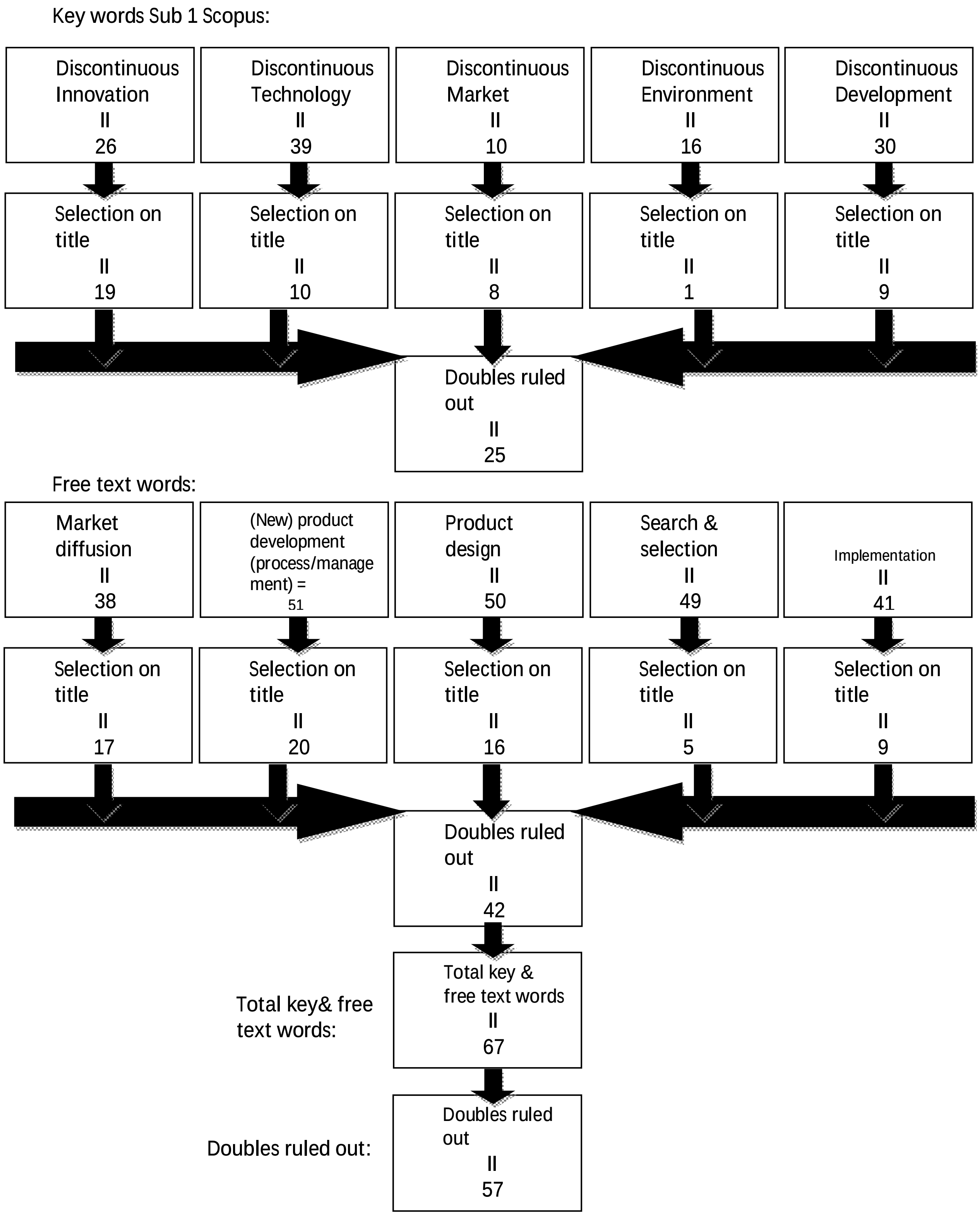

Figure 3: Selection of articles sub-question 1 Scopus

Key words Sub 1 Web of knowledge:

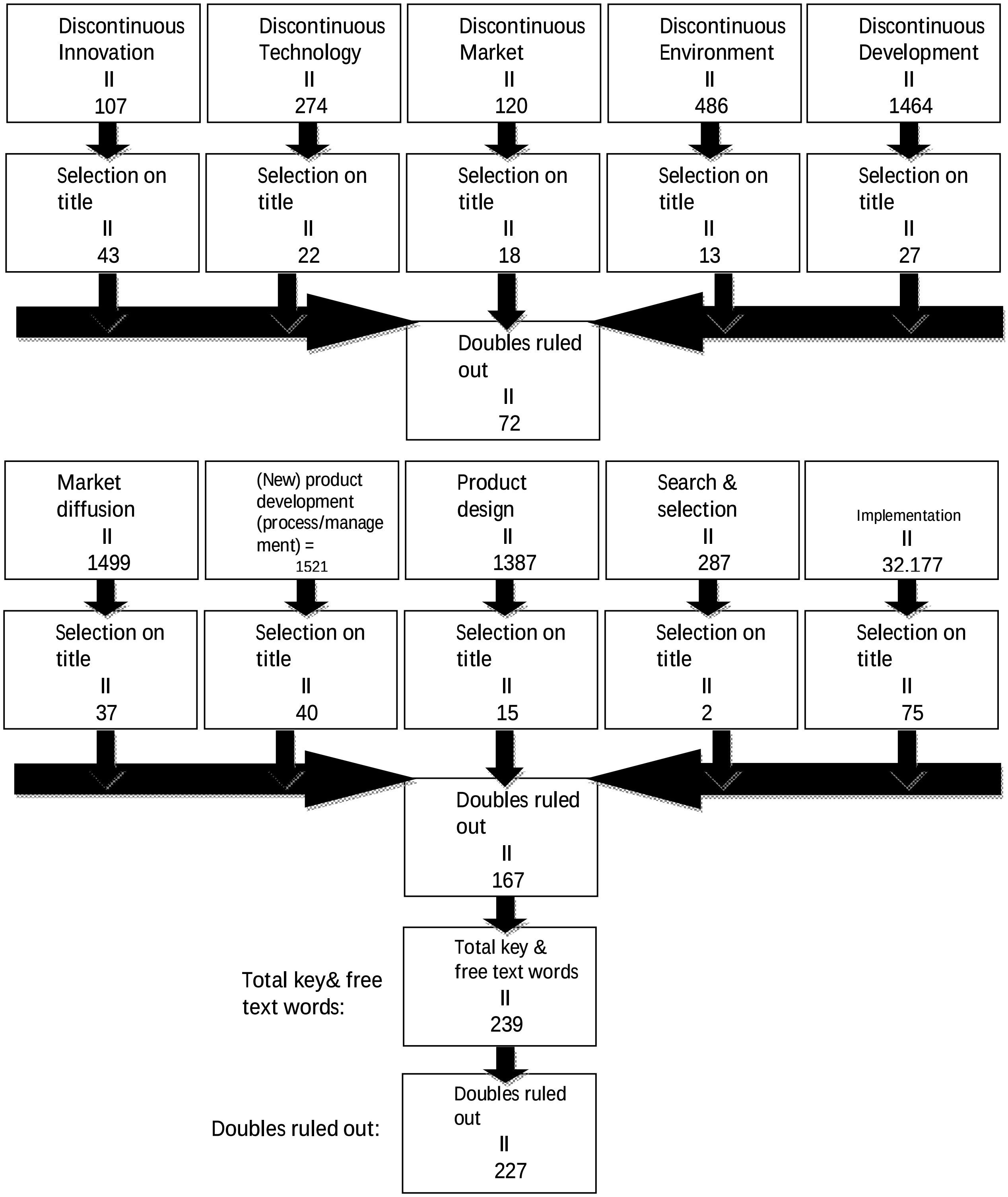

Figure 4: Selection of articles sub-question 1 Web of Science

Sub question 1 total

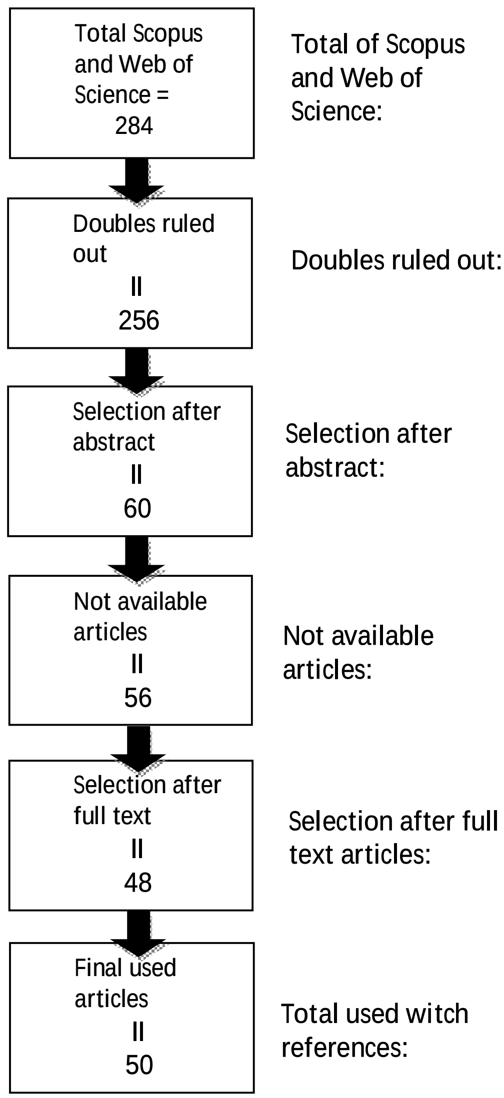

Figure 5: Total used sub question 1

Key words Sub 2 Scopus:

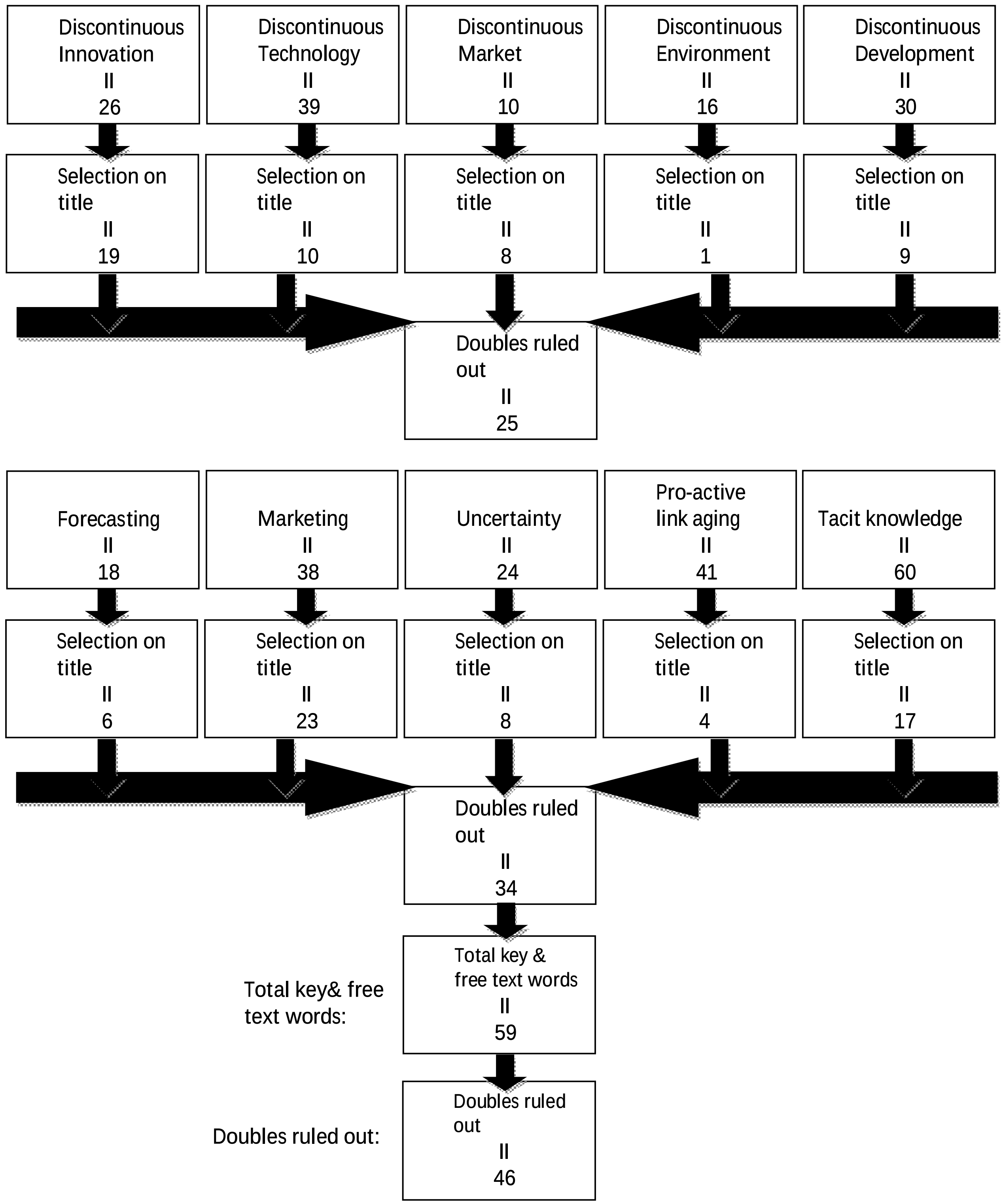

Figure 6: Selection of articles sub-question 2 Scopus

Sub question 2: Web of Science

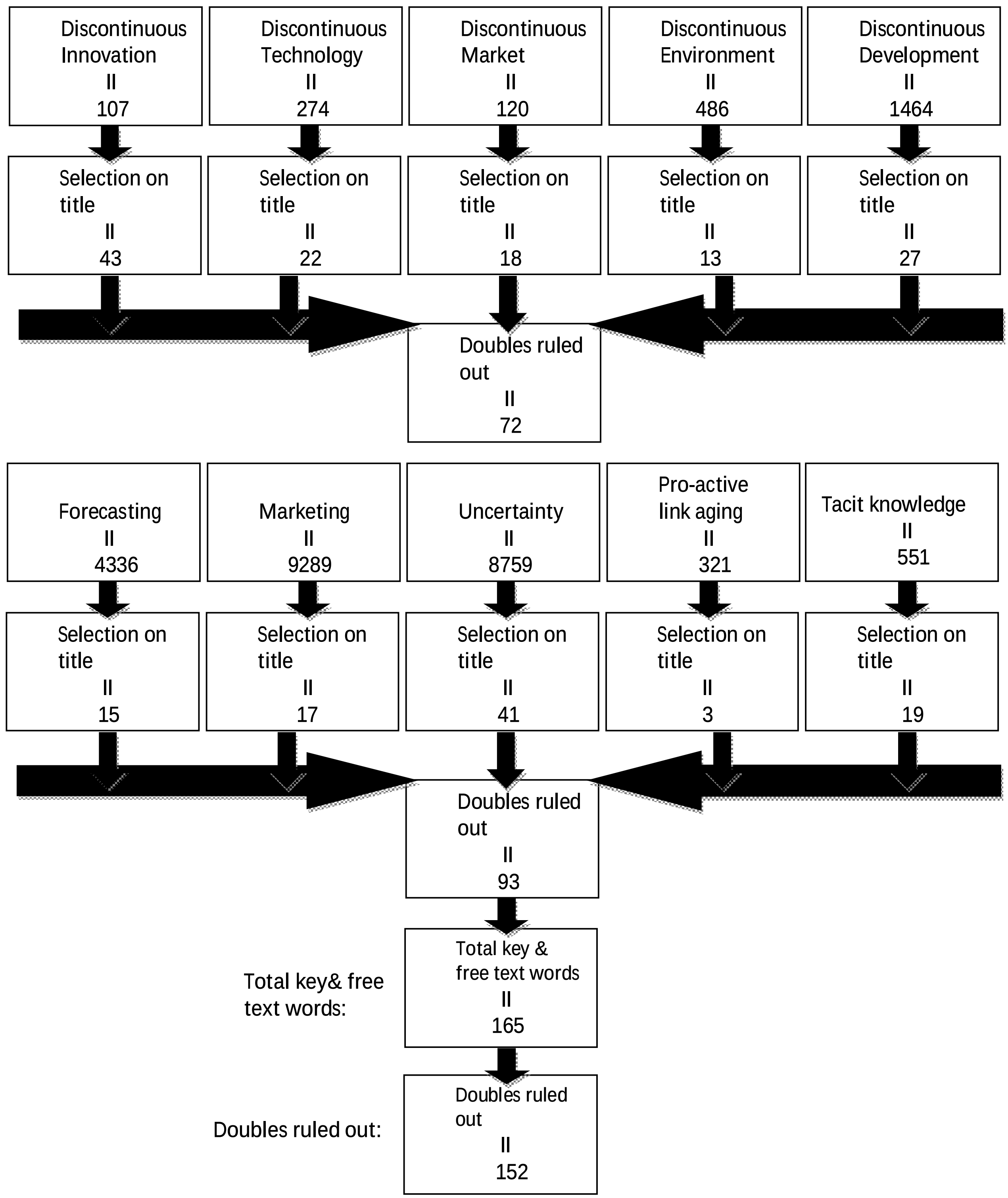

Figure 7: Selection of articles sub-question 2 Web of Science

Final sub question 2

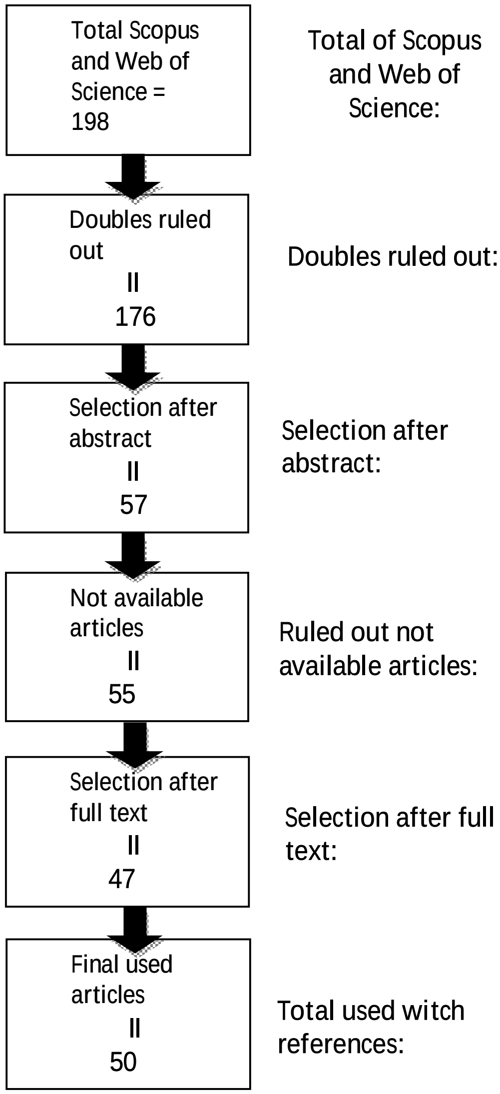

Figure 8: Total used sub question 2

Author	Year	Title	Magazine
Adner, R., Levinthal, D.A.	2002	The emergence of emerging technologies	California management review ,vol. 45(1), p. 50-66
Anderson, R. L., Ortinau, D.J.	1988	Exploring consumers' postadoption attitudes and use behaviors in monitoring the diffusion of a technology-based discontinuous innovation	Journal of business research, vol. 17(3), p. 283-298
Bessant, J.	2005	Enabling continuous and discontinuous innovation: Learning from the private sector	Learning from the private sector." Public money & management, vol. 25(1), p. 35-42
Bessant, J.	2008	Dealing with discontinuous innovation: The European experience	International Journal of Technology Management, vol. 42(1-2), p. 36-50
Bessant, J., Lamming, R., Hannah, N., Phillips, W.	2005	Managing innovation beyond the steady state	Technovation, vol. 25(12), p. 1366-1376
Birkinshaw, J., Bessant, J. and Delbridge, R.	2007	Finding, forming, and performing: Creating networks for discontinuous innovation	California management review, vol. 49(3), p. 67-84
Boschma, R. A., Knaap van der, G. A.	1999	New high-tech industries and windows of locational opportunity: The role of labour markets and knowledge institutions during the industrial era	Geografiska annaler. Series B, Human geography, vol. 81(2), p. 73-89
Chen, T., Chen, J.	2005	How the weaker China firms surpass the stronger competitors in the process of discontinuous technology change: A case from China in vitamin industry	IEEE International Engineering Management Conference, vol. I, p. 68-71
Cooper, L.	2000	Strategic marketing planning for radically new products	Journal of marketing, vol. 64(1), p. 1-16
Costa, C., Fontes, M., Heitor, M.V.	2004	A methodological approach to the marketing process in the biotechnology-based companies	Industrial marketing management, vol. 33(5), p. 403-418
Danneels, E., Kleinschmidt, E. J.	2001	Product innovativeness from the firm's perspective: Its dimensions and their relation with project selection and performance	The journal of product innovation management, vol. 18(6), p. 357-373
de Brentani, U	2001	Innovative versus incremental new business services: Different keys for achieving success	The journal of product innovation management, vol. 18(3), p. 169-187
Dekimpe, M. G., Parker, P. M., Sarvary, M.	2000	Global diffusion of technological innovations: A coupled-hazard approach	JMR, Journal of marketing research, vol. 37(1), p. 47-59
DeTienne, D. R., Koberg, C. S.	2002	The impact of environmental and organizational factors on discontinuous innovation within high-technology industries	IEEE transactions on engineering management, vol. 49(4), p. 352-364
Ding, H., Peters, L. S.	2000	Inter-firm knowledge management practices for technology and new product development in discontinuous innovation	International Journal of Technology Management, vol. 20(5-8), p. 588-600
Ehrnberg, E., Jacobsson, S.	1997	Indicators of discontinuous technological change: An exploratory study of two discontinuities in the machine tool industry	R & D management, vol. 27(2), p. 107-126
Francis, D., Bessant, J.	2005	Targeting innovation and implications for capability development	Technovation, vol. 25(3), p. 171-183
Garcia, R., Calantone, R.	2002	A critical look at technological innovation typology and innovativeness terminology: A literature review	The journal of product innovation management, vol. 19(2), p. 110-132
Gilbert, C. G.	2006	Change in the presence of residual fit: Can competing frames coexist?	Organization science, vol. 17(1), p. 150-167
Hang, C. C., K. B. Neo, Chai, K.H.	2006	Discontinuous technological innovations: A review of its categorization	IEEE International Conference on Management of Innovation and Technology, vol. 1, p. 253-257

Author	Year	Title	Magazine
Kaplan, S., F. Murray, Henderson, R.	2003	Discontinuities and senior management: Assessing the role of recognition in pharmaceutical firm response to biotechnology	Industrial and Corporate Change vol. 12(2), p. 203-233
Kassicieh, S., B. A. Kirchhoff, Walsh, S.T., McWhorter, P.J.	2002	The role of small firms in the transfer of disruptive technologies	Technovation, vol. 22(11), p. 667-674
Kostoff, R. N., R. Boylan, Simons, G.R.	2004	Disruptive technology roadmaps	Technological forecasting and social change, vol. 71, p. 141-159
Lamont, B. T., D. Marlin, Hoffman, J.J.	1993	Porters generic strategies, discontinuous envrionments, and performance - a longitudinal - study of changing strategies in the hospital industry	Health services research, vol. 28(5), p. 623-640
Linton, J. D.	2002	Forecasting the market diffusion of disruptive and discontinuous innovation	IEEE transactions on engineering management, vol. 49(4), p. 365-374
Lynch, M., Sutton, S. A.	1999	The Panda syndrome II: Innovation, discontinuous change, and LIS education	Journal of education for library and information science, vol. 40(4), p. A8-A8
Lynn, G.S., Morone, J.G., Paulson, A.S.	1996	Marketing and discontinuous innovation: The probe and learn process	California management review, vol. 38(3), p. 8-37
Lynn, M. L.	2005	Organizational buffering: Managing boundaries and cores	Organization studies vol. 26(1), p. 37-61
Mackay, M. M., Metcalfe, M.	2002	Multiple method forecasts for discontinuous innovations	Technological forecasting and social change, vol. 69(3), p. 221-232
Magnusson, M., Martini, A.	2008	Dual organisational capabilities: From theory to practice - The next challenge for continuous innovation	International Journal of Technology Management, vol. 42(1-2), p. 1-19
McDermott, C., Handfield, R.	1996	Does the parallel approach make sense in the development of discontinuous innovations	IEEE International Engineering Management Conference, p. 370-374
McKee, D.	1992	An organizational learning approach to product innovation	The journal of product innovation management, vol. 9(3), p. 232-245
Michel, S., Brown, S.W., Gallan, A.S.	2008	An expanded and strategic view of discontinuous innovations: deploying a service-dominant logic	Journal of the Academy of Marketing Science, vol. 36(1), p. 54-66
Moreau, C. P., Lehmann, D.R., Markman, A.B.	2001	Entrenched knowledge structures and consumer response to new products	JMR, Journal of marketing research, vol. 38(1), p. 14-29
Noke, H., Perrons, R.K., Hughes, M.	2008	Strategic dalliances as an enabler for discontinuous innovation in slow clockspeed industries: evidence from the oil and gas industry	R & D management, vol. 38(2), p. 129-139
Norling, P. M., Statz, R. J.	1998	How discontinuous innovation really happens	Research technology management, vol. 41(3), p. 41-44
O'Reilly III, C. A., Tushman, M. L.	2004	The ambidextrous organization	Harvard business review, vol. 82(4),p. 74-81
Phillips, W., Lamming, R., Bessant, J., Noke, H.	2006	Discontinuous innovation and supply relationships: Strategic dalliances	R & D management, vol. 36(4), p. 451-461
Reid, S., de Brentani, U.	2004	The fuzzy front end of new product development for discontinuous innovations: A theoretical model	The journal of product innovation management, vol. 21(3), p. 170-184

Author	Year	Title	Magazine
Rice, M. P., Leifer,R., O'Connor, G.C.	2002	Commercializing discontinuous innovations: Bridging the gap from discontinuous innovation project to operations	IEEE transactions on engineering management, vol. 49(4), p. 330-340
Rice, M.P., O'Connor, G.C., Peters, L.S., Morone, J.G.	1998	Managing discontinuous innovation	Research technology management, vol. 41, p. 52-58
Rothaermel, F. T.	2002	Technological discontinuities and interfirm cooperation: What determines a startup's attractiveness as alliance partner?	IEEE transactions on engineering management, vol. 49(4), p. 388-397
Schwery, A., Raurich, V. F.	2004	Supporting the technology-push of a discontinuous innovation in practice	R & D management, vol. 34(5), p. 539-552
Tushman, M. L., O'Reilly III, C. A.	1996	Ambidextrous organizations: Managing evolutionary and revolutionary change	California management review, vol. 38(4), p. 8-30
Veryzer Jr, R. W.	1998	Discontinuous Innovation and the New Product Development Process	The journal of product innovation management, vol. 15(4), p. 304-321
Veryzer Jr, R. W.	1998	Key factors affecting customer evaluation of discontinuous new products	The journal of product innovation management, vol 15(2), p. 136-150
Veryzer Jr, R. W.	2005	The roles of marketing and industrial design in discontinuous new product development	The journal of product innovation management, vol. 22(1), p. 22-41
Walsh, S. T.	2000	Infrastructure for emergent industries based on discontinuous innovations	Engineering management journal, vol 12(2), p. 23-31
Walsh, S.T., Boylan, R.L., McDermott, C., Paulson, A.	2005	he semiconductor silicon industry roadmap: Epochs driven by the dynamics between disruptive technologies and core competencies	Technological forecasting and social change, vol. 72(2), p. 213-236
Watts, R.	2001	Commercializing discontinuous innovations	Research technology management, vol. 44(6), p. 26-31

Table 1: Final articles SLR

3. How is discontinuous innovation defined?

3.1 Introduction

There are many articles written about discontinuous innovation. But there is no consistent of what exactly discontinuous innovation is. There are explanations about the definition of discontinuous innovation and there are authors who point out the relation between different innovation types. In this chapter we will give an overview about what the current understanding is of discontinuous innovation. There are three main differences, authors who give a definition of discontinuous innovation, authors who describe the output of discontinuous innovation and authors who describe the inter-linkages between innovations. An overview will be given between the different effects of discontinuous innovation. The authors who describe one of the definitions are found in the beginning of each paragraph in a overview table. There are also some authors who not give an explanation, those authors are not subdivided into the three explanations.

3.2 Characteristics of discontinuous innovation

There are many authors who describe discontinuous innovation by explaining different characteristics. Some authors quantify the characteristics and others explain the impact they have. The different characteristics are put in a Table 2 and behind it are authors who use that kind of explanation to describe discontinuous innovation. After the table examples are given with the different characteristics. The characteristics are clustered to gather with characteristics that are a bit similar. What stands out in most of the characteristics of discontinuous innovation is that it is difficult to accomplish discontinuous innovation and that there are many uncertified.

Characteristics	Authors
Ambiguity and fuzziness	
No clear rules	(Bessant, 2005; Bessant, Lamming, Hannah & Phillips, 2005)
High tolerance for ambiguity	(Bessant, 2005; Bessant et al., 2005)
Development	
Greater company effort	(de Brentani, 2001)
Difficult to execute	(Costa, Fontes & Heitor, 2004; de Brentani, 2001; Hang, Neo & Chai, 2006; Rice, O'Connor, Peters & Morone, 1998)
New entrants developing	(Birkinshaw, Bessant & Delbridge, 2007; Hang et al., 2006; Kassicieh, Kirchhoff, Walsh & McWhorter, 2002; O'Reilly III & Tushman, 2004; Tushman & O'Reilly III, 1996; Watts, 2001)
Competitive advantage companies	(de Brentani, 2001; Kassicieh et al., 2002; McDermott & Handfield, 1996; O'Reilly III & Tushman, 2004; Reid & de Brentani, 2004)
Lots of uncertainties	(Adner & Levinthal, 2002; Costa et al., 2004; de Brentani, 2001; Hang et al., 2006; Lynn, Morone & Paulson, 1996; McDermott & Handfield, 1996; Phillips, Lamming, Bessant & Noke, 2006; Reid & de Brentani, 2004; Rice et al., 1998; Veryzer Jr, 1998a)
Long in duration of development	(McDermott & Handfield, 1996; Rice et al., 1998)

Characteristics	Authors
Economics	
Frequent need of accompanying innovation in business model	(Hang et al., 2006)
Traditional financial methods fall short in capture the potential	(McDermott & Handfield, 1996)
Benefit customers	
Benefits according to customers	(Anderson & Ortinau, 1988)

Table 2: Characteristics of discontinuous innovation

3.2.1 Ambiguity and fuzziness

As Bessant et al. (2005) stated: *discontinuous innovation is an innovation where there are no clear rules. These rules will emerge over time but cannot be predicted in advantage. Discontinuous innovation will need to have a high tolerance for ambiguity, seeking multiple parallel possible trajectories. The innovation space is defined by open and fuzzy selection environment. Probe and learn experiments needed to build information about emerging patterns and allow dominant design to emerge* (Bessant, 2005; Bessant et al., 2005).

3.2.2 Development

De Brentani (2001) explains: *discontinuous innovations entail a much higher degree of risk, require greater company effort and resource commitment, but are usually the only types of new product ventures by which a firm can gain really outstanding profits or achieve a major competitive advantage* (de Brentani, 2001). Rice et al. (1998) put it: *the discontinuous innovation life cycle; these projects have long time horizons, starts and stops, and periods of seemingly going nowhere. They are highly unpredictable and uncertain, like a river winding its way to the ocean. Like a river, they have a general direction but don't get there directly. Sometimes they dry up to only a trickle, sometimes they go underground, and at other times they spill over and flood. They not only make twists and turns but also sometimes give rise to new streams. However, like a river, they are generally constrained by their environment* (Rice et al., 1998). Rice et al. (2002) stated: *firms expected multiplicity of uncertainties besetting a discontinuous innovation project this would be sufficiently reduced by the time of handoff of the project to the operating unit that the transition could be accomplished with minimal difficulty. But this is not the case, in reality it is much more difficult. There are different transition uncertainties, there are technical, market, resources and organizational uncertainties* (Rice, Leifer & O'Connor, 2002).

Bessant (2005) argues: *It are usually new entrants firms who are able to exploit the 'fluid phase' in terms of developing innovations to take advantage of these conditions, while existing incumbents do badly. The problem is that the conditions to manage steady-state innovations work as a barriers to pick up signals about, and effectively respond to, innovation threats and opportunities associated with discontinuous shifts. To pick up these signals a new kind of management style is required. A key challenge is to develop a alternative routines for discontinuous innovation* (Bessant, 2005)

Kassecieh et al. (2002) stated that: *Competitive advantage is build and renewed by discontinuous innovation based on disruptive technology that creates new families or products and business. Discontinuous innovation offers the potential for competitive advantage and requires greater attention by management practitioners (Kassicieh et al., 2002).*

3.2.3 Economics

McDermott and Handfield (1996) stated: *because of a high degree of uncertainty with discontinuous innovations, market analysis become fuzzier and traditional financial measures fall short in their ability to capture the potential of these new products in a meaningful way. Traditional process control methods may not be easily applicable in these situations* (McDermott & Handfield, 1996).

3.2.4 Benefit customers

Anderson and Ortinau (1998) describe discontinuous innovation as: *when a product or service innovation is perceived by consumers as being a new product established by a major technological advance. It represents a major change in benefits afford to consumers and in behaviours necessary for them to own and use the product* (Anderson & Ortinau, 1988).

3.3 Output of discontinuous innovation

There are authors who describe the output a discontinuous innovation has. There are authors who describe the main output characteristics of this output. The output characteristics are main characteristics caused by discontinuous innovation. The output can also be described as changes on the product curve. The output factors as a product curve means that change caused by discontinuous innovation are causing movements on the product curve. A third way to describe the output of a discontinuous innovation is to look at what output/effect discontinuous innovation has on environmental factors, and looking at which environmental factors have an output/effect on discontinuous innovation. Table 3 shows the different output explanations and the different authors who uses this explanation of discontinuous innovation.

Characteristics	Authors
Output Characteristics	(Anderson & Ortinau, 1988; Bessant, 2005, 2008; Bessant et al., 2005; Birkinshaw et al., 2007; Chen & Chen, 2005; Costa et al., 2004; de Brentani, 2001; DeTienne & Koberg, 2002; Ding & Peters, 2000; Garcia & Calantone, 2002; Hang et al., 2006; Kassicieh et al., 2002; Kostoff, Boylan & Simons, 2004; McDermott & Handfield, 1996; Michel, Brown & Gallan, 2008; Noke, Perrons & Hughes, 2008; O'Reilly III & Tushman, 2004; Phillips et al., 2006; Rice et al., 2002; Rice et al., 1998; Rothaermel, 2002; Tushman & O'Reilly III, 1996; Veryzer Jr, 1998a; Walsh, 2000; Walsh, Boylan, McDermott & Paulson, 2005; Watts, 2001)
Product curve	(Chen & Chen, 2005; DeTienne & Koberg, 2002; Ehrnberg & Jacobsson, 1997; McKee, 1992; Tushman & O'Reilly III, 1996)
Discontinuous innovation effecting environmental factors	(Adner & Levinthal, 2002; Bessant, 2005; Bessant et al., 2005; Boschma & van der Knaap, 1999; Francis & Bessant, 2005; Lamont, Marlin & Hoffman, 1993; Lynch & Sutton, 1999; Lynn, 2005; Tushman & O'Reilly III, 1996)

Table 3: Output of discontinuous innovation

3.3.1 Output Characteristics

The output a discontinuous innovation is causing is described by different output characteristics. Some authors describe the characteristics the discontinuous innovation is causing, these characteristics are shown in Table 4, after the table some examples are given of the different output characteristics.

Characteristics	Authors
Development	
Displacing current products	(DeTienne & Koberg, 2002; Hang et al., 2006; Noke et al., 2008)
Restructuring economics	(Michel et al., 2008; Noke et al., 2008)
Displaces an old technology	(Bessant, 2008; Chen & Chen, 2005; Rice et al., 2002)
Changing markets and customers	
Creating or restructuring entirely new product categories/markets/industries/technology/ new-to-the-market	(Anderson & Ortinau, 1988; Bessant, 2008; Birkinshaw et al., 2007; de Brentani, 2001; DeTienne & Koberg, 2002; Ding & Peters, 2000; Garcia & Calantone, 2002; Hang et al., 2006; Kassicieh et al., 2002; McDermott & Handfield, 1996; Michel et al., 2008; Noke et al., 2008; Rice et al., 2002; Rice et al., 1998; Rothaermel, 2002; Veryzer Jr, 1998a)
Changing behaviour/attitude/infrastructure of customers	(Anderson & Ortinau, 1988; Costa et al., 2004; de Brentani, 2001; Kassicieh et al., 2002; Kostoff et al., 2004; Michel et al., 2008; Phillips et al., 2006; Veryzer Jr, 1998a; Walsh, 2000; Walsh et al., 2005)
Quantifying	
Ten times improvement in performance compared to the existing products	(Ding & Peters, 2000; Garcia & Calantone, 2002; Rothaermel, 2002)
A 30 to 50% reduction in costs	(Ding & Peters, 2000; Garcia & Calantone, 2002; Rothaermel, 2002)
Old firms	
Incumbents have difficulties in reacting/ignored by incumbents	(Birkinshaw et al., 2007; Chen & Chen, 2005; Hang et al., 2006; Kassicieh et al., 2002; O'Reilly III & Tushman, 2004; Tushman & O'Reilly III, 1996; Watts, 2001)

Table 4: Output characteristics

3.3.1.1 Development

DeTienne and Koberg (2002) stated that: *discontinuous innovation is able to let entire industries and markets emerge, transform, or disappear. They are technological breakthroughs that help companies rewrite industry rules or create entire new industries. Technological discontinuities in which new, radically superior technologies displace old, inferior ones* (DeTienne & Koberg, 2002).

Michel et al. (2008) describe the output as: d*iscontinuous innovations significant changes how customers co-create value. Discontinuous innovations significantly affect market size, prices, revenues or market shares. It changes the firm's value creation. It is composed of embedded operant resources. It is caused by a change of value integration, specifically, by changing the firm's and customer's integration role. Discontinuous innovation often includes reconfiguring the value constellation* (Michel et al., 2008).

Bessant (2008) describes it as: *Discontinuity is a disruption from a blow, a simpler cheaper technology displaces an established but over sophisticated one and a new market where disruption is an unmet or unimagined needs in the market or a segment of it. The role of technological advantage is of* *limited significance. It is not radical nature of the technology but rather its recombination into a new bundle whose performance characteristics are valued by a different market groups which leads the disruption. Radical technological change can lead to discontinuous conditions across industries* (Bessant, 2008)

3.3.1.2 Changing markets and customers

Walsh (2000) describes it as: *with discontinuous innovations there is often the emergence of a new market. This new market needs to develop its infrastructure, the pool of knowledge, technical abilities, customer knowledge and marketing channels. Infrastructure has "downstream" and "upstream" components. Upstream infrastructure addresses the technical novelty associated with discontinuous innovations. Downstream infrastructure addresses the identification and development of a customer base. While these two infrastructure components can be considered independently, they must be considered together to evaluate the current status of the infrastructure of an industry that is emerging from radical innovation. There are different stages of acceptance in which the infrastructure is made. At stage 1, the scientific base or principles that the innovation is based on exist, but products and supplies do not. Stage 2, is the eventually initial market acceptance of one product. Stage 3 is the market augmentation stage, the one product that has entered the market has reduced potential users' perception of newness and the associated risk. Stage 4, completely new markets accept other discontinuous-innovation products or services based on the disruptive-technology base, as customers either actively seek solutions for their problems or are familiar enough with the technology to accept it without reservation. Management needs to watch the stages of infrastructure development in an emergent industry to determine whether their firm should enter immediately or if they would be better off waiting for further development to occur. The infrastructure model allows the policy maker to examine an emergent market and determine what actions are required to encourage infrastructure growth. By looking at the different stage, firms can understand the development of a new market for a discontinuous innovation* (Walsh, 2000).

De Brentani (2001) argues that: *responding to clearly defined customers problems/needs in a large and attractive market is both likely and essential for discontinuous innovations. It is likely and essential for discontinuous innovation because these types of innovations provide entirely new ways to solve customer problems and thus offer significant opportunities for differentiation and competitive advantage, giving them tremendous potential for market success. But expecting a high degree of market attractiveness and a precise definition of customers needs for discontinuous innovations is most of the time unrealistic and not always necessary. With discontinuous services innovations these are more flexible than products and therefore they can be better be adjusted to the customers' needs. Also the development of these discontinuous services involves a high degree of client contact during service production and delivery. This offers service providers to adjust and fine-tune the discontinuous service to individual client needs* (de Brentani, 2001).

Other examples are: *Discontinuous innovation is about creating new behaviour patterns. The grater the change in behaviour is the greater the adopter needs to learn how to use or maintain the innovation* (Danneels & Kleinschmidt, 2001). *Discontinuous innovation focus on the customer behaviour, product newness and market factors* (Kassicieh et al., 2002).

Company 1:

"Discontinuous innovation is when you do something totally different than you were doing before. If you are looking for new ways to do thing to let the profit grow. If you come up with something totally new within the organization is also a discontinuous innovation" (10/27/2008)

3.3.1.3 Quantifying

Ding and Peters (2000) among others use these characteristics to measure discontinuous innovation. They use three different kinds of measurements: the first one is that *the new innovation needs a 5-10 times improvement in performance compared to the existing products.* Secondly the *new innovation creates the basis for a 30 to 50% reduction in costs.* And finally *it can also be an innovation that is has new-to-the-world performance features* (Ding & Peters, 2000; Garcia & Calantone, 2002; Rothaermel, 2002).

3.3.1.4 Old firms

Birkinshaw et al. (2007) stated: *discontinuous innovation can take many forms, it is often driven by the development on an entirely new technology. Or it might be brought about by the emerge of new markets. Regardless of the initial source of change, the effect of such discontinuities on incumbent firms can be dramatic. Researchers has shown consistently that new technology or market opportunities are typically develop first by new entrants, and established players either find themselves scrambling to catch up or they lose out altogether. But there are some cases where incumbent firms have successfully managed there firm into a new business model to incorporate discontinuous technologies. That suggests that there are possibilities for firms to be successful at discontinuous innovation. But the changes are very low of being successful* (Birkinshaw et al., 2007). Noke et al. (2008) confirms that in some cases incumbents successfully react to discontinuous innovations that: *some incumbent organizations can and do adapt, survive, and regain historic performance levels in the face of discontinuous innovation. Some existing firms have also leveraged a discontinuous innovation to expand their business in a market segment that they created outside their usual customer base* (Noke et al., 2008).

3.3.2 Product curve

Discontinuous innovation has an output/effect on the product-curve. The product curve is the development of a product that is shown as a curve that is shaped in a S form. The product performance slowly improves in time which evolves in a s-shape line. The product line can also be with market share, in low-end, mainstream and hi-end market users. A product slowly obtains more users, mostly starting in one of the three markets. When customers are adopting the technology a bell-curve is created. Every product in a company follows the s-curve (Tushman & O'Reilly III, 1996). Authors try to explain what discontinuous innovation is, by looking what output it has on the evolving around the product curves. At the end of the curve a organization need to evolve and need to introduce a new product. To succeed over the long haul, firms have to periodically reorient themselves by adopting new strategies and structures that are necessary to accommodate changing environmental conditions (Tushman & O'Reilly III, 1996). Linton (2002) explains: *discontinuous innovation involves shifting from one technological learning curve to a more attractive technological learning curve thereby obtaining a substantial gain in one or more performance metrics. Discontinuous innovation might not have an adverse effect on the existing technology base of the firm* (Linton, 2002).

Ehrnberg and Jacobsson (1997) stated that the process which a discontinuous innovation achieves an economic significance is introduced in time when another technology/product is maturing. The new product with a superior performance in the specified performance dimension. This evolving is done in a s-curved shaped line. There are distinct phases or sub-processes which all need to be identified and understood by the different firms, this process is shown in Figure 9. At time T_0 the emerging technology is first incorporated in a new product, discontinuous innovation takes place. In the maturing phase there is frequent competition between various designs (T_1). The major innovation can have scale advantages and price reduction which can be collected, keeping a innovation superiority. But evolving these minor discontinuous innovations will get major and new sub-systems may replace previous ones, making a discontinuous innovation replacing the established product. This is such a technological change that it is a (minor) technological discontinuous innovation. The economically most interesting 'minor' discontinuity is one which allows the firms supplying the product to begin to capture the mass market (Ehrnberg & Jacobsson, 1997).

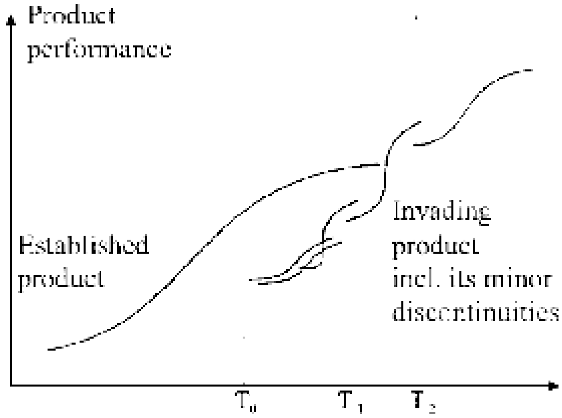

Figure 9: a technological discontinuity including its 'minor' discontinuities (Ehrnberg & Jacobsson, 1997)(page, 109)

Mckee (1992) explains it not only for the product point of view but in a way of organizations learning. Movement along the product innovation learning curve represents incremental product innovation within a particular technology. Movement between product-innovation learning curves represents discontinuous product innovation. This shift is necessary when a particular technology reaches an inherent upper performance limit. This shift in learning innovation curve is shown in Figure 10 (McKee, 1992). It is the combination of discontinuous innovation and incremental that leads to maintaining market leadership. Incremental product line extensions and improvements are essential for maintaining leadership, but only after it has been established through the more discontinuous form of innovation (Lynn et al., 1996).

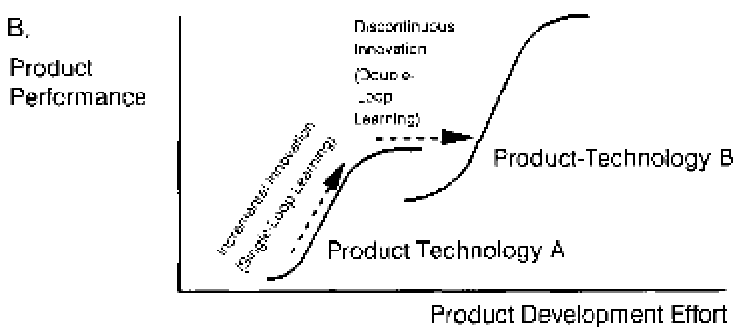

Figure 10: Learning innovation curve relationship (McKee, 1992)(page, 234)

DeTienne and Koberg (2002) stated that discontinuous innovation is able to let entire industries and markets to *emerge*, *transform*, or *disappear*. These factors are technological breakthroughs that help companies rewrite industry rules or create entire new industries. Technological discontinuities in which new, radically superior technologies displace old, inferior ones. However when a (new) dominant design emerges, technological advancement returns to incremental improvements and elaboration of the dominant technology occur (DeTienne & Koberg, 2002). Incremental improvements keep discontinuous innovations profitable for the long-run (de Brentani, 2001). Chen and Chen (2005) point out that the new product curve gives weaker firms the opportunity to surpass incumbents firms. In the dynamic and complex environment, technology development shows itself discontinuous. Larger and stronger firms are primarily interested in improvement to sustaining technologies rather than discontinuous technology. Discontinuous technology is a technical advance so significant that no increase in scale, efficiency, or design can make the older technologies competitive with the new technology. Product discontinuities are reflected in the emerge of new product classes or in fundamental product improvements. Discontinuous processes are reflected in either process substitution or in process innovations that result in radical improvements in industry-specific dimensions of merit. When a technology have reached its limits, discontinuous technology is likely to *invade an industry*, sparking a new period of ferment. This can be shown with the product s-curve, the visualisation of the technological development which evolves in a s shaped curve. When the old one has reached its end, a new one will emerge (Chen & Chen, 2005).

The output of a discontinuous innovation can be shown in a product-curve. As stated above discontinuous innovation can let entire industries and markets emerge, transform, or disappear. This is the start of a new s-shaped curve, replacing an old technology or product. Discontinuous innovation will cause a shift in the market.

3.3.3 Discontinuous innovation effecting environmental factors

Discontinuous innovation can cause environmental factors to become discontinuous. This discontinuous innovation can cause a discontinuous change. An example of this is that the emerge of discontinuous innovations can create new markets. New market causes the environment to become discontinuous (Bessant, 2008). This is the output of discontinuous innovation on the environment. The influence/output of the environment on discontinuous innovation is explained in the process of discontinuous innovation in the next chapter.

The output of discontinuous innovation is compared by some authors with the evolution theory of Darwin and other ecology models. Models of the population ecology are applied to the organizational population. Tushman and O'Reilly III (1996) explain that theories of ecology explain how a discontinuity in the environment can lead to the total extinction of organizations. Ecological pressures in which companies evolve are through periods of incremental adaptation punctuated by discontinuities. Over time the fittest survive until there is a major discontinuity. At that point, managers of firms are faced with the challenge reconstituting their organizations to adjust to the new environment. The processes of variation, selection, and retention that winnow the fittest of animal population seems to apply to organizations as well (Lynch & Sutton, 1999; Tushman & O'Reilly III, 1996). There are triggers that cause discontinuities in the environment. DeTienne and Koberg (2002) found out that discontinuous innovations increased with environmental dynamism. Effective organizational environments with substantial technological and/or legal and/or social uncertainty tend to undertake reorientations at discontinuous change (DeTienne & Koberg, 2002). There are different triggers for discontinuities in the environment and those are described in the next chapter when the model of the DI-lab is described.

3.4 Inter-linkages

Another way to describe discontinuous innovation is to look how discontinuous innovation is related to other forms of innovation. There are three different ways of inter-linkages of discontinuous innovation. The first relation is that discontinuous innovation is used as umbrella term. Another inter-linkage is that disruptive technology leads to discontinuous innovation. The final inter-linkages is description of how other innovations that not continuous relate to discontinuous innovation. The different forms of inter-linkages and the authors are found in Table 5.

Discontinuous innovation movements	Authors
Umbrella term	(Cooper, 2000; Danneels & Kleinschmidt, 2001; Magnusson & Martini, 2008; Noke et al., 2008; Veryzer Jr, 1998a, 2005)
Disruptive technology leads to discontinuous innovation	(Kassicieh et al., 2002; Linton, 2002; Walsh, 2000; Walsh et al., 2005)
Inter-linkages between discontinuous innovation and other non-continuous innovations	(Garcia & Calantone, 2002; Hang et al., 2006)

Table 5: Inter-linkages of definition discontinuous innovation

3.4.1 Umbrella term

Some authors use discontinuous innovation as an umbrella term. This inter-linkages means that all non-continuous innovations are equal to discontinuous innovation or that discontinuous innovation is a central term (an umbrella term). Garcia en Calantone (2002) stated that: *there are different kinds of innovations. There are authors who describe radical innovations, disruptive innovations and discontinuous innovations. They all are examples of innovations that describe a total new technology or product. Some authors make a distinction between what are radical, disruptive or really new innovations. But an innovation that one researcher calls really new innovation it termed radical or discontinuous by another researcher. There has been no embracement of any consistent dimension in constructs of the different innovations* (Garcia & Calantone, 2002). Noke et al. (2008), stated: S*ome innovations disturb various states of equilibrium in an industry. These innovations are often characterized as 'radical', competence-destroying', or 'disruptive', these discontinuous innovations are capable of bringing about major upheavals in the industries they impact, fundamentally transforming relationships between customers and suppliers, restructuring the marketplace, economics, displacing current products and creating entirely new product categories* (Noke et al., 2008). He places discontinuous innovation as an umbrella term; it is a central term between the other non continuous innovations. Another example of this is de Brentani (2001) who describes discontinuous innovations as: *discontinuous or radical innovations are characterized as: truly novel or unique technological solutions, the development or application of new technologies or state-of-the-art breakthrough in technology or product category. This means that discontinuous innovations can be described as new products that are perceived as totally different and require major changes in thinking and behaviour on the part of customers or that involve dramatic leaps in terms of customer familiarity and use* (de Brentani, 2001). Veryzer Jr (1998) also uses discontinuous innovation as an umbrella term. He describes discontinuous innovations as: *an innovation that refers to radically new products that involve dramatic leaps in terms of customer familiarity and use. Frequently these types of products involve development or application of significant new technologies* (Veryzer Jr, 1998a).

<u>Company 2:</u>

"We try to transform technologies into first of a kind products. We apply technologies for the first time. You could describe it as discontinuous innovation, and sometimes it is. But it can also be simply the putting together something that already exists. That is innovation but not necessarily discontinuous innovation" (09/30/2008).

3.4.2 Disruptive technology leads to discontinuous innovation

Some authors state that discontinuous innovation is created by disruptive innovations. This inter-linkage means that disruptive technologies generate discontinuous innovations that require users/adopters to change their behaviour in order to use the innovation (Kassicieh et al., 2002). Linton (2002) argues that: *discontinuous innovation involves shifting from one technological learning curve to a more attractive technological learning curve thereby obtaining a substantial gain in one or more performance metrics. Discontinuous innovation might not have an adverse effect on the existing technology base of the firm. Disruptive technologies are discontinuous innovations but discontinuous innovations do not have to be disruptive technology* (Linton, 2002).

Kassicieh et al. (2002) stated that: *continuous improvements of the discontinuous innovation used together offer potential for sustained competitive advantage. Competitive advantage is build and renewed by discontinuous innovation based on* *disruptive technology that creates new families or products and business. Discontinuous innovation offers the potential for competitive advantage and requires greater attention by management practitioners. Many large firms seem reluctant to familiarize themselves with these technologies quickly, they react to a proven technology that has already changed the product market paradigm* (Kassicieh et al., 2002).

3.4.3 Inter-linkages between discontinuous innovation and other non-continuous innovations

A radical innovation that is used by some author is termed disruptive or discontinuous by another researcher. There has been no embracement or any consistent dimension in constructs of the different innovations (Garcia & Calantone, 2002). The conclusion can be drawn that there is some overlap between the different non continuous innovations. Some authors (Garcia & Calantone, 2002; Hang et al., 2006) try to explain discontinuous innovations by looking how other innovations are related to discontinuous innovation. They define the inter-linkages between them.
Hang and Chai (2006) have made an overview how to place disruptive and radical innovation in the discontinuous innovation concept. The overview of the concept shown in Figure 11. There are two different kinds of disruptive innovation, Type I and a Type II shown in the figure. Type one disruptive innovation is low-performance and low-price innovations serving existing markets. Type two disruptive innovation is low-performance and low-price innovations serving in new low end markets. There are three different types of radical innovation. Type one radical innovation is an innovation within technology/market domains of existing businesses. Type two radical innovation is an innovation within the "white spaces" between a firm's existing business. Type three radical innovation is an innovation outside a firm's current strategic context. But the use of these different types in the literature is not always that consistence. For instance "Nucor Corporation" on mini-steel-mill market was quotes as disruptive innovation by Christensen while being used as an example of radical innovation by Leifer, and there are more of these examples. Disruptive and radical innovations that not the only two types of discontinuous innovation. Hybrid innovation also a discontinuous innovation, this is a discontinuous innovation with a direct market entry into the mainstream market and replaces the dominant design. Two different types of hybrid innovations exists. Type one hybrid innovation has high performance but is relatively expensive and more costly than the current design in the industry. Type two hybrid innovation has lower performance and is more costly but it has features that customers valued highly (Hang, Neo et al. 2006). Figure 12 shows how hybrid innovations occur in the market with radical and disruptive innovations.

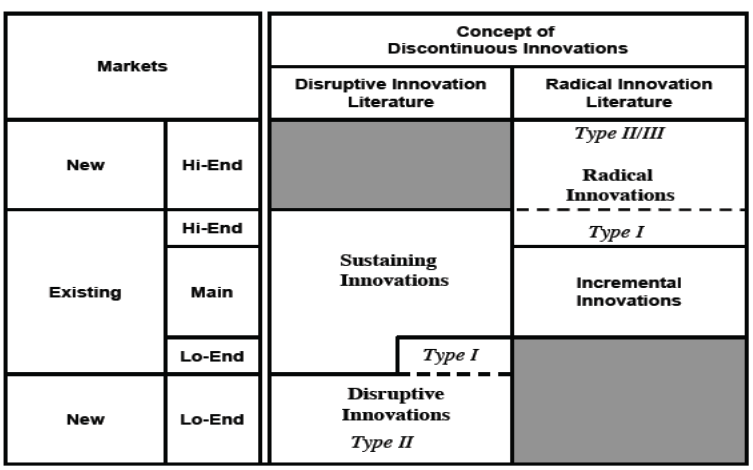

Figure 11: Concept of discontinuous innovations (Hang et al., 2006)(page, 254)

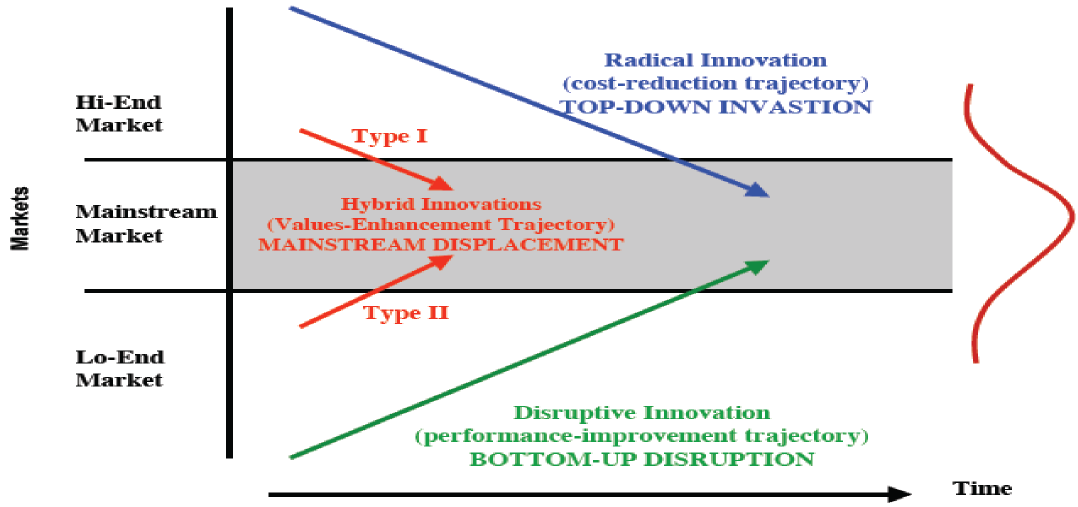

Figure 12: Radical, hybrid and disruptive innovation in the markets are together discontinuous innovations (www.eng.nus.edu.sg)

Garcia and Calantone (2001) also looked at all the different innovations and found that discontinuous innovation may be either a radical innovation or a really new innovation. Radical innovations are innovations that have discontinuities along both levels (macro/micro) and both sub-levels (marketing/technology). Really new innovations are innovations that are indented as having discontinuities along just one single level of the macro level (macro-marketing/macro-technology) but not both, and at the sublevel on any dimension micro-marketing and micro-technology (Garcia & Calantone, 2002).

3.5 Conclusion

This systematic literature review is an overview about discontinuous innovation. The first chapter gives an answer to the question: How is discontinuous innovation defined? An answer is given by structuring the different definitions of discontinuous innovation, those are: the characteristics of discontinuous innovation, the output of discontinuous innovation and the inter-linkages between discontinuous innovation and other innovations. The characteristics of discontinuous innovation are divided into: ambiguity & fuzziness, development, economics and benefit customer. The output of discontinuous innovation is divided into output characteristics, the product curve and discontinuous innovation effecting environmental factors. The output characteristics are divided into: development, changing markets and customers, quantifying and old firms. Discontinuous innovation effecting environmental factors is about the output effect discontinuous innovation has on the environment. The final output of discontinuous innovation is about the inter-linkages between discontinuous innovation and other innovations. There are three different inter-linkages those are: Umbrella term, disruptive technology leads to discontinuous innovation and inter-linkages between discontinuous innovation and other non-continuous innovations.

The three aspects of discontinuous innovation; characteristics-, output- and inter-linkages of discontinuous innovation, model together how discontinuous innovation is defined. Discontinuous innovation is a very wide concept, important is to look at the three different aspect to get a full understanding.

4. What is the current process of discontinuous innovation?

4.1 Introduction

The model the DI-lab is taken as a starting point for this chapter. Before using the model, it is important to point out that there are also other models for explaining the process of discontinuous innovation. First we will take a look at how the other models describe the total process of discontinuous innovation development. After that the model of the DI-lab is described.

Bessant (2005) points out that an area which represents good practice in innovation management is the use of some form of organized and accepted process for managing risk and progressing projects from initial selection through to strategic commitment of resources. Such portfolio management/state gate models are essential in organizations with multiple product and process innovation projects. The function of it is to provide common rules of the game for product development, making clear decisions at the right moment and to clarify responsibility. A limitation of this model is that risky new concepts as discontinuous innovation the information is limited. There are only weak signals which form the basis for a major new opportunity but are not strong enough to made it through the stage-gate model (Bessant, 2005). The New Product Development process (NPD) systems are not well adjusted for innovations that are "fuzzy" and difficult to evaluate like discontinuous innovations. Therefore it is difficult to use this kind of system. But it is also possible that companies underestimate the advantages of formal and well planned NPD approach and not adjust them to discontinuous innovations (de Brentani, 2001). Reid & de Brentani (2004) made a New Product Development process model. They point out that NPD moves different for discontinuous innovations then for incremental innovation. If you look at the fuzzy front end, the part where firms are searching for structuring problems and opportunity, identification/recognition of ideas and information collection/exploration. This fuzzy front end is different for discontinuous innovation then for other innovations. Discontinuous innovation move different into the organization, they tend to originate in the environment and are initiate by individuals operating as boundary spanners and gatekeepers for the firm. It is the process of *identifying*, *understanding*, and *acting on emerging patterns* in the environment that is the essence of the "fuzzy front end" and that, so far, largely has eluded articulation in the form of NPD process models. The model for NPD attempts to articulate the NPD process for discontinuous innovation as a series of first, individual-level and second corporate level decisions. Which occur over three key interfaces: the boundary interface, the gate-keeping interface, and the project interface. The first two interfaces leading up to the third,

<u>Company 3:</u>

The process of discontinuous innovation starts when somebody within the organization believes in an idea. Then you need to be within environment where the governance understands what you are doing and there is balance found between creativity and structure. There comes a moment that also the environment and the rest of the organization needs to be convinced of the idea. Finally there comes a time that there needs to be profit made from the discontinuous innovation (09/25/2008) the decision to invest in a given project or not essentially comprise the fuzzy front end (Reid & de Brentani, 2004). Rice et al. (1998) point out that there have been five different managerial levers that can be used to influence the process of NPD. These are setting boundaries to direct and constrain discontinuous innovation activities. Taking proactive approaches to stimulate discontinuous innovation. Establish a systematic approach to evaluation and screening. Creating incubating organizational arrangements. And finally recognizing the key role of individual initiative and capabilities, and supporting those individuals who champion and lead discontinuous innovation efforts (Rice et al., 1998).

Veryzer Jr (1998) also developed a model for the NPD of discontinuous innovation. The model is divided into different parts that together form the process of discontinuous innovation. The different phases can have an overlap with each other, and will be most of the time gone through informal. The process starts with the dynamic drifting phase, the initial ideas development. After the initial idea development the convergence phase will start influenced by *visionary* from the market and technology and influenced *contextual factors*. The idea will be formulated and then the first preliminary design is made. A formal evaluation will follow on, followed by a formative prototype. This prototype will be tested by lead users and will be adjusted. A new prototype will be made which finally will end in commercialization activities (Veryzer Jr, 1998a).

Bessant (2005) and Bessant et al. (2005) looked at good practices that can be applicable to deal with discontinuous innovation. They described different phases with different good practices. The phase he described are: search, strategic choice and portfolio management, implementation, innovation strategy, innovative organization, pro-active linkages and the last phase is learning and capability development. The different phases are combined in a model that shows how the different phases work together in developing discontinuous innovations. Triggering the process is the search process which will lead to strategic choices and portfolio management. Those phases will lead to implementation and then to the learning phase. Those are influenced by innovation strategy and innovation organization which is all influenced by pro-active linkages (Bessant et al., 2005). The model of Bessant (2005) looks similar to the model used by the DI-lab as a starting point. The model of the DI-lab is used in this chapter to structure the information that is found in the different articles. The model of the DI-lab is shown in Figure 13. The model of the DI-lab explains discontinuous innovation as a process. Discontinuous innovation is influenced by the environment, the innovation strategy and innovation culture. The process of development/dealing with discontinuous innovation is split-up in four different phases, search, select, implement and control the discontinuous innovation. In this chapter the information is selected about the different elements of the model. First the environmental factors are described, then the innovation strategy, followed by the innovation culture. Then the process is described in the different phase: search, select, implement and control.

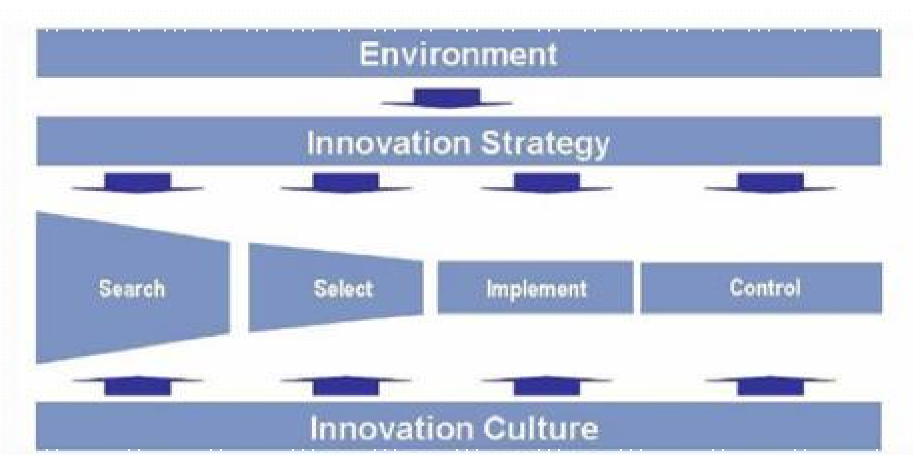

Figure 13: Discontinuous Innovation Model DI-lab (https://intranet.unternehmertum.de)

4.2 Environment

In the model of the DI-lab environment is described as*: local, national and global factors who define the environment and the dynamics of an industry. These factors are: capital, infrastructure, regulations, workforce skills & knowledge, human resources, geographical climate, etc* (https://intranet.unternehmertum.de).

Sources of discontinuity in the innovation environment can create an environment in which a discontinuous innovation can be developed. There are long periods of gradual change interrupted periodically by massive discontinuities (Lynch & Sutton, 1999). Eleven different triggers or sources of discontinuity are described by Bessant et al (2005), these eleven sources are taken as a base and other literature is subdivided in these eleven triggers if it is possible. The eleven triggers are: new market emerges, new technology emerges, new political rules emerge, running out of road, sea change in market sentiment or behaviour, deregulatory/shift in regulatory regime, fractures along 'fault lines', unthinkable events, business model innovation, shifts in 'techno-economic paradigm' and architectural innovation (Bessant et al., 2005). The triggers are explained in Table 6. Deregulation/shifts in regulatory regime is further explained after the table, to explain the "open window of locational opportunity" (OWLO) concept.

Environmental triggers	Description
New market emerges	Most markets emerge through a process of growth and segmentation. But sometimes a market evolve which cannot be predicted or analysed in advantage, or can be explored through using conventional market research or analytical techniques (Bessant, 2005; Bessant et al., 2005). Problems can arise with established companies because they do not see the new markets emerging because they are too much focused on their excising market. Another problem is when companies see it as a too small or not representing their preferred target markets, or do not see potential in the markets and ignore the signals (Bessant et al., 2005).
New technology emerges	Step change take place in product or process technology may result from convergence and maturing of several streams or as a result of a single breakthrough (Bessant, 2005; Bessant et al., 2005; Lamont et al., 1993). Difficult with this is that firms do not see it because it is beyond the periphery of technology search environment. It is also possible that companies miss the new technology because it is not an extend of current areas but it is a completely new field or approach. Tipping point may not be a single breakthrough but convergence and maturing of established technological streams, whose combined effect is underestimated. The not invented here effect can occur, new technology represents a different basis for delivering value. (Bessant et al., 2005).
New political rules emerge	Political conditions which shape the economic and social rules may shift dramatically (Bessant, 2005; Bessant et al., 2005; Lamont et al., 1993). Problems with this source of discontinuity are that incumbents can have an old mindset of how business is done. Established firms can fail to understand and learn the new rules which can give problems (Bessant et al., 2005).

Environmental triggers	Description
Running out of road	Firms in mature industries may need to escape the constrains of diminishing space for product and process innovation and the increasing compensation of industry structures by either exit or by radical reorientation of their industry (Bessant, 2005; Bessant et al., 2005). Current systems are build around a particular trajectory and embedded in a steady-state set of innovations routines which militate against widespread search or risk taking experiments (Bessant et al., 2005).
Change in market sentimental or behaviour	Public opinion or behaviour shifts slowly and then tips over into a new model (Bessant, 2005; Bessant et al., 2005). Companies can miss this tipping over because they do not pick up the signals. Another problem is that cognitive dissonance arises, firms persists in alternative explanation, until it may be too late (Bessant et al., 2005).
Deregulation/shifts in regulatory regime	Political and market pressures lead to shifts in the regulatory framework and enable the emergence of a new set of rules (Bessant, 2005; Bessant et al., 2005). Problems can arise when companies have old mindset when the new rules of the game have established. Existing players are unable to move fast enough or miss the new opportunities that have opened up (Bessant et al., 2005).
Fractures along 'fault lines'	Long standing issues of concern to a minority accumulate momentum and suddenly the system switches/tips over (Bessant, 2005; Bessant et al., 2005). Rules of the game suddenly shift and then new pattern gathers rapid momentum. Wrong-footing existing companies can still be working with old assumptions causing problems (Bessant et al., 2005).
Unthinkable events	Unimagined and therefore not prepared for events which sometimes literally changes the world and set up new rules of the game (Bessant, 2005; Bessant et al., 2005). The new rules may dis-empower existing players or render competencies unnecessary (Bessant et al., 2005).
Business model innovation	Established business models are challenged by a reframing, usually by a new entrant who redefines/reframes the problem and the consequent rules of the game (Bessant, 2005; Bessant et al., 2005; Lamont et al., 1993). New entering firms see opportunity to deliver product/service via new business model and rewrite the rules. Existing players can be at best fast followers (Bessant et al., 2005).
'Techno-economics paradigm'	Systemic changes which impact whole sectors or even whole societies. This change takes place at system level, involving technology and market shifts. This involves the convergence of a number of trends which in a 'paradigm shift' where the old order is replaces (Bessant, 2005; Bessant et al., 2005). For companies is hard to see where new paradigm begins until rules become established. Existing players tend to reinforce their commitment to old model, reinforced by 'sailing ship' effects (Bessant et al., 2005).

Environmental triggers	Description
Architectural innovation	This changes at the level of the system architecture rewrite the rules of the game for those involved at component level (Bessant, 2005; Bessant et al., 2005). Established players develop particular ways of seeing and frame their interactions according to a set of views. Architectural shifts may involve reframing but at the component level it is difficult to pick up the need for doing so. New entrants are better able to work with new architecture can emerge (Bessant et al., 2005).

Table 6: Environmental triggers Bessant (2008)

Deregulation/shifts in regulatory regime

To look at how these new deregulations or shifts in regulatory regimes emerge, you can look at *"open window of locational opportunity" (OWLO)* (Boschma & van der Knaap, 1999) concept. This model looks at how new industries develop in new places because of a change in deregulation or a shift in regulatory regime. Therefore it is a complement to the explanation given in Table 6.

Boschma & van der Knaap (1999) explains that the OWLO concept takes a critical stand towards a functionalist interpretation of space that posits as central the importance of static location factors for the rise of new techno-industrial activities. It would be misleading to interpret the spatial formation of newly emerging industries as an alleviative process in which rational firms that are about to exploit economically new inventories, strive for mineralization of production costs are as low possible. The OWLO concept is reluctant to claim that new industries develop in places where existing local structures best correspond to or are most in tune with the new requirements. The OWLO concept departs from a point of view where spatial information of a new industry is a fundamentally dynamic process of growth. The process of local development is what makes leading regions more attractive compared to others, it is not the geographical area. The development of this new area's come with the emerge of new discontinuous techno-industrial activities. These activities break with the past with regard to the techno-industrial development process, and therefore place new demands on the production environment, such as those on the labour market and on knowledge institutions. As a result the new techno-industrial activities are denied to make use of existing spatial conditions, which are strongly oriented towards established techno-industrial structures. Because of mismatches of the traditional industries and the new emerging techno-industry the new emerging techno-industry is highly dependent on their own creative ability to generate their own local production environment. The creative ability of new industries may be linked to the process whereby the generic conditions are transformed into (location-) specific conditions as their development proceeds. New clusters will emerge which will form a new techno-industrial structure. Figure 14 shows the role of the different institutions in the OWLO concept (Boschma & van der Knaap, 1999).

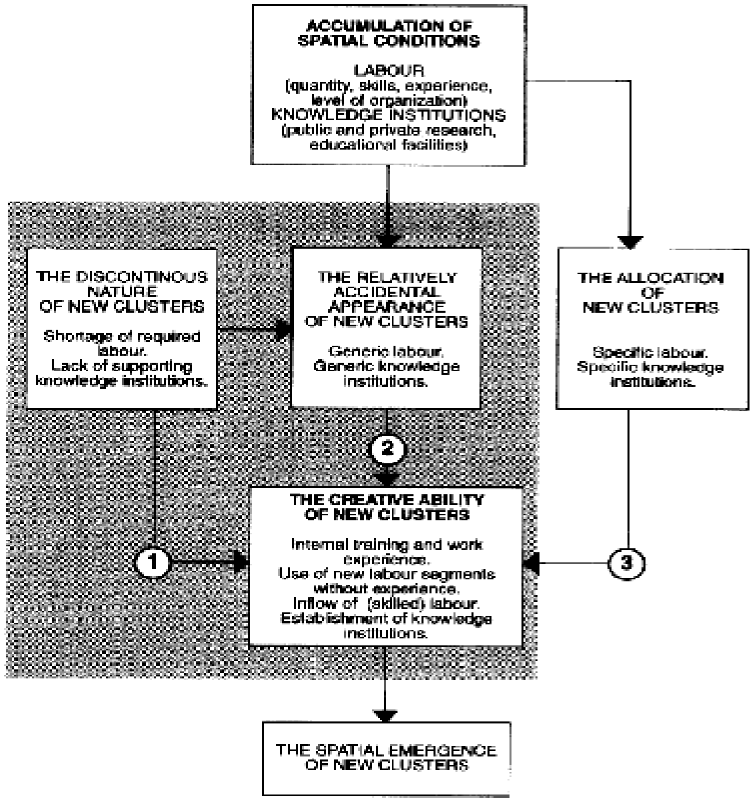

Figure 14: Role of labour and knowledge institutions in the OWLO concept (Boschma and van der Knaap 1999)(page, 78)

Dekimpe et al. (2000) stated that countries can have a major influence on the replacement of technologies. Governments can decide to replace technologies fully and invest in the technology beyond the capabilities of firms. Countries trying the discontinuous innovation later can learn from previous adopters' experiences with the technology and can reach full confirmation sooner. For example; telecommunication innovations are replaced when the government decided to implement new innovations. This implementation diffusion process exists out of two stages, the implementation stage and will be followed by the confirmation stage. The diffusion processes result in the acceptance or penetration of the new innovation over time by a given social system. Countries with homogeneous social systems reach full confirmation faster (Dekimpe, Parker & Sarvary, 2000).

The eleven different triggers described by Bessant (2005) together form the factors described by the DI-lab: capital, infrastructure, regulations, workforce skills & knowledge, human resources, geographical climate, etc (https://intranet.unternehmertum.de). There is no author describing if one of the different triggers is more important than another.

4.3 Innovation strategy

In this chapter a closer look is taken on the strategy a firm needs to develop to successfully react to discontinuous innovations. The DI-lab explains innovation strategy as an important factor that will be made-up by the top management. The strategy must have a fit with the needs, environment and culture of the company. The strategy needs to be understood by all stakeholders in the organization (https://intranet.unternehmertum.de).

First we will look how organizations develop strategies for dealing with discontinuous environment this because the strategy needs to be in line with the environment. After that we look at the role of management in developing an innovation strategy. Because innovation strategy is made up by top management this is important in the development of the innovation strategy. Together, dealing with a discontinuous environment and the role of management, they form the innovation strategy.

4.3.1 Dealing with discontinuous environment

Mckee (1992) argues that organizations developing discontinuous innovations need to deal with a discontinuous environment and need to learn new strategies. These organisations need to develop new organizational learning. The first thing the organizations need to learn is that interpersonal contact is often external. The organization is attempting to redefine the way it fits into its environment. The learning goal is to convert new environmental opportunities into new organizational norms and technologies. Discontinuous innovations change the firm and the way it fits into its environment. This requires techniques that enable employees to make novel associations and linkages. It may require a shift in organizational paradigms that underlie the way we do things around here. Employees need to unlearn how they use to do things and need to learn to embrace error in order to learn new skills. Organizations dealing with discontinuous environment need to learn to increase the diversity of information obtained from the environment, they need to increase the capacity of feedback systems and they need to increase the sensitivity of the organization to remote signals (McKee, 1992). Organizations with a proper strategy-environment fit will outperform organizations without a proper fit. Organizations that do not alter their strategy in response to a discontinuous environment will not exhibit any changes in relative performance and organizations who have not a proper strategy-environment fit but are able to alter their strategy to achieve a proper fit, will exhibit an increase in performance (Lamont et al., 1993).

Brikinshaw et al (2007) stated that dealing with a discontinuous environment is very difficult. There are three main reasons why companies struggle with discontinuous innovation.

I. The profitably of the discontinuous innovation is unclear. The new offering comes together in a fragmented and apparently ad hoc manner. Many firms give up along the way and fall back on their investments in more incremental but predictable projects (Birkinshaw et al., 2007).
II. Companies find it difficult to break out of their established and previously successful routines. Their structures and processes are organized around a historically determent set of customers and products. The reward and incentive systems are based on maintaining and improving the established system. It is very difficult to break out of this (Birkinshaw et al., 2007).
III. Networks of established companies are most of the time long-term and deep relationships. These are very powerful resources for incremental innovation. However the strength of an existing web of relationships is itself a fundamental obstacle to change. To have a successful strategy for discontinuous innovation it is important to change the strategy from continuous to discontinuous innovation (Birkinshaw et al., 2007).

Company 2:

"Discontinuous innovation is indirect integrated in our strategy, because we want to make a clear distinction as preferred technology supplier. It is indirect intergraded because it is not named directly. But if you read between de lines you see that it is clearly integrated in our strategy. We have a stimulating climate where risk taking is allowed. Innovation is our goal, we want to deliver first of a kind products"
(09/30/2008)

A solution to deal with an uncertain environment can be organizational buffering. Buffering is the regulation and/or insulation of organizational processes, functions, entities or individuals from the effect of environmental uncertainty or scarcity. Buffering can regulate or insulate; various processes, functions, or entities. These can buffer or be buffered. Buffering can occur at various organizational levels and in varying degrees; buffering can be functional or dysfunctional, intentional or unintentional; and buffers may vary in locale, amount, and form. It is important to note, however, that while buffering includes efforts to mitigate uncertainty's effects, it does not encompass actions taken to alter the environment directly (Lynn, 2005).

There are two different types of environmental uncertainty, namely continuous and discontinuous change. As continuous change increases in occurrence, organizations have an incentive to decrease buffers. But with discontinuous change increases buffers increases because they offer dual benefits: they offer resources to insulate organizational units from threat and they focus on innovation which is partially isolated from the pressures and patterns of the current environment. Figure 15 shows the model of buffering and continuous/discontinuous change. As continuous change (variation around a norm) increases in occurrence (that is, as you move forward in the figure, illustrated by Path 1), organizations have an incentive to decrease buffers. When discontinuous or unpredictable change increases (i.e. as you move to the right in the figure, illustrated by Path 2), buffers increase because they offer dual benefits: they offer resources to insulate organizational units from threat, and they allow focus on innovation which is partially isolated from the pressures and patterns of the current environment. When environments have both high continuous and discontinuous change it is difficult to predict an optimal buffering solution. Only a small difference in the balance of types of continuous and discontinuous change will require radically different degrees of buffering — low buffering would be functional for Path 3, for instance, and high buffering for Path 4 (Lynn, 2005).

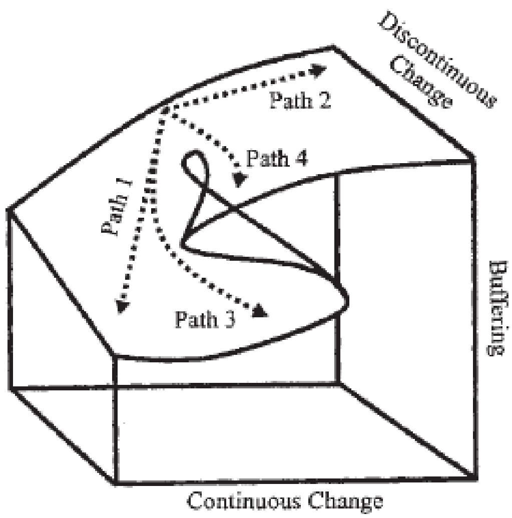

Figure 15: Buffering in continuous and discontinuous change (Lynn, 2005)(page, 51)

There are different forms of organizational buffering. They are shown in Table 7. The can be functional or can be dysfunctional.

	Functional	Dysfunctional
Insulate	*Dynamic Adaptation* Innovate in changing environments while protecting stability-sensitive areas from threat	*Digressive Insularity* Maintain internal order but become desensitized to environmental shifts; or, fail to achieve internal order because of chaotic exposure or overexposure to the environment

Regulate	*Input and Output Smoothing* Regulate fluctuations as needed to maintain internal order, yet remain in tough with environmental dynamics	*Smoothing Imbalance* Maintain regulatory resources beyond or beneath what is needed for efficient and effective functioning

Table 7: Forms of Buffering (Lynn, 2005)(page, 39)

'Dynamic adaptation' and 'input and output smoothing' are functional because they maintain an appropriate level of buffering. 'Digressive insularity' and 'Smoothing imbalance' are dysfunctional for they do not maintain adequate buffers. 'Dynamic adaptation' and 'digressive insularity' are protective, and thus generally used when dealing with discontinuous marketplace shifts. The functional and dysfunctional forms are somewhat tautological and they don't clarify exactly when buffering is excessive, ideal, or inadequate (Lynn, 2005).

4.3.2 Role of management

In this paragraph the role of the management is elaborated. With this is meant how management effects the innovation strategy. What kind of challenges and tests does management need to deal with and how can management react to those uncertainties and how can management deal with those challenges and test.

The management of discontinuous innovation poses an unique set of challenges for management. Lynn et al. (1996) point out that the process of discontinuous innovation is:

- A long (often more than a decade) and investment-intensive (often more than $ 100 million) process
- The process is marked by set back and unpleasant surprise
- There is no guarantee of success
- Its most persistent feature is high uncertainty
- There are questions of timing;
  - Time required to develop the technology
  - Time required for the market to emerge
  - Time required for competing technology to develop
- There are endogenous factors such as government regulations over which the firm has little or no control

These factors are all single challenges for the management to manage successfully, and they are most of the time very difficult to control (Lynn et al., 1996). Kaplan et al. (2003) argue that responding to discontinuous change senior management may at least partially responsible for the difficulties many firms face in responding effectively to discontinuities. Managers face many difficulties in responding to discontinuous process and they need to maintain legitimacy in the eyes of key stakeholders. This makes significant organizational change extraordinarily hard but often very important in reacting to discontinuous innovations (Kaplan, Murray & Henderson, 2003).

Kaplan et al. (2003) point out that it is possible that companies react and manage discontinuous innovations in its business even when senior management fail to recognize a number of major shifts in the firm's environment. In the case of Intel it was because senior management team did not interfere with autonomous decisions generated at the local level of the company, so they could successful react to discontinuous change. But even so, marginal sense making, recognition and interpretation of the environment may be an additional explanatory factor in understanding firm's actions during technological discontinuity. There are four factors playing an important role:

- Management sense making is important in shaping a firm 's response to discontinuity
- Successful research drives managerial recognition
- It is important the commitment of the senior management with dealing with discontinuity
- Recognition of key environmental uncertainties at the most senior level shapes certain types of enduring strategic action. Management can play a crucial role in both interpreting the external environment and shaping the internal response to this environment.

Bessant pointed out that discontinuous innovation strategy decisions are based on high level of risk taking since there is no clear trajectory. There is emphasis on fast and light weight decisions rather than heavy commitment in initial stages. Dominant themes in strategy are: *parallel bets*, *fast failure* and *learning*. There needs to be a high tolerance of failure but risk is managed by limited commitment. Influences on the trajectory are those who are prepared to 'stick there neck out'. Also entrepreneurial behaviour is very important (Bessant, 2005; Bessant et al., 2005). Ding and Peters (2000) stated that strong internal resistance to discontinuous innovation will lead to a decrease in the availability of internal knowledge sources to the innovation projects. It is important for management to pick-up signals of resistance and dealing with them before they prevent the company to deal with the discontinuous environment (Ding & Peters, 2000). Bessant et al (2005) states that discontinuous innovation requires a much more open ended and agile approach to manage and emergent field where search strategies are difficult to predict in advantage. Figure 16 gives a good simple representation of the issue.

Company 3:

"It starts with some self-willed managers, or intrapreneurs, who want to walk outside the lines, willing to change something. It is not that it work like the theory, that when senior management is not supportive of the discontinuous innovation that it will not happen. That would mean that discontinuous innovations will never be developed. I believe that senior management is busy with managing the bigger whole en that there are innovators who believe in the idea and put pressure on when they think there is a market for it."
(09/25/2008)

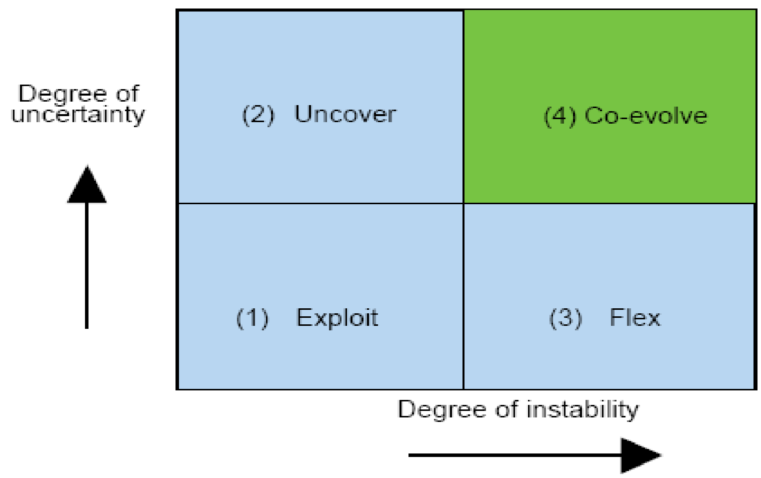

Figure 16: Steady state vs. discontinuous innovation strategies (Bessant et al. 2005)(page, 1372)

In Figure 16 the bottom axis is one of stability and as we move to the right we reach an area of unpredictable, unstable conditions. The vertical axis is about the extent to which is knowledge can be acquired to help deal with the environment. Zone one is a steady state environment with stable rules of the game and we can use tried and tested approaches to fill gaps in our knowledge and develop certainty. Zone two is still stable in terms of the rules of the game but it is less clear and we need to find new things. Zone three is instability, rules of the game change but we have a high knowledge about these shifts or how to find out and respond. Zone four poses significant problems because none of our existing repertoire of innovation management routines may help (Bessant et al., 2005). There are different management styles required for dealing with steady state innovations than dealing with discontinuous innovations. How to deal with discontinuous innovation is shown in Table 8.

Management styles	Discontinuous innovation - archetype
Interpretive schema—how the organisation sees and makes sense of the world	No clear 'rules of the game'—these emerge over time but cannot be predicted in advance Need high tolerance for ambiguity—seeing multiple parallel possible trajectories 'Innovation space' defined by open and fuzzy selection environment Strategic direction is highly path dependent Probe and learn experiments needed to build information about emerging patterns and allow dominant design to emerge Highly path independent

Management styles	Discontinuous innovation - archetype
Strategic decision making	High levels of risk taking since no clear trajectories—emphasis on fast and lightweight decisions rather than heavy commitment in initial stages Multiple parallel bets, fast failure and learning as dominant themes High tolerance of failure but risk is managed by limited commitment Influence flows to those prepared to 'stick their neck out'—entrepreneurial behaviour
Operating routines	Operating routines are open ended, based around managing emergence Project implementation is about 'fuzzy front end', light touch strategic review and parallel experimentation. Probe and learn, fast failure and learn rather than managed risk Search behaviour is about peripheral vision, picking up early warning through weak signals of emerging trends Linkages are with heterogeneous population and emphasis less on established relationships than on weak ties

Table 8: Different innovation management archetypes (Bessant et al., 2005)

One of the tests of leadership for incumbents is to be able to compete successfully by both increasing the alignment or fit among strategy, structure, culture and processes while simultaneously preparing for the inevitable revolutions required by discontinuous environmental change. This requires organizational and management skills to compete in a mature market and to develop new products and services. A focus on either one of these skill sets is conceptually easy. Unfortunately, focusing in only one guarantees short-term success but long-term failure (Lynch & Sutton, 1999). Gilbert (2006) argues that in the case of discontinuous technology change, the challenge is not only to move from one configuration to another but often to maintain multiple competencies simultaneously. In such settings, the emerge of a new external context may develop while some portion of the historical context continuous to evidence tight fit with traditional firm competencies. Effective response requires managers to maintain competencies that address multiple even inconsistent contexts at the same time. But recognizing this environmental change is very difficult. There are bias indicators and even unbiased actors may fail to observe a decline in performance during the period the firm needs to respond. When change is discontinuous and there is a residual fit with some portion of the external environment, the decline may not be visible until it is too late to respond. Under conditions of residual fit, managers are not able to motivate response by framing an external change as an eventual treat, even when there is no visible evidence of a decrease in current performance. Research in decision theory has shown that individuals are more willing to commit significant resources when faced with a potential *loss* than with a potential *gain* (Gilbert, 2006).

Treat frames can lead to increases in resource commitment. However treat-inducted response can lead to intensive individual, group and organizational rigidity. Also crisis restricts the pool of decision makers to top managers, thereby reducing the number of alternatives that are considered. It also

tents to focus on existing resources, rather than evolving out of a search for new solutions, which is important for discontinuous technological change (Gilbert, 2006).
Opportunity frames are opportunity based decision making. This has as a disadvantage that people are less willing to commit significant resources but can open search processes and relax the rigidities produced by treat. Looking for new opportunities is the key to creating new sources of entrepreneurial growth, but it does not lead to the commitment that is created by threat framing. Opportunity framing lead to flexible plans, but fail to inspire adequate organizational commitment. Threat framing arouse commitment but produces inflexible plans that confine response (Gilbert, 2006).
The challenge of management is to *combine the two frames* to shape response to discontinuous change. Discontinuous change requires managers to maintain competing competencies that meet the requirements of multiple, simultaneously inconsistent contexts. Threat and opportunity frames are part of a broader class of competencies activities that lie at the root of dynamic capabilities more generally. The two competing frames can coexist because of the creation of different subunits. By restricting operating overlap, structural differences allow competing frames to enact different behaviours simultaneously across different subunits of the organization. A second mechanism is senior-team frame integration. They are forced to understand and embrace the different competing frames. The lack of direct operating responsibility prevents senior frame integration from negatively impacting implementation processes (Gilbert, 2006).

4.4 Innovation culture

An important factor in the development of discontinuous innovation is the culture in a company. The DI-lab definition of innovation culture is the predominating attitudes and behaviour that characterize the functioning of a group or organization. There is no definitive recipe for creating a culture of innovation within an organization (https://intranet.unternehmertum.de).
Lynch and Sutton (1999) point out that a culture for discontinuous innovation is a different culture than needed to maintain the core business by incremental improvements. Organizations need to compete in their *mature markets* where cost, efficiency, and incremental innovations are the key and they need to compete in the *changing environment* where they need to develop/react to discontinuous innovations where speed and flexibility is critical. A solution for this dilemma is the ambidextrous organisation which will be explain at the implementation phase. How do individuals in an organization react to this changing environment and changing cultures? Lynch & Sutton (1999) stated that discontinuous innovations “tear at the political, structural, and cultural fabric” frequently leading to “revolutionary organizational change”. Highly discontinuous innovations inevitable lead to new knowledge and new practices that displace the old, to cannibalize is to render obsolete. Therefore, for the individual professional, cycles of discontinuous change point to another frequently heard warning, the need for life-long learning. Lifelong learning is the individual human response to the dynamics of a model of change based in punctuated equilibrium (Lynch & Sutton, 1999). Important is that the culture of the company is suited for the result a company needs to establish. Firms need to reward their employees for what they want to accomplish. If risk taking is important, reward them for taking the risk, otherwise a discontinuous culture will not emerge (de Brentani, 2001).
De Brentani (2001) points out that creating an *entrepreneurial* and *team-orientated climate* with strong support and involvement from top management is important for facilitating successful discontinuous innovations within a firm. Senior manager involvement and “visioning” cross-fertilizing teams of involved players, and support for venture champions who create excitement and commitment are essential. With discontinuous innovations *pioneering, risk-taking* and *developing new competences* are every days business, because of this it is important that the internal environment where managers encourage this. *Creativeness* and *risk-taking* needs to be rewarded and personnel needs to work in *project teams that are closely-knit, cross-functional* and *fashion* so that they can learn about and develop highly creative concepts and technologies. This kind of corporate culture calls for extensive involvement by senior managers who must create the right kind

of environment and champion innovative ideas, as it is typically their name, their vision and their unique approach to solving a type of customer problem on which the reputation of the firm is founded. To develop discontinuous innovations it is of high importance to have highly trained and skilled personnel for front line, production purpose and for performing judgemental tasks during service creation and delivery. Firms can match their clients' experts buyers with your own front-line which can have a positive effect in developing discontinuous innovations (de Brentani, 2001).

Tushman and O'Reily (1996) stated that it is important that the employees feel a sense of *autonomously* and feel *responsible* for their result. The size of a department can better be small to have this feel autonomous and responsible. Size can be used to leverage economics of scale and scope, not becoming a checker and controller that slow the company down. The reliance of the culture is on strong social control. Corporate culture in each department is broadly shared and norms that are critical for innovation such as *openness, autonomy, initiative* and *risk taking* need to be emphasized. These common values are expressed varies according to the type of innovation required. A common overall culture keeps a company together, the reliance on a strong, widely shared corporate culture to promote integration across the company and to encourage identification and sharing of information and resources (Tushman & O'Reilly III, 1996).

4.5 Search

The process of discontinuous innovation is divided into four different phase: search, select, implement and control. The first phase is select and will be explain in the section. The Di-lab definition of search is the recognition of weak signals, which gives a hint that discontinuous changes will come up. Organizations are constantly looking for new ideas to renew themselves. In the world of discontinuous innovation the DI-lab argues that firms need to extend their repertoire of practices to help them in this search activity (https://intranet.unternehmertum.de).

Bessant (2008) stated that searching for discontinuous innovation has a degree of potential advantage and is associated with the capability to pick up early and weak signals about emergence of discontinuities. To do this firm need to extend and enhance their peripheral vision and extend their research activities into new and unexpected areas. This is often difficult because it is complicated to decide where to put the focus on. The context needs to change for the searching behaviour. Companies need to look at the limitations of their current models and need to extend and develop new routines. Some examples of these changes in routines are:

- Acceleration of knowledge production; companies need to created new knowledge and extending the frontier along with 'breakthrough' technological developments may happen.
- The global distribution of knowledge production is increasing involving new players especially in emerging market fields. There is a need for search routines to cover a much wider search space increases.
- Market fragmentation and globalisation has massively increased the range of markets and segments so that these are now widely dispersed and locally varied. This puts pressure on search routines to cover much territory, often far from 'traditional' experiences.
- Market virtualization is the increasing use of internet as marketing channel. Meaning that different approaches need to be developed. At the same time emergence of large-scale social networks in cyberspace pose challenges in market research approaches.
- The rise of active users has long been identified as a good search for innovation. Now however it has taken an acceleration in the ways in its is used.
- The development of soft technological and social infrastructure increased linkages enabled by information and communications technologies around the internet. Broadband have enabled and reinforced alternative social networking possibilities. At the same time the increasing availability of simulation and prototyping tools have reduced the separation between users and producers (Bessant, 2008)

Search behaviour is about peripheral vision, picking up early warning through weak signals of emerging trends (Bessant et al., 2005). Bessant (2008) describes twelve different strategies: sending out scouts; multiple futures; using the web; working with active users; deep diving; mobilising the mainstream; corporate venturing; corporate entrepreneurship; brokers and bridges; deliberate diversity; and idea generators. The twelve search techniques are taken as a basis in this paragraph. Additional information from other authors is used supplementary to the theory of Bessant (2008).

The first strategy is sending out scouts, these are scouts who can be fulltime or part-time actively searching for new ideas to trigger the innovation process. This can be for example technological triggers, emerging markets or trends and competitor behaviour. What they all have in common is that it is a remit to seek things out, often in unexpected places (Bessant, 2008). Rice et al. (1998) point out that a good tool to scan for ideas is to use individuals or small groups.

The second strategy is exploring multiple futures. Use futures techniques to explore alternative possible futures. With this they want to develop innovation options they can use (Bessant, 2008). Rice et al. (1998) describes a "holy grail", a common understanding among researchers and research managers that a technical "holy grail" existed within their industries, based on clear articulation of this opportunity by senior management. "Holy grail" is a potential technical breakthrough that everyone knows will transform their industry, should it be achieved. Looking for this holy grail stimulates employees to try different techniques (Rice et al., 1998). This can stimulate to explore multiple futures.

The third strategy is using the web. In its simplest form this search strategy is a passive information resource to be searched, an additional space into which the firm sends its scouts. Increasingly there are organizations who offer focused search capabilities to help with this hunting. Internet can also be used as a multidirectional information marketplace. It can be used as online laboratories for conducting experiments or prototype testing.

The forth strategy is working with active users. There is a huge scope for engaging users in active co-creation of products. Companies point out that users at the fringes of the mainstream tend to be more tolerant of failure and prepared to accept that through mistakes they can get to sometimes better. This makes them the ideal target group for the 'perpetual beta testing' approach increasingly used in software development and other online products (Bessant, 2008). Users can become a part of the innovation process by feeding ideas and improvements to help to define and shape innovation. The concept of the idea emerged in the early 1990s and is essentially a series of product development activities carried out with a small group of key professional. The use of this is to *identify*, *discuss* and *prioritize user needs* and to *evaluate product development projects* from idea generation through to international marketing (Bessant, 2005).
A limitation of active users is that it can develop in 'vicious circles' which do not support the entry or active evaluation of alternative concepts but is primarily about reinforcing the existing products (Bessant, 2005). Lead users can play an important role in the ultimate success of these types of new products. By taking part in quasi beta-testing lead users often provide developers with the opportunity to enhance core technologies and to augment their understanding of customer requirements through the creation of highly innovative solutions (de Brentani, 2001).

Company 1

"An organization is not going to work from some strategy, you are looking what fits you organization. The current strategy of the organization but also the future, desirable, organization. We use some strategies, one of them is mobilize mainstream. We have very good experience with this strategy. We organize a great part of the organization under one specific area. Here is a mainstream focus to make a strategy to a success" (10/27/2008)

The fifth search strategy is deep diving. This is about conducting a research about the actual behaviour of people. Not looking at people say that they do but look at what they really do (Bessant, 2008).

The sixth strategy is probe and learn. This strategy is aimed at addressing the problem that is often difficult to imagine a radically different future, and even harder to predict how things will actually develop. Prototypes and concepts will be put into the market and consumer's reactions are carefully watched and monitored. Through this process continuing learning can be develop by looking at emerging trends, potential designs can explored and redefined. It allows companies to devise experiments to explore alternative hypotheses (Bessant, 2008). Lynn, Morone et. Al (1996) sees dealing with discontinuous innovation as a process of probing and learning. Rather than analyzing the market and selecting the best alternatives, they develop their products through:

- Successive approximations;
- Introducing an early version of the product to an initial market based on learning;
- Trying again, this time with somewhat better information and understanding and somewhat lower uncertainty.

Probe and learning is a process of experimental design and exploration that must take place within a context of strategic relevance to the innovating firm (Lynn et al., 1996).This process contains out of experimenting with potential markets with early versions of the product, learning from the probes and probing again with an improved version. This process should be seen as experimental design and exploration, rather than blind trial and error. The authors also conclude that unless the opportunity for a discontinuous innovation is a strategic imperative to the business, management will fail to persist in the probing and learning process. (Costa et al., 2004)

The seventh search strategy is mobilising the mainstream. It is about bringing the mainstream actors into the service or product development process (Bessant, 2008).

The eight strategy is corporate venturing. It is creating and deploying venture units (Bessant, 2008). Rice et al. (1998) point out that venture boards, designed to review proposals for funding breakthrough innovation projects are a good tool for looking for new discontinuous innovations (Rice et al., 1998).

The ninth search strategy is corporate entrepreneurship and intrapreneurship. This strategy is about stimulating and nurturing entrepreneurial talent in the company and use it to develop new idea's (Bessant, 2008).

The tenth strategy is use brokers and bridges. Cast the idea net far and wide and connect it with other industries (Bessant, 2008). The knowledge that needs to be acquired and created are different for discontinuous innovation than for continuous innovation. Therefore a different kind of network needs to be designed. A gap emerges when a company is mapping and discovering knowledge, product innovation teams tend to explore external sources. Networks increase the probability for new innovations in product and processes by bringing together advances from several fields and sources (Ding & Peters, 2000). Developing discontinuous innovation is often problematic because it may involve building and working with significant different set of partners than the firm is accustomed to working with (Bessant, 2005). Many studies are done about building and maintaining existing networks, and not on the challenges of *creating a new set of relationships* that might complement or even supplant the existing one. In Table 9 you find different examples of networks for discontinuous innovation (Birkinshaw et al., 2007).

Networks	Explanation
Idea Networks	A set of relationships with individuals and organizations who the firm can tap into to help solve technical problems or to brainstorm new ideas. For example, P&G's Connect and Develop and Eli Lilly's Innocentive.
Corporate Venturing Networks	Involves building relationships with hundreds of prospective new ventures and other VCs with a view to developing a window on new technologies and making selective investments in promising new ventures. For example, Intel Capital Nokia Ventures.
Lead User Groups	A set of relationships with leading-edge customers who help the firm to experiment with and try out new product ideas. For example, Lego's Mindstorm User Group or the BBC's Backstage.com project.
Cross-Industry Alliances	Creation of relationships with various different actors in a particular industry to achieve something that they cannot achieve on their own. For example, Rio Tinto's work with sustainable development agencies on its Breaking New Ground initiative.
Communities of Practice	Cross-boundary and cross-organizational groupings engaged in experience and idea sharing around shared knowledge fields, particularly at the intersection point where two "knowledge worlds" collide. For example, technical groups/knowledge communities at 3M, Xerox, and HP.
Supplier Networks	Networks of partners with whom firms share their strategic roadmaps and invite ideas and inputs to shaping and delivering on new and alternative visions. For example, Rolls Royce and its strategic supplier program.
Open Invitation Networks	Networks of self-selecting volunteer partners who organize around a specific project or issue. A recent example was the innovative approach to film financing by Thai-American film producer Tao Ruspoli who invited investors to contribute a dollar (or more) and become associate producers of his next film.

Table 9:Examples of networks for discontinuous innovation (Birkinshaw, Bessant & Delbridge, 2007)(page, 70)

Building networks can be broken down into two different parts:

- Indentifying the relevant new partners
- Learning how to work with them

Once the necessary relationship is build, they can be converted into high-performing partnerships. There is a three stage process: *finding, forming* and *performing*.

Finding is about indentifying the right partners with which can be interacted. It is about the search that needs to be done to find them. Finding is enabled by the scope and diversity of your operations and by your capacity to move beyond the traditional way of thinking in the industry. The finding process is hindered by a combination of geographical, technological and industrial limitations.

Forming is about the prospective partners towards your firm. Are they interested to collaborate, building a relationship or do they have different perspective on things. Forming is enabled with your past experiences with relationship building, the strength of your position within your industry and an open attitude about knowledge sharing. It is hinder by barriers that can be of ideological,

demographic and ethic in nature as well as by more generic concerns about the protection of intellectual property.
The last phase is about performing. Important is that the network is kept up-to date and engaged. That trust and reciprocity is building across the network. The firm needs to know his own position in the network and needs to learn when to let a partner go (Birkinshaw et al., 2007).

There are different strategies for building a network shown in Figure 17. Important is to look at how easy partners can be found and how easy it is to form a relationship with them. Are they reluctant or keen to engage with you. These factors will lead to:

- Creating new networks in proximate areas;
- Seeking out new networks in distant areas;
- Building relationships with unusual partners;
- Moving into uncharted territory.

Important is that the company tries to build a relationship with the partners in the sector they have selected. They need to overcome the different obstacles and choose the partners that will be most successful for the firms strategy (Birkinshaw et al., 2007).

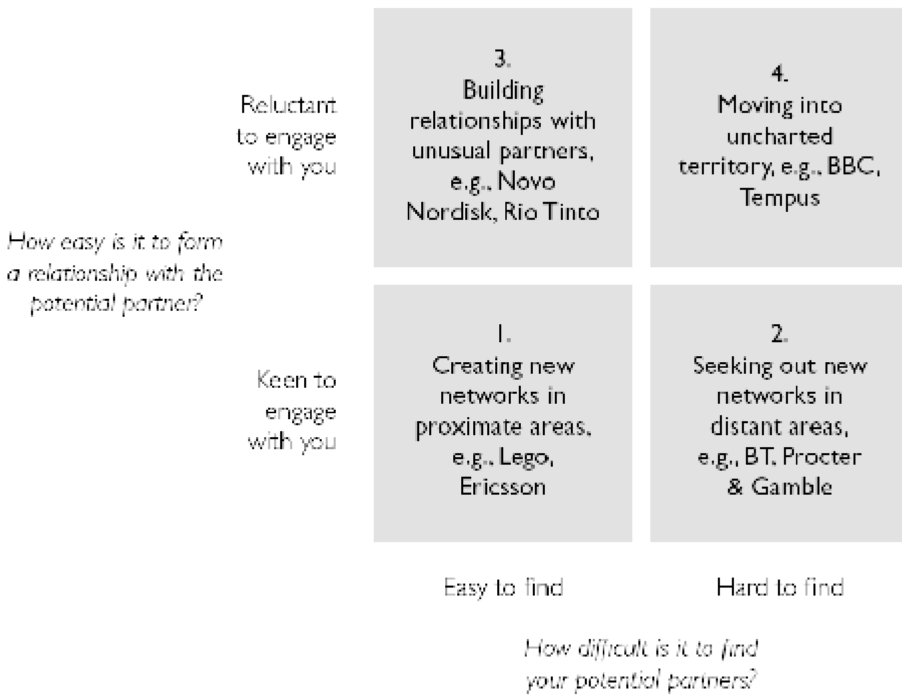

Figure 17: Four generic approaches to network building (Birkinshaw et al. 2007) (page, 72)

Noke et al. (2008) point out that established and maintaining long-term R&D relationships with outside organizations has proven to be a highly successful model of innovation development. But this tactic is less effective in developing discontinuous innovation (Noke et al., 2008). To maintain and improve its main business activities firms need to maintain close relationships with its key suppliers (Phillips et al., 2006). Developing discontinuous innovation it is better to develop *strategic dalliances*. Develop a broad range of non-committal supply relationships that it can 'dip in and out of', or dally with, in concurrence with its longer-term strategic partners. This is because longer-term strategic partners cannot provide enough new knowledge for the development of discontinuous innovations. Firms innovation networks are often act as loosely coupled system of autonomous firms. W*eek ties*, the distant but non-redundant relationship that a firm holds with a variety of stakeholders, are valuable because of their ability to provide access to novel information by bridging disconnected groups and individuals (Noke et al., 2008). Bessant et al. (2005) point out that linkages with heterogeneous population, emphasis less on established relationships than on weak ties (Bessant et al., 2005) Strategic dalliances allow exposure to novel information that could aid in the creation of discontinuous innovation (Noke et al., 2008).

Phillips et al. (2006) points out that managing the two different kinds of networks to maintain key business but also developing discontinuous innovation can give some tensions and is a challenge for the firm. There are two different kind of links with suppliers in strategic dalliances, *horizontal* links who can complement resources and *vertical* where they become a key source of ideas and offer and extension to the core firm's selection environment. The challenge for purchasing and supply strategists in addressing discontinuous innovation threats to undo years of strategic development, based upon established understanding and practice. It is important to embrace both traditional and radical approaches simultaneously, to be loyal and experimental. But discontinuous innovation can be so uncertain that it is impossible to accommodate within existing ways to engaging with supply networks. Innovative approaches in supply management are needed to effectively deal with discontinuous innovation in products, technologies, processes and ways of working. With strategic dalliance firms can look for new competitive advantage for their organization for dealing or developing discontinuous innovations (Phillips et al., 2006).

Differences in success of these strategic dalliances can occur in different kind of industry a firm is active in. Some industries evolve slower than the other one, they operate in different clock-speed. There are firms operating in high, medium and slow clock-speed, this is determent at looking at the long term industry trends and norms. In a case study of Noke, Perrons and Hughes (2008), they found that in a slow clock-speed industry, the oil and gas sector, strategic dalliances was a good method in developing discontinuous innovation. But further research need to be done to see how the results of this case can be generalize through this industry and other slow clock-speed industries (Noke et al., 2008).

Company 2:

"Within our organization there is deliberate search for different people. There is looked which employee is on which position, App.Tech wants to have different mix of employees. We want to have specialists of some technology but also generalists who can generalize the technology. This is done consciously within a time span of several years" (09/30/2008).

The eleventh strategy is deliberate diversity. Create diverse teams and a diverse workforce in the firm (Bessant, 2008).

The twelfth and final search strategy for discontinuous innovation is idea generators. This is the use of creativity tools and techniques to develop discontinuous innovation (Bessant, 2008). Rice et al. (1998) describe a tool that is corporate request for proposals. A company-wide request for proposals to pursue breakthrough innovations (Rice et al., 1998).

Another strategy is that is not identified by Bessant (2008) to search for discontinuous innovation is to look for indicators, as warning signals that the environment is getting discontinuous. Ehrnberg and Jacobsson (1997) points out those indicators in a market can help to analyze and function as warning signals for discontinuous technical change which opens up a mass market for a new substitute. There are different classical indicators: patents, bibliometric data, number of entries into an industry/technology, technometrics and relative price changes of substitutes. Patents, bibliometric data and the number of entries into an industry or technology are indicators for the activity levels in a particular technology area. An increased level of activity may be expected to mirror increased expectations of the economic potential of a technology/product. Relative price changes and diffusion data on the new substitute are of course indicators of change but these indicators necessarily appear after the significant innovations which open up mass markets. But after research in a two different cases the conclusion is that different patterns arise looking at the different indicators. Only a few indicators preceded the events which led to the exploitation of a mass market. *New entrants* come out as the most interesting indicator whilst relative price changes and *bibliometrics* were useful in only one of the two investigated cases. The patterns of these indicators vary between the cases. Sometimes an increase and even a peak in patenting do precede a discontinuity and can be a warning signal. But it does not always hold. In further research it would be useful to look at why different paters arise (Ehrnberg & Jacobsson, 1997).

The different strategies to search for discontinuous innovations some are more thorough elaborated then others. The search strategies together form the basis of looking for new developments/searching for discontinuous innovations. The old way of doing things is not applicable anymore in this new discontinuous environment.

4.6 Select

The definition of the DI-lab of selection is the phase where firms need to evaluate and select the innovations. It is about making strategic choices. Does the idea fit with the business strategy, does it build on something we know or can we get access to the knowledge. The problem with discontinuous innovation is that it has most of the time total different possibilities and is highly uncertain. It is difficult to make decisions when the normal rules would throw the idea out in the first place. Organizations need to pick up weak signals about what they could do and make decisions about what they are going to do. Organizations need to manage the challenges of their old mindset to avoid blindsided by new development, or to avoid the 'not invented here' kind of decisions (https://intranet.unternehmertum.de).

Selecting innovations on a bases of forecasting new products has a long history in the literature but forecasting discontinuous innovations is still not much explored (Mackay & Metcalfe, 2002). Discontinuous innovations are *longer in duration*, and often deal with *uncertain and evolving technologies* which are being created for markets which may *not* yet *perceive* a *need* for the product. Because of a high degree of uncertainty, market analysis become fuzzier and traditional financial measures fall short in their ability to capture the potential of these new products in a meaningful way. Traditional process control methods may not be easily applicable in these situations (McDermott & Handfield, 1996).

Linton (2002) points out that for selecting discontinuous innovations it is important to look at the *forecasting of a product*, *the expected growth of the in yearly sales of the product*. There are models build on the bases of product forecasting and discontinuous innovation. These models are formulated in economic formulas which are build to take into account the separated markets that are served. By considering the markets separately and then summing them, the forecasts are more accurate parameter estimates and it is possible to take into account learning curve effects when it is applicable (Linton, 2002). Mackay and Metcalfe (2002) stated that combining different methods for forecasting discontinuous innovations can be the key to predicting accurate. Combining *quantities* and *qualitative* methods using a multiple perspective concept as the philosophical basis. The increasingly common "wicked" problem of forecasting demand for discontinuous innovation at the concept testing stage of development was used to ground the discussion. Managers acknowledge that a non-objective, multiple approach that acts to seek and learn from the diverse views of stakeholders is required to forecast discontinuous innovation (Mackay & Metcalfe, 2002).

When selecting a discontinuous innovation it is important to look at the *market potential*. De Brentani (2001) argues that the investment in time, resources and technology are often enormous. Therefore it can be important to make long-term volume and growth potential an important selection tool. But important can also be that the product fits the problem or needs of one customer and it is superior solution. In most service discontinuous innovations high volume is not the norm, most of the time a number of lead clients can provide the required demand (de Brentani, 2001).

Francis and Bessant (2005) stated that there are four elements that need to be evaluated when developing discontinuous innovations and can help in selecting discontinuous innovations for development. These are *product, process, position* and *paradigm*. How do you change the need of changing the *product/service* in what is offered. A radical shift to new product concept for the firm and industry. The *process* innovation-change need to change in the way which products are created and delivered. These are radical shifts to new process routes for the firm and perhaps for the firm as well. The third element is the *positioning* of the innovation that is changed in the context that is applied. This requires creating completely new markets rather than extending and deepening existing segments or incremental brand identity changes. The last element is the *paradigm* innovation that changes in the underlying mental models that are surrounding it. These are new business or industry models (Francis & Bessant, 2005).
In selecting a discontinuous innovation it is clear that traditional methods fall short. Forecasting discontinuous innovation formulas have been made. Other authors suggest that combining quantities and qualitative methods is the best way to forecast discontinuous innovations. Important is to look at the market potential and evaluate four different elements: product, process, position and paradigm.

4.7 Implement

The definition of the DI-lab of implementation is overcoming innovation barriers like the lack of competent people, non-existing project management structures or internal resistance. Having chosen an option, organizations need to grow it from an idea through various stages of development to final launch - as a new product or service in the external market place or a new process or method within the organization (https://intranet.unternehmertum.de).
The model of the DI-Lab the implement and the control phase are very close related. To make a clear distinction, the implement phase is used to look at how the overcome internal barriers. After selecting an innovation they need to be developed internally. This is the implement phase. First, elements are described to implement discontinuous innovations in the organization. Secondly the organizational structure is explained.

4.7.1 Organizational learning and management interventions

Reid and De Brentani (2004) point out that information from the outside is entered and developed by the employees of the organization. Pattern recognition is a form of distinction making, which effectively allows individuals to separate potentially relevant from irrelevant background information through processes of:

- Perception: quick identification, clear understanding and interpretation ability.
- Reconstruction: representation ability, creative imagination, inference, synthesis
- Classification: evaluation

It is the individual's ability to make a distinction regarding an unaddressed market needs or new technology path, that is the starting point for building new organizational knowledge (Reid & de Brentani, 2004). To overcome barriers within the company building new knowledge is important. McKee (1992) argues that organizations need to develop organizational learning. Organization learning requires that information is shared and stored in a form convenient to all relevant organizational members. Organizational learning involves the ability of the organization to position itself vis-a-vis the environment. It is distinct from individual learning and responds to contextual factors such as organizational culture, strategy, structure and environment. This relation between product development effort is a result of organization learning and product performance. For discontinuous innovations organizations need to learn double-loop learning. Double-loop learning involves changing what the organization is doing in terms of its underlying norms and technologies. Double-loop learning entails that the organization sees the environment in a new way, and leads to invention, production and evaluation of response compatible with these new viewpoints. Such changes requires that the organization unlearn what they believed, and they need to develop variety of new organizational learning skills (McKee, 1992). Table 10 shows single and double-loop learning.

Learning Skills	Incremental/Single-loop learning	Discontinuous/double-loop learning
Interpersonal	*Inter-functional Contact* Inter-functional teams Job rotation Communication rewards	*Environmental Contact* Out-rotation Outsider involvement Boundary-spanning rewards
Analytic	*Analytic Depth* Analytic training Conclusive methods "Competency trap" avoidance	*Analytic Breadth* Skill acquisition Exploratory methods Confrontational methods
Organizational	*System Maintenance* System stability "Camouflage" avoidance	*Organizational Adaptability* "Unlearning" error tolerance Slack resources
Ecological Interfacing	*Contact Depth* Computerization Informal networking Communications efficiency	*Contact Breadth* Feedback diversity Feedback capacity Early warning

Table 10: Innovation Learning Skills Framework (McKee, 1992) (page, 237)

Rice et al. (2002) found that it is very difficult to transfer from the initial idea, the discontinuous innovation team, to the operating units. The implementation of the idea of the discontinuous innovation to the operation teams who will develop it to the final product that can be used. Firms expected that the multiplicity of uncertainties besetting a discontinuous innovation project would be sufficiently reduced by the time of handoff of the project to the operating unit that the transition could be accomplished with minimal difficulty. But this is not the case, in reality it is much more difficult. There are different transition uncertainties, there are technical, market, resources and organizational uncertainties.

- Technical:
  - Are technical specifications set and manufacturing issues resolved?
- Market:
  - Do expectations about market development match reality?
  - How will applications and market unfold?
  - How do manufacturing challenges impact market entry objectives?
  - How should the business model be finalized?
  - How should the expectations of the receiving operating unit related to the transition be addressed?
- Organizational:
  - Do expectations about market development match reality?
  - How should the business model be finalized?
  - What is the right operating home for discontinuous innovations?
  - How should the expectations of the receiving operating unit related to the transition be addressed?
  - How can the organization structure/process gap between the project team and the receiving operating unit be bridged?
  - Who should be assigned to participate in transitioning the project to operations?
- Resource:
  - How can funding be sustained during the transition?

These uncertainties can be overcome partially by managerial interventions Rice et al. (2002) describe seven different proposals to help to overcome these uncertified.

The first managerial intervention is transition teams. Problems that can arise with transfer from the discontinuous innovation unit (sending unit) to the operating unit (receiving unit) can be solved with a transition team. A disadvantage of this is that there needs to be a double transition, from the project team to the transition team and from the transition team to the operating team. But the advantage is that the team can include employees from the discontinuous innovation team, employees from the receiving unit and employees of the transition unit. Together it is easier to transit from discontinuous innovation project to receiving operating unit (Rice et al., 2002).

The second managerial intervention is transition oversight board. The transition team needs to be evaluated, that is very difficult to do for the sending and receiving unit. With the creation of a separate oversight board for each transition effort, this can concentrate the power of senior management supporters. It also provides a natural mechanism for reviewing progress of the transition team and ensuring cooperation of the various stakeholders (Rice et al., 2002).

The third managerial intervention is an assessment of transition readiness. This is the information sharing and negotiation between the project team and the receiving operating unit. The two sides can determine how much progress the project team will make and how much progress the receiving team will require. With this mutual understanding, the transition tasks can be identified and the resources and competencies required for completing the transition can be defined (Rice et al., 2002).

The fourth managerial intervention is detailed transition plan. This plan should define the tasks, a timetable, roles, and responsibilities of the team members. The transition plan should guide the efforts of the team and provide a yardstick for measuring progress. Since the transition will inevitably involve confronting residual uncertainties, some of which will only emerge during the transition, the plan needs to provide slack time, resources and the opportunity to redirect based on learning. Of course, it should also provide for a mechanism to kill the project if progress is limited or unacceptably slow (Rice et al., 2002).

The fifth managerial intervention is commitment from corporate resources. Unwillingness on the part of the receiving business unit to commit sufficient resources needed to realize the innovation's full potential is a major threat to successful transition. Senior management must ensure that corporate funding provided via funding separate from allocations to business units, whether through the R&D unit or from general corporate funds, is available to complete the transition. This avoids the unwillingness of the receiving units to commit sufficient resources (Rice et al., 2002).

The sixth managerial intervention is groundwork for a big market. The ultimate goal of any project of discontinuous innovation is a successful business. From a market development perspective, that goal can be reached along several alternative paths, ranging from pursuit of a killer application to building revenues through many niche applications. It is difficult, but critically important, to set realistic expectations about the likely evolution of the market. Requiring new businesses based on discontinuous innovations to meet high obstacle rates too soon may kill them before they have time to develop and mature (Rice et al., 2002).

The seventh and final managerial intervention is senior management champions of the transition effort are identified, recruited, and charged with the responsibility of completing the transition successfully. The leadership of the firm (senior corporate management, the chief technology officer, the R&D Director, and the receiving business unit managers) need to give the transition process a high priority if it wants to be successful. Typically discontinuous innovation projects do not reach the transition phase without a "push" from senior technical managers. The probability of transition success is enhanced if there is also "pull" from the receiving business unit (Rice et al., 2002).

The seven proposals are all intended to help to implement the chosen discontinuous innovation in the organization and to overcome uncertainties. Bessant et al. (2005) point out that project implementation is about 'fuzzy front end', light touch strategic review and parallel experimentation. Probe and learn, fast failure and learn rather than managed risk. Build flexible project development organizations, emphasise probe and learn rather than predictive project planning. Work actively with users on co-evolution of innovation and build parallel resource networks. This can work for searching for discontinuous innovations but can also be helpful for implementing (Bessant et al., 2005)

4.7.2 Organizational structure

Organizational structure is very important in successful implement discontinuous innovations in the organization. There are different factors of the organizational structure that influence the success of discontinuous innovations. DeTiene and Koberg (2002) looked at how organizations are build, size and age of the firm, age of CEO and intra-firm linkages. O'Reilly and Tushman (2004) found a solution to keep developing the core business but also develop discontinuous innovation. They suggested the 'ambidextrous organizations'. Watts (2001) looked at how to developing and commercializing discontinuous innovations and suggested the 'entrepreneurial spin-off'. First we will take a closer look at the organizational components of developing discontinuous innovations. After that a closer look is taken at the ambidextrous organization. At last we will elaborate on the 'entrepreneurial spin-off' solution.

DeTienne and Koberg (2002) found three elements that are of influence to the development of discontinuous innovations. These are age, size and intra-firm link aging.

- The age of the firm has a *negative* influence on developing discontinuous innovation. The older the firm the less discontinuous innovations that are developed within the company. They also found a difference between the *age of the CEO* and the effect of witch the age of the firm had is negative influence on discontinuous innovation. The younger the CEO, the slower the rate.
- The size of the firm has a *negative* effect on discontinuous innovation but for this the same effect of the CEO is applicable. The younger the CEO, the slower the effect is. Intra-firm linkages have a positive effect on discontinuous innovation.
- Intra-firm link aging has a *positive* effect. The more inter-firm link aging the more stimulation there is for discontinuous innovation. Here a young CEO has also a positive effect by increasing the effect. Structure and processes within the firm contributes to discontinuous innovation, specifically intra firm linkages, experimentation and transitioning or sequencing from one product, project and program to another. Top managers can structure their firms and implement process such as experimentation and transitioning in such a way as to contribute to the firm's ability to innovate. Management cannot ensure innovation but can influence its odds. Intra firm linkages provide a free-flowing exchange and cross pollination of information. In many instance, innovation depends on team rather than individual effort, and the cross flow of information among a wide variety of people working concurrently on different aspects of a project helps develop an environment conductive to innovation (DeTienne & Koberg, 2002).

All these factors are important to make a firm more suitable to develop discontinuous innovations but there is still a tension between the development of discontinuous innovations and maintaining the core business. O'Reilly III and Tushman (2004) stated that in order to develop discontinuous innovations, organizations need to use the resources of the main business and most of the time organizations still want to improve their core business by continuous innovations. This is in order to keep the competitive advantage at their main market.

A solution for this dilemma is the 'ambidextrous organization', developing continuous and discontinuous innovations. This is an organization that is structured in two different project teams that are independent units, each having its own processes, structures, and cultures, but are integrated into the existing management hierarchy. Ambidextrous organizations contain two profoundly different types of businesses those focused on exploiting existing capabilities for profit and those focused on exploring new opportunities for growth. The two require very different strategies, structures, processes, and cultures. The culture in the existing business is one of efficiency, low risk, quality and customers. The exploiting business is one of risk taking, speed, flexibility, experimentation and entrepreneurship. Figure 18 shows the ambidextrous organization and Table 11 shows differences between the different units. There are more ways to organize for innovation but ambidextrous organizations have proven to be the most successful, not only introducing new products but also in maintaining or improving the main business (O'Reilly III &

Tushman, 2004). The not so obvious difficulty in the development of an ambidextrous organization is the willingness to build an organizational culture in which some part of the organization is focused on incremental and architectural change in services or products while another plots the demise of those same services and products through significant innovation. The goal is to supplant existing services and products through innovation before the competition gets around to doing so (Lynch & Sutton, 1999)

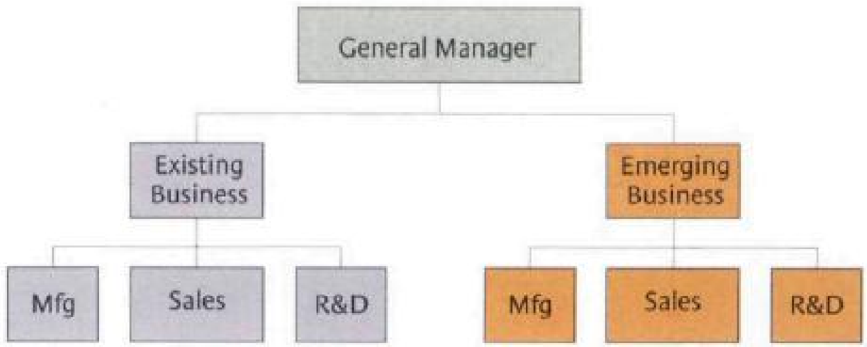

Figure 18: Ambidextrous organizations (O'Reilly III & Tushman, 2004) (page, 79)

Alignment of:	Exploitative Business	Exploratory Business
Strategic intent	Cost, profit	Innovation, growth
Critical tasks	Operations, efficiency, incremental innovations	Adaptability, new products, breakthrough innovation
Competencies	Operational	Entrepreneurial
Structure	Formal, mechanistic	Adaptive, loose
Controls, rewards	Margins, productivity	Milestones, growth
Culture	Efficiency, low risk, quality, customers	Risk taking, speed, flexibility, experimentation
Leadership role	Authoritative, top down	Visionary, involved

Table 11: Ambidextrous Leadership (O'Reilly III & Tushman, 2004)(page, 80)

Watts (2001) found another option, the 'entrepreneurial company spin-off'. Entrepreneurial cultures are more suited to develop and commercialize discontinuous innovations because of their small sizes, compensation through success and sharing of knowledge. Start-up's have higher return on investment than incumbents have. Because of this it can be very successful for incumbents to create autonomous business venture, using start-up style processes and controls to manage the business venture. They function as a 'spin-off- from the company. Table 12 shows the main differences between the start-ups and corporate organizations. If the business turns out to be successful it will be integrated back into the organization. With this construction the advantages can be used of start-up companies and can it be successful for the incumbent organizations (Watts, 2001).

Characteristics	Corporate	VC/Start-up
Compensation	Primarily salary Emphasis on fairness	Primarily stock ownership No concern for fairness
Project controls	Stage Gate processes Internal review boards Annual budgets	Funding rounds Boards of directors Capital markets
Financial objectives	Quarterly P&L results Predictable financial results Stable stock price increases	Liquidation value of the company within 10 years >10x return on investment
Staffing/Human resources	Internal staff re-use Career paths, training Company loyalty	Hire the appropriate experience/talent Fire if unproductive

Table 12: Basic management approaches: corporate organizations and VC/startup organizations (Watts, 2001)(page, 27)

O'Reilly III and Tushman (2004) did a research about different organizational structures and their success in developing discontinuous innovations. They found nine organizations that were set up as cross-functional teams; groups operating within the established organization but outside the existing management hierarchy. Four took the form of unsupported teams; independent units set up outside the established organization and management hierarchy. Four took the form of unsupported teams; independent units set up outside the established organization and management hierarchy. And 15 were pursued within ambidextrous organizations. While none of the cross-functional or unsupported teams and only a quarter of the functional designs produced real innovations, more than 90% of the ambidextrous organizations achieved their goals. (An exception was breakthrough innovations intended to directly substitute for existing products; in these instances, functional designs performed as well as ambidextrous designs). They found out in developing discontinuous innovations and keeping the main business ambidextrous organizations are most successful (O'Reilly III & Tushman, 2004).

Company 3:

"To develop discontinuous innovations you need to imitate in some way the dynamics of the market environment within the organization. A new idea needs to prove its market potential. This works like a entrepreneurial start-up, you start small and if the idea is successful it will grow in of the organization making it a part of the core business" (09/25/2008)

4.8 Control

The definition of the DI-lab of control is how the discontinuous innovation will perform; is it a market success. The most common method of measuring innovation is by using indicators like different input-, and output-indicators. Money spent on R&D does not always equal successful innovation (https://intranet.unternehmertum.de). In the model of the DI-Lab the implement and the control phase are very close related. To make a clear distinction the control phase is used to look at how the discontinuous innovation will perform external and how this performance can be controlled.

Costa et al. (2004) stated that discontinuous innovation involves fundamental changes in the customers attitude and behaviour and in the infrastructure. A discontinuous innovation is more difficult to market, since there are greater changes required in the way things are done, but the rewards can be more significant (Costa et al., 2004). Bessant (2005, 2008) argues that the challenge for managing discontinuous innovation lies less in the absolute scale of novelty or dislocation but rather in the *firm's experience* of these conditions as something which takes it beyond its normal operating envelope. Established firms are often unable to deal with discontinuous innovation effectively even though they have very sophisticated routines for managing steady state innovation process (Bessant, 2008). Routines to manage continuous innovation can be ineffective or inappropriate when the firm is dealing with discontinuous innovation. Discontinuous innovations do not emerge every day, established firms are often unable to deal with them effectively. It are usually new entrants firms who are able to exploit the 'fluid phase' in terms of developing innovations to take advantage of these conditions, while existing incumbents do badly. The problem is that the conditions to manage steady-state innovations work as a barriers to pick up signals about, and effectively respond to, innovation threats and opportunities associated with discontinuous shifts. To pick up these signals a new kind of management style is required. A key challenge is to develop a alternative routines for discontinuous innovation (Bessant, 2005)

Adoption life cycle model can be very applicable for looking how discontinuous innovations will evolve and perform after market introduction. Costa et al. (2004) point out that when a company introduce a new technology in the market, the customer adoption process follow a specific *path* in terms of the type of customer profile reached, because people differ strongly in their readiness to try new products and new technologies. This model is represented by a bell curve with five segments representing groups of customer psychographic profiles in terms of the relative adoption time: *innovators, early adopters, early majority, late majority* and *sceptics*. There is a major differences between early adopters and early majority, the chasm (Costa et al., 2004). Anderson and Ortinau (1988) point out that there are innovators and there are late adopters, and there are significant differences between them. There are difference why innovators adopt discontinuous innovations and why late adopters do. The critical factor is the ready to use innovation, the low risk of adopting for late adopters. Late adopters do not want to view an innovation as discontinuous because are not willing to take the risks it is bringing (Anderson & Ortinau, 1988). To break through this chasm companies need to change their market strategy. The evolution along the technology adoption life cycle for discontinuous innovation requires companies to change market strategies at the various stages, often to opposite approaches. When in the early phases over diversify occurs it causes difficulties. The problem is that companies are then *not able to concentrate* its scare resources and efforts in the same market-learning path. Problems occur then when companies are introducing discontinuous innovations and do not possess are *not able to access or acquire the competences* needed to address the whole product process adequately. This can be very counterintuitive and confusing for the companies, making it a difficult path to follow. The challenges are even greater if for companies with limited business and marketing competencies (Costa et al., 2004).

De Brentani (2001) stated that adequate control can comes from selecting sites where it is possible to specify the *who, when* and *what*: "Who" will use the discontinuous innovation so adequate training can be provided. "When" will the innovation be used, so company personnel can be on hand to observe the experiment. "What" will the innovation be used for so that an effective application and protocol can be specified (de Brentani, 2001) Before launching the new discontinuous innovation important is that it has had *formal testing* to make sure that when it is launched it is likely to be *error free, reliable, user-friendly,* and *right delivered*. This testing before launch can be of less importance when the discontinuous innovation is develop on an one-on-one basis (Lynn et al., 1996).

Moreau et al. (2001) argue that the base domain a discontinuous innovation is related and can influence the comprehension of a discontinuous innovation. The *primary base domain* is the existing product category, this is the product category that is most similar in terms of the benefits provided. Because many discontinuous innovations do not fit neatly into any existing product category, knowledge from *additional domains* may also influence the adoption process for these new products. This is called the supplementary base domain knowledge. Knowledge in the primary base domain may have a *negative influence* on the perceived net benefits of the new product. Only when high level of primary base domain knowledge is combined with high level of supplementary base knowledge, people where able to overcome their difficulty in comprehending the discontinuous innovation and see the benefits associated with it. But there is a different relationship between the primary and supplementary base domains. Only people with high experience in the primary base domain would know why the supplementary base domain was relevant. The relationship between *experience* and *the processing* of new information is more complex than mostly is thought. The relationship is not one-directional or necessarily independent of other types of knowledge (Moreau, Lehmann & Markman, 2001). De Brentani (2001) points out that after implementation of a discontinuous service innovation in the market to make it a success, customers really need to understand how this unique and totally foreign concept will benefit them. Service experts can play a compelling role; this time, in helping clients take the risk associated with "stepping out" beyond familiar and adopting a discontinuous innovation (de Brentani, 2001).

Anderson and Ortinau (1988) stated that it is important is to:

- Determine if you are really dealing with discontinuous innovation;
- Understand that there are different key marketing requirements between the various innovation types;
- Identify the diffusion process of innovation so that the proper marketing programs can be directly toward the proper segment.

Marketing programs and strategies need to be designed in a way they enhance consumers to *accept the innovation*, that the resistance to change is overcome, to develop a primary demand for the innovation and to *create new consumers consumption habits*. But creating a marketing program can be very difficult because there is no history of the product or comparable products. Another problem is one of misperception, the innovations are most of the time not market driven but manufacturer driven. Then consumers tends to be technology obsolescence, consumer market can view innovations as discontinuous when producers see them as continuous. The adoption of discontinuous innovations is not always very rapidly, there are disappointing adoption rates for many discontinuous innovations. Important is to look at post purchase attitudes, perceptions and use behaviour traits (Anderson & Ortinau, 1988).

Company 2:

"How does the consumer receives the product, how does he unwraps it, how is it installed? It is about the average consumers. If the consumer just paid their last 1000 euro's to a flat TV, what happens then? If it resolves in a disillusionment, something went wrong. So you need to test the product before you bring it to the market. Not only the product but also the wrapping around it and the manual" (09/30/2008).

Veryzer Jr (1998) argues that positive consumer evaluation on a discontinuous innovation is important to successfully implement it. There are factors relating to discontinuous innovations that can influence the *customer evaluation*. These factors involve a balance of the degree of discontinuity in terms of *consumption patterns* and *capabilities* with the *expectations* and *acceptance levels* of the *customer*. With respect to these expectations and acceptance levels, it seems that there is *a limit on "discontinuousness".* Customers need to feel comfortable with the products, exceeding the limits there is the danger of being ahead of their time. Customer input can help to understanding these limits. But the input is not always necessary in the beginning of the development process. Discontinuous innovations process involve revolutionary new way of thinking about how something can be done, dramatic shifts in thinking and the new applications for emerging, frequently proprietary new technologies are not apt to come from customers. The products can be somewhat removed from the context of the market due to

the long development time of discontinuous innovations, it is difficult for consumers to think beyond their current situations. But customer input can be very helpful. First it can be very helpful to study customers in order to indentify latent needs that may suggest product ideas. Second it can be helpful to observe customers in order to determine product specifications. Finally reactions to discontinuous innovations can be extremely useful for examining assumptions underlying the new product and its design. Integrating marketing personnel into customer testing early in the developing process can help to make the discontinuous innovation successful (Veryzer Jr, 1998b).
Marketing is not a single process, there are many factors influencing marketing. Marketing is related to the industrial design which is both affected by different factors. Customers and market input is of importance but also the degree of discontinuity, the project origins, the process discontinuity and the industrial design functions. Figure 19 shows how these different factors are related (Veryzer Jr, 2005).

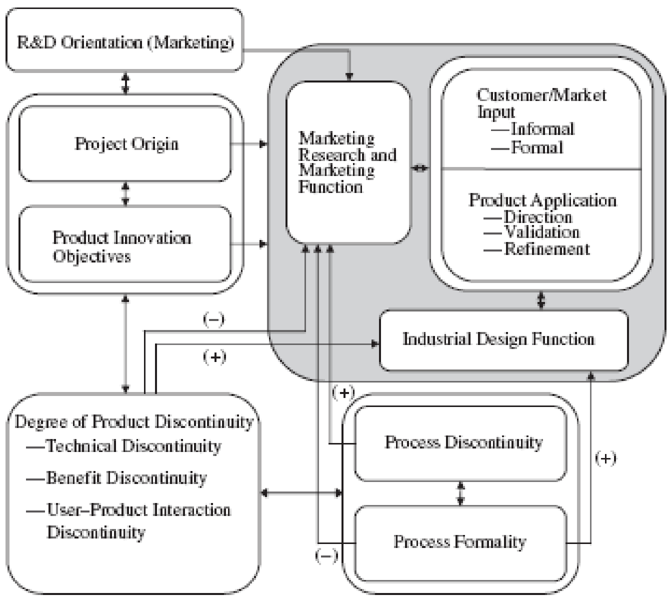

Figure 19: Factors Affecting Marketing and Industrial Design Roles in Discontinuous NPD (Veryzer Jr, 2005)(page, 38)

Rothaermel (2002) argues that commercializing discontinuous innovations is for small or new entrants quite difficult to do successfully. Therefore it can be for new entrants a solution to have an *alliance partner* that is an incumbent firm. Incumbents can survive radical technological change through strategic alliance established prior to the emergence of a technological discontinuity or by utilizing complementary assets in the aftermath of a discontinuity. Incumbents have an advantageous position in commercializing a discontinuous innovation via inter-firm cooperation with new entrants. Incumbents choose alliance partners from the population of new entrants based on the starts-up new product development, economics of scope, public ownership, and location in a regional technological cluster. Public ownership has the strongest impact on the start-up's attractiveness as alliance partner, followed by location in a technology cluster and then by a start-up's new product development and economics of scope. It seems that public firms have earned legitimacy and thus are attractive alliance partners for incumbents. External legitimacy seems to be particularly important in high-technology industries, where the dynamic environment can lead to the extinction of many new entrants. Firms that have gone public have obtained the stamp of approval from the financial community and have reduced their liability of newness (Rothaermel, 2002). Costa et al. (2004) found that most small biotechnological based companies had problems with introducing discontinuous innovations. Most of the conducted companies did not jet cross the chasm and were facing problems doing so. Half of the companies were able to define a market strategy and marketing implementation plan but were suffering from market skills and management skills. The other half was not even able to describe a *appropriate market strategy* and *marketing implementation plan* and were also missing the right *marketing skills* and *management skills*. In their research only one out of the nine companies had a success story in crossing the chasm. They have difficulties in defining and implementing chasm-crossing strategies. The main problem was indentify or focus on the critical market niches to privilege followed by inadequate pricing and regulatory problems. Companies introducing discontinuous innovation experiences particular difficulties in becoming aware of the obstacles in their path and finding strategies to overcome them (Costa et al., 2004).

Controlling the discontinuous innovation externally is mostly done by effective marketing. The firm's experience is of importance. The market can be divided by innovators, early adaptors, early majority, late majority and sceptics. They have all different reaction to discontinuous innovations. With discontinuous innovations it can important to create new consumer habits. The relation of the product base can have a negative influence to acceptance of the consumers and the acceptance level of a consumer can be reached. The marketing process is a very difficult process with many factors influencing the process. For incumbents it can be difficult to market discontinuous innovations but for small firms it can even be harder because of imitated recourses. Strategic alliances can help.

4.9 Conclusion

The second question is: What is the current process of discontinuous innovation? This question is answered by looking at the model of the DI-lab and selecting information around the different factors that together make the process of discontinuous innovation. First the factors are discussed who influence the process of discontinuous innovation these are: environment, innovation strategy and innovation culture. After that the process factors are discussed, these are: search, select, implement and control. First we have looked at the triggers that make an environment discontinuous. These triggers are: new market emerges, new technology emerges, new political rules emerge, running out of road, change in market sentimental or behaviour, deregulation/shifts in regulatory regime, fractures along 'fault lines', unthinkable events, business model innovation, 'techno-economics paradigm' and architectural innovation. The second element is the innovation strategy. This can be divided into dealing with the discontinuous environment and the role of management. Together they form the organizational strategy. Dealing with the environment can be very difficult because of different factors. Dealing with these environmental factors organizational buffering can be a solution. The role of management is very important when dealing with discontinuous innovation. Management can react on changes from the environment and stimulate the organisation to react on the changing environment. Together, dealing with the environment and the role of management make the organisational structure. Innovation culture is the last element which influences discontinuous innovation process in the model of the DI-lab. The innovation culture determines what is accepted and what is not accepted within an organisation. Dealing with discontinuous innovation the culture needs to support among other things: entrepreneurship, autonomy, risk taking and creativeness. The three elements, environment, innovation structure and innovation culture influence the discontinuous innovation process: search, select, implement and control. The search phase has thirteen different strategies for looking for innovation. They are: sending out scouts; multiple futures; using the web; working with active users; deep diving; mobilising the mainstream; corporate venturing; corporate entrepreneurship; brokers and bridges; deliberate diversity; idea generators; and market indicators. Selecting a discontinuous innovation it is important to forecast how discontinuous innovations will perform, and selecting the one which is will probably be most successful. Formulas have been made to forecast discontinuous innovations, authors point out that it is important to combine quantitative and qualitative methods. It is important to look at the market potential and evaluate four different elements: product, process, position and paradigm. Implementation phase is about how discontinuous innovation is implemented within the organization. Employees are the key factor in dealing with implementation. There are different uncertainties that occur from transferring the initial idea from the discontinuous innovation team to implementing within the organization to the operating teams. This can be marketing, technical, organizational and resources uncertainties. These uncertainties can be overcome by different management interference. Organizational structure is important in the implementation phase. There are different ways to organize for discontinuous innovations. The size, age and intra-firm linkages can have effect on dealing with discontinuous innovation. Organizing for discontinuous innovation a solution can be the “ambidextrous organisation” or the “entrepreneurial spin-off”. The final phase, the control phase, is about how externally the discontinuous innovation can be controlled. The market can be divided in different phases. These are innovators, early adaptors, early majority, late majority and sceptics. They have all different reaction to discontinuous innovations. There is a relation between the product base and the acceptance of the innovation. The innovation will need to change the behaviour of the customer but there is a limit on what can be reached.

5. Discussion

Conducting the systematic literature review answer is given to the research questions: *"How is discontinuous innovation defined?"* and *"What is the current process of discontinuous innovation?"*

Conducting the systematic literature review fifty articles are reached about discontinuous innovations. The question is if every article is reached. Searching for the articles, the same key- words were used for the two research questions, but different free text words were used. With this construction the research subjectivity is minimized and also the changes of missing relevant articles. The subject discontinuous innovations is very new, because of this there is a change that there is still relevant information that is not jet published. The same goes for the DI-lab, it is started only a few years ago, and a lot of conferences were held. Some of this information is not yet published and therefore not yet assessable for Scopus and Web of Science. Probably when a new SLR is done after two years a lot of new articles can be reached.

The model of the DI-lab is used to select the information about discontinuous innovations, but there are some limitations in the model and additional research is needed. The model is build out of different phases, but while conducting the SLR and dividing the founded information, it became clear that the distinction is not clear. For example the probe and learn is by Bessant (2008) labelled as a search strategy but by Lynn (1996) as an implementation phase. Also the implement and control phase is not clearly separated. In this SLR the interpretation is that implement is the internal controlling of discontinuous innovation and control the external implementation of discontinuous innovation. But looking at other authors as Bessant (2008) control can also be seen as a learning phase. The model now presented there are no feedback-loops or learning curves. This can be a limitation of the model because there is much overlap in the different phases. Like Reid and de Brentani (2004) point out that interpreting information out the environment is done by employees which can differ and evolve overtime. With this, learning curves can occur. The model of the DI-lab can be used to look at discontinuous innovation but additional research is needed to make a clear distinction between implementation and control. There is also additional research needed to look at how the feedback-loops can be applied at the model.

The information that is found shows that there are still many areas where additional research needs to be done. There are subjects within discontinuous innovation process that are more elaborated than others. There is still a lot unknown about the process of discontinuous innovations. Suggestions for further research are given. First of all, looking at the different published articles most authors have done research by case-studies. These case-studies are most of the time about incumbent organisations. This brings up the question what is the effect of discontinuous innovation on SMI's or what are the differences between different industries? Noke et al. (2008) pointed out that the clock speed of an industry can be a relevant factor for success of how to deal with discontinuous innovation. They have looked at the slow speed industry but what is the effect for medium or high speed industries? And what are the differences between industries?

There are difference between entrepreneurial firms and incumbents of how they react on discontinuous innovations. Many authors like Watts (2001) stated that entrepreneurial firms have an advantage in developing discontinuous innovations and those incumbents have problems reacting on discontinuous innovation. Some authors like Rothaermel (2002) stated that entrepreneurial firms need to make alliances with incumbents for successful commercializing discontinuous innovations. This all raises questions like: When have incumbents and when have entrepreneurial firm advantage in the discontinuous innovation process? When do incumbents stops being a threat to entrepreneurial firms? How can the alliances between incumbents and entrepreneurial firms be successful developing discontinuous innovation? What explains a firm's ability to identify new business models (ambidextrous organization or entrepreneurial spin-off) necessary to commercialize discontinuous innovation? How is this ability developed or grown?

Developing discontinuous innovation a lot of authors make the statement that in the process there are many uncertainties. But what are those uncertainties and are there different uncertainties between industries and between different firm sizes? How can the uncertainties be found and controlled? What are the different relationships between those different factors and the uncertainties occurring with discontinuous innovation.

When developing discontinuous innovation, the final phase is the commercialization of the product. When does a product become successful? Are there differences between the success of a discontinuous innovations that is superior in final product characteristics or discontinuous innovations that have an economic advantage? What factors determines the success or failure of discontinuous innovation?

Developing discontinuous innovation authors point out that it can take many years to develop discontinuous innovation (McDermott & Handfield, 1996). But what is the real factor of time? If the process of discontinuous innovation is rushed does this lead to more incremental innovations?

Michel et al. (2008) point out that dealing with discontinuous innovation is mostly investigated in develop countries, but also in developing countries it can be very useful. In developing countries, the cultural context, the value system, social relationship and status is typically not build around or impacted by a consumer culture. But by reconfiguring the roles of the consumers discontinuous innovations can be created. If you look at micro-credit to serve the poor as small teams of customers. Discontinuous innovation that is innovating embedded operant resources is also relevant when serving the poor. The poor often lack the skills to gain access to recourses they need to improve their capabilities. This quandary can be overcome by embedding operant resources into offerings which 'deskill' the customers value co-creation (Michel et al., 2008). This needs more research to look how discontinuous innovations can be applicable in develop countries and where the model needs to be differently interpreted.

A final suggestion for further research is that authors like McDermott & Handfield (1996) pointed out that traditional financial methods fall short when developing discontinuous innovations. How can discontinuous innovations be measured? Are all tradition methods not suitable for discontinuous innovations and can they be changed in such a way that they are suitable?

There is still a lot unknown about the real effect of discontinuous innovations. To really understand the effect that discontinuous innovation has on the different industries much more research needs to be done. The DI-lab at the University of Twente and the Benelux can play an important role in developing additional theory about discontinuous innovation. There are many different companies allied with the DI-lab. The companies come from different industries and have different sizes. With those different companies the DI-lab can look at how difference can occur between size and industries looking at uncertainties, development, successfulness of the discontinuous innovation and introduction speed. Other differences can also occur and therefore it can be very interesting for the DI-lab to look at the difference between the organisations. Another interesting aspect of the development of discontinuous innovation is importance of the culture of the organisation. The culture of the organisation is called by (O'Reilly III & Tushman, 2004) as an crucial factor for success. But as Hofstede (Hoecklin, 1996) pointed out that there are different cultures dimensions in different countries. Because the DI-lab is situated in different countries around the world it could be very interesting to look at how different cultural aspects influence the process of discontinuous innovation. This can also be interesting for multinational organisations that are allied with the DI-lab of Twente and the Benelux. Finally it can be very interesting for the DI-lab of Twente and the Benelux to look at model of the DI-lab and then especially at the implementation and control phase and the feedback-loops. This would improve the utility of the model.

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