Case analysis of innovation in the packaging industry using the cyclic innovation model

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Abstract:

This paper builds upon Berkhout et al.'s (2010) the cyclic innovation model (CIM). This model was shown to provide an effective framework for understanding and managing the innovation process and to address many of the shortcomings of previous models. Building on that article we have applied CIM to an in-depth case study featuring packaging firm Chesapeake. Using data gathered from twenty-eight interviews conducted over a three year period, CIM, for the first time, is applied to a low technology industry. In so doing, this paper contributes to a growing body of literature exploring low technology industries and, in turn, demonstrates the wider applicability of CIM beyond technology intensive industries.

Key words: Cyclic innovation model, innovation management, new product development, packaging industry, process industries.

Introduction

The importance of developing innovative products, services and processes is acknowledged by numerous studies of innovation (D'Alvano and Hidalgo, 2012; Bergfors and Lager, 2011; McNally et al., 2010; Ahlstrom, 2010). However, the innovation management process is complex and full of uncertainties (Rose and Baier, 2011; Stanko and Calantone, 2011; Leiponen and Helfat, 2010; Huang et al., 2010). These complexities and uncertainties have led to the development of various models and schools of thought attempting to describe and systematise the innovation process in order to aid the management of successful and sustained innovation (Xu et al., 2007; Chesbrough, 2004; Rogers, 2003; Cooper, 1990).

Building on previous discussions (Berkhout et al., 2010), we argue that many current models of innovation fail to reflect the dynamics of modern business practice. A contemporary model for innovation that integrates many functions and disciplines is required to aid the future development of innovative products, services and processes. In this paper the cyclic innovation model (CIM) is applied to an in-depth case study featuring packaging firm Chesapeake and its innovative paperboard blister pack for pharmaceutical products. This case study included twenty-eight interviews with various R&D Managers, Product Managers, and other members of the development team. Previous articles using CIM have shown it to be both a unique concept, as well as a useful framework for demonstrating how firms can deal with the new challenges of innovation (Berkhout and Van Der Duin, 2007; Van Der Duin et al., 2007; Kroon et al., 2008; Bakker et al., 2010). These articles, however, much like the majority of literature on R&D and Innovation have focused on technologically intensive industries, with lower technology industries (including process industries) being overlooked. More recently we have seen a growing body of innovation literature devoted to the innovativeness of these low technology intensive industries. This research interest is mainly motivated by criticism of the mainstream of innovation research and innovation policy, which regards a high investment in R&D and advanced technologies as the key to growth and prosperity (for a summary see cf. Robertson et al., 2009; Hirsch-Kreinsen, 2008). Research in the area of low technology intensive industries shows a dominance of incremental, mostly process driven innovations where disruptive innovation activities are scarce. Generally, the dominant pattern of technological development in low technology intensive industries is characterised by a high path-dependency which is continuously stabilised by incremental innovation activities. High returns on investment are generated from continuous optimisation of processes and of the existing technologies, thereby reinforcing the development paths (Cohendet and Llerena, 2010; Malerba, 2010). For example, the technologies being employed are well known and established and the processes and products are embedded in routines. This familiarity with the technologies extends to markets and customer preferences. This leads to a situation where companies continuously optimise their processes and technologies rather than pursue radical or risky innovation activities.

The purpose of this paper is to explore the applicability of CIM to industries beyond the high technology examples found in prior literature. The paper will explore the following research question: How do low technology intensive industries develop innovative products?

The focus of this study is on the packaging industry. The main customers of the packaging industry are fast-moving consumer goods (FMCG) and pharmaceuticals firms. An increasing number of firms from these industries are exploiting packaging as a method of differentiating and improving the performance of their products (Wells *et al.,* 2007; Mahalik and Nambiara, 2010). A number of factors have contributed to this growing significance of packaging processes: (i) government and consumers concerns over the impact of packaging on the environment (Rundh, 2005; Prendergast and Pitt, 1996; Thøgersen, 1999; Bone and Corey, 2000; Roper and Parker, 2006); (ii) increased logistics costs (Rundh, 2005; Lockamy, 1995); and (iii) the expanding competition from retailer brands (Vazquez *et al.,* 2003; Southgate, 1994). By applying CIM to the packaging industry, a contribution is made to innovation theory by exploring the unique characteristics of a low technology industry in a way that prior literature has not.

The paper begins by reviewing literature on innovation management and relevant processes and models and the unique aspects of process industries that are pertinent to this study. The methodology used for this research is then discussed. The case study featuring Chesapeake and it's formable paperboard blister pack is described and then analysed using CIM. Finally, conclusions are drawn and the practical and theoretical implications are discussed.

A new conceptual approach to innovation

For decades the innovation process was dominated by the application of pure science toward market entry (technology push). Linear models were developed that presented the innovation process as a sequence of separate stages or activities. These models have since been criticised for failing to consider the interactions that occur between development stages and for overlooking the dynamics and the iterative nature of innovation processes. Responding to these criticisms, alternative models for innovation have been developed that attempt to incorporate these various interactions (von Hippel, 1978; Galbraith, 1982; Rothwell and Zegveld, 1985) and emphasise the need for firms to look beyond their own technologies and expertise in the innovation process (Allen and Cohen, 1969; Rothwell, 1992; Chesbrough, 2003; Xu et al., 2007). Despite amending some of the shortcomings of prior linear models of innovation, the following limitations of these and other linear models have been identified (Berkhout et al., 2010, p. 480):

- Variations on linear thinking continue to dominate models of innovation. Actually, most innovation models show innovation paths, representing a stage-gate type of activity, controlling the progress from idea to market introduction, rather than giving insight into the dynamics of actual innovation processes;

- Science is primarily viewed as technology orientated (physical sciences) and R&D is closely linked to manufacturing, causing insufficient attention to behavioural sciences. As a consequence, service innovation is hardly addressed;

- The complex interactions between new technological capabilities and emerging societal needs are a vital part of the innovation process, but they are underexposed in current models;

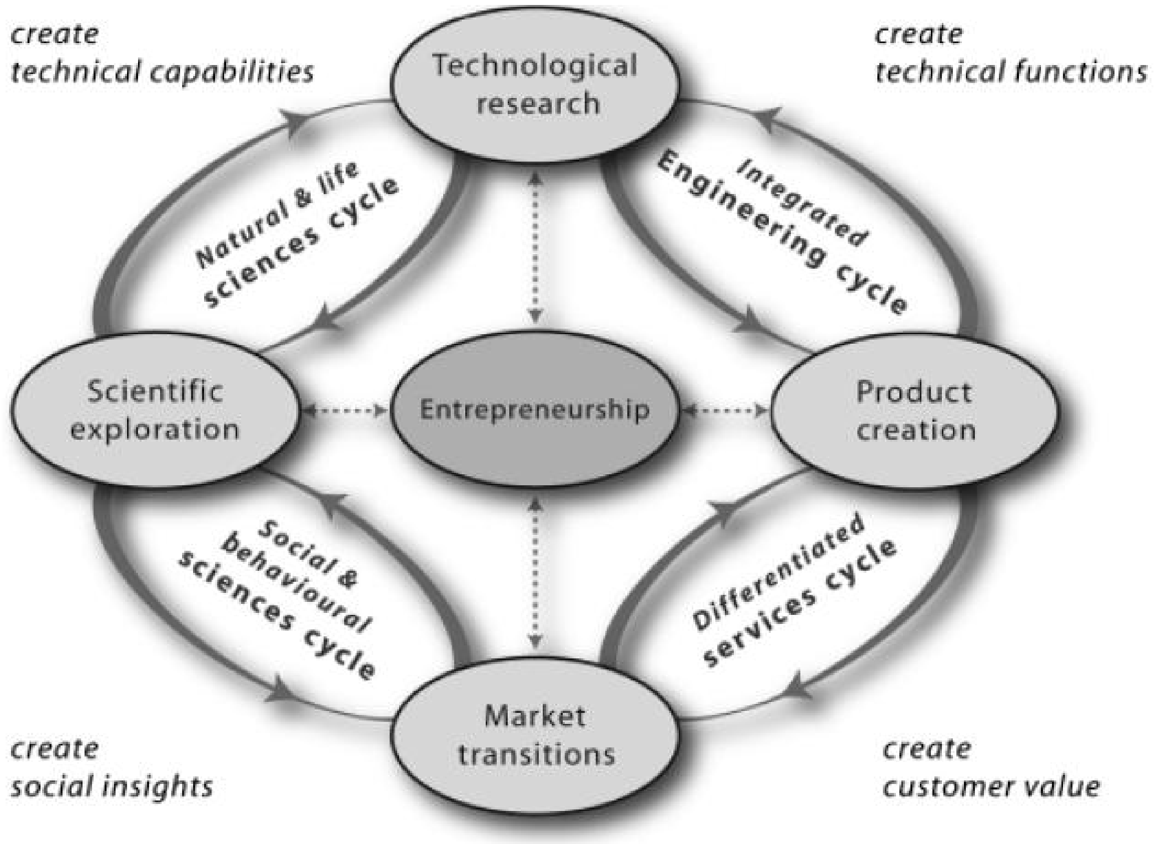
- The role of the entrepreneur (individual or team) is not captured;

- Current innovation models are not embedded within the strategic thinking of the firm; they remain isolated entities.

A contemporary model that addresses these limitations is the cyclic innovation model (CIM; Figure 1). CIM represents a change from traditional sequential models by presenting a circle with four 'cycles of change' within which activities can occur simultaneously in four cycles which connect the four nodes (Bakker et al., 2010). CIM is differentiated from other models by asserting that innovation can be initiated in any of the four cycles (See Figure 1). CIM addresses the four nodes that are essential in any innovation process and studies the activities in the four cycles which connect these nodes. CIM also provides a platform to formulate specific challenges pertaining to each cycle, along the way of the innovation process. In this way, CIM covers the entire innovation process in a non-linear way.

Another distinguishing feature of CIM is the emphasis on the role of entrepreneurs. The Entrepreneur in the centre of the model plays a crucial role in overseeing and managing the activities in the four cycles. Van der Duin et al. (2007, p. 205) stress the importance played by entrepreneurship within the innovation arena, stating that, "Without entrepreneurship there would be no innovation". In CIM, the entrepreneur occupies the central position and initiates and oversees the activities in the four cycles (Bakker et al., 2010). There are many economic models of innovation (Lundvall, 1992; Kim, 1993, Nelson, 1993; Freeman , 1995; Malerba, 2010) that incorporate the role of entrepreneurship at the national and regional level, such as those that explore knowledge spillovers and geographic clusters (for example, Silicon Valley and science parks). Also, there have been many studies examining technology systems as dynamic sources of knowledge or ideas for new firms (Clark, 1985; Pavitt, 1990; Utterback, 1994; Freeman, 1995; Nonaka and Takeuchi, 1995). For example, the role of networks of relationships among scientists and technologists has been examined to explore the social context of innovation. However, when it comes to examining innovation at the firm level there are few models if any that explicitly capture the role of the entrepreneur. At the firm level the role of the entrepreneur is taken for granted and emphasis is placed on factors that need to be in place such as investment in R&D and activities that need to be undertaken such as new product development.

Figure 1: The cyclic innovation model (CIM) represents the processes in innovation by a circle of change. Changes in science (left) and industry (right), and changes in technology (top) and markets (bottom) are cyclically interconnected. Entrepreneurs function as circle captains.



We argue that the family of linear models is a false representation of what really happens in innovative environments. Innovation projects must not be managed along the familiar linear pipeline but should be organised via cross-disciplinary networks along an innovation circle with ample internal feedback paths (Bakker et al., 2010). Innovation may start anywhere on the circle and previous innovations will inspire new ones: innovations build on innovations (Kroon et al., 2008). Although an innovation can originate in any of the four basic cycles of the innovation circle, the involvement of the other cycles is indispensable. Innovations cannot arise from the confines of a single cycle, only modifications and improvements can. At best, this leads to incremental innovation. Genuine innovation needs the collaboration of all actors in the circle.

CIM and low technology intensive industries

CIM, like the majority of models of innovation, has so far been used to study higher technology industies (Biazzo, 2009), such as the mobiles telecoms (Berkhout and Van der Duin, 2007) and chemical (Van der Duin et al., 2007; Kroon et al., 2008) industries. This has meant that lower technology industries (including process industries) have been overlooked (Francis et al., 2008; Lager, 2000). These industries have been shown to possess unique characteristics, impacting on the management of new product development (Ashayeri and Teelen, 1996;Lager, 2000; Lager and Blanco, 2010). Process industries span a number of sectors (Lager and Blanco, 2010), which can be divided into the following main groups: food, paper and cardboard, raw oil, rubber and plastics, building materials, pottery and glass, primary metal, and energy (Koene, 1988; Lager and Blanco, 2010; Lager, 2000). Within process industries, such as the packaging industry, developing new and improved products with greater functional performance is essential for delivering improved margins and profitability (Reichstein and Salter, 2006; Leonard-Barton, 1992). This can be achieved by adding to the level of differentiation in the product offering (Linn, 1984; Lager, 2000), allowing a company to increase premiums by moving the product from commodity status (Lager, 2000; Lager and Blanco, 2010), thereby switching the buying decision away from being purely cost driven (Bomsel and Roos, 1990).

The packaging industry has many characteristics of a typical low technology process industry, such as high capital investment, high production speed, rigid process control, clear determination of capacity, one routing for all products, low product complexity, and strong impact of changeover times (Fransoo and Werner, 1994; Wallace, 1984). This can act as a barrier to innovation, as the associated importance of being cost-effective in production forces R&D to look both ways in terms of delivering process innovation improvements and creating new product opportunities. This represents a dilemma in the management of innovation and R&D as it creates a high level of pressure on the latter to provide evidence of its contribution (Lager and Blanco, 2010).

An orientation towards minimizing costs is particularly apparent in many mature industries, such as both the FMCG and packaging industries, where price based competition is high. This is captured in Utterback and Abbernathy's innovation lifecycle (1975), in which the third *specific* phase is where competition shifts from differentiation to product performance and costs. Companies will focus on serving specific customer segments, and manufacturing will use highly specialised equipment with the ability to produce the product on a large scale. Some 97% of innovations incorporate both product and process innovation attributes (Simonetti *et al*., 1995).

Benner and Tushman (2002)'s study of the paint and photographic industries suggests that the focus on minimum costs within a firm can result in a shift in the balance of innovation towards efficiency, at the expense of long term adaptation. This in turn creates an emphasis on exploitative activities, crowding out more significant innovations (Benner and Tushman, 2002). Whilst these activities may help firms learn and adapt quickly in the short term, they were seen to inhibit a longer-term focus and lead to inertia (Levinthal, 1991, 1997; Repenning and Sterman, 2002).

The literature on organisational capabilities provides further insight into the emphasis on exploitative activities in low technology process industries. Capabilities are difficult to create and costly to adjust (Nelson and Winter, 1982; Hannan and Freeman, 1984). Incremental innovation reinforces the capabilities of established organisations, while radical innovation forces them to ask a new set of questions, draw on new technical and commercial skills, and employ new problem-solving approaches (Burns and Stalker, 1966; Hage, 1980; Ettlie, Bridges and O'Keefe, 1984; Tushman and Anderson, 1986). The impact of this on the nature of innovation activities is that as the organisation learns and increases its efficiency, subsequent innovation is increasingly incremental (Levinthal and March, 1993; Benner and Tushman, 2003; Aylen, 2013). Another constraint that can arise from this is a shift to meeting existing customer needs (Christensen and Bower, 1996; Trott, 2001; Christensen, 1997). Hence within large well-established organisations, the environment tends to favour incremental innovations that deliver benefits for existing customer groups, and process developments. Using CIM to analyse a case study from the packaging industry,

Methodology

The research for this paper forms part of a broader collaborative research project (Adler et al., 2003; Shani et al., 2007), which has been running in excess of three years, investigating R&D management within the packaging industry. Collaborative research is considered a good means to study and model managerial practices and issues (i.e., Shani et al., 2007). This paper focuses on presenting the results of a case study with a single firm, based on the researchers collaboration with Chesapeake who sponsored the research project. The researchers were invited to the organisation to study a problem that was identified as being relevant and critical to both practitioners and researchers (Starkey and Madan, 2000; Hatchuel, 2001). During this three-year period, over fifty R&D projects (historical and current) have been examined, covering most of the company's significant clients, and a detailed database of projects has been assembled. It is from this population that we have selected our case.

A qualitative methodology was used in order to achieve a more complete, holistic, and contextual understanding (Jick, 1979). The study employed an exploratory longitudinal case-study-based research design (Eisenhardt, 1989; Yin, 2003) over a three-year period. A case study method was used as this strategy is optimal when 'how' or 'why' questions are being posed. The use of a case study was considered appropriate for this work, as it involves intensive analysis with a view to identifying issues and generating insights (Bryman and Bell, 2003). Focusing on a single case has been found to illustrate interesting phenomena and provide important learnings (Siggelkow, 2007). Furthermore, it is not uncommon in research studies to select a single case for purely practical reasons (Daymon and Holloway, 2004), especially if it is considered that that case has 'intrinsic value' (Stake, 1995) and can provide access to information that would not be available with the ability to focus time and effort solely on one case (Noke et al., 2008).

Multiple sources of data were used in accordance with principles of 'triangulation' (Yin, 1994; Flick, 1998; Eisenhart, 1989) in order to minimise subjectivity, which included interviews and observations over the three-year period, attendance at R&D meetings, and meetings with key suppliers and customers. Data were also gathered from internal presentations and documentation, as well as email communications. With respect to the interview study, the paper draws upon information gathered from key members of the organisation, as well as interviews with other key supply chain partners relevant to the R&D projects and process (summarised in Appendix 1). The case study followed the procedures set out by Yin (2009). Set questions were developed for the interviews, although departures from this structure were permitted in the interest of exploring new and potentially fruitful points. Some adaption in the format of discussions was allowed from one discussion to the next to pursue interesting and particularly relevant new facets of the case study as they emerged (Nag et al., 2007).

Case study: Chesapeake formable board packaging

Chesapeake is a leading supplier of cartons, labels and leaflets and specialist plastic packaging. The company currently produces packaging for a range of FMCG brands, as well as for many pharmaceutical firms. Part of Chesapeake's pharmaceutical packaging range is blister packs for tablets and pills. Currently, the packaging of almost all tablets/pills is made from board, plastics and foil. However, growing customer concerns about environmental issues have lead firms to question their reliance upon non-recyclable plastics. This then formed the basis for the development of Chesapeake's Paperboard Blister Pack.

In 2005, a paper mill located in northern Italy began developing an innovative paperboard material. While the material offered the same robustness and protection as traditional paperboard, it also featured a unique characteristic: it was malleable. Compared to traditional paperboard, the new formable material could be manipulated into a variety of dynamic shapes (see Image 1) and offered the ability of increased indentations (with heights of 5mm possible compared to 0.2mm indention with traditional paperboard). These qualities offered a number of potential packaging improvements and allowed brand owners the opportunity to differentiate their products. The development process for the formable material is much the same as those for traditional paperboard (for a breakdown of the properties and applications of the most common types of paperboard see Table 2), but with two distinct differences. The first difference is the use of several thin layers of laminated paper forming the basis for the paperboard, unlike traditional paperboard that features a thicker single layer. "*These layers of paper allow for the material to be manipulated during the production process to a far greater extent than a single sheet would allow*" [P7]. These layers are then agitated at a higher rate than standard paperboard, creating a unique orientation of the fibres within the material and a texture that is more corrugated. The second difference lies in the final stage of the production process: the forming of the material using roller machines. The same machines are used as those with traditional paperboard; however, the roller is engaged using differential speed patterns. This process alters the structure and orientation of the fibres further, resulting in a malleable material with "*up to 15% more movement than the average 2% found in standard paperboard*" [P1].

Image 1: Product applications of the formable paperboard material.

The first firm interested in the malleable paperboard was Swedish packaging company Billerud who invested twelve million Euros in gaining intellectual property rights for the material. These rights granted Billerud access to know-how regarding the development of the material in terms of pulping, ingredients and production processes. However, despite this investment Billerud lacked the technological capabilities to develop product applications for the material. Moreover, with no specific target customer or application in mind, the material was effectively being developed blind. To overcome these challenges Billerud sought a partner.

The Head of R&D at Chesapeake first received a sample of the paperboard in 2006 following contact from Billerud. The possible applications for the formable board for Chesapeake transcended product and industry boundaries and included: replacing existing packaging materials; differentiating products from their competitors by using unique packaging in terms of materials and decoration; improving the functionality of new or existing packaging; and use in areas outside of packaging, such as improving the quality of Braille texts. Such was the extent to how widely the material could be applied, Chesapeake felt as though they could replace almost any packaging with this new material, and considered it to be "*one of the most significant packaging innovations in the history of the paperboard packaging industry*" [P11] .

Chesapeake initially discovered through experimentation that it was possible to use the material for small items of packaging such as the blister pack. During these experiments they also discovered that the production of small items like the blister pack was possible using existing production line machinery and with only minor changes to the manufacturing process. This provided a considerable advantage that the company could avoid the costs of investing in new machinery. In July of 2006 Chesapeake approached Billerud with an offer to purchase intellectual property rights to the formable paperboard to "*gain exclusivity for their packaging*" [P1]. This offer was initially declined, along with alternative proposals from other companies hoping to gain an exclusivity deal. Chesapeake faced fierce competition in gaining rights to the material. Following twelve months of intense negotiations lead by the Head of R&D, the two parties reached an agreement allowing Chesapeake exclusive rights to the use of the material, but only for pharmaceuticals packaging.

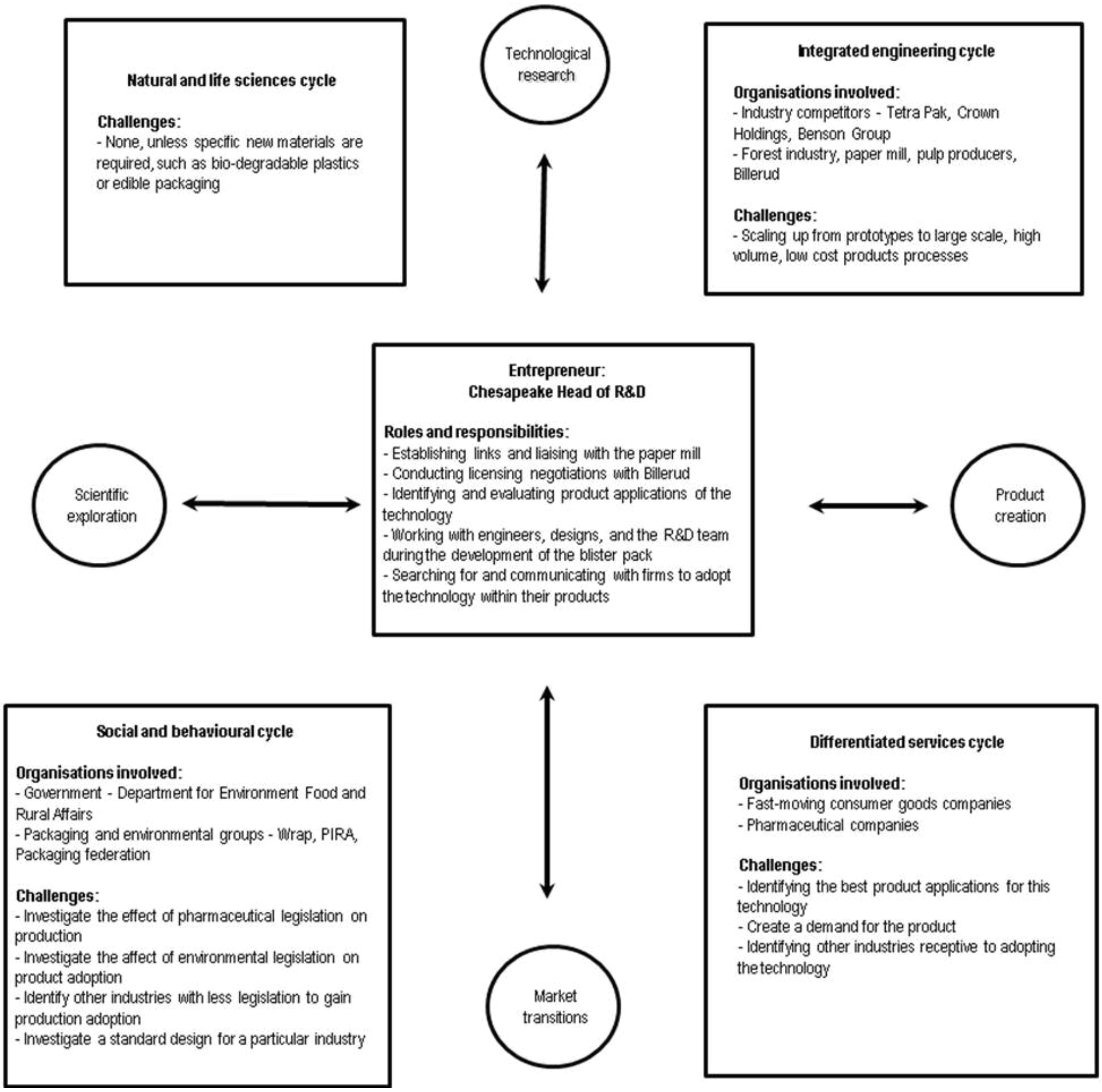
The product development process of the new blister pack packaging soon ran into difficulty. The initial relatively shallow indentations created as part of the early experimental development stages were produced using the existing machine tools; more significant indentations (including deeper and larger areas), however, required new machinery with the capability to produce a much larger force to compress the board. *"Clearly, additional machinery costs would raise adoption barriers for potential customers"* [P6]. Chesapeake's tooling partner was initially sceptical about the concept and the likelihood of success. This was because the firm had over 40 years of experience of producing polymer based blister packs, it was wedded to the idea that only polymers could be moulded to its tooling. It was therefore reluctant to become involved it what it saw as *a 'crazy idea,* *that was unlikely to be commercially useful*". It argued that the development costs were likely to be too high especially given the unique nature of the material and the radical changes required to the production processes. Margins are tight in this industry and any cost increase is usually met with derision. Despite these concerns the R&D team at Chesapeake were confident that the benefits the new packaging brought were so great that firms would be willing to incur these cost increases: *"Looking at the toothpaste market, recently we have seen firms spend more than double on new packaging simply because of the improved decoration that they provided"* [P10]. After several months of co-development new tooling was eventually developed to accommodate the formable paperboard at a cost of £25,000.

The formable paperboard blister pack is now in production and is awaiting a customer to take the decision to incorporate the technology into its packaging: *"With the many benefits this innovative packaging brings, the total costs to the customer are more than double that of traditional plastic and foil packaging. Operating in an industry where decisions are so often based on costs has made adoption for the new packaging challenging."* [P1]. To accelerate the diffusion process Chesapeake are targeting leading pharmaceuticals companies for the adoption of the new packaging.

Analysis

CIM distinguishes four different classes of innovations. A class 1 innovation is characterised by changes being made in only one of the four cycles of CIM (the processes that connect two nodes, such as technological research and product creation). Class 2 innovations require changes to be made in two cycles, and so on. In the case of the Chesapeake paperboard blister pack, this innovation necessitates changes in three of the four cycles and is therefore classified as a complex class 3 innovation (Berkhout et al., 2010). This is illustrated in Figure 3. The following analysis will examine in closer detail the key challenges facing Chesapeake within the four cycles of CIM as well as the critical role played by the entrepreneur.

Figure 3. CIM visualises the challenges facing the development of Cheseapeake's paperboard blister pack



Natural and life sciences cycle

The natural and life sciences cycle is located at the top-left in CIM, and connects the scientific exploration node with the technological research node. Activities in this cycle are mainly concerned with (a) the fundamental understanding of a technological process, and (b) the technological application of fundamental knowledge. For low technology industries such as the packaging industry, this cycle rarely plays a significant role. However, in the current case the unique process through which the formable paperboard is created meant that this cycle was of significance. The production of the formable paperboard is associated with a patented technology (see patent number EP2505348 A2). The key challenge was developing a material that was both flexible and robust. This was achieved by using by several thin layers of paperboard and rolling them using differential speed patterns to alter the material fibres. A further challenge that could arise is if specific new materials are required, such as bio-degradable plastics or edible packaging.

Integrated engineering cycle

At the top-right in CIM is the integrated engineering cycle which connects the technological research node with the product creation node. In this cycle, technologies are turned into products either clockwise (a technology in search of a viable product) or anti-clockwise (a product in search of a suitable technology). The main challenge in this cycle is to scale up a prototype to the industry requirements of a reliable large-scale, high-volume, low-cost production process. For example, a particular challenge in the current case was the necessary investment in new machinery to create larger indentations in the formable paperboard. When developing prototypes of small items with the new material, existing machinery to Chesapeake proved sufficient. However, the firm found that new costly machinery was required when scaling up their production with the formable paperboard. If Chesapeake were to develop packaging for other markets using the formable paperboard (see Differentiated services cycle) new machinery may again be required. As increases in costs are often met with derision in process industries, this investment would act as a barrier to innovation.

Differentiated services cycle

The differentiated services cycle is located at the bottom-right in CIM, and connects the product creation node with the market transitions node. The main challenge in this cycle is to identify products for which there is a demand in the market. This cycle poses the most important challenges to Chesapeake within the entire innovation process: how to successfully commercialise the new packaging technology. Although the functionality of the new packaging does not differ substantially compared to traditional blister packs, the combination of the new material, the new production processes, and the marketing required to communicate the benefits of the new packaging to consumers does represent a significant change for firms adopting the technology. While Chesapeake's experiments and prototyping have demonstrated the product capabilities to be superior to existing packaging, the changes required for firms in adopting the technology may be too great. Such changes go beyond those to the production processes and include consumer perceptions of the new product. Marketing communications activities will be required from Chesapeake to demonstrate the superiority of the new product to potential customers and to diminish any concerns regarding product integrity for end users.

By targeting large pharmaceuticals firms Chesapeake are seeking a lead user to adopt the formable board for their blister packs and in turn to help the technology cross the chasm and gain wider market adoption. This is the most difficult step in making the transition between a few early adopters and the large mass markets of pragmatists (Moore, 1991). To achieve this aim Chesapeake will need to effectively communicate the benefits of the product relative to existing packaging and to bridge the gap between technological uncertainty and market need. They will also need to demonstrate that the benefits of the new packaging outweigh the significant increase in costs compared to existing methods. As was stated in the case, the total costs of the new packaging are more than double those of traditional blister packs. This increase comes from the new materials and more complex production process, as well as the investments in licenses, tooling and the inevitable new marketing communications for the new product.

Appreciating and understanding the potential product applications of a technology and uncovering whether markets will embrace these products is critical in the innovation process. As was uncovered in the case, firms in certain markets (i.e., toothpaste) appear more receptive to making packaging investments. Chesapeake must discover which product application from the technology will deliver a return on their investments and efforts in the innovation process. For example, using the increased indentations (5 mm depth) possible with the technology, a new box could be developed for Kellogg's featuring the brands signature cockerel protruding from the pack. This would create unique packaging, differentiating Kellogg's from their competitors on the shelf. Due to the nature of the product it may also be an application of the technology that poses fewer challenges than the blister pack. However, the decision to pursue product applications with increased indentations would necessitate greater investment from Chesapeake and incur higher costs to those firms adopting the new packaging.

Social and behavioural cycle

The social and behavioural cycle is at the lower-left in CIM, and connects the market transitions node with the scientific exploration node. The main challenges in this cycle are predominantly concerned with safely and legislation. These include the effects of pharmaceutical and environmental legislation on production. For example, pharmaceutical legislation dictates that when a new packaging format is adopted for an existing drug, a new license for that product must be applied for despite the drug itself remaining the same. New packaging formats must be shown to preserve the stability and quality of medicinal products and to protect them against all forms of spoilage and tampering (World Health Organisation, 2002). The pharmaceutical industry was identified as an important potential market but these challenges, as a direct consequence, are tougher than for a lot of other industries. Therefore, an additional challenge is to investigate the legislation for other markets that are less difficult to enter. A further challenge in this cycle is to develop a standard design for a particular industry. If Chesapeake were able to demonstrate the safety of their new packaging, as well as the benefits to the environment, and achieve a standard design for the packaging of pills and tablets this would rapidly accelerate the diffusion of their new product. For example, child-resistant closures have become a standard feature for the packaging of many pharmaceutical products. By promoting the environmental benefits of the formable paperboard material, such as biodegradability, recyclability and renewability (Vishtal and Retulainen, 2012), Chesapeake could achieve a similar dominance with their new packaging.

The role of the entrepreneur

Figure 3 depicts the central position that the entrepreneur occupies in CIM. As described earlier, the role of the entrepreneur is to coordinate the dynamic processes in all four cycles and to act as a shortcut facilitator when a need in one cycle has consequences for another cycle. For example, when the differentiated services cycle discovers that there the market wants bio-degradable packaging, or when the social and behaviour cycle reports that bio-degradable packaging will be mandatory in a the near future, the entrepreneur will act upon that by posing the new challenge to the natural and life sciences cycle.

In the present case study the role of entrepreneur in the innovation arena is played by the Head of R&D at Chesapeake. The innovation literature has consistently acknowledged the importance of the role of the individual within the industrial technological innovation process (Allen, 1997; Rothwell et al., 1974; Langrish et al., 1972; Utterback, 1975; van de Ven, 1986; Wolfe, 1994). Furthermore, a variety of key roles have developed from the literature stressing particular qualities such as gatekeeping, technology and commercial scanning, product championing and sponsorship. Such activities are typically performed or managed by the entrepreneur driving and coordinating the innovation. The entrepreneur in the current case is shown to perform many such tasks, including driving negotiations to acquire exclusivity for the material and by championing the technology despite negative assertions from other departments within the firm. CIM explicitly recognises that these formal and informal "people" activities, including formal decision-making and delegation of authority are at the heart of the innovation process, and thus fall within the category of entrepreneurship.

Firms need to consider how and in what ways the innovation will cause changes to its existing supply chain and whether new business relationships need to be nurtured that will help it develop the required supply chain. Furthermore, negotiating financial arrangements and agreeing costs, margins and royalty payments will help the firm achieve the right mix of partner firms to build its business model. As the present case demonstrates, such agreements and contracts take time to secure and are often overlooked in models of innovation. Such activities are recognised by CIM and it is the entrepreneur at the centre of the model that plays this key role and is responsible for creating a convincing business case.

Conclusions

This paper presented a unique case study demonstrating the development of an innovative technology and the challenges faced in gaining market adoption. Using a case study, we have contributed to innovation management literature by providing further evidence to show how linear models fail to capture the reality of the business process. The innovation process within the current case study was shown to be iterative. Challenges such as those faced in scaling up production required that previous development stages to be revisited. This iterative process in a low technology industry is not represented in linear models that depict a sequential stage-gate process.

This paper has also contributed to innovation management literature by applying CIM to a low technology process industry for the first time. The NPD and innovation literature contains relatively few studies on process industries (Simms and Trott, 2011; Lager and Blanco, 2010). The case study research method has made it possible to gain rich insights into a number of characteristics of the packaging industry and of challenges to technological change within the industry. The evidence from this paper reinforces previous research into process industries and confirms that the packaging industry is similar to other process industries in that high returns on investment are generated from continuous optimisation of manufacturing processes and of the existing technologies, thereby reinforcing the development paths. This leads to an environment where companies optimise their processes and technologies rather than pursue radical or risky innovation activities (Cohendet and Llerena, 2010; Malerba, 2010). This was apparent in the current case from warnings by individuals within the firm towards changing long-standing production processes. This resistance to change was also reflected in the reluctance of firms to adopt the new technology. However, the case study also revealed a level of technology development that was surprising for low technology process industries. R&D was being undertaken to develop the paperboard technology with no specific product application in mind. This reveals that even with relatively low levels of R&D investment, there is evidence of fundamental research being undertaken.

Using CIM we have explicitly highlighted the importance of the activities of the entrepreneur within a low technology process industry. As Figure 3 depicts and the case study demonstrates, the entrepreneur is responsible for overseeing the innovation process and for engaging with individuals across the organisation and many external parties. As was highlighted in the analysis, in the current case the entrepreneur was responsible for driving the development of the new technology and performed a number of key tasks throughout the innovation process. CIM has shown how complex management relationships need to be developed because organisations are trying to produce complex products and services and do so across geographic boundaries. For example, the paperboard supplier was based in Sweden while Chesapeake's production operations were based in Nottingham England. Cross-functional and cross-border task forces often need to be created and managers have to manage without authority. An important part of getting work done without authority is having an extensive network of relationships. For example, during the early stages of developing the paperboard technology the paperboard supplier sought a partner to exploit the technology. In today's complex and virtual organisations, managers need information and support from a wide range of individuals. Having the entrepreneur as central to the innovation process encourages firms to bestow responsibilities for accessing and exchanging information and for managing the innovation process to capable individuals.

This paper draws some implications for managers and firms. Firstly, the cyclic and iterative nature of CIM encourages firms to develop a structure where departments across the organisation work collaboratively and continually provide feedback to one another. This feedback acts as an important source of information and allows managers to accelerate the innovation process. Secondly, within low technology industries the case study has shown that it is possible to uncover pockets of exceptional fundamental research being undertaken. This implies that firms should continue to search for technology partners within low technology industries to help improve their innovation performance.

Finally, we would like to suggest recommendations for future research. Continuing from this paper we feel that use of CIM in other low technology industries would contribute to innovation management literature. For example, CIM could be applied in a wide-range of other process industries such as the food industry, agriculture, and metals. This would require a number of in-depth longitudinal case studies examining technology development and innovation in process industries. The application of CIM to other industries and R&D contexts would further test the robustness of the model.

References:

Adler, N., Shani, A.B. and Styhre, A. (2003). Collaborative research in organizations: Foundations for learning, change and theoretical development. Sage: London.

Ahlstrom, D. (2010). Innovation and Growth: How Business Contributes to Society. Academy of Management Perspectives, 24 (3), 11-24.

Allen, T. J. (1977). Managing the Flow of Technology. MIT Press: Cambridge, MA.

Allen, T. J. and Cohen, W. M. (1969). Information Flow in Research and Development Laboratories. Administrative Science Quarterly, 14 (1), 12-19.

Ashayeri, J. Teelen, A. (1996). A production and maintenance planning model for the process industry. *International Journal of Production Research*, *34* (12), 3311-3326.

Aylen, J. (2013). Stretch: how innovation continues once investment is made. *R&D Management, 43* (3), 271-287.

Bakker, E. J., Berkhout, A. J., Hartmann, L. and Rem, P. C. (2010). Turning Magnetic Density Seperation into Green Business Using the Cyclic Innovation Model. The Open Waste Management Journal, 3, 99-116.

Benner, M., and Tushman, M. (2002). Process Management and Technological Innovation: A longitudinal Study of the Photography and Paint Industries. *Administrative Science Quarterly, 47* (4), 676-706.

Bergfors, M., and Lager, T. (2011). Innovation of process technology: exploring determinants for organizational design. International Journal of Innovation Management, 15 (5), 1113-1140.

Berkhout, G. and Van Der Duin, P. (2007). New ways of innovation: an application of the cyclic innovation model to the mobile telecom industry. International Journal of Technology Management, 40 (4), 294-309.

Berkhout, G., Hartmann, D. and Trott, P. (2010). Connecting technological capabilities with market needs using a cyclic innovation model. R&D Management, 40 (5), 474-490.

Berkhout, G., Hartmann, D. and Trott, P. (2011). The role of entrepreneurship in innovation. International Journal of Entrepreneurship and Innovation Management, 14 (1), 60-79.

Bomsel, O. and Roos, P. (1990). From commodities to evolutionary materials: towards new forms of customer-supplier relationships. *Resource Policy, 16* (2), 104-114.

Bryman, D. and Bell, E. (2003). Business Research Methods. Oxford University Press: New York.

Burns, T., and Stalker, G. M. (1966). *The Management of Innovation, 2nd edition.* London: Tavistock Publications.

Chesbrough, H. W. (2003). The era of innovation. MIT Sloan Management Review, 44 (3), 34-41.

Chesbrough, H. W. (2004). Managing Open Innovation. Research Technology Management, 47 (1), 23-26.

Christensen, C. M., and Bower, J. L. (1996). Customer Power, Strategic Investment, and the Failure of Leading Firms. *Strategic Management Journal, 17,* 197-218.

Christensen, C. M. (1997). *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail.* Cambridge, MA: HBS Press.

Clark, R. B. (1985). The Interaction of Design Hierarchies and Marketing Concepts in Technological Evolution. *Research Policy, 14*, 235-251.

Cohendet, P. and Llerena, P. (2010) The Knowledge-Based Entrepreneur: The Need for a Relevant Theory of the Firm, in: F. Malerba (Ed), *Knowledge-Intensive Entrepreneurship and Innovation Systems. Evidence from Europe*, pp. 31–51 (London and New York: Routledge).

Cooper, R. G. (1990). Stage-gate systems: A new tool for managing products. Business Horizons, 33 (3), 44-54.

D'Alvano, L. and Hidalgo, A. (2012). Innovation management techniques and development degree of innovation process in service organizations. R&D Management, 42 (1), 60-70.

Daymon, C. and Holloway, I. (2002). Qualitative research methods in Public Relations and Marketing Communications. Routledge: London.

Eisenhardt, K. (1989). Building theories from case study research. Academy of Management Review, 14 (4), 532-550.

Ettlie, J. E., Bridges, W. P., and O'Keefe, R. D. (1984). Organisation strategy and structural differences for radical versus incremental innovation. *Management Science, 30* (6), 682-695.

Flick, U. (1998). An Introduction to Qualitative Research. Sage: London.

Francis, M., Dorrington, P., and Hines, P. (2008). Supplier-led New Product Development Process Improvement in the UK Fast Moving Consumer Goods Industry. International Journal of Innovation Management, 12 (2), 195–222.

Freeman, C. (1995). The National Systems of Innovation in historical perspective. *Cambridge Journal of Economics, 19,* February, 5-24.

Fransoo, J. C., and Werner, G. M. M. (1994). A typology of production control situations in process industries. *Production Control Situations, 14* (12), 47-57.

Galbraith, J. R. (1982). Designing the innovative organisation. Organisational Dynamics, 11 (1), 5-25.

Hage, J. (1980). *Theories of Organizations.* New York: John Wiley & Sons.

Hannah, M., and Freeman, J. (1984). Structural inertia and organizational change. *American Sociological Review, 49,* 149-164.

Hatchuel, A. (2001). The two pillars of new management research. British Journal of Management, 12 (4), 33-39.

Hirsch-Kreinsen, H. (2008) Low-tech Innovation, *Industry and Innovation, 15* (1), 19–43.

Huang, J. Y., Chuo, T. C. and Lee, G. G. (2010). Understanding resource management of component followers. Management Decision, 48 (6), 952-975.

Huang, F., and Rice, J. (2012). Openness in product and process innovation. International Journal of Innovation Management, 16 (4), 24 pages.

Jick, T. (1979). Mixing qualitative and quantitative methods: triangulation in action. Administrative Science Quarterly, 24 (4), 602-611.

Kim, L. (1993). National System of Industrial Innovation: Dynamics of Capability Building in Korea. Appeared in: Nelson, R., (Editor), 1993, National Innovation Systems; A Comparative Analysis, Oxford University Press, New York.

Koene. (1988). logistick in de procesindustrie, Tijdschrift voor Inkoop en Logistiek, jrg. 4, No. 12 (Dutch)

Kroon, M. C., Hartmann, D. and Berkhout, G. (2008). Toward a Sustainable Chemical Industry: Cyclic Innovation Applied to Ionic Liquid-Based Technology. Industrial & Engineering Chemistry Research, 47 (22), 8517-8956.

Lager, T. (2000). A new conceptual model for the development of process technology in Process Industry. International Journal of Innovation Management, 4, 319-346.

Lager, T., and Blanco, S. (2010). The Commodity Battle: a product-market perspective on innovation resource allocation in the Process Industries. International Journal of Technology Intelligence and Planning, 6 (2), 128-150.

Langrish, J., Gibbons, M., Evans, W. G. and Jevons, F. R. (1972). Wealth from Knowledge. Macmillan, London.

Leiponen, A. and Helfat, C. E. (2010). Innovation objectives, knowledge sources, and the benefits of breadth. Strategic Management Journal, 31 (2), 224-236.

Leonard-Barton, D. (1992). The factory as a learning laboratory. *Sloan Management Review, 34* (1), 23-38.

Levinthal, D. (1991). Organizational adaptation and environmental selection: Interrelated processes of change. *Organization Science, 2,* 140-145.

Levinthal, D. (1997). Adaptation on rugged landscapes. *Management Science, 43* (7), 934-950.

Levinthal, D., and March, J. G. (1993). The myopia of learning. *Strategic Management Journal, 14,* 95-112.

Linn, R. A. (1984). Product Development in the Chemical Industry: A Description of a Maturing Business. *Journal of Product Innovation Management, 1* (2), 116-128.

Lockamy, A. (1995). A conceptual framework for assessing strategic packaging decisions. International Journal of Logistics Management, 6 (1), 51-60.

Lundvall, B. A. (1992). *Introduction to national systems of innovation, in National systems of innovation*. Lundvall B A (ed), 1-22. London: Pinter.

Malerba, F. (2010) *Knowledge-Intensive Entrepreneurship and Innovation Systems. Evidence from Europe.* London and New York: Routledge.

McNally, R. C., Casvusgil, E. and Calantone, R. J. (2010). Product Innovativeness Dimensions and Their Relationships with Product Advantage, Product Financial Performace, and Project Protocol. Journal of Product Innovation Management, 27 (7), 991-1006.

Moore, G. (1991). Crossing the Chasm: Marketing and Selling Technology Products to Mainstream Customers. Harper Business: New York.

Nelson, R. R. (Ed.). (1993). *National Systems of Innovation: A Comparative Study*. Oxford University Press.

Nelson, R. R., and Winter, S. G. (1982). *An Evolutionary Theory of Economic Change.* Harvard University Press.

Noke, H., Perrons, R. and Hughes, M. (2008). Strategic dalliances as an enabler for discontinuous innovation in slow clockspeed industries: evidence from the oil and gas industry. R&D Management, 38 (2), 129-139.

Nonaka, I. and Takeuchi, H. (1995). *The knowledge-creating company.* New York: Oxford University Press.

Pavitt, K. (1990). What we know about the strategic management of technology. *California Management Review*, 32 (3) 17–26.

Reichstein, T., and Salter, A. (2006). Investigating sources of process innovation among UK manufacturing firms. *Industrial and Corporate Change, 15* (4), 653-682.

Repenning, N. P., and Sterman, J. (2002). Capability traps and self-confirming attribution errors in the dynamics of process improvement. *Administrative Science Quarterly, 47,* 265-295.

Robertson, P. L., Smith, K. and von Tunzelmann, N. (2009) Innovation in low- and medium-technology industries, *Research Policy*, *38*, 441–446.

Rogers, E. (2003). The Diffusion of Innovations, 5th Edition. The Free Press, New York.

Rothwell, R. (1992). Successful industrial innovation: Critical factors for the 1990's. R&D Management, 22 (3), 64-84.

Rothwell, R., Freeman, C., Horlsey, A., Jervis, V. T. P., Robertson, A. B. and Townsend, J. (1974). SAPPHO Updated: Project SAPPHO phase II. Research Policy, 3 (3), 258-291.

Rothwell, R. and Segveld, W. (1985). Reindustrialisation and Technology. Longman, London.

Rundh, B. (2005). The multi-faceted dimension of packaging: Marketing logistic or marketing tool?. British Food Journal, 107 (9), 670-684.

Shani, A.B., Mohrman, S.A., Pasmore, W.A., Stymne, B. and Adler, N. (2007). Handbook of Collaborative Management Research. Sage, London.

Siggelkow, N. (2007). Persuasion with Case Studies. Academy of Management Journal, 50 (1), 20-24.

Simonetti, R., Archibugi, D., and Evanelista, R. (1995). Product and process innovations: How are they defined? How are they quantified? *Scientometics, 32* (1), 77-89.

Stake, R. (1995). The art of case research. Sage, California.

Stam, E. and Nooteboom, B. (2011) Entrepreneurship, innovation and institutions, in: D. Audretsch, O. Falck, S. Heblich & A. Lederer (Eds), *Handbook of Research on Innovation and Entrepreneurship*, pp. 421–438 (Cheltenham and Northampton, MA.: Edward Elgar).

Stanko, M. A. and Calantone, R. J. (2011). Controversy in innovation outsourcing research: review, synthesis and futures directions. R&D Management, 41 (1), 8-20.

Starkey, K. and Madan, P. (2001). Bridging the Relevance Gap: Aligning Stakeholders in the Future of Management Research. British Journal of Management, 12 (1), 3-26.

Trott, P. (2001). The role of market research in the development of discontinuous new products. *European Journal of Management, 4* (3), 117-125.

Trott, P. and Hartmann, D. (2009). Why 'open innovation' is old wine in new bottles. International Journal of Innovation Management, 13 (4), 715-736.

Tushman, M. L., and Anderson, P. (1986). Technological discontinuities and organizational environments. *Administrative Science Quarterly, 31,* 439-465.

Utterback, J. M. (1975). The process of technological innovation within the firm. Academy of Management Review, 12 (1), 75-88.

Utterback, J. M., and Abernathy, W. J. (1975). A dynamic model of process and product innovation. *Omega, 3* (6), 639-656.

Utterback, J. M. (1994). *Mastering the dynamics of innovation.* Harvard Business School Press, Boston, Mass.

Van der Duin, P., Ortt, R. and Kok, M. (2007). The Cyclic Innovation Model: A New Challenge for a Regional Approach to Innovation Systems? European Planning Studies, 15 (2), 195-215.

Van der Ven, A. H. (1986). Central problems: the management of innovation. Management Science, 32 (5), 590-607.

Vishtal, A., and Retulainen, E. (2012). Deep-drawing of paper and paperboard: the role of material properties. *BioResources, 7* (3), 4424-4450.

Von Hippel, E. (1978). Users as innovators. Technology Review, 80 (3), 30-34.

Wallace, T. F. (Ed.), APICS Dictionary, 5th ed., American Production and Inventory Control Society, Falls Church, VA, 1984.

Wells, L. E., Farley, H. and Armstrong, G. A. (2007). The importance of packaging design for own-label food brands. International Journal of Retail & Distribution Management, 35 (9), 677-690.

Wolfe, R. A. (1994). Organisational innovation: review and critique and suggest research directions. Journal of Management Studies, 31 (3), 405-431.

World Health Organisation (2002). *Guidelines on packaging for pharmaceuticals products.* Retrieved July 30th, 2013, from http://apps.who.int/medicinedocs/documents/s19638en/s19638en.pdf

Xu, Q., Chen, J., Xie, Z., Liu, J., Zeng, G. and Wang, Y. (2007). Total innovation management: a new paradigm of innovation management in the 21st century. The Journal of Technology Transfer, 32 (9), 9-25.

Yin, R. (1994). Case Study Research; Design and Methods. Sage, California.

Yin, R. (2003). Application of Case Study Research 2nd Edition. Sage, California.

Yin, R. (2009). Case Study Research: Design and Methods, 4th Edition, Applied Social Research Methods Series, 5. Sage, London.

Appendix 1

Table 1: Summary of interviewees throughout the research period

Participant code	Position	Job Role
P1	Head of R&D	Overview of R&D department, collaboration with suppliers, customer meetings and networking where possible
P2	Sales manager for retailers (own brand)	Manager of sales to retailers, and suppliers, for own branded products. This provided an overview of sales to each of the four major UK retailers.
P3	Sales manager for branded clients	Managed two accounts to branded companies
P4	Sales manager for individual client- FMCG & OTC Pharmaceuticals	Managed the account for a single client, with on site visits to production facilities on a regular basis
P5	Design member of R&D team	Managed the design of packaging for clients that approached the firm with a brief
P6	Marketing Manager	Overview of marketing plans, product plans, and customer relationships
P7	R&D: Technical manager/engineer	Technical development, including working with suppliers and customers where necessary/possible
P8	Head of Marketing in key supplier and collaborative partner	This member of staff worked jointly for the case firm, as well as one of its suppliers, and an industry body for the paperboard packaging industry.
P9	Industry body representative and partner to firm	This interviewee worked for a packaging industry body, but also worked closely with the case firm.
P10	Technical packaging manager in retailer	The interviewee worked as a technical manager of packaging for one of the UK's leading retailers
P11	Head of packaging design	Head of design team within one of the worlds largest food and drinks product manufacturers and brand owners.
P12	Head of packaging and reprographics at Retailer	Head of a packaging team and reprographics team, reporting to each key category manager within the own brand food and drinks operations of the retailer