Organizing for Exploration at a High Tech Firm

UNIVERSITY OF TWENTE.

Master Thesis

Jaap Rosink

UNRESTRICTED VERSION

Organizing for Exploration at a High Tech Firm

– MASTER THESIS –

Important: This is an unrestricted version. The names of the companies and people involved have been replaced with fictional names or have been left out. Moreover, a substantial part of the case description, together with chapters 5 and 6 have been left out. The final chapter has been partly summarized.

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Name of supervisor of the firm is confidential

Preface

With this thesis I complete the program Master Business Administration at the University of Twente. The track Innovation & Entrepreneurship I chose, provided me many interesting insights in organization theory and the management of innovation.

In March 2009 I started this case study at Trion Kromhout, the company which allowed me to investigate how their organization deals with the exploration of radically new/different possibilities. By choosing this topic, which was hard to frame initially, I ensured myself with a long period of investigation, writing and rewriting. However, eventually I made it to the finish. Therefore I would like to especially thank the R&D director, for all his support and input to build the case and for his patience and confidence in me. Next to that I want to thank the Business Development (BD) Director for all the interesting conversations about innovation related topics and also the history of Trion.

I also want to thank Klaasjan Visscher for all the support needed to write this thesis. He especially provided me with insights on how to conduct academic research in order to come up with relevant results and be critical at every stage of the research process. I want to thank Dries Faems as well for giving me critical remarks about this study and for useful tips in doing this research.

Of course I want to thank my parents. Without their support, not only during my period at the University but also before, I probably wouldn't have come this far. The same goes for my girlfriend Suus, who repeatedly pushed me to work not only on this thesis, but on all university related things as well. Who I also want to thank are my father- and mother-in-law for connecting me with Trion. Finally I would like to thank my grandmother for all her interest and motivational talks. Thank you all for that.

With finalizing this study, the story does not end for me at Trion Kromhout. Since January this year I am member of the Trion team. I am now (among others) involved in innovative processes, intellectual property, and business development, thus a great opportunity to begin a great career! For this I again would like to thank the directors of BD and R&D, but also the managing director and head of human resources for having confidence in my capabilities.

Enjoy reading this paper…

Kind regards,

Jaap Rosink Kromhout, 06-07-2010

Management summary

Innovation is increasingly recognized as a major driver for organizational performance. Whereas most established firms are proficient in enhancing their stream of rents on the current competences, they somehow seem to struggle when it comes to the exploration of radically new opportunities. Almost a year ago, top management of Trion Kromhout, a physical amalgamation of several distinct subsidiaries of Trion N.V., started to recognize the challenges, and moreover the importance of exploration (i.e. experimenting with new opportunities) within their own organization. Since the factors that can negatively influence exploration often grow within an organization and can be deeply rooted in its strategy, processes and structure, an in depth case study is conducted to answer the following central research question:

"How has Trion Kromhout evolved over time with respect to exploration, and how can Trion Kromhout enhance exploration?"

The goal of this study is to identify specific factors that negatively influence exploration at Trion Kromhout. The results of 12 open ended interviews with several top and middle managers, desk research and the collection of narratives contributed to an extensive, retrospective case description of Trion in both its early days to create a contextual view, and the contemporary Trion Kromhout.

Below, the findings of this study are described in general:

1. A large production site with heavy investments is rather inflexible. Data showed that in several cases, exploration was limited due to the production site's inflexibility.
2. A strategic shift from acquiring other companies to explore new opportunities to positioning an internal R&D department implied that R&D remained largely occupied after this shift with troubleshooting and optimization of production. R&D's capacity to explore remained limited after an increase of the R&D department.
3. The production department still has a strong voice in early stages of NPD. Therefore new opportunities are risked to be reflected to the production capabilities, resulting in refining existing competences.

4. A mechanism of positive mutual feedback between experience and competences has been recognized, indicating that Trion Kromhout has fallen into a familiarity/maturity trap. Creating breakthroughs is therefore hard to achieve at Trion Kromhout.
5. A mainstream management system recently was introduced at Trion Kromhout. The focus of this system is on doing more with less. Many ingredients of the mainstream management system are focused on upward migration, i.e. increasing the stream of rents on current competencies. The exploration of new opportunities is therefore left unattended. Moreover, e.g. the handling of strict go-or-kill criteria hardly apply for explorative projects, decreasing the likelihood of these types of projects to get delayed or even killed.

Another substantial part of this study was to create directions for Trion Kromhout to overcome these barriers to exploration. These directions are described below in general:

1. To get out of the familiarity/maturity traps, Trion Kromhout should explore novel/emerging technologies. The appendix shows which areas Trion Kromhout should explore.
2. A boundary spanning role should be formalized to initiate the exploration of the above mentioned novel/emerging technologies.
3. An innovation management system has to be created to enhance explorative activities, applying appropriate evaluation metrics. Moreover, in the case of Trion Kromhout, a platform approach around the mentioned technologies should be applied to build a knowledge base in these specific areas and reduce uncertainties.
4. Finally, the above mentioned activities should be conducted in a separate organizational space, next to the mainstream organization. Key is that exploitation and exploration will balance healthy, which can be enabled by applying contingency rewards.

A main recommendation for Trion Kromhout to apply the directions is that Trion Kromhout should initiate from bottom up. This means that Trion Kromhout has

to start small with little investments. Over time when uncertainties start to reduce, investments may increase.

A limitation of this study is that the relation between internal R&D and external knowledge acquisition has not been investigated. Therefore no comments can be given about whether Trion Kromhout should continue to acquisition strategy next to internal R&D. Also what not has been investigated is the initiation and integration process of the R&D department. This process also can affect the output of the contemporary R&D department. Finally, a patent analysis has been conducted. The result is that the model of innovation dynamics (Utterback, 1994) shows similarities with those at Trion Kromhout. However, Utterback's model applies on industrial level and the patent study is on organizational level. No further investigation has been done in order to validate the results to some extent. The results of the analysis however, appeared to be useful as an awareness creating tool for a need for exploration.

Content

1 Introduction

1.1 Toward the Problem

The field of innovation is increasingly recognized as a major driver of organizational performance. The American Management Association (AMA)[1] commissioned a global survey of 1,396 top executives conducted by the Human Resource Institute[2] (HRI). Of all respondents, 68% ranked innovation in their company as "extremely" or "very" important nowadays. When asked to look 10 years out, this percentage augmented to 86%[3].

Through extant literature in the field of innovation, two types of innovative activities have been generally acknowledged, i.e. exploitation and exploration (Holland, 1975; March, 1991). The essence of exploitation is the refinement and extension of existing competences, technologies, and paradigms… The essence of exploration is experimentation with new alternatives (March, 1991: p.85). As most established firms are proficient at refining and extending their existing competences (i.e. exploitation), they seem to struggle with pioneering radically new products and services (i.e. exploration) (e.g. McDermott & O'Connor, 2002; Hill & Rothaermel, 2003; O'Reilly & Tushman, 2004).

Though, many scholars have pointed out the importance of radical or breakthrough innovation and an organization's capability to realize these types of activities. As many firms fail to maintain leadership when facing radical technological innovations (e.g. Anderson & Tushman, 1990; Christensen, 1997) and the nature of radical change is often unpredictable, organizations have to be able to either initiate these breakthrough innovations or react rapidly (Cohen & Levinthal, 1990). In other words, organizations have to facilitate *explorative* activities within their structures. This will enrich the probability for an organization to flourish on the long run (McDermott & O'Connor, 2002).

[1] http://www.amanet.org/

[2] http://www.i4cp.com

[3] The percentage of those rating innovation as "extremely" important jumped from 32.5% to 51.3%

This specific challenge of experimenting with and initiating radical technological innovations is a major struggle especially for *incumbent* firms. For example, established firms can get caught up in a success trap (Levinthal & March, 1993). The results of exploitation are more certain and proximate, and therefore often favored over exploration, with outcomes that are initially poor and uncertain (March, 1991). Since the development of existing technologies and competences often leads to early success, further exploitation is emphasized. This process can lead firms into a 'success trap', firms can get blindsided for exploration by this.

Leonard-Barton (1992) describes core capabilities and their dysfunctional flipside (i.e. core rigidities). Since core capabilities are part of the organization's taken-for-granted reality, organizations are having difficulties with performing projects that are misaligned with these core capabilities. Next to that they find little support from top management for that same reason. As a consequence, important new competences may be neglected.

Recently, an R&D director of an established firm in the purification industry, Trion NV, recognized the importance of being able to experiment with and initiate radical technological innovations. The strategy Trion NV pursued when it involved getting access to new technology – different from their core competences (i.e. membrane technology and activated carbon) – often was one of acquiring other companies and integrating them in the Trion NV organization. This resulted in the current Trion NV as a conglomerate existing of several subsidiaries, all with different areas of expertise in the purification sector. The conglomerate, nowadays has engineering and manufacturing facilities in seven countries and is active in more than a hundred countries around the world. Trion NV, founded in 1918, has more than 1500 FTEs.

The just introduced R&D director, runs the R&D department of Trion Kromhout, a 'physical amalgamation' of four subsidiaries of Trion NV: Trion Process Technology (TPT), Trion Membrane Technology (TMT), Trion Wolf, and Trion Components and Services (TCS). These four companies are all situated under one roof in Kromhout since 2003. In line with the General Manager and Business Developer (both from Trion Kromhout), the R&D director's major concern is how Trion Kromhout can be enabled to explore the new possibilities themselves. Other

than that, they want to be sure that Trion Kromhout does not fail to notice promising technologies, and that Trion Kromhout is able to embed these, in particular radically new technologies in its own organization.

1.2 Objective

Therefore, the main objective of this thesis is to:

"Draw up recommendations for Trion Kromhout on how it could *organize for exploration"*.

1.3 Central Question

As mentioned, especially established firms seem to struggle with this type of activities (i.e. exploration). Therefore, it is likely to argue that an organization evolves and undergoes certain processes, which eventually may hamper explorative activities (e.g. Tripsas & Gavetti, 2000; Chandy & Tellis, 2000). For Trion Kromhout, (as part of) an established firm, it is important to find out if and why it is struggling with the exploration of new possibilities and with embracing them. To achieve this goal, the following central question is posed:

"How has Trion Kromhout evolved over time with respect to exploration, and how can Trion Kromhout enhance exploration?"

1.4 Research Questions

Although the focus (which will be described later) will be on Trion Kromhout, it is important to go back further in time. To provide proper insights on the context of Trion Kromhout as it currently exists and how potential impediments to exploration may have arisen, the evolution of Trion *before* the foundation of Trion Kromhout in 2003 has to be analyzed as well, instead of merely analyzing the period of 2003 until now. Moreover, incidents in the far past may influence today's explorative capacity as well. Therefore, the first research question reads:

1. *How did Trion evolve from its foundation until 2003, especially concerning its explorative capacity?*

To analyze the period from 2003, when the four mentioned companies were clustered into Trion Kromhout, until the present, a multilevel approach will be employed. This means that Trion Kromhout will be analyzed at both organizational and project level. The purpose of this multilevel approach is that it enables to analyze the organizational evolution in extend to research question 1, and the content of projects aligned with this period. The latter can provide for characteristics (e.g. alignment with corporate strategy) which could give insights into why a project thrives or not. For the analysis on project level, several fail- and success cases will be used. Paragraph 1.5 is used to elaborate more on this research methodology. The second research question is:

2. *How did Trion Kromhout evolve from 2003 until the present, especially concerning its explorative capacity?*

The former two research questions result in a description of the complete journey that Trion, in specific Trion Kromhout has been through. Aiming for the central question, the complete journey is being critically assessed. Via this critical analysis main influential factors impeding exploration, are to be recognized. Moreover, a closer look is taken at peculiarities which might have positively influenced explorative behavior. Through the third research question, these influential factors are evaluated, judged, and criticized:

3. *Which major factors negatively influencing exploration can be recognized throughout the case of Trion Kromhout?*

By answering the first three research questions, the first part of the central question (i.e. how Trion Kromhout has organized for exploration in the past) is covered and has created a link to the second part, i.e. how Trion Kromhout *could* organize for exploration. The specific goal is to indicate how and which enhancing factors can be emphasized and how and which impeding factors can be turned around or be made less influential. The fourth and final research question is:

4. *How could the explorative activity at Trion Kromhout be enhanced?*

1.5 Scope

This study will focus on Trion Kromhout. There are several arguments for this decision.

1.5.1 Not broader

As pointed out by the director of the R&D department, Trion Kromhout is functioning as a role model to the other subsidiaries (e.g. Nijhuis, Nafhams, and Trifix) in several fields (e.g. R&D, marketing, and sales). This way, the latter companies don't have to be included in the study. Another reason for excluding these companies is, just as not making Trion NV the focal organization, that the scope of the study would be too broad.

1.5.2 Not narrower

Throughout the entire company (Trion NV), Trion Kromhout is considered as one company, and it is acting this way. The individual corporate identities within Trion Kromhout are diminishing due to several factors, for instance one General Manager is governing all four companies. Other factors are joint purchasing, marketing and sales which make Trion Kromhout act as one company. This is a reason to not pick one of the (former) individual companies as a focus for the study.

Next to that, the innovation process is multi-faceted (Dougherty, 1992), which means that this process involves for example R&D, marketing, sales, and production. Since every department contains employees whose contracts are with either TPT, Wolf, TMT or TCS, it is a major challenge to derive all employees from only one company. These are reasons to focus on Trion Kromhout, and not narrower.

2 Theoretical Framework

An unrelenting theme in the literature on the process of innovation is that well-managed, established firms in the face of radical technological innovations often struggle to 'bridge the chasm'. These firms go into decline while new entrants penetrate and conquer to dominate the market with the new technology. This chapter first highlights in what way organizations transform their strategies, structures and processes. Another section elaborates on the definition of radical technological innovation. Furthermore, one paragraph highlights some of the relevant rationales of why incumbents find it hard to meet the challenge of dealing with radical technological innovation. Finally, the flipside of the coin is told, how established Trion Kromhout could experiment with and initiate radical technological innovations.

2.1 The Dynamics of Technologies and Innovation

In due course, organizations are changing their strategies, structures, and processes in order to renew their offerings and herewith remain competitive. Extant literature provides several models which describe how technologies and innovation change over time. One model that enjoys many support is the principle of punctuated equilibrium (Gersick, 1991; Romanelli & Tushman, 1994). The punctuated equilibrium model depicts organizational transformation as long, stable periods of incremental change, punctuated with short bursts of radical, discontinuous change. These short bursts of radical change, or revolutionary periods (Romanelli & Tushman, 1994), substantially alter an organization or industry. Whereas the periods of incremental change are assumed to take place, the focus in literature is on the discontinuous, revolutionary periods in the model (Anderson & Tushman, 1990; Utterback, 1994; Christensen, 1997).

For example, Anderson & Tushman (1990) are elaborating on the punctuated equilibrium theory by

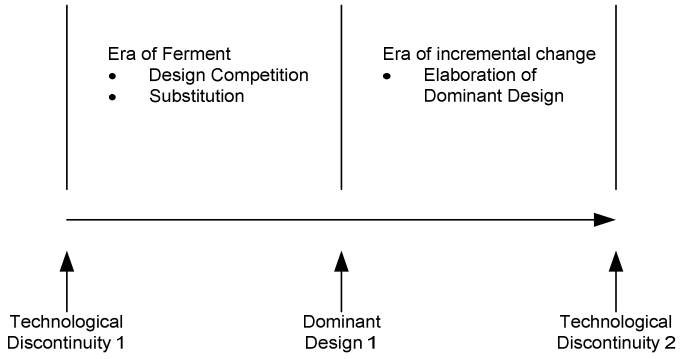

Figure 2.1 - *The Technology Cycle (Anderson & Tushman, 1990)*

describing the technology cycle (see figure 2.1). They state that an 'era of ferment' succeeds every technological discontinuity. This era of ferment is characterized by extensive product-class variation, technological uncertainty, and strong competition between distinct technologies. Eventually, this tumult period results in the emergence of a dominant design. A dominant design is defined by Utterback (1994: p.24) as: "… the one that wins the allegiance of the marketplace, the one that competitors and innovators must adhere to if they hope to command significant market following. [It] usually takes the form of a new product … synthesized from individual innovations introduced independently in prior product variations." This dominant design introduces a new set of (technical) standards, rendering the existing standards obsolete. This dominant design and its standards are then the basis for a lot of future products.

In his model (see figure 2.2), Utterback (1994) distinguishes rates of innovation in particular phases. He, for example defines a fluid phase, quite similar to the era of ferment in the model of Anderson & Tushman (1990). In this fluid phase, the rate of product innovation is high, whereas the rate of process innovation is relatively low. The period in which the dominant design emerges, is defined as the transitional phase by Utterback (1994).

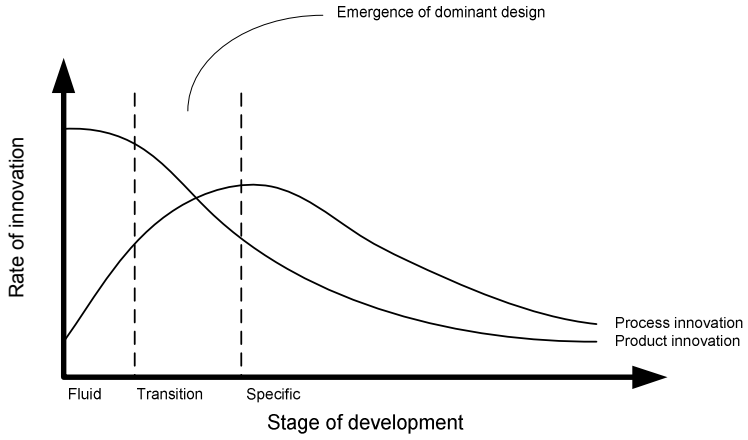

Figure 2.2 - *The Model of Innovation Dynamics (Utterback, 1994)*

After the emergence of the dominant design, the needs of customers become clearer, therefore the focus in this transitional phase is on product variation, aimed to serve specific customers. The rate of process innovation is increasing rapidly in this phase, in order to reach significant production volume. Subsequent, a period of elaboration of the dominant design takes place. This is what is recognized as the specific phase, or in terms of punctuated equilibrium theory as the period of incremental change. The final, *specific* phase is characterized by very specific

products produced at a high level of efficiency, where the rate of innovation is declining. Product and process innovation are very tightly linked, and a modification in either product or process is now becoming extremely difficult and expensive. In this phase, the competitive emphasis is on cost reduction.

In this final *specific* phase, the rules of the game are apparent. The product and process are highly specific, and the market is very clear. At some point in time, the firm reaches a status quo, which it can only get out from through a radical change in product or process. Existing standards are made obsolete by new technological discontinuities, and the search for a new dominant design is initiated in a sequential *fluid* phase or era of ferment. Characteristics of each phase are presented in table 2.1.

	Fluid Phase	Transition Phase	Specific Phase
Innovation	Frequent major product changes	Major process changes required by rising demand	Incremental for product and with cumulative improvements in productivity and quality
Source of innovation	Industry pioneers; product users	Manufacturers; users	Often suppliers
Products	Diverse designs, often customized	At least one product design, stable enough to have significant production volume	Mostly undifferentiated, standard products
Production processes	Flexible and inefficient, major changes easily accommodated	Becoming more rigid, with changes occurring in major steps	Efficient, capital intensive, and rigid; cost of change high
R&D	Focus unspecified because of high degree of technical uncertainty	Focus on specific product features one dominant design emerges	Focus on incremental product technologies; emphasis on process technology
Equipment	General-purpose, requiring skilled labor	Some sub-processes automated, creating islands of automation	Special-purpose, mostly automatic, with labor focused on tending and monitoring equipment
Plant	Small-scale, located near user or source of innovation	General-purpose with specialized sections	Large-scale, highly specific to particular products
Cost of process change	Low	Moderate	High
Competitors	Few, but growing in numbers with widely fluctuating market shares	Many, but declining in numbers after emergence of dominant design	Few; classic oligopoly with stable market shares
Basis of competition	Functional product performance	Product variation; fitness for use	Price
Organizational control	Informal and entrepreneurial	Through project and task groups	Structure, rules, and goals
Vulnerabilities of industry leaders	To imitators, and patent challenges; to successful product breakthroughs	To more efficient and higher-quality producers	To technological innovations that present superior product substitutes

Table 2.1 – *Phase characterization (Utterback, 1994)*

2.2 Radical Technological Innovation

Exploration is defined in this study as experimenting with new possibilities (e.g. March, 1991). The main premise in this study is that radical technological innovations are explorative and that exploration leverages the initiation of radical technological innovations within the company (Levinthal & March, 1993). A further

definition of the latter (radical technological innovation) is required. This definition is provided for in this section.

A lot has been written about radical technological innovation, therefore it is first important to elucidate how radical technological innovation is defined in this study. Terms like discontinuous vs. continuous, disruptive vs. sustaining, and radical vs. incremental are used ubiquitously throughout extant literature to define innovation. What characterizes these terms is that they all describe the degree of departure from existing technologies, competencies or paradigms. Since in this study Trion Kromhout is considered as an established firm in the purification sector, technology is referred to as this existing technology used *prior* to the radical innovation (Henderson, 1993). Technology itself is defined as the processing of raw materials subjected to a certain branch in the industry (derived from *Van Dale Online Dictionary*, 11-06-2009).

Throughout extant literature the radicalness of innovations has been evaluated and characterized several times (e.g. Green et al., 1995; Garcia & Calantone, 2002). The discussion on the radicalness of innovations however remains rather ambiguous. Therefore in this study, an attempt is made to define a radical innovation along three dimensions: (1) a firm's competences, (2) technology, and (3) market. Through a literature review these dimensions were recognized as common and underlie most of the definitions.

2.2.1 Competences

When describing technological discontinuities, Anderson and Tushman (1990) focused on the *firm's competences* and distinguished technological discontinuities as competence-enhancing and competence-destroying. Competence-enhancing discontinuities build on know-how embodied in the technology that it replaces. Competence-destroying discontinuities render obsolete the expertise required to master the technology that it replaces (1990: p.609). Henderson (1993) used these terms in a different manner, where she refers to incremental innovation as competence-enhancing and radical innovation as competence-destroying. An incremental innovation in this sense requires a logical extension of existing knowledge and capabilities, whereas a radical innovation makes existing technological and scientific principles (partially) obsolete. This latter definition

(Henderson, 1993) is employed in this study, which in turn is in line with competence-destroying innovations.

2.2.2 Technology

The second dimension proposed in the definition of radical technological innovation is *technology*. According to Chandy and Tellis (1998), a radical innovation incorporates a substantially different core technology relative to the previous product generation. The technological rules of the game are thus radically changed, whereas technology doesn't develop along a sustaining path anymore, but is disrupted by a new technology with a substantial different set of technological rules (Christensen, 1997). In addition, Rosenkopf & Nerkar (2001) define radical exploration, which builds upon 'distant' technology that resides outside the firm (2001: p.290). The technological domain differs from the prior source of technology, and is not located in other sub-units of the firm. Ahuja & Lampert (2001) complement this dimension by defining radical innovation, or breakthrough inventions as serving as the basis for future technologies, products, and services.

2.2.3 Market

The third and final dimension of a radical innovation presented in this study is market related and describes the customer benefits derived from a radical innovation. Chandy & Tellis (1998) defined radical product innovations along two dimensions, i.e. technology (as discussed above) and market. The latter determines the extent to which the new product fulfills key customer needs better than existing products (on a per-dollar basis) (1998: p.476). The authors presented four types of innovation among which radical product innovations, innovations that provide substantially greater customer benefits per dollar, relative to existing products. In their study, Rice et al. (2001) further specified this increase in customer benefits. Their definition states that a radical technological innovation means 5-10 fold (or greater) improvement in performance and/or a 30-50% (or greater) reduction in cost. Moreover, radical innovations have the potential of opening up entirely new lines of business.

2.3 Impediments to exploration

The importance of radical technological innovation has been pointed out through the model of punctuated equilibrium. Organizations need to be able to make a quantum jump in technology to get out of the eventual 'status quo' as described. Moreover, radical technological innovation (facilitating these quantum jumps) has been defined as well. What has been pointed out as well is that organizations seem to struggle with conducting exploration. Numerous explanations have been presented throughout extant literature on why organizations are struggling with exploration. This section will highlight some key factors that impede the explorative activities of an organization.

2.3.1 The myopia of learning

Many organization theorists have discussed the differences between exploration and exploitation (e.g. March, 1991). March (1991) discussed the trade-off between the exploitation of existing competences and the exploration of new opportunities. Both exploitation and exploration are competing for the same resources within the same organizational context, and the main challenge that organizations face is the creation of a balance in resource allocation between the two. This trade-off discussion is emphasized by the very distinct characteristics that both phenomena exhibit. The returns of exploitation are generally recognized as positive, proximate, and predictable. Outcomes of exploration are the opposite, i.e. uncertain, distant, and often negative. The struggle arises in the balancing of the two themes, since the exploitation of existing competencies is often favored over the exploration of new ones, due to decreased uncertainty in results and more proximate and positive results.

Levinthal & March (1993) further elaborate on this discussion by introducing the learning trap. The authors state that over time, organizations develop their skills in particular markets, in particular competences and in particular technologies. Herewith they propose a mechanism of mutual positive feedback between experience and competence (1993: p.102). More often organizations tend to engage in activities at which they are more competent (exploitation) than in activities at which they are less or not competent at all (exploration). Due to increased positive outcomes of exploitative activities, it are these activities that are favored over explorative ones and

firms may enter a success trap. In other words, firms become myopic for explorative learning.

An emphasis is put on these downsides of a firm's core competences by Leonard-Barton (1992), who introduced core rigidities. With core capabilities, Leonard-Barton refers to a knowledge set that distinguishes and provides competitive advantage (1992: p.113). In core capabilities reside four dimensions, namely (1) employee knowledge and skills, (2) technical systems, (3) managerial systems, and (4) the values and norms. Choices that are made in the past on which technologies, competences, and markets the focus will be put, are now strongly embedded in a taken-for-granted mentality and can result in strong path dependence (Garud & Karnoe, 2001). Managers are influenced by these choices made in the past in contemporary decision-making and are often not willing to challenge these accepted core capabilities.

Core capabilities therefore are becoming static in nature, and can eventually inhibit the adoption or initiation of radical technological change, thus turning into rigidities. Since managers are not eager to challenge core capabilities, projects that are misaligned with the core capabilities are often not embraced. For example, when the necessary skills and knowledge for a project in a certain domain are lacking, the project is nonaligned and will seldom be pursued. The same goes for technical systems, which are deeply rooted in the company but can easily get outdated, e.g. software systems. The adjustment of the current system or shifting to a new one, is very time-consuming and therefore can cause serious delays. Abernathy and Wayne (1974) provide a good example of this by describing Ford's highly efficient production of the Model T. Ford enabled itself in driving down costs of this production. However, the transition to the Model A suffered great difficulties and even required shutting down manufacturing for a considerable period of time.

Next to that, misaligned projects often enjoy little status, and firm and top management support. Finally, incentive systems discourage employees to pursue projects that aren't aligned with the core capabilities. The greatest risk as a result of embracing only projects that are aligned with the core capabilities of the firm, is that significant new capabilities get neglected.

Whereas the theme discussed above relates to projects, learning theory also discusses problem solving as well. Ahuja & Lampert (2001) have defined three pathologies which inhibit radical technological innovation. The first, the familiarity trap, is closely related to the theme as discussed above. That is, due to the mechanism of mutual positive feedback between experience and competence, firms tend to seek for approaches in problem solving with which they are familiar. The authors describe it as an example of path dependence that increases the risk of falling into a familiarity trap. The second trap, the maturity trap, is closely related to the familiarity trap, but conceptually different. Mature technologies are technologies that have been in existence for some time and are relatively well known and understood in the industry (2001: p.527). These technologies are closely tied to the advantages and characteristics of the established firm. The final trap Ahuja & Lampert (2001) discuss regarding problem-solving is the propinquity trap, in which the nearby solutions are favored over distant solutions. Phene et al. (2006) have further defined this phenomenon of local knowledge search as in the 'distance' of knowledge. They state that knowledge can be both technologically and geographically distant. When knowledge has no relation with prior knowledge within the company, it then is considered technologically distant. When knowledge resides outside organizational boundaries and even outside the industry, the knowledge is considered geographically distant. Companies tend to favor local knowledge over distant knowledge in their problem solving activities, which increases the risk of missing out on 'external' opportunities (Rosenkopf & Nerkar, 2001).

2.3.2 Mainstream management systems

Large, established firms are enjoying, protecting, and trying to increase their current stream of rents on their products, which are mostly located in large, established markets. This need to increase these rents and therewith to grow as a firm, is termed by Christensen (1997) as upward migration. Firms create routines to serve customers and investors in the mainstream market well and eventually to realize this growth. Structural inertia theory explains that firms are favored for cooperation when they are reliable in producing collective action, and when they can account rationally for their activities (Hannan & Freeman, 1984). The routines – the capacity to reproduce a structure with high fidelity – that firms create, are constructive for

creating reliability and accountability. The downside is that these routines (e.g. information systems) impede radical change, because the reproducibility of structures requires bureaucracy and formalization of processes (Hill & Rothearmel, 2003).

O'Connor et al. (2008) build further on this, by describing the key characteristics of a mainstream, or operational excellence management system which are proficient at serving mainstream operations. Moreover, they propose it as a system that nurtures new product development within current lines of business rather than radical technological innovation. The key characteristics are displayed in table 2.2 below:

	Mainstream Management System
Objectives and mandate	Efficient, effective management of current markets and operations
Leadership and culture	Planning and delivery oriented
Structures	Clear and delineated
Processes	Stage-gate, project management oriented; avoid deviations from budget or schedule
Governance and decision making	Go-or-kill criteria clear in advance, hierarchical decision making
Skills and talent development	Functional expertise
System resources	Annual budget allocation
Metrics	On-time delivery, cost containment, profitability

Table 2.2 - *Key Characteristics of a mainstream management system (O'Connor et al., 2008)*

As O'Connor et al. (2008) state: "[a system like this] *efficiently leverages what the organization knows for responding quickly and effectively to* customer *needs or competitive threads to* current *product lines or markets"* (2008: p.17, emphasis added). These management systems traditionally do not reward experiment-, or exploration-oriented activities.

Christensen et al. (2008) have approached one particular aspect of the management system which is according to the authors one of the major reasons innovations get killed, i.e. the use of financial tools (especially in the early stages of radical technological innovations). As the importance of radical technological innovations already has been pointed out, large established firms also face a disincentive to invest in them due to initial market size (i.e. often smaller than the mainstream market). The following example provided by Christensen points out this disincentive:

…while a $40 million company needs to find just $8 million in revenues to grow at 20 percent … a $4 billion company needs to find $800 million in new sales. No new markets are that large … [therefore] the larger and more successful an organization becomes, the weaker the argument that emerging markets can remain useful engines for growth." (1997: p.xxiv-xxv).

Moreover, Christensen (1997) states that markets that don't exist can't be analyzed, which is often the case in radical technological innovations. Radical

innovations are often paired with many market and technological uncertainties. Mainstream management systems of apply financial tools as evaluation metrics in typical stage-gate processes, and top management demands market data when none or (too) little exists and make judgments based upon these financial projections when neither revenues or costs can, in fact, be known sufficiently. And therefore, when incremental or sustaining projects are compared with projects of radical nature, it will (often) be the incremental projects that get top management support and prevail, while radical technological projects get delayed or even die (Christensen et al., 2008).

Mainstream management systems effectively leverage existing technologies to serve current markets. Product development is therefore mostly based on known competences and technologies. Song et al. (1998) described that cross-functional joint involvement in a new product development (NPD) process is not beneficial in all stages of the process. They for example recognized that in the first stage (i.e. market opportunity analysis), joint involvement of an R&D department and a production department (technical system) acts counterproductive. Often new ideas do not fit within the current production processes and since these are very expensive and time-consuming to adapt or adjust, new opportunities are often not pursued.

2.3.3 Conclusion

Several mechanisms have been identified that influence the exploration capability of an organization. A strong mechanism is that of mutual positive feedback between experience and competences, which results in favoring the existing competencies over radically different ones. This is reflected on two levels, i.e. on the level of problem solving, where employees find it difficult to escape the bounded rationality. The second level is that of projects or organization level, which implies that only projects will be pursued that fit the current competencies. Moreover, a management system often is applied by incumbents which is beneficial for incremental new product developments rather than the initiation of radical innovations. Thus, individuals and organizations are trapped in a bounded rationality which impedes them to act properly, especially in the early stages of radical technological innovations.

2.4 Enabling exploration

This paragraph presents the counterpart of the prior paragraph, in which was described how incumbent firms suffer from a multitude of constraints and how they can grow into an inert organization incapable of dealing with radical technological innovation. This paragraph illuminates how organizations could prevent themselves from organizational decline and inertia in the face of radical technological innovations. In this sense, the story of incumbents in the face of radical technological change will be completed, since some established firms do survive and prosper in the period after the radical change or can even be the source of radical innovations (e.g. Schumpeter, 1950; Teece, 1986; Methé et al. 1996; Ahuja & Lampert, 2001).

2.4.1 Escaping from competence traps

The previous section described how firms can get caught up in a competence trap. Ahuja & Lampert (2001) elaborate on entrepreneurship in large, established firms, and point out the importance of experimenting with technologies explicitly not related to prior knowledge to break out of these traps. As mentioned before, firms can get caught up in either a familiarity trap (i.e. favoring the familiar), a maturity trap (i.e. favoring the mature), or a propinquity trap (i.e. favoring the nearby). The authors suggest that in case of each of these traps, a strategy exists to overcome these traps and enable *adaptation* or even creation of radical technological innovation. Succinctly, in the case of the familiarity trap where firms are merely exploiting technologies known by the firm, organizations should explore and experiment with novel technologies. These are technologies that are new to the firm, even when they already exist for a while. In the case of a maturity trap, favoring technologies that are relatively long in existence and well-known, organizations should explore emerging technologies. Emerging technologies are technologies that are new in chronological terms. Finally, when a firm got caught in a propinquity trap, i.e. only exploring the solutions in the neighborhood of existing solutions, the firm should explore pioneering technologies. In the case of pioneering solutions, researchers are ignoring all existing solutions and are exploring fundamental, new solutions. The basic premise of purposively exploring other technologies is to step out of the bounded thought process. Sloane (2003) defined this as the process of lateral thinking.

The exploration of novel, emerging or pioneering technologies also points out the importance of external information and the acquisition and assimilation of it. Cohen & Levinthal (1990) defined this as absorptive capacity: an organization's ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends (1990: p.128). The authors argue that absorptive capacity depends (among others) on specialized actors that are intermediating between either organization and environment, or between different subunits within the firm. Rosenkopf & Nerkar (2001) elaborated on a critical role needed in innovation and proposed *boundary spanning*, essential according to Cohen and Levinthal (1990) when external information is not closely related to the established knowledge. A similar role was introduced by Bessant & Von Stamm (2007) as a search strategy to enhance discontinuous innovation: the Idea Hunter. Rosenkopf & Nerkar (2001) introduced a typology of boundary spanning where two distinct boundaries can be crossed, i.e. the organizational boundary and the technological boundary. In terms of radical technological exploration, the authors suggest that both organizational and technological boundaries should be crossed. Radical exploration builds upon distant technology that resides outside the firm (2001: p.290). The boundary spanning role is emphasized by Reid & De Brentani (2004) who argue that radical innovations only enter the organization at the discretion of individuals such as boundary spanners.

Huston & Sakkab (2006) investigated in their study the new innovation model of Procter & Gamble, connect and develop. This is a good example of how boundary spanners or in terms of Huston & Sakkab, technology entrepreneurs, are used to explore new opportunities. The main premise is, these technology entrepreneurs aggressively scan scientific literature and patent databases. The authors however emphasize that only spanning electronically is insufficient. Technology entrepreneurs at P&G therefore physically visit research labs, universities, congresses, fairs etc. Their findings will be actively communicated back to P&G's decision makers.

2.4.2 An innovation management system

Important in the face of radical technological innovations is to properly evaluate the opportunities. The previous section described management systems in established organizations which do not apply for radical technological innovations (O'Connor et al., 2008). The authors state:

"For example, if the decision-making criteria used to evaluate projects for funding are based on what is already known about success in familiar markets and with known technologies, but the projects being evaluated are characterized by high uncertainty and ambiguous outcomes (Will the technology work? What are the most likely applications? How might we derive value from this as a business? How will we develop the process innovations necessary to make this economically justifiable?), it's very unlikely they'll be funded." (2008: p.16)

Here, the mainstream management system's counterpart is described, i.e. an innovation management system, which is beneficial to the pursuit of radical innovations. In table 2.3 the key characteristics of an innovation management system are displayed.

	Innovation Management System
Objectives and mandate	New business creation in new and existing markets
Leadership and culture	Learning and building oriented
Structures	Flexible
Processes	Learning and experimentation oriented, allow redirection based on new insights
Governance and decision making	Decisions made based on strategic intent and continued learning; criteria not clear in advance; governance rather than hierarchy
Skills and talent development	Entrepreneurial expertise
System resources	Resources acquired through many avenues
Metrics	Portfolio health and balance; connection with strategic intent of firm; new domains accessed; new resources garnered; new business starts

Table 2.3 - *Key characteristics of an Innovation Management System (O'Connor et al., 2008)*

For increasing the survival chances of radical innovations within the mainstream organization, O'Connor et al. (2008) further elaborate on the discussion between a project and a platform approach, and state that projects aren't the way to go. Instead, platforms (e.g. nanotechnology or energy reuse) create an increased number of options because they can be the foundation for a variety of business models, products, and applications (2008: p.62). Again the authors emphasize the strategic intent which is important, focusing e.g. idea generation in domains of strategic interest for new opportunities creates more leverage for ideas than one-off projects.

For the creation of successful technology platforms, firms should get involved in Open Innovation, a paradigm introduced by Chesbrough (2003). The paradigm opposes the traditional vertical integration model, where only internal R&D activities lead to developed products, which he refers to as *closed innovation*. Chesbrough et al. (2006) define *open innovation* as: "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (2006: p.1). R&D is considered an open system in this paradigm, where (radical technological) innovations can originate within

organizational boundaries as well as outside these boundaries. Next to that can these innovations be commercialized from inside the company as well as outside the company. The processes of both *closed* and *open innovation* are visualized in figure 2.3.

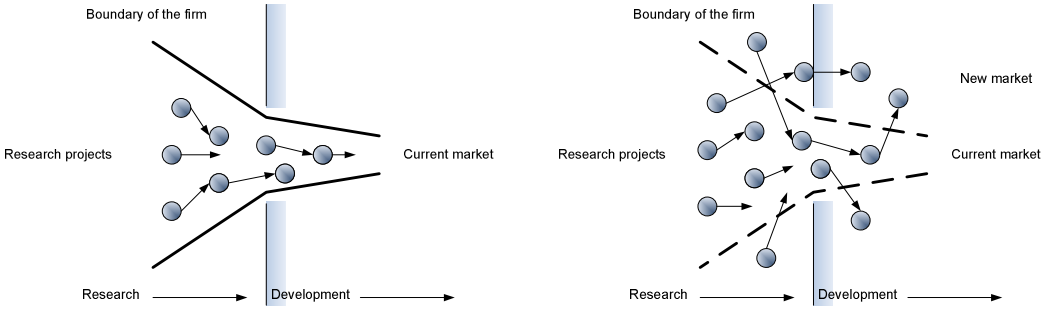

Figure 2.3 - *The process of respectively closed and open innovation (Chesbrough, 2003)*

In table 2.4, the main principles of closed and open innovation are presented.

Chesbrough et al. further emphasized that open innovation enhances both the creation and capturing of innovations. The use of the required business model thus enables the initiation of, and response to change.

Closed Innovation Principles	Open Innovation Principles
The smart people in our field work for us.	Not all the smart people work for us so we must find and trap into knowledge and expertise of bright individuals outside our company.
To profit from R&D, we must discover, develop, and ship it ourselves.	External R&D can create significant value; internal R&D is needed to claim some portion of that value.
If we discover it ourselves, we will get to market first.	We don't have to originate the research in order to profit from it.
If we are the first to commercialize an innovation, we will win.	Building a better business model is better than getting to market first.
If we create the most and best ideas in the industry, we will win.	If we make best use of internal and external ideas, we will win.
We should control our intellectual property (IP) so that our competitors don't profit from our ideas.	We should profit from other's use of our IP, and we should buy other's IP whenever it advances our own business model.

Table 2.4 - *Contrasting Principles of Closed and Open Innovation (Chesbrough, 2003)*

Organizations engaging in open innovation, have to find a way to couple the internal research and external ideas. Moreover, firms need to deploy these ideas within their own business model and through the business of other firms. Chesbrough (2003) notes that it is key for firms to identify what the firm is lacking internally, where to attain those missing parts, and integrate these parts into their systems. The open innovation paradigm thus emphasizes the importance of interaction with the

environment, and the creation and maintenance of networks, which is the emphasis in the connect-and-develop model of P&G as well (Huston & Sakkab, 2006).

2.4.3 An independent organizational space

March (1991) discussed that both exploitation and exploration should co-exist within organizations and that it is important to make the correct tradeoff between the two. This means that a mainstream management system as described in the previous section should not entirely be replaced by an innovation system, since exploitation is beneficial for success in the nearer term and organizations enjoy greater certainties from it. This section provides useful insights in how organizations can nurture both exploitation and exploration.

Christensen & Overdorf (2000) state in their article, that the capabilities of a firm reside not only in their resources, but also in their processes, and values. Emphatically, as recognized by many other scholars, the processes of a firm (i.e. patterns of interaction; coordination; communication; and decision making. Christensen & Overdorf, 2000) are designed for tasks to be performed efficiently and or meant not to change. Though, in the face of radical technological change, these processes are not applicable any longer. Moreover, Christensen & Overdorf (2000) discuss the values of the firm which also affect what a company can or cannot do. They define the firm's values as: "…the standards by which employees set priorities that enable them to judge whether [something is attractive or unattractive, more important or less important]." (2000: p.69) The perception of value changes, when companies grow. Due to increasing overhead costs, the gross margins that were once attractive, are now becoming unattractive. Besides, small markets don't solve the growth needs of large companies (Christensen, 1997; Christensen & Overdorf, 2000).

As the occurrence and importance of radical technological innovations has been discussed, companies face the challenge to change the capabilities of the firm. To overcome the mentioned problems, Christensen & Overdorf (2000) suggest to create a new, independent organizational space alongside the mainstream organization. In terms of O'Connor et al. (2008), alongside the mainstream organization with its mainstream management system, an organizational space has to be created which is managed through an innovation system. This can be achieved in three different manners:

1. Create new organizational structures within corporate boundaries in which new processes can be developed.
2. Spin out an independent organization from the existing organization and develop within it the new processes and values required to solve the new problem.
3. Acquire a different organization whose processes and values closely match the requirements of the new task.

(source: Christensen & Overdorf, 2000: p.73)

The authors refer to Wheelwright & Clark (1992) as the first solution, regarding heavyweight teams. This means that new organizational boundaries are to be created internally, in which a new group of people is installed suitable for the new problem. O'Reilly & Tushman (2004) refer to quite a similar solution as the ambidextrous organization. These organizations involve project teams that are structurally independent units, each having its own processes, structures, and cultures, but are integrated into the existing management hierarchy (2004: p.79). O'Reilly & Tushman (2004) emphasize the advantages of cross-fertilization and no cross-contamination between the established and the new business, other than in case of for example unsupported, or cross-functional teams. The ambidextrous organization is visualized in figure 2.4.

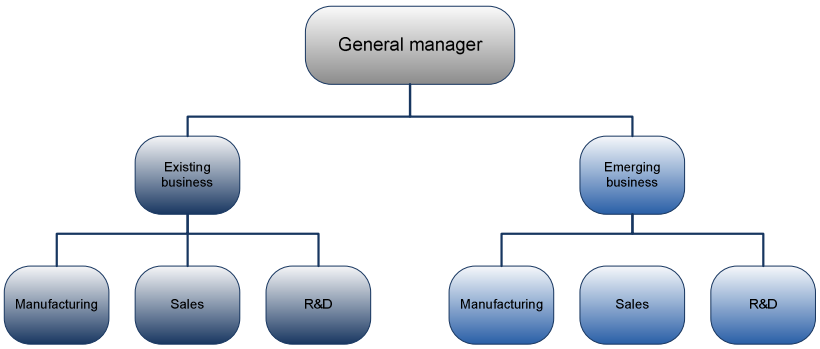

Figure 2.4 - *The Ambidextrous Organization (O'Reilly & Tushman, 2004)*

Birkinshaw & Gibson (2004) defined the concept of contextual ambidexterity which often acts complementary to structural ambidexterity. The authors refer to contextual ambidexterity as a phenomenon that calls for individual employees to make choices between alignment-oriented and adaptation-oriented activities in the

context of their day-to-day work (2004: p.49). The capability of alignment is referred to as a clear sense of how value is being created in the short-term and how activities should be coordinated and streamlined to deliver that value. Furthermore, the capability of adaptability, of which the importance is evident, is described as the ability to move quickly toward new opportunities, to adjust to volatile markets and to avoid complacency (Birkinshaw & Gibson, 2004). According to Jansen et al. (2008) the role of transformational leadership is key in creating and sustaining ambidexterity. They found that the development of a strong shared vision and contingency rewards have a positive influence on achieving ambidexterity. In specific, these mechanisms influence management behavior so that resource allocation will be correctly balanced.

Large organizations seem to be incapable in allocating the necessary resources for a radical technological innovation, located in an emerging, initially small market. In this case, Christensen & Overdorf (2000) suggest to spin out an independent organization. Chesbrough & Rosenbloom (2000) acknowledge the lack of a clear path to market for spillover technologies. They as well suggest that a business model distinct from the established one is necessary, which can be achieved via spin-offs. This method is in extension of the open innovation model, which characterizes technologies that can be either commercialized internally or, in the case of spin-offs, externally.

The third and final solution Christensen & Overdorf (2000) suggest, is that of acquiring the necessary capabilities. The authors distinguish between the acquisition of processes and values, and the acquisition of resources. In the case where a the goal is to acquire capabilities that reside in the processes and values of the other company, Christensen & Overdorf suggest that the other business should be left stand-alone. This is because, when fully integrating the company and its capabilities, the processes and values will be overruled by, and vaporize within the parent organization. Though, when the capabilities needed reside in the resources of the firm, than the parent organization can fully integrate the other company. This is because these resources (such as people, technologies, etc.) can enhance the parent capabilities.

2.4.4 Conclusion

This last section of the theoretical framework proposed several insights on how established organizations can overcome the constraints regarding exploration. Three

main themes have been discussed which can help firms organize for exploration. First, as many companies favor their known technologies over the unknown due to mutual positive feedback, it is important that firms which have fallen in a competency trap that they deliberately explore novel, emerging or pioneering technologies. Second, mainstream management systems don't apply for radical innovation, therefore firms should create an innovation system which entails different evaluation criteria and where the mandate is not efficiency, but new business creation. However, an organization cannot rely totally on one management system (either a mainstream or an innovation system). That is why firms need to create an independent organizational space which is separated from the mainstream management system and is governed through an innovation system.

3 Research Methodology

This chapter elaborates on how the answers to the research questions and herewith the central question are found. Choices on methodology are being explained and justified. This chapter elaborates on the research strategy, the data collection methods, and the method of analysis of the data.

3.1 Research strategy

In this research, a retrospective case study will be conducted. Along three conditions provided by Yin (1994) is discussed why this research strategy is to be employed.

The first condition provided by Yin is the type of research question. The central question in this thesis ("*How has Trion Kromhout evolved over time with respect to exploration, and how could Trion Kromhout enhance exploration?"*) is a typical 'how' question, and is meant to deal with operational links needing to be traced over time rather than mere frequencies or incidences. Therefore the preferred strategy is either a case study, history or experiment (1994: p.6). From these three strategies, one can be eliminated through the second condition: the extend of control over behavioral events. After assessing the first condition, an experiment is still an option. However, when conducting an experiment a control over behavioral events is required. Since this is not the case in this research, the experiment as research strategy is no longer an option. The third condition is the degree of focus on contemporary events. As described along the research questions, this study goes back in time, even to certain periods where the study can only rely on documents, cultural and physical artifacts (1994: p.8). Though, this is only part of the study, as data will also be gathered in the nearer history and current situation, where sources are for example managers or employees who are still 'around'. Leonard-Barton (1990) points out that a case study is actually a history of a past or current phenomenon (1990: p.249), therefore the strategy will be concluded as a case study.

3.2 Research design

Some aspects of the research design have to be emphasized. Since part of this research is the study of the evolution of the explorative capacity of an organization, the case study will be in retrospect. Data are obtained after certain events have occurred, as comes forth from the research questions provided in chapter 1.

As described before, Trion Kromhout is the focus of this study, which means that this study is a single case study. Next to that, as proposed before research question 2, the case study will contain a multilevel approach. Again referring to Yin (1994), this is called an embedded case study. This leads to a Type 2 case study design (1994: p.39), a single case (i.e. Trion Kromhout) study with multiple units of analysis (i.e. projects).

3.3 Data collection methods

3.3.1 Principles of data collection

Elaborating on the collection of data in a case study, Yin (1994) introduced three distinct principles which enhance the benefits of the evidence collected. First, Yin (1994) points out that a broader range of historical, attitudinal, and behavioral issues can be addressed by employing multiple sources of information. Moreover, findings or conclusions in a case study are likely to be more convincing and accurate if based on *multiple sources of evidence*. Therefore, to increase validity of the research, the data collected in this study is based on different primary or secondary sources. Sources of evidence in this research are documentation, archival records, interviews, and physical artifacts.

The second principle proposed by Yin (1994) involves the organization and documentation of the data collected. Yin points out that documentation in case studies generally consists of (1) a data or evidentiary base, and (2) the report of the investigator (e.g. a article, report, or book). The main purpose of this distinction is that the 'critical' reader has a recourse if he or she wants to inspect the database that led to conclusions. Furthermore, by creating a separate, independent database, other investigators can easily review this evidence and are not limited to the written report. This enhances the reliability of the entire case study. For creating a proper database in

this study, data is collected and archived as case study notes, case study documents, tabular materials, and narratives.

The third and final principle is to *maintain a chain of evidence*. This principle is to enable the reader of the report to follow derivation of any evidence from initial research questions to ultimate case study conclusions and the other way around. Thus, implications made in the conclusions of the study have to be traceable throughout the report. This along with the other two principles generally increases the reliability and herewith the quality of the study substantially.

3.3.2 Interviews

Interviews were held in an open-ended nature in which respondents were asked for opinions about events, and to propose their own insights into certain occurrences. Herewith respondents are considered more an informant instead of a respondent, which is essential since informants rather than respondents are more essential to the success of a case study. Open-ended interviews give the interviewer more flexibility. Moreover, informants can suggest other, surprising sources of evidence and even give access to them (Yin, 1994: p.84).

The interviews were constructed as semi-structured. These type of interviews give clear direction toward collecting the right data, but also leave enough room for the interviewee to propose other interesting insights.

The desired results from the interviews involve data which tell the story of origin and growth until the current situation of Trion Kromhout and its relevant subsidiaries. Therefore some of the interviewees were people who are engaged with Trion for a long time, i.e. ten years or longer.

Since interviews usually take a long time to conduct, the amount of interviews is limited eventually to 12. Therefore, middle and top management were approached to take part in the interviews because usually it are these people who can tell (most of) the story.

Besides interviewing people who are within the company for a long time, the goal is also to interview people who are around for not so long. The main reason for this is that usually these people are not influenced by embedded cultures and usually have a more objective view on the situation. This further enhances the possibility to

link the past to the present properly and to explain why the current situation is as it exists.

People have been selected on tenure and position. The goal was to find a right balance between employees with a rather long tenure (approximately 25 years) and a shorter tenure (down to 2 years). Experienced employees still active in the company can face-to-face tell the story as they experienced it. Furthermore, employees with a shorter tenure are approached because they can give more objective opinion on contemporary situations since they are not that much influenced by the past. Moreover, due to long tenure most of the relevant developments will be covered. Position is another aspect, which influenced the selection of interviewees. That is, managers and directors are the most involved in organizational processes, strategy etc. Since barriers to exploration are often embedded in an organizations processes, structures and strategy, it is considered more likely that employees with a director or managing function contribute to relevant data since these employees have most of the insights in this. People that have been interviewed include the general manager, the R&D director, business development director, directors of sales and marketing and several technology and patent managers of different departments. Several follow-up interviews were conducted to gain additional information. All the interviews have been recorded and transcribed.

Moreover, throughout basically the entire study is searched for narratives by employees about relevant topics in addition to the interviews. This is done since not all the data required was retrieved during the interviews. These narratives are from people within the company ranging from top managers, middle managers and other employees (e.g. scientists, engineers and sales people).

3.3.3 Desk research

The collection of documentation and archival records is performed via desk research. Desk research is meant to provide insights in the background of the case, i.e. Trion. With documentation is meant e.g. press releases, internal memos, websites, and administrative documents. As for archival data go organizational records (e.g. charts and budgets) and previously collected survey data. Access was obtained to total of 22 quarterly, internal news bulletins, 16 third party publications, 8 internal presentations, 1 previous survey on employee satisfaction and publicly available documents (from

the website). The main purpose of the data collected via this desk research is that this information can confirm and add to other sources of evidence, herewith increasing reliability. Moreover, these sources of information help to determine the chronology of the case.

Additional desk research has also been conducted in order to identify novel/emerging technologies for the benefits of organizing for exploration. Also a brief study has been conducted in order to identify universities and institutes for potential joint research activities.

3.4 Data analysis

The analysis of case study data is often difficult since analytic techniques and strategies are ill-defined. Moreover, there is a strong dependence of outcomes on the researcher's own style of rigorous thinking, just as the adequate presentation of evidence and consideration of alternative interpretations (Yin, 1994). For analyzing case study data, a researcher should therefore have a general analytic strategy. The author introduced two general strategies, i.e. (1) relying on theoretical propositions, and (2) developing a case description. For answering research questions 1 and 2:

1) *How did Trion evolve from its foundation until 2003, especially concerning its explorative capacity?*
2) *How did Trion Kromhout evolve from 2003 until the present, especially concerning its explorative capacity?*

a case description is build. The transcripts of the interviews form the main input for the case. In addition, the documents are used to support results from interviews and to support the creation of a chronologically correct story. All the sources of data (i.e. transcripts of interviews and organizational documentation) have been read and re-read in order to identify incidents, statements, actions etc. which could contribute to the limited capacity in exploration. Phenomena that are repeatedly emphasized during interviews and in documents were considered relevant for building the case description. Moreover, before building the case the different phenomena identified were tested by asking several of the interviewees about the relevance and correctness of these facts.

The third research question:

3) *Which major factors negatively influencing exploration can be recognized throughout the case of Trion Kromhout?*

is answered by applying the theoretical framework as proposed in the previous chapter. The framework describes different influential factors that could contribute to a limited exploration capacity. This stage, at theoretical level, served the goal of creating an explanatory framework in which is tried to emphasize how concepts like for example learning traps, core rigidities and a mainstream management system are related to the limited exploration capacity at Trion Kromhout. The goal was to create a conclusion based explanations that appear most congruent with the facts (Yin, 1981).

The data retrieved through the interviews and desk research is reviewed and facts or statements that indicate an influencing factor for exploration are categorized and coded through the themes of the theoretical framework.

The final research question:

4) *How could the explorative activity at Trion Kromhout be enhanced?*

is addressed by applying the second part of the theoretical framework, which describes mechanisms that can contribute to enhancing radical innovation capabilities within the firm. This part of the theoretical framework formed the basis for context specific solutions on how Trion Kromhout can enhance its exploration capacities, directly related to the identified impediments to exploration in the firm.

4 The Case: Trion N.V. and Trion Kromhout

This section provides an extensive description of the development of Trion as a company and some of its relevant subsidiaries with as final point Trion Kromhout as it currently exists. Research questions 1 and 2 are addressed in this section. The chapter is structured as follows. First, the origins of Trion are discussed and its growth in the Activated Carbon (AC) industry. This period reaches to the mid 90's when Trion complemented their traditional AC technologies with process and membrane technology. Then, the second part will go a step back in time and elaborate on the origins and evolution of the firms which actually delivered the process and membrane technology at Trion.

Whereas the first two parts of this section mostly describe the context of the company, hereafter the development of Trion will be discussed more extensively, especially with regard to the explorative capacity of Trion Kromhout. Starting in the mid 90's, several companies were acquired by Trion. Some of these acquisitions will be discussed regarding their potential influence on exploration. Finally is elaborated on the period from 2003 until now. From this point several subsidiaries are situated under one roof in Kromhout. Throughout the case description certain projects will be used to illustrate and further emphasize the development of the organization. The goal is to pinpoint the main factors influencing the explorative behavior of Trion Kromhout. Figure 4.1 shows a timeframe of the case history.

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Figure 4.1 - *Timeframe Trion*

4.1 Origin and growth of Trion N.V.

Back in 1910, a vegetable decolorization carbon known as 'noir épuré', 'eponit' or 'Trion' was used in the sugar refining process. Dr. A. Wijnberg, an expert in the sugar industry those days, recognized the possibilities of using this decolorization carbon in sugar refinement. This idea eventually led to the development of Activated Carbon (AC) and its practical application in various industries. Moreover, this idea led in 1918 to the origin of Trion as NV Algemene Trion Maatschappij. The company was a merger of the Amsterdamse Suikerfabriek De Granaatappel, which was the first production facility that used the sugar refining

technology, the NV Nederlandse Trion Maatschappij Declora, producer of AC from charcoal and the NV Chemisch-Technisch Handels- en Adviesbureau, which supported the construction of purification installations in sugar refinement facilities. In the first decennium several production sites in both the Netherlands and Germany were acquired, herewith increasing the production capacity of AC. In the late 1920's, the German factories were sold to the German Verein für Chemische Industrien. Eventually this resulted in a cartel established in 1929, called the Carbo-Trion-Union. In this cartel, several West-European countries were allocated to both Trion and the Verein.

From the beginning of Trion, the company investigated the growth possibilities in the United States. This investigation led to the first factory in the U.S. back in 1933, which was established in Jacksonville, Florida. This was accomplished in cooperation with the before mentioned German Verein für Chemische Industrien. It took one year before the American Trion Company started production of activated carbon obtained by incinerating pine tree stumps. In 1966 the production was brought to an end due to increasing charcoal prices, but the American Trion Company remained existence as a sales organization. In 1984 a producer of activated carbon from lignite named Darco was acquired by Trion. Darco was located with its production facility in Marshall, Texas and owned a market share of 20-25 percent in the U.S. Twelve years later, in 1996 Trion acquired another U.S. AC factory, located in Pryor, Oklahoma from former owner Elf Atochem North Americas, Inc. which led to a fivefold increase in Trion's capacity for the production of granular AC from coal.

4.2 Towards a purification provider (1/2)

In the 1990's, the demand for AC in Trion's traditional markets like the chemical and foodstuff industries declined. This was partly due to the increasing replacement of powdered carbon by granular carbon. Moreover, in the purification sector more and more use was made of membrane technology. As a response to these changing market situations, Trion changed its organization drastically. Where it initially was product-oriented, the company became market-oriented, the profit accountability changed from centralized to decentralized, and from a single product focus they shifted to a diversified product line. Most important, the company couldn't

be profiled as an AC producer anymore, instead they became a purification solutions provider. By studying several alternatives for purification methods, Trion found that membrane technology seemed to be a strategic add-on. Through several acquisitions Trion enabled itself to expand in that direction. In the succeeding two paragraphs the companies that were acquired are described. First the company Wolf is described, a specialist in the area of membrane development and production. Subsequently Elusius is described briefly along with Elusius Micro, both companies with a focus on the (process) technology 'around' membranes.

4.2.1 Wolf

Wolf was founded in 1984 by Dick Grobben, in 1986 accompanied by the current Business Development (BD) Director of Trion Kromhout, former classmate and colleague at the University of Twente. At the time the company was founded, the market already provided for microfiltration membranes, though all rejecting water, among experts known as *hydrophobic*. Therefore their first project involved the creation of a *hydrophilic* microfiltration membrane, one not rejecting water. The project was in cooperation with the University of Twente and was enabled due to 90% of the project being subsidized. A PhD student, Trion Kromhout's current R&D Director, was assigned to the project to conduct the research and took until May 1989. During this period revenues were besides sales, mostly generated by consultancy. Whereas at the one side money was coming in, on the other side a tenfold of this amount was again to be spent in R&D, making Wolf an actual R&D center, exploring new opportunities on a daily basis. After approximately three years Wolf was able to produce and sell membranes on a small scale. By the time the membrane was further developed and made suitable for mass production, Grobben and the BD director started the search for a corporate partner to exploit their membrane on large scale. They found in Shell their appropriate partner, since Shell already possessed a worldwide network of sales offices. Moreover, Shell itself conducted research in membrane technology as well, herewith already having affinity with this technology. The interest from Shell was gained by the possibilities with membranes in the oil-industry. With investments of Shell and the support of Rabobank Almelo, Wolf was able to move their business from Bedrijfstechnologisch Centrum Twente (BTC) to Bedrijvenpark Twente in Almelo in 1990. The two main reasons to move their

business was first to expand production facilities, therefore an appropriate factory site was built in Almelo. Second, Wolf still 'suffered' from a spin-off image, which wasn't how Wolf wanted to be recognized. As Grobben quoted: "People kept looking at us as young researchers, while we wanted to be an adult company."

The first few years in Almelo, Wolf still remained a technology-driven company, with relative high investments in R&D. This resulted in a diversified range of technologies and products for wine and beer purification and even an artificial skin (a product that never made it to the market). Moreover, other types of membranes were developed, e.g. a flat membrane, a tubular membrane with woven and non-woven structures, and a capillary membrane. Though, a turnaround toward market pull was about to happen in 1993. At that time, citizens of Milwaukee, Wisconsin, suffered from the largest waterborne outbreak ever in history, when water supply became contaminated with a parasite called Cryptosporidium Parvum ('Crypto'). Over 400,000 people got infected and about 120 people died from this. Due to this outbreak, legislation on drinking water supply was more emphasized and tightened. The result of this was that membrane technology retrieved more attention than before, which triggered Wolf to explore the possibilities in the water purification industry.

At the end of 1994, a collaboration started with PWN, a clean water supplier that time located in Andijk, Netherlands. This company was interested in the purification of water with membranes. Wolf at that time, already invested in research on water purification with membranes. The goal of the project which was initiated in collaboration with PWN was to deliver a testing facility including membranes of Wolf. The building of the pilot was subsidized by the government and performed by Elusius Micro, a company which is discussed later. The project resulted in the AGIX concept, a concept of water purification by ultra-filtration membranes. Another result from this project was that with the AGIX concept, a global standard was introduced of 8-inch modules, which still is the standard. The reason for becoming a global standard was that it was the first and only module with capillary membranes. Moreover, the 8-inch modules were successfully evaluated on performance and outcome.

That time Wolf was only providing the membrane modules. This was and still mainly is their strategy, i.e. only providing for membrane modules and selling to original equipment manufacturers (OEM). Their main consideration was that it was

almost impossible to enter the filtration market themselves, since then they should possess knowledge and expertise in building processes. This they found undoable, therefore they mainly focused on the OEM sector. Though, from the moment of initiation of AGIX, Wolf got more involved in the processes and the system in which the membranes would be put, still this was rather limited. This involvement in the process side of purification with membranes was because membranes require very specific settings in the process to function the right way, which could not totally be left over to the OEMers. The main reason was to decrease the risk of failure in installations.

4.2.2 Elusius

It was the acquisition of Elusius in 1996 that was the first step into the direction of process and membrane technology. Elusius, originally founded in 1915, became Elusius Projects & Engineering (EPE) in 1988. The company's expertise was liquid flow process systems, where projects involved the food and beverage industry. In 1994 the current BD director left Wolf to set up a daughter company at EPE called Elusius Micro (EM), because he found more should be done with the applications around the technology. Whereas Wolf merely delivered membrane modules to OEMers, EM's goal was to link membrane technology to different applications in the market, initially in beer membrane filtration (BEMEFI). This was achieved in cooperation with Heineken, where EM developed BEMEFI mainly on the cost of Heineken. In their role as technology supplier, EM mostly used membrane modules of Wolf in their systems.

4.3 Towards a purification provider (2/2)

This part is CONFIDENTIAL. The next section provides a general summary of the entire case.

4.4 Conclusion

In this chapter is tried to answer the first ("*How did Trion evolve from its foundation until 2003, especially concerning its explorative capacity?"*) and second research question (*How did Trion Kromhout evolve from 2003 until the present, especially concerning its explorative capacity?*). The case initiated with the very

origins of Trion N.V., its rather abundant growth and acquired facilities abroad (e.g. Jacksonville, USA), and the dramatic strategic change of adopting two core technologies alongside Activated Coal, namely process and membrane technology. This period only provides for a contextual view on the organization in total and describes where the roots of the process and membrane technology lie within Trion N.V. In this first part no particular incidents have been identified regarding contemporary exploration at Trion Kromhout.

Thereafter, the first steps of Trion N.V. towards a purification provider are described. Trion acquired TPT, Wolf, and TMT in a short period of time and was herewith enabling itself in process and membrane technology. These subsidiaries of the later Trion Kromhout were discussed from their foundation until the moment they were acquired by Trion. Whereas the main focus in this section still is providing contextual insight, some criticalities can already be recognized. For example, a key decision made that time was to put a narrow focus on Wolf's technological directions. Wolf moved from a 'fluid' organization with multiple technological and market directions toward a more focused organization with three main areas of markets (beer, water, wastewater). The last decade Wolf and herewith also Trion Kromhout (in later stages) developed core competencies in these three domains. The choice to focus is still influencing contemporary activities since the markets mentioned are still the main focus today (e.g. taking the road to excellence into account, where core competences are used to 'do better' in existing markets).

Moreover, the integration of Steng Friesland in Wolf can also be recognized as rather critical. That is, the integration of two companies, or merger/acquisition, is not a straightforward thing. Difficulties have been recognized in cultural differences for example. This has strongly influenced the (strategic) decision making process within the company. At this point it became clear that Wolf/Steng and later on Trion Kromhout seem to struggle with the cannibalization of existing products.

The physical amalgamation in 2003 of all TPT, TMT and Wolf also has implications for the explorative character of the firm (Trion Kromhout). For example, the large production site that was created. Herewith, a substantial inflexibility arose within the company. Although Trion Kromhout enabled itself in efficient production of membranes, the large spinning machines also were costly (both monetary and

timely) the adjust to (radically) new products. Moreover, the large production site asked for a substantial amount of troubleshooting or attention in other kind. The relative small R&D department therefore spent most of their time serving the production site, herewith leaving little time for explorative (actual R&D) activities. In 2008 this changed due to a substantial increase in R&D employees at Trion Kromhout. Examples were given on how Trion Kromhout enhanced R&D and herewith exploration.

In the beginning of 2009, the road to excellence was introduced to the company, a process also with some implications for exploration at Trion Kromhout. Again a focus was put on the three customer groups/markets as was done before. Moreover, the entire company is now organized around these markets (water, wastewater and beverage), core competences are thus evermore emphasized. Also, the road to excellence involves certain processes among which the Product Development Review, in which financial tools are strongly influencing decision making, even in the fuzzy front end.

The Efficient Performance Technology understanding is part of the road to excellence process, which stimulates a lean culture in which the basic premise is to do more with less. The focus herewith is put on decreasing costs (energy, waste, materials etc) and increasing outcome and reliability; thus doing better what they already do.

In sum, certain choices or incidents in the past are still influencing today's explorative behavior. Moreover, very recent developments have had implications for exploration as well. However not all is negatively influencing exploration at Trion Kromhout, an example is the substantial increase in employees on the R&D floor. The next chapter will analyze the case through the theoretical framework. Here will be discussed what the criticalities are explicitly what they imply for the contemporary organization of exploration at Trion Kromhout.

5 Analysis

This part is CONFIDENTIAL.

6 Enhancing exploration at Trion Kromhout

This part is CONFIDENTIAL.

7 Conclusions

7.1 The main objective

This part is CONFIDENTIAL. A succinct summary is provided. According to the data, several barriers to exploration are present at Trion Kromhout. The barriers described in the first part of the theoretical framework were all recognized in this case to some extent. The ultimate goal was:

"Draw up recommendations for Trion Kromhout on how it could *organize for exploration".*

These recommendations were based on the second part to the theoretical framework and to large extend applied in the specific context of Trion Kromhout.

7.2 Discussion

In this final section remarkable patterns in the case of Trion (Kromhout) will be discussed. Some aspects which were not discussed in the case description and analysis will be highlighted.

7.2.1 Internal and external R&D

Looking at exploration at Trion, it is remarkable to see that the organization has shifted from first acquiring other companies to later doing endogenous R&D. It is a rather unusual pattern because many firms often adjust their strategy one from conducting R&D internally to acquiring knowledge externally. Moreover, Cohen & Levinthal (1990) stressed the importance of a stock of prior knowledge to effectively scan the environment for external knowledge and increase the absorptive capacity. Considering this it is remarkable that the explorative acquisitions (Wolf, Elusius (EPE), and Steng Friesland) seem to proved their success, because there was very limited prior knowledge in this case (i.e. mainly in the production of AC and decolorization processes). When looking at the acquisition of Steng Friesland, according to Cohen & Levinthal the relative success seems more plausible due to the created knowledge stock prior to this acquisition.

Cassiman & Veugelers (2004) suggest that both internal R&D and external knowledge acquisition can well be complementary, i.e. because the one can leverage the other and have positive impact on innovative behavior of an organization. In sum,

companies should be engaged in both internal R&D and external knowledge acquisition. Additionally, e.g. Christensen & Overdorf (2000) have suggested that companies should, in the face of radical change, should create an independent organizational space and argue that this could be also achieved through the acquisition of an external organization.

Concluding, it remains unclear why Trion (Kromhout) shifted from buying to making. Due to the experience they have built up in the buying exercise, it remains a remarkable, non logic shift. Regarding the above elaboration on internal and external R&D, Trion should also be engaged in both. Thus, the buying experience should be further exploited alongside the internal R&D activities.

7.2.2 Integration of an R&D department

In this case study, themes like core rigidities and mainstream management systems have been discussed. However, what also could have influenced the limited exploration is the cost of integrating the R&D department in the organization. Before, R&D was more a production process improvement and implementation department. Hiring many employees to compose an actual R&D department also involves an integration trajectory of such a department in the mainstream organization. Integration aspects or a lack of an adequate integration protocol may influence the output of an R&D department as well.

7.2.3 Dynamics of innovation on organizational level

Prior to the actual analysis of the case of Trion an analysis of patent data of Trion Kromhout (and its prior subsidiaries) has been conducted. A remarkable aspect is that the theory of Utterback (1994) about innovation dynamics, which applies on industrial level, also can be *recognized* at organizational level. The patent data analysis was conducted in order to support to some extent the original central problem (i.e. a need for exploration). Interesting about this patent case was that once the analysis was done and put on paper, the document started to be distributed very fast within the organization, although it was only sent to two employees. Apparently the analysis created awareness of the current situation at Trion Kromhout. This type of analysis could be applied in other organizations as well to do such a kind of awareness creating exercise.

7.3 Limitations and implications for further research

7.3.1 Internal and external R&D

The previous section described how organizations can combine internal R&D with external R&D. This leads to a first limitation of this research and also to an implication for further research. That is, Trion Kromhout is currently focusing on internal R&D, however a large stock of knowledge has been built up in membrane technology, process technology and also biotechnology. Therefore, the already built up experience in acquiring other companies and the extensive stock of knowledge present at Trion, the company should be able to proceed in this strategy of buying companies to access external knowledge. The limitation is that this research focused in the solution side only on the internal R&D and has not analyzed the strategy of acquiring external knowledge through acquisitions. This is mainly because several internal issues have been recognized with regard to exploration that needed to be addressed and external knowledge acquisitions are a complex, not straightforward exercise and thus need more careful and in depth analysis. Therefore further research is suggested.

Since there is enough support in extant literature to engage in external knowledge acquisition, an implication for future research is to examine if Trion should again initiate a strategy of explorative acquisitions. Moreover, characteristics could be identified which contributed to the success of the previous acquisitions. The reproducibility can help determine whether to again acquire external knowledge beneficial to exploration. Moreover, in specific a closer look could be taken at the acquisitions of EPE and Wolf, which to some extent challenge what Cohen & Levinthal (1990) argue about a prior knowledge stock and absorptive capacity. The acquisitions have proven successful which implies that prior knowledge is not a requisite for acquiring external knowledge.

7.3.2 Integration of an R&D department

In implication for further research can be the analysis of the integration process of the R&D department within the organization. What is needed to conduct successful creation and integration of an R&D department? Moreover, how could

Trion Kromhout use this information to improve the explorative output of the R&D department?

7.3.3 Dynamics of innovation on organizational level

As discussed before the type of patent analysis could be applied to create awareness in an organization on how their technological trajectory's state is. However, since the model on process and product innovativeness of Utterback applies for industries, an implication for further research is to investigate whether this pattern of innovation dynamics can be validated on organizational level as well. Thus, is product innovation in the early days of an organization higher and eventually decreasing, followed by increasing process innovativeness, and ultimately a status quo in which the organization might get into? The study could involve an analysis of patent data of competitors in the same industry, or organizations in industries with the same pace of technological change, in order to validate that innovation dynamics apply also on organizational level.

The above discussed analysis to some extent is pointing out the relevance of exploration in addition to the introduction chapter, moreover this study has pointed out several impediments to exploration and how to overcome them. A limitation in this study however, is the timing aspect. This means, the current technologies are believed (among Trion managers) to lead the industry for a while. However, it is still not certain when Trion has to come up with a radical technological innovation or when the market will be disrupted. An implication for further research therefore is to identify for example where Trion's technologies are located in the product life cycle, or S-curve (Christensen, 1997). However, this does not mean that exploration shouldn't be enhanced on immediate terms since firms engaging in both exploitation and exploration are on average more successful.

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9 Appendix A - Overview of novel/emerging technologies

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