Uncovering the complementarity between product and process innovation in New Product and Process Development Projects: An investigation in the UK food and drink sector

Sponsored by Kern Ltd.

Dušana Hullová

Director of Studies: Doctor Christopher Don Simms

Second Supervisor: Professor Paul Trott

This thesis is submitted to the University of Portsmouth for the degree of Doctor of Philosophy

Declaration

This thesis is submitted to the University of Portsmouth for the degree of Doctor of Philosophy.

Whilst registered as a candidate for the above degree, I have not been registered for any other research awards. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

This dissertation is the result of my independent work/investigation, except where otherwise stated. A reference list is appended.

I hereby give consent for my dissertation, if accepted, to be available for photocopying and inter-library loan, and for the title and summary to be available online.

Signed ……… ………………………….

Dusana Hullova

Acknowledgements

I would like to thank my supervisors, Dr. Christopher Simms and Professor Paul Trott for their constant support, ideas and encouragement. They devoted significant amount of time to help me shape my ideas and guided me through the entire research. They provided me with several different opportunities to present my research at conferences at the Portsmouth Business School as well as at International conferences such as the 22nd Innovation and Product Development Management Conference in Copenhagen in 2015. Moreover, they provided me with the opportunity to join the Doctoral Summer School in Belgium at the end of my first year. The participation in the Summer School and possibility to meet with Journal Editors of the leading Innovation Journals provided me with valuable feedback on the conceptual working paper containing the theoretical grounding of my PhD thesis. My supervisors have always encouraged me to attend Food and Drink sector exhibitions that also enabled me to build new contacts for primary data collection as well as to get up-to-date information about what is happening the sector. I would like to say thank you also to my PhD sponsorship company, KernPack Ltd. for providing me with valuable insights into the food and drink sector and contacts for my primary data collection.

Last, but not least, I would also like to say thank you to my parents, sisters Eva and Silvia, partner Pavel and grandmother Elenka, who were always there for me when I needed them the most.

Abstract

The purpose of this research project is to provide a starting point in examining the relationship between product and process innovation beyond the industry and company level. This is the first study to integrate perspectives from project portfolio management, contingency theory and the resource-based view of the firm. This study further demonstrates how differences in resources and capabilities, combined with the specific needs of the New Product and Process Development Projects will influence the type of complementarity between product and process innovation.

The research project contributes to the research on complementarities by proposing a new classification that defines seven unique complementarities between product and process innovation and plot them on a Product-Process Complementarity Map. This map was developed to help Product and Process Development Managers to visualise the variety of options available to the companies during their New Product and Process Development Projects. This research project is further enriched by identifying three contingency factors that influence adoption of complementarity strategy at the project level: (1) technology trajectories, (2) power of supply chain, (3) potential and realised absorptive capacity. These three discrete, but interrelated resources and capabilities, are widely referenced in the context of low technology process industries - particularly the food and drink sector. These two contributions are brought together in the Typology: The Complementarity-Capability Matrix. This Matrix proposes seven complementarity strategies and identifies resources and capabilities, necessary to achieve them.

The theoretical contributions are tested and extended in the empirical part of the research project, using qualitative data collection techniques. The findings from Phase 1 highlight that choice of complementarity strategy is not an integral part of the New Product and Process Development project planning. Food and drink companies do not actively manage and consider complementarity types available to them during the project - some of the companies are not even aware of their existence. Innovation strategies adopted within projects are mainly influenced by sunk costs, premature scrapping of existing production machinery and by retailer's order specifications for their own-label products. Furthermore, internal organisational perception of innovation within food and drink companies negatively influences product and process innovation. Companies are, to a large extent, focused on efficiency and day-to-day operations leaving limited space for exploration of new ideas. Findings from Phase 1 led to a Revised Product-Process Complementarity Map and identification of an additional complementarity; Incremental Reciprocal complementarity.

Phase 2 of data collection tested and extended the Typology: The Complementarity-Capability Matrix using eight 'illustrative' case studies. Although, the data from case studies generally supported the three proposed contingencies to influence the complementarity strategy. Several non-confirming cases revealed limitations of the Matrix and provided further guidance in allocation of resources and capabilities towards different projects. The revised version of the Typology is designed to contribute to the understanding of complementarities beyond the industry and company level. This Typology aims to guide managers' decisions when facing New Product and Process Development Projects within the food and drink sector (as well as other low-technology sectors).

Table of Contents

List of Tables

List of Figures

Figure 31. Visualisation of New Product and Process Development projects identified during the Phase 1 within the Revised Product-process complementarity map to position a portfolio of projects

Abbreviations

BIS Department for Business, Innovation and Skills

CFC Cross-functional collaboration

CIAA European Confederation of the Food and Drink industry

CIS Community Innovation Survey

DEFRA Department for Environment, Food and Rural Affairs

EAMA Engineering and Machinery Alliance

EPSRC Engineering and Physical Sciences Research Council

EU European Union

FDF Food and Drink Federation

GCA Groceries Code Adjudicator

IGD Institute of Grocery Distribution

KPI Key Performance Indicators

LMT Low-medium technology industries

NPD New Product Development

OECD Organisation for Economic Co-operation and Development

R&D Research and Development

PAC Potential absorptive capacity

PCS Prospective Case Study Design

RAC Realised absorptive capacity

ROI Return on investment

RBV Resource-based View

SME Small and Medium sized

TSB Technology Strategy Board

UK United Kingdom

CHAPTER 1. INTRODUCTION

1.1 Overview of limitations of the literature: Understanding the complementarity between product and process innovation

Product and process innovation are commonly interrelated. The introduction of a cost-reducing process is often accompanied by changes in product design and materials, while new products frequently require the development of new equipment (Lager, 2002; Reichstein and Salter, 2006; Tang, 2006). Companies that are able to develop a tighter relationship between product and process innovation are likely to enhance the cost efficiency of production, achieve smoother launch of new products, and create new opportunities for product and process development (Pisano and Wheelwright, 1995; Pisano, 1997). Despite all of these benefits, over the past decades, the understanding of complementarity between these two types of innovative activities has been a rare theme in the innovation literature (e.g. Damanpour and Gopalakrishnan, 2001; Damanpour, 2010; Kotabe and Murray, 1990).

Models of the dynamics of product and process innovations were mainly developed at the industry level (Abernathy and Utterback, 1978; Barras, 1986). Given the limited number of models developed at the company level (Damanpour and Gopalakrishnan, 2001), the majority of studies have focused on studying these two phenomenon separately. Researchers claimed, that product and process innovation are two different ways of contributing to the competitiveness of the company and as such, are influenced by environmental and organisational factors, such as intensity of competition (Kotabe, 1990; Weiss, 2003), company size (Cabagnols and Le Bas, 2002; Fritsch and Meschede, 2001) and the industrial context (Berchicci et al., 2013).

The stream of research investigating complementarities has followed two different perspectives. One group of researchers directly tested the economic value of combining different activities and practices on organisational performance, termed and defined by Ballot et al. (2015) as *complementarities-in-performance* (Pisano and Wheelwright, 1995; Pisano, 1997). The other group of researchers focused on *complementarities-in-use*, aiming to identify links between the two sets of activities and argued that one practice often requires (depends on) the another practice. These authors identified "mutual and beneficial integration between two sets of activities" (Ballot et al., 2015, p.218). Four sub-categories emerged following the second approach: i) product and process innovations are interrelated - often implying expressions such as "brothers" (Reichstein and Salter, 2006) or "fuzzy set" (Limet al., 2006), ii) product innovation creates a need for process innovation (Damanpour and Gopalakrishnan, 2001; Kraft, 1990), iii) process innovation creates a need for product innovation (Kurkkio et al., 2011; Novotny and Laestadius, 2014), iv) portfolio of relationships exists between product and process innovation (Evangelista and Vezzani, 2010; Hayes and Wheelwright, 1979; Pisano and Shih, 2012).

These studies frequently proclaimed that the synchronous adoption of product and process innovation is the 'single best complementarity strategy' (Lager, 2002; Damanpour, 2010). It was also common for these studies to generalise their findings to a single industry sector, i.e. companies operating in the metal manufacturing industry should follow the product-process sequential pattern in their innovation strategies (Kraft, 1990). It may be that, these two common features of prior studies have resulted in the 'fallacy of the wrong level', because companies operating within a single industry sector could differ in their complementarity strategies (Hullova et al., 2016, p. 930). Moreover, the extant literature does not account for the fact that companies are likely to be working on a portfolio of New Product and Process Development Projects that have different aims and require different set of resources and capabilities (Bruch and Bellgran, 2014; Cooper et al., 1997; Hullova et al., 2016). A review of prior studies also reveals that they have adopted a wide variety of approaches and methodologies, and explored different industries, sectors and structures. This suggests the immaturity of this research field, which has not progressed sufficiently to constitute a theory that would offer specific scenarios defining different types of complementarities or conditions for their emergence (Ennen and Richter, 2010). The intent of this research project is to provide a starting point in this research area.

1.2 Theoretical background

To understand complementarity between product and process innovation, industry, company and project levels of analysis are required. Nonetheless, research has predominantly favoured the perspectives portrayed in the two industry level models (Abernathy and Utterback, 1978; Barras, 1986). These models propose sequential complementarity between product and process innovation. However, it was soon noticed that these models oversimplified the industrial reality (Pisano, 1997; Lager, 2011). 'The fallacy of the wrong level' has been recognised by Utterback (1994) in his book *Mastering the Dynamics of Innovation*, where he also referred to the company level. Models such as The Product-process matrix (Hayes and

Wheelwright, 1979a; Hayes and Wheelwright, 1979b) and The Modularity-maturity matrix (Pisano and Shih, 2012) published in the Harvard Business Review, moved away from the industry level and tried to portray the different complementarity options at the company level. On the other hand, studies based on the Community Innovation Survey (CIS) tended to classify the complementarity innovation strategies using company level (Battisti and Stoneman, 2010). For example, Evangelista and Vezzani's (2010) study identified four innovation modes with an aim to synthesise the highly heterogeneous nature of firm's innovation behaviour (product oriented / process oriented / organisational and complex innovation modes).

All of these classifications fail to take into an account the possibility that companies within a single industry sector could differ in the types of complementarities they adopt in their New Product and Process Development Projects. This research project builds on the assumptions of Bruch and Bellgran (2014) and Cooper et al. (1997) and argue that companies can be working on a portfolio of projects. In these portfolios more breakthrough innovations with a high degree of risk, but a potential for development of a competitive advantage, are combined with "safer" projects with a high success probability ratio. Perhaps the most commonly cited model in this area is the typology of development projects by Clark and Wheelwright (1993) where they differentiate between New Product Development (NPD) projects based on the extent of product change and manufacturing process change. However, this work failed to uncover the pattern in which the product and process innovation take place within these projects.

Significantly, Child (2005) stressed the importance of expanding the boundary conditions in applying the contingency theory in order to address changes in organisations that occurred throughout the past 20 years. Van de Ven et al. (2013) started to question the assumption of ‘one best way’ and argued that due to the organisational complexity applying the organisational contingency theory is a way to uncover it. For the purposes of the current research, the contingency perspective is perceived as the most relevant theory. Prior studies have argued that the complementarity between product and process innovation does not resemble a common pattern across organisations, even when they belong to the same industry. Due to the differences in organisational contingencies the fit between product and process innovation may be unique, even across a different types of organisations (Ballot et al., 2015; Damanpour, 2010).

Furthermore, within the contingency approach, there seems to be a broadly shared view that there is a need to understand those contingencies that may influence the types of complementarities evident inside the company (Lager, 2002; Lim et al., 2006; Damanpour, 2010; Storm et al., 2013). A recent empirical study conducted by Ballot et al. (2015), identified great firm-to-firm variances in different complementarity strategies among UK and French companies based on the Community Innovation Surveys (CIS). They concluded that *“the effectiveness of the various combinatorial strategies is dependent on the institutional context and firm characteristics in which these combinatorial strategies are embedded”* (Ballot et al., 2015, p. 13). Further factors identified by these studies include financial knowledge and market obstacles (Ballot et al., 2015), firm characteristics (Battisti and Stoneman, 2010; Evangelista and Vezzani, 2010; Storm et al. 2013; Lim et al., 2006), different phases of product and process development and customers (Lager, 2002), but also complex, less uncertain and tighter environment (Kim et al., 1992). The majority of these studies were based on the results of CIS, a questionnaire among manufacturing and service companies that takes place every two years in all European Union (EU) member countries (e.g. Battisti and Stoneman, 2010; Evangelista and Vezzani, 2010; Ballot et al., 2015). Due to the differences among the sectors investigated in this study, the results are difficult to generalise. Furthermore, the identified contingencies were based on assumptions and propositions that were developed without a clear guidance on the type of complementarity likely to result. To resolve this, this research project combines the perspectives from contingency theory and Resource-Based View (RBV), which contends that resources across companies are unevenly distributed. Furthermore, RBV argues that there are considerable differences in ways in which the companies are able to deploy their resources and achieve new product and process development strategies (Barney, 2001; Fredericks, 2005). Moreover, companies do not achieve success only due to their superior resources, but rather because of distinctive capabilities that enable them to utilise organisational resources in order to achieve a certain end result (Helfat and Peteraf, 2003; Mahoney, 1995).

1.3 Research context and Research questions

Given the theory-building purposes of this research, the research project is positioned within the context of process industries in order to demonstrate the relationship between product and process innovation. Previous research has emphasised that within the process industries a product innovation is related to process innovation (Kurkkio et al., 2011; Lager, 2002; Lim et al., 2006; Storm et al., 2013). A few studies have taken place in high-technology industries (e.g. pharmaceutical, biopharmaceutical industry), in which both product and process technology are rapidly evolving and therefore must be well synchronised (Feldman and Ronzio, 2001; Pisano and Wheelwright, 1995; Pisano, 1997). There is, however, a lack of academic attention to low-medium-technology (LMT) sectors of process industries (e.g. food and beverage, metal, mineral, pulp and paper).

This research is positioned in a context of low-technology process industry, the food and drink sector. There is only a handful of studies investigating product and process innovation in this sector. Moreover, the existing studies examined these two innovation types as separate phenomena (Avermaete et al., 2004; Baregheh et al., 2012; Capitanio et al., 2009).

Food and drink manufacturing is the United Kingdom's largest manufacturing sector worth £81.8 billion and accounting for 15.7% of UK manufacturing (FDF, 2016). The sector feeds almost 27 million households, serving 64 million people. This equals to £113.5 billion of household expenditure on food and drink in 2015, making it the major contributor to the UK economy (Department for Environment, Food and Rural Affairs, 2016).

The UK grocery market is dominated by four major supermarkets, known as the 'Big Four' due to their significant power within the supply chain. These are; Tesco with the highest market share of 28.6%, Sainsbury's 16.5%, Asda 16.5% and Morrison's covering 11% of the market. However, the hard discounters, Aldi, Iceland and Lidl, continue to increase their market share, currently accounting for 11.4% of the grocery market (Euromonitor International, 2015). The sector is commonly described as mature and slow-growing low-technology process industry with a level of investment into R&D of less than 1 per cent (Costa & Jongen, 2006; Lager, 2011; Vyas, 2015). This equaled to £425 million in 2013 (Food and Drink Federation, 2016). It is also clear from the literature that companies operating within this industry are focused on minimisation of production costs with a very low R&D investment in comparison to medium and high-technology sectors of process industries (Beckeman et al., 2013; Costa and Jongen, 2006; Galizzi and Venturini, 1994).

Only 10% of businesses have their own R&D facilities (Vyas, 2015). There are only a few examples of new product development projects that move away from this perspective (Bigliardi & Galati, 2013; Simms & Trott, 2010). Positively have performed packaged food categories such as ready meals, especially hot cereals with the on-the-go breakfast pots, as consumers are constantly looking for ways to make their lives easier (Euromonitor International, 2015).

The UK Food and drink manufacturing sector has been traditionally known as the one lagging behind other industries in terms of adoption of new production technologies (Simms and Trott, 2014). The features of food products are variable in terms of shape and size and therefore majority of companies is still using low-skilled labour. It is expected that in the coming years there will be a shortage of workforce willing to work for minimum wages and therefore, an automation of food processing and installation of robots is seen as one of the major growth areas in the food industry (Automation Study, 2010). According to the results of the UK Annual Manufacturing Report (2016), companies are generally not aware of the benefits of automations and they poses limited knowledge about other companies that have been already successfully automated. Moreover, the European Confederation of the food and drink industry concluded on the basis of findings from report on the competitiveness of the European food and drink industry that its innovation potential has to improve to stay competitive (CIAA, 2008). Globalisation, consumers' demand for variety and quality, presence of powerful players in the supply chain, combined with developments in biotechnology all lead to the need for innovation of food processing companies (Brinkmann et al., 2014; Fortuin and Omta, 2009; Tell et al., 2015; Traill and Meulenberg, 2002). Furthermore, research provided evidence that radical food and drink innovations are more successful than incremental line extensions and me-too products (Baker, 2013; Knox et al., 2001; Lagnevik et al., 2003; Lefebvre et al., 2015). All the above factors make management of product and process innovation and understanding of factors that influence relationship between the two a pressing issue (Fortuin and Omta, 2009).

This research project builds upon the existing limitations of the five streams of literature on complementarities with an aim to provide a classification of complementarities between product and process innovation occurring at the New Product and Process Development Project level. Moreover, it aims to identify contingencies (resources and capabilities) that influence the choice of a certain complementarity strategy in the context of the food and drink sector.

This leads to the following research questions;

1) *How do food and drink companies manage the complementarity between product and process innovation in New Product and Process Development Projects?*

2) *How different contingencies, in terms of resources and capabilities, influence the adoption of different complementarity strategies?*

1.4 Overview of research approach

To address the research questions, this study utilised a two-phased approach. The first of the two main phases presents an exploratory study of semi-structured interviews undertaken in the food and drink manufacturing and packaging sector with NPD, Innovation, Production, Sales Managers as well as industry consultants. This phase enabled the researcher to develop insights into the management of the complementarity between product and process innovation in the New Product and Process Development (NPPD) projects in the UK food and drink industry. The design of this phase was based on questions to be addressed in answering research question 1. Overall, this phase enabled the researcher to gain further insights into companies' attitudes towards product and process innovation as well as their understanding of complementarity between these types of innovation. Phase 1 was also used to confirm the complementarities identified in the Product-Process Positioning Map, and identify any further complementarities that occur in the NPPD projects to be further investigated in the Phase 2 as case studies (Edmondson and McManus, 2007).

The Phase 2 of data collection subjects the Typology: Complementarity-Capability Matrix to validation and extension using abductive approach and eight case studies of New Product and Process Development Projects from the food and drink sector (each complementarity strategy examined on a single 'illustrative' case study). Dubois and Gadde (2002) argue that a standardised conceptualisation of research process as several sequential phases does not provide the potential to utilise the advantages of a case study research. The researcher is able to make the most out of the theoretical and empirical phenomena by going 'back and forth' across different research activities, known as matching; e.g. theoretical framework, existing literature, theories and empirical data. The initial theoretical framework served as a guidance for the research project or in other words as 'preconceptions' and was continuously developed over time following the findings in the empirical world. The main logic in the research was that the theory cannot be understood without observations in the empirical world.

1.5 Contribution of the research project

This research project contributes to the existing literature on complementarities between product and process innovation by providing conceptually developed, evidence based research. The study of complementarities in New Product and Process Development projects contributes to the existing literature and research in the Innovation Management field in particular. But, also to the fields of Technology and Operations Management. This study makes six unique contributions to the literature.

First, the research project builds upon perspectives from Contingency theory (Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Thompson, 1967), and brings together five existing streams of literature on complementarities between product and process innovation (Abernathy and Utterback, 1978; Barras, 1986; Lim et al., 2006; Wheelwright and Clark, 1992). This results in a first attempt to identify seven different complementarities between product and process innovation at the New Product and Process Development Project level: *Reciprocal, Product* and *Process Sequential, Incremental Reciprocal, Process Amensalism* and *Product* and *Process Pooled*. The complementarities identify a specific pattern between product and process innovation at which the complementarity occurs. In addition, the complementarities are arranged by the extent of complementarity between product and process innovation, from high to low extent.

This classification is illustrated in the form of "The Product-Process Complementarity Map." The Product-Process Complementarity Map is further tested and extended on the basis of semi-structured interviews with knowledgeable informants from the food and drink sector. Although, existence of the Product Amensalism is not confirmed; a new complementarity type, Incremental Reciprocal complementarity, was identified. Moreover, on the basis of feedback from respondents, the Map was divided into exploration and exploitation sections.

Second, the literature on Project Portfolio Management is complemented with perspectives from the Resource-based View to uncover resources and capabilities required in different complementarity strategies in NPPD projects (Barney, 2001; Barney and Clark, 2007; Helfat and Peteraf, 2003; El Shafeey and Trott, 2014). The result are three discrete, but inter-related contingency factors that are widely referenced within the food and drink sector. In doing so, the research project provides new insights into contingencies influencing development of complementarities by identifying: *Technology trajectories, Supply chain rigidities and Levels of Absorptive capacity*. This answers the calls for future research to understand those contingencies that may influence types of complementarities evident inside the companies (Lager, 2002; Lim et al., 2006; Damanpour, 2010). These contingencies are divided between those required to achieve product innovation and those necessary to achieve process innovation in each complementarity type. Contingencies are defined within a spectrum from high/medium/low extents of technology trajectories, degrees of supply chain rigidities and levels of potential and realised absorptive capacity. Seven types of complementarities between product and process innovation are related with contingencies necessary for moving towards achieving each complementarity and result in development of a novel Typology: The Complementarity-Capability Matrix. This Typology is the first conceptual attempt to provide guidance on complementarity strategies at the New Product and Process Development Project level. It is aimed to bring more insights and a starting point for academics willing to investigate the complementarity between product and process innovation.

1.6 Structure of the research project

This research project consists of ten Chapters, including this Introductory Chapter. Chapter one presents overview of the limitations of the existing literature on complementarities between product and process innovation, theoretical background of the research, research context and research questions, overview of the research approach and concludes with contributions of the research project.

Chapter two discussed the research context, particularly the food and drink sector characterised as low-technology process industry. It examines the challenges facing the sectors as well as importance of product and process innovation to maintain its competitiveness.

Chapter three provides an overview of five streams of literature on complementarities between product and process innovation. This Chapter particularly highlights the limitations of the level of analysis of included models, conceptual and empirical studies. Moreover, a lack of holistic theoretical framework that would provide an overview of different types of complementarities.

Chapter four provides a starting point in the research area by proposing a theoretical underpinning to studying the complementarity between product and process innovation. In addition, three contingencies identified to influence product and process innovation in the food and drink sector are introduced.

Chapter five brings together five streams of literature on complementarities with perspectives from contingency theory and project portfolio management and introduces a classification of complementarities between product and process innovation at the New Product and Process Development level. In addition, the classification of complementarities is linked with three contingency factors in the Typology: Complementarity-Capability Matrix. This Matrix portrays seven complementarity strategies (propositions) that will be empirically tested.

Chapter six described the methodology. The Chapter demonstrated the reasoning behind a two-phased approach of data collection. Provides insights into selection of respondents and data collection techniques, exploratory semi-structured interviews in the Phase 1 and single case studies in Phase 2.

Chapter seven presents the findings of Phase 1 of semi-structured interviews with 18 key informants across the food and drink sector. This phase provides insights into management of complementarity in the sector and factors influencing product and process innovation among companies. Furthermore, the Product-Process Complementarity Map is tested and extended, while respondents identify 'illustrative' case studies of the seven complementarity types to be built upon in Phase 2.

Chapter eight presents the findings of Phase in the means of eight case studies of New Product and Process Development Projects. These are written to provide insights into the three contingency factors, while providing additional insights into allocation of resources among food and drink companies.

Chapter nine presents a pattern-matching analysis of ‘illustrative’ case studies with the proposed complementarity strategies (propositions) in the Typology: Complementarity-Capability Matrix. This results in a Revised Typology: Complementarity-Capability Matrix and additional propositions, providing further insights into allocation of resources and capabilities in different complementarity strategies.

Chapter ten details the conclusions, contributions to the literature, managerial implications, limitation of research project as well as future research recommendations.

CHAPTER 2: RESEARCH CONTEXT

2.1 Introduction

This Chapter provides an overview of the research context; the product and manufacturing process innovation environment in the food and drink sector. This sector can be characterised as low-technology process industry. It outlines characteristics of the sector and provides insights into some of the key challenges influencing the extent of product and manufacturing process innovation. This chapter also focuses on the importance of product and manufacturing process innovations in achieving the success of the food and drink sector and companies embedded within.

2.2 Business environment: Food and drink sector

The Food and Drink sector is the largest manufacturing sector in the United Kingdom accounting for 15.7% of the total manufacturing sector. There are 6,100 food and drink manufacturing SMEs, these account for turnover of nearly £22 billion and over 127,000 employees. While 86% of companies operating within the food and drink industry employ less than 20 employees (FDF, 2016). The industry feeds almost 27 million households, serving 64 million people. This equals to £113.5 billion of household expenditure on food and drink in 2015, making it the major contributor to the UK economy (Department for Environment, Food and Rural Affairs, 2016). Figure 1. provides an overview of the UK food and drink manufacturing by product type. The number of SMEs operating in the baking industry is the highest with the Gross Value Added (GVA) to the economy of £3.7 billion. The second largest is the meat production with £2.8 billion, followed by beverages and £ 6.3 billion (Food Pocketbook, 2015).

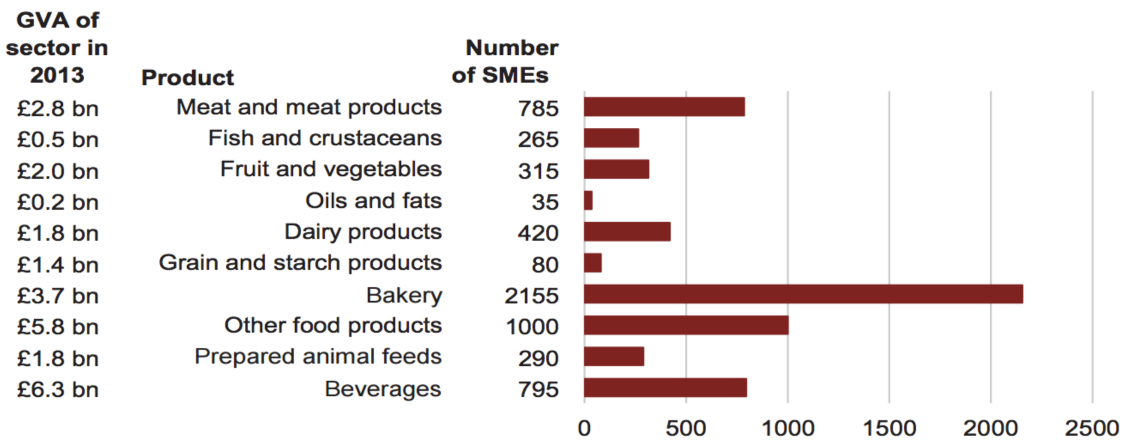


Figure 1. UK food and drink manufacturing by product type. Adopted from: Food Pocketbook (2015, p.12)

The sector is commonly described as mature and slow-growing low-technology process industry, with a level of investment into R&D of less than 1 per cent (Costa & Jongen, 2006; Lager, 2011; Vyas, 2015). This equaled to £425 million in 2013 (FDF, 2016). It is also clear from the literature that companies operating within this industry are focused on minimisation of production costs with a very low R&D investment in comparison to medium and high-technology sectors of process industries. Only 10% of businesses have their own R&D facilities (Vyas, 2015). This creates environment in which more significant innovation is stifled. There are only a few examples of new product development projects that move away from this perspective (Bigliardi & Galati, 2013; Simms & Trott, 2010). The overall number of product innovations, including both branded and private label, has decreased by 30% between 2012 and 2014 in the UK (Institute of European and Comparative Law, University of Oxford, 2015).

The food and drink industry is also characterised with a limited collaboration between the food-related R&D centres and universities (FDF, 2016). According to the FDF (2015, p. 6) there are “pockets of funding available in different areas, but no one funding body provides support for the Food and Drink industry.” According to a report by European Confederation of the Food and Drink industry (CIAA) companies should constantly work on improving their innovation potential in the years to come (CIAA, 2008). As radical product innovations are often more successful than incremental innovations, such as line extensions or flavour changes, enabling companies to stand out from competition (Knox et al., 2001; Menrad, 2004). In addition to the above mentioned characteristics of the food and drink industry there is a number of characteristics that process industries have in common, See Table 1. Also, See Table 2. for an overview of differences between Process Industries and Discrete Industries.

General characteristics of process industries	Examples from the food and drink sector
Long and complex supply and value chains (Lager et al., 2013; Lager and Storm, 2013; Storm et al., 2013)	Value chain often suffers from product/category commoditisation in food and drink industry - for example frozen ready meals category in UK with 2-4% operating margins offering 0% profitability (Delivanis and Rendle, 2015). This often leads to an aggressive trading behaviour among the supply chain. After the well-known scandal caused by the complexity and the consequent lack of communication within the supply chain (Tesco's Horse meat Scandal in 2013 - see Lawrence, 2013) the regulatory bodies are aiming to achieve higher level of transparency and communication in the already complex supply chains of food and drink manufacturers and retailers (Knott, 2016).
Asset intensive (located in few physical places), hence changes are limited in short-term (Lager et al., 2013)	For companies to achieve 'long-term' changes and to further increase their output, they often need to invest into the acquisition of new assets. For example, premium dessert manufacturer Rhokett, invested over £1.5mil to expand its production by opening new factory (Atherton, 2016a). Also, Hogs Back Brewery had to invest over £400 000 to expand its operational capacity by 30% - this was achieved through purchase of new production lines and planned warehouse extension (Atherton, 2016b)
Product and process development takes place in collaboration with manufacturers of process equipment/suppliers of raw materials (Lager and Frishammar, 2012; Reichstein and Salter, 2006; Storm et al., 2013)	Most food packaging equipment manufacturers will offer the option of tailoring a machine to the specific needs of a product (Gander, 2016- Food Manufacture). Often two different manufacturers with different skills set collaborate with one another to bring final solution to the customer. This was the case with LINPAC and GPI who together developed combined innovative packaging for patisserie products (LINPAC, 2016). Also, Macpac, the packaging manufacturer, in order to increase its product flexibility and to 'widen up' the offer for its existing and new customers worked very closely with its cleanroom environment and equipment provider Connect 2 Cleanrooms (Lake, 2016)
Products supplied to them and delivered from them are often raw materials or ingredients (Lager et al., 2013; Lager and Storm, 2013)	The packaging industry's inputs are from raw materials suppliers with their processed product being outputted to B2B manufacturers (classified as commodity process industry) (Lager and Blanco, 2010; Simms and Trott, 2014). This often has a significant impact on margins and profitability. Companies cannot control the prices and availability of the raw materials and as it can be seen in case of Macphie of Glenbervie who took a hit of over £180 000 to its profits (Addy, 2014), the commodity prices are often volatile and determined by global supply and demand which SMEs have no impact on (Bruce, 2011).

Product and process development are an interlinked process (Lager, 2002)	Boran Mopack, the Irish printing company that specialises on extrusion and flexographic printing processes had invested over £2.4 million to enhance its production capability and improve its processes in order to be able to offer new products to its customers and to enter new markets. The company is aiming to double its exports within the two years (Corbin, 2016).
Majority of product and process developments are not radical, rather incremental refinements of existing products and processes (Lager, 2002)	Meeting the customer needs in the food industry often results in introducing incremental innovations (Christensen and Bower, 1996). For example, food companies often innovate their products by introducing new flavours (The Food and Drink Innovation Network, 2016)
Focused on process improvements in terms of economy-of-scale and cost (Lager, 2002; Lager and Frishammar, 2012)	Food industry is characteristic with its high volume, broad range of products and high variety of choices. It is oriented towards price minimisation as the price-based competition is very high (Francis et al., 2008). For instance, the packaging machinery manufacturer Packaging Automation Ltd is building is competitive advantage among its customer base on provision of fast output and energy efficient machinery. The company only recently introduced tray sealing machine that is 20% faster than any other available machine in the market. Furthermore, it offers up to 98% savings when compared to pneumatically operated tray sealers (Lake, 2015). Output and cost are the driving factors in the food industry.

Table 1. Summary of common characteristics of process industries with examples from food and drink sector

	Process Industries	**Discreet Industries**
Relationship with the market		
Product type	Commodity	Custom
Product assortment	Narrow	Broad
Demand per product	High	Low
Cost per product	Low	High
Order winners	Price	Speed of delivery
Transporting costs	Delivery guarantee	Product features
New product	High	Low
	Few	Many
The production process		
Routings	Fixed	Variable
Lay-out	By product	By function
Flexibility	Low	High
Production Equipment	Specialised	Universal
Labour intensity	Low	High
Capital intensity	High	Low
Changeover times	High	Low
Work in progress	Low	High
Volumes	High	Low
Quality		
Environmental demands	Yes	Hardly
Danger	Sometimes	Almost never
Quality Management	Sometimes long	Short
Planning and Control		
Production	To stock	To order
Long-term planning	Capacity	Product design
Short-term planning	Utilisation capacity	Utilisation personnel
Starting point planning	Availability capacity	Availability material
Material flow	Divergent+ convergent	Convergent
Yield variability	Sometimes high	Mostly low
Explosion via	Recipes	Bill of material
By and Co-products	Sometimes	Not
Lot tracing	Mostly necessary	Mostly not necessary

Table 2. Differences between Process Industries and Discreet Industries. Adapted from (Ashayeri et al., 1996, p.3320)

The UK grocery market is dominated by four major supermarkets, known as the 'Big Four' due to their significant power within the supply chain. These are; Tesco with the highest market share of 28.6%, Sainsbury's 16.5%, Asda 16.5% and Morrison's covering 11% of the market. However, the hard discounters, Aldi, Iceland and Lidl, continue to increase their market share, currently accounting for 11.4% of the grocery market (Euromonitor International, 2016). This could be demonstrated by results of the Europanel survey among 11 European countries out of which the UK had the highest decrease in the size of a major retail group by 4% since 2012 (Institute of European and Comparative Law, University of Oxford, 2015). On the other hand, in countries such as Poland was observed an increase by 3.9% and in Portugal by 2.4%. Despite this, the top 4 retail groups account for 72.6% in the UK in 2016, classifying the UK grocery market into one of the most concentrated in the Europe (Food Pocketbook, 2015; IGD Retail Analysis, 2016). Further intensifying the power of the 'Big Four' within the supply chain. The above mentioned retailers operate a range of different retail formats (See Table 3.). Out of these supermarkets, convenience stores and discounters account for the highest market share value by channel (See Table 4.). Even though the online sales of food and drink have attracted a significant part of media coverage over the past few years, they still account only for 5% of food retailer's sales (IGD Retail Analysis, 2016).

Retail format	Definitions
Hypermarkets	Large format stores that sell a full range of grocery items and a substantial non-food range. Sales areas are typically 60,000 sq ft+
Supermarkets	Defined as food-focused stores with sales areas of between 3,000 and 60,000 sq ft
Convenience stores	Stores with a sales area of less than 3,000 sq ft, which are open for long hours and sell products from at least seven grocery categories. Includes standalone forecourts with convenience stores
Discounters	Includes all sales through food discounters Aldi, Lidl and Netto and the grocery sales of the high street discounters such as Poundland and B&M
Other retailers	Includes stores with a sales area of less than 3,000 sq ft, typically newsagents, off-licences, some forecourts and food specialists, such as butchers and bakeries. This channel also includes the grocery sales of predominantly non-food retailers such as department stores
Online	Internet orders placed at grocers and online food specialists for home delivery and customer collection

Table 3. Definitions of the retail formats: Adopted from UK Groceries retailing. Adapted from IGD Retail Analysis (2016)

Channel	Value by channel
Supermarkets	£86.6bn
Convenience	£37.5bn
Discounters	£17.9bn
Hypermarkets	£16.5bn
Online	£10.5bn

Table 4. Market share value by channel in grocery retailing Great Britain in 2016. Adapted from IGD Retail Analysis (2016)

According to Mintel Academic (2015) majority of consumers prefer to shop at Tesco due to the benefits they could receive through the Tesco loyalty card. On the other hand, consumers shop at Sainsbury's because they offer a wide range of good quality fresh products. Asda is associated with low price, however this comes along with poor quality fresh food, store decór and lack of cleanliness. Moreover, it is missing to provide the most important factor in the consumer's eyes and this is the value for money. This attribute has been identified at the best performing supermarkets, Aldi, Lidl, Marks & Spencer and Waitrose. This could be demonstrated by the campaign "pick your own offers" for users of the loyalty card by Waitrose. The retailer aims to provide further personalisation of its services by providing their customers an opportunity to pick 10 products from the list of 1,000 and enjoy 20% discount. This will enable Waitrose to differentiate itself from the loyalty card schemes such as Nectar, Boots and Tesco Clubcard that have relied upon collecting points that often took long time to accumulate (Mintel Academic, 2015).

GBP million	2010	2011	2012	2013	2014	2015
Baby Food	602.24	662.13	708.93	753.49	756.35	769.32
Baked Goods	6,367.45	6,395.06	6,517.66	6,547.23	6,401.45	6,315.34
Biscuits and Snack Bars	2,546.49	2,692.47	2,904.97	3,013.56	3,063.40	3,147.61
Breakfast Cereals	1,687.35	1,756.81	1,834.87	1,879.66	1,893.42	1,918.53
Confectionery	7,286.16	7,568.93	7,926.06	8,144.36	8,257.69	8,370.45
Dairy	9,545.29	9,781.90	10,061.89	10,217.98	10,198.01	10,202.44
Ice Cream and Frozen Desserts	1,662.14	1,738.20	1,841.36	1,892.79	1,938.88	1,976.18
Oils and Fats	1,624.01	1,727.94	1,801.00	1,783.85	1,789.70	1,785.27
Processed Fruit and Vegetables	2,221.31	2,269.06	2,323.17	2,388.02	2,350.88	2,339.98

GBP million	2010	2011	2012	2013	2014	2015
Processed Meat and Seafood	7,748.59	7,941.11	8,052.00	8,264.61	8,320.94	8,240.20
Ready Meals	3,788.42	3,988.85	4,163.24	4,192.20	4,316.97	4,416.31
Rice, Pasta and Noodles	1,190.53	1,288.56	1,356.57	1,391.72	1,438.24	1,475.86
Sauces, Dressings and Condiments	2,532.38	2,654.18	2,746.14	2,813.65	2,886.96	2,938.25
Soup	612.68	649.09	680.74	694.07	670.78	656.39
Spreads	492.27	516.44	538.24	561.47	572.15	589.29
Sweet and Savoury Snacks	3,685.50	3,903.73	4,128.39	4,319.89	4,394.20	4,473.27
Packaged Food	53,592.81	55,534.47	57,585.23	58,858.54	59,250.03	59,614.69
Source: Euromonitor International from official statistics, trade associations, trade press, company research, store checks, trade interviews, trade sources						

Table 5. Sales of packaged food by category 2010-2015. Adopted from Euromonitor International (2016)

Table 5. provides insights into the sales of packaged food by category 2010-2015. It identified the size of the market and outlines the growth in spending within the key sectors.

The growth in packaged food has been less than 1% in value terms. Some of the main reasons for this were; British public increasingly visiting foodservice outlets, a low number of successful innovations and deflationary movement in unit prices due to increasing sales at discounters. The competitive landscape is dominated by the supermarket and hypermarket chains offering private label products, while Tesco Plc (9.15%), J Sainsbury Plc (6.14%) and Asda Group Ltd (5.11%) account for the highest market share of the private (own) label products (See Table 6.). There is a number of other major players that provide a range of branded products breaching the £1 billion threshold in value sales. The retail value of private label products has only slightly increased between 2011 and 2015 by 0.4% reaching 34.8% (Euromonitor International, 2016).

% retail value rsp	2011	2012	2013	2014	2015
Tesco Plc	9.15	9.12	9.11	9.04	9.00
J Sainsbury Plc	6.14	6.15	6.19	6.27	6.30
Asda Group Ltd	5.11	5.10	5.10	5.13	5.12
Mondelez UK Ltd	-	4.13	4.21	4.27	4.29
Mars Food UK Ltd	3.30	3.29	3.32	3.27	3.27
Wm Morrison Supermarkets Plc	3.02	3.01	2.97	2.92	2.89
Walkers Snack Foods Ltd	2.27	2.34	2.39	2.35	2.37
Nestlé UK Ltd	2.25	2.21	2.15	2.05	1.98
Premier Foods Group Ltd	2.22	1.97	1.81	1.77	1.74
Heinz Co Ltd, HJ	1.95	1.92	1.83	1.74	1.71
Marks & Spencer Plc	1.49	1.54	1.59	1.67	1.71
Kellogg Co of Great Britain Ltd	1.23	1.57	1.58	1.53	1.52
Arla Foods Ltd	1.13	1.18	1.34	1.41	1.46
United Biscuits (UK) Ltd	1.32	1.34	1.34	1.35	1.40
Unilever Foods UK Ltd	1.67	1.56	1.48	1.36	1.35
Warburtons Ltd	1.40	1.37	1.37	1.26	1.16
Dairy Crest Group Plc	1.32	1.28	1.17	1.15	1.15
Unilever UK Ltd	0.72	0.91	0.96	1.01	1.05
Müller Dairy (UK) Ltd	0.97	0.95	1.00	0.99	0.98

Table 6. Overview of companies with highest retail value (%) of packaged food in the UK 2011-2015. Adapted from Euromonitor International (2016)

2. 3 Challenges facing the sector

In recent years the UK food and drink sector has undergone some major changes. These relate mainly to the increasing power of the 'Big Four' supermarkets in the supply chain, growth of discount retailers, changing consumer shopping habits and Industrial Revolution 4.0.

2.3.1 Discount retailers

The economic conditions have significantly improved with 2.5% real GDP growth in comparison to the previous decade in the UK. Despite this, consumers preferred to shop packaged food products at the discounter retailers rather than at the traditional supermarkets and hypermarkets (Euromonitor International, 2016). As stated by Denney-Finch, Chief Executive of IGD: *"The biggest disruptive force of the food and drink sector were the discount retailers, Lidl and Aldi. As they have both aggressively focused on increasing the number of stores to improve their nationwide presence. This was caused due to the maturity stage in which is the UK Food and Drink retail. The major retailers have held huge market share and hence disruption could have been easily caused by any other channel, 'just upping their game'. The major retailers have been victims of their own success"* (IGD Convention Keynote speech, 2014). Further expansion by Aldi and Lidl is predicted to fuel the growth of the channel from £17.9 billion (2016) to £24.9 billion (2021). This will be mainly due to development of new store formats offering a "supermarket style customer experience" and the "treasure trove experience" that will bring in new customers (IGD Retail Analysis, 2016). For instance, Tesco has retained its market share for decades, however in 2015 it reached its 10 year low in terms of the market share. Richard Perks, Director of Retail Research at Mintel argued that there are several reasons for Tesco's poor performance. These include the fact that Tesco's UK business has been treated as a cash cow for decades with a lack investment, decreasing service levels and quality of food. Marketing strategy was ineffective and did not respond effectively to Asda's price guarantee (Perks, 2015). With an aim to maintain its dominant position Tesco put into place a 'Turnaround Strategy' and with an aim to restore the trust of their suppliers and customers. Some of the key steps were;

- to decrease the number of stock keeping units by 15%
- to simplify choices made by consumers
- to update store formats to align with shoppers missions and local demographics
- to put Tesco back into the heart of local communities
- to reduce the number of stores with 24 hours opening (IGD Retail Analysis, 2016).

2.3.2 Powerful retailers

Another characteristic of the market is the anxiety of the shoppers about the price of everyday goods. They tend to choose cheaper private label products that successfully imitate branded goods and charge lower price. The 'Big Four' response to this situation is mainly through price reductions. However, the most negative impact of this situation is being experienced by suppliers of the food and drink products, who are constantly under financial constraints and tight regulations from retailers. This can be supported by a response of manager from a frozen food sector, who stated: "Retailers want to compete with the discounters but still make a large margin by beating up manufacturers. Food service is in danger of inertia by stifling innovation through commoditisation" (Pendrous, 2015, p.1). A number of fresh and packaged foods are being continuously discounted by the major retailers, i.e. milk and bread, causing further issues for others down the supply chain. Dairy farmers are loudly voicing their fear about their inability to maintain the price pressures on the production costs (Euromonitor International, 2016). This power imbalance resulted in an appointment of the Groceries Code Adjudicator following a Competition Commission Market Investigation into the groceries sector. The Competition Commission has identified that the 10 large retailers were transferring excessive risks and unexpected costs to their direct suppliers leading to discouraging suppliers from investing into quality and innovation. Small businesses could have even failed, leading to further disadvantages being imposed on consumers. Groceries Code of Practice was established in 2010 and it was designed to regulate the relationship between the 10 groceries retailers with the UK annual turnover of more than £1 billion (the large retailers) and their direct suppliers. At the beginning the Government gave these retailers time to set up a voluntary Ombudsman, however this self-regulatory approach was not successful and therefore was established the Groceries Code Adjudicator.

Groceries Code Adjudicator- Christine Tacon, was appointed as the first Groceries Code Adjudicator (GCA) in 2013 to monitor and enforce the Groceries Supply Code of Practice. The GCA is responsible for encouraging suppliers to continue to bring Code issues and evidence to its attention in order to be able to gather the evidence and justification for action. The Adjudicator has now right to charge up to 1% of their UK revenues, in case she finds an evidence that the Code of Practice has been breached (Groceries Code Adjudicator, 2016). Such case has arisen during the investigation of Tesco Plc that breached the Rule number 5 by widespread nature of the delays of payments. The Adjudicator, however, was not able to impose relevant fines as the breaches were committed before she was given the right to impose them. Following the investigation, Tesco is trying to bring its supplier and consumer loyalty back by initiatives such as the Fair For Farmers Guarantee. This logo is placed on each milk bottle, providing evidence of Tesco's British provenance and supplier support by paying them above the cost of production for their milk (White, 2016). There has been also a significant increase in the written supply agreements between Tesco with direct and indirect suppliers, increasing from 53% in 2015 to 65% in 2016 (Groceries Code Adjudicator 2016). Figure 2. portrays some of the major issues being faced by direct suppliers when dealing with the supermarkets. The three most critical issues are late payments, variation of supply agreements and terms of supply and no compensation to suppliers for forecasting errors made by the supermarkets (Groceries Code Adjudicator Survey, 2016b).

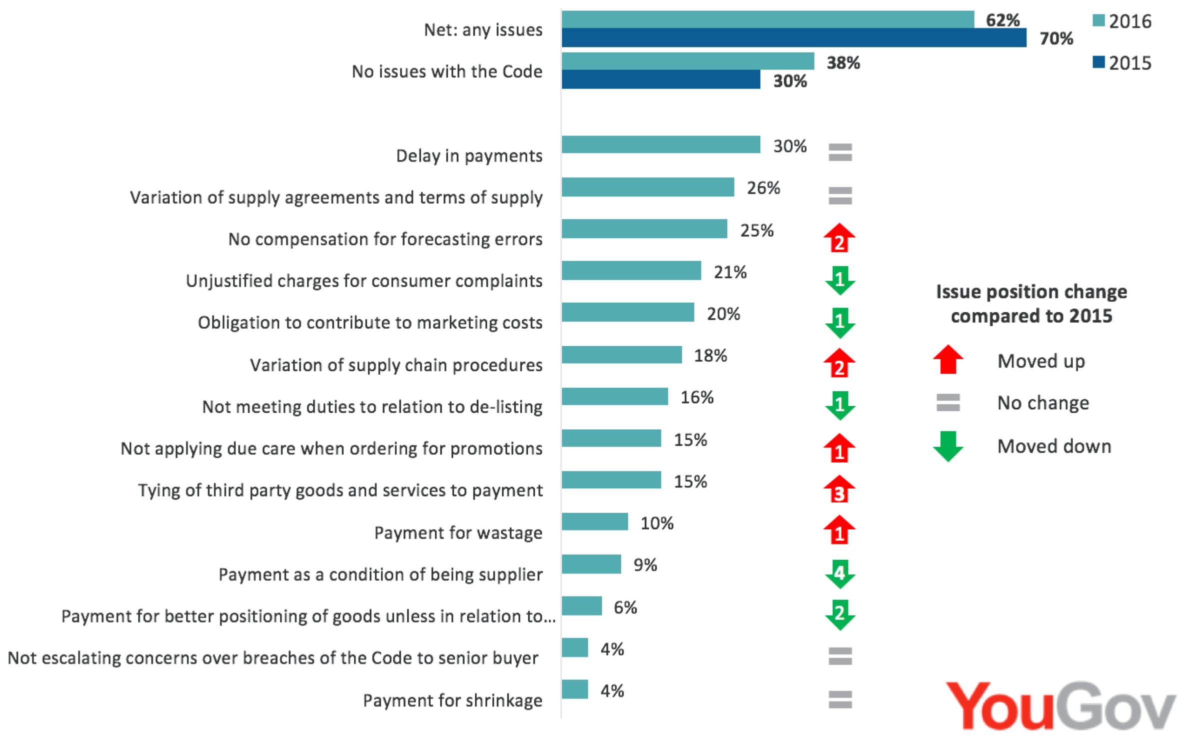


Figure 2. Issues in the language of Code of Practice from the Annual GCA Survey 2016. Adopted from: Presentation by Ellison, YouGov Director at the Groceries Code Adjudicator presented at the Conference (2016)

2.3.3 Changing shopping habits

The shopping habits of UK consumers are changing. We are seeing a shift away from superstores towards online retailing and convenience stores (C-stores) such as Tesco Express, new Co-op and Sainsbury's Local. Consumer buying behaviour has shifted from one weekly shop to shopping within consumer means and topping-up more at convenience stores when they run out. The increasing prices of petrol and car insurance are causing that younger consumers in the urban areas are cutting car usage or do not drive at all (Mintel Academic, 2015). Shoppers perceive convenience shopping as simple with high visibility of merchandise, in comparison to the huge shopping formats. The convenience channel is worth £37.5 billion (IGD, 2016). Its value is predicted to increase to £46.2 billion by 2018 (GOV.UK, 2015). This is combined with an optimistic vision the UK high street as the food retailing is coming back. Greggs, quality freshly baked food, has been specifically successful in increasing their range to include take away products.

As a response to this recent trend, the out-of-town supermarkets started to roll out new ideas such as Tesco's concept at Watford that includes Giraffe restaurant, Euphorium Bakery and Harris and Hoole coffee shop under one roof, Morrison's Format Flex Lab in Weybridge or Sainsbury's partnership with Argos (Retail Gazette, 2013).

2.3.4 The online grocery shopping sector

As stated by Monk (2016, p.1) *"the online sector is starting to mature- this way of shopping is not for everyone. That is good news for retailers as they have a vested interest in customers using their physical stores where they can market opportunity buys."* Although, the online grocery shopping has grown, by 14.9% in 2014 to reach £7.5 billion, it still accounts for only 5% of the consumer spending on food, drink and tobacco. Therefore, it has until now been perceived as more of a service to consumers than another channel that will dominate (Mintel Academic, 2016b). However, according to the Five Year Forecast Survey conducted by IGD Retail Analysis, the online channel is predicted to become one of the fastest growing at +68% throughout the next five year period (Gladding, 2016).

Some of the benefits of shopping online are saving time, effort and money. Especially consumers aged over-65, see online shopping as an advantage as they do not need the effort to bring the goods home. For instance, the Amazon Prime Now has been available in several cities in the UK and offers a number of fresh grocery items. The next big disruption on the market could be caused by Amazon Fresh, an online retailer that is popular in the US, Amazon Fresh launched on the 9th of June 2016 in 69 central and east London postcodes (Weinbren, 2016). Moreover Tesco, the largest UK retailer, took the online shopping to another level by partnering with Google Glass and combining it with its online shopping application that now allows shoppers to browse and buy Tesco products using their glasses (Farrell, 2015). Tesco responded also to the increasing number of connected home devices and introduced their own channel on the If This Than That (IFTTT) with two triggers and single action. Consumers are now able to trigger any action in case the price of any product changes or falls beyond a certain price level or use any of the triggers to add a specified item into the basket (Wilkinson and Holmes, 2016).

Another disruptive force in the online grocery shopping could become buying food, drink and household products directly from manufacturers instead of from retailers. The research carried out by Harris Interactive uncovered that consumers were mostly willing to buy toilet paper (45%) and household cleaning products (44%) directly from manufacturers if they offered them free or more convenient delivery options than their current retailer. In regards to the purchase of the food and drink products, 37% would purchase alcoholic drinks, 33% snacks and treats, 33% frozen food, 32% fresh food and 30% packaged food. These results are proposing that in the years to come, there might occur another radical shift in the UK grocery shopping, and manufacturers will gain their dominant power back (Glotz, 2016).

2.3.5 Social lifestyle

British consumers are increasingly becoming more conscious about their health and well-being, particularly obesity and diabetes. Manufacturers need to make sure that the consumer is heard and everything what is happening along the supply chain responds to the changing needs of the consumer. Food companies are constantly searching for new solutions to develop new products that are healthier to improve their brand image by reducing sugar, increasing fibre and lowering salt. All of these developments were initiated by the UK's obesity challenge (Addy, 2014b). For example the popular cereal brand Honey Monster Puff has decreased the amount of sugar from 29% to 22%, equal to 6 grams of sugar in every 30g serving (Banford, 2014).

Another way of winning new customers was by offering them single-friendly product packaging. According to the Office for National Statistics (ONS) by 2031 the number of one-person households will rise to 10.9 million, opening space for NPD in this area (Mintel Academic, 2015). Consumers are increasingly purchasing less with a higher intensity. For example, Tesco has recently introduced a two-portion packs for chicken breasts to keep food fresher for longer, “eat one and keep one” (White, 2016b). Moreover, the ageing UK population, especially over-55s is posing a challenge towards innovation in the food market (Clifford, 2016). An important role in consumer decision making is also played by the supply chain waste management that was reduced by 7.4% (217,000 tonnes) per year over three year period to 2015. The average UK household throws away around £470 a year in food that could have been eaten, this equals to 15 million tonnes of food (Food Pocketbook, 2015).

2.3.6 Brexit

Product categories that will particularly feel negative impact of Brexit will be confectionery, ready meals, snacks, fresh produce and soft drinks. This will result in confectioners as well as soft drink producers being hit by the war on sugar even more, with expected decrease in sales by 1.4% in the period between 2015 and 2020 that equals to 475 million litres. Moreover, the sharp drop in the pound could lead to increasing price of imported goods for retailers. It might be the beginning of a greater reliance on the products from Commonwealth than the European Union. Brexit will have also a significant impact on the food and drink industry workforce. Out of 450,000 people, 130,000 are Eastern European immigrants (Tatum, 2016).

2.4 Importance of Product Innovation: Food and drinks sector

The growth of packaged food remained relatively low in 2015 and the sales are predicted to grow by less than 1% by 2020 (Euromonitor International, 2015). ‘State of the industry’ has been investigated by Food Manufacture in a survey among 511 food and drink manufacturers.

According to the results 69% of the respondents agreed that the company they are working for plans to invest more into NPD in the forthcoming year. On the other hand, 65% of these respondents agreed that their customers are more focused on price than ground breaking NPD (UK Annual Manufacturing Report, 2016). In terms of NPD, positively have performed categories such as ready meals, especially hot cereals with on-the-go breakfast pots. Consumers are constantly looking for ways to make their lives easier. This was evident in the sales of dessert mixes, dinner mixes and sauce dressing where are British consumers trying to minimise the effort of preparation of a more complex food (Euromonitor International, 2015). Some further well-performing packaged products were:

- Energy and nutrition bars posts the fastest current value growth, with a 28% increase in 2014
- Sales of impulse and indulgence products reach £20 billion following value growth of 3% in 2014 (Euromonitor International, 2015)
- The total soft drinks market amounted to a value of £15.46 bn in 2013, while the fruit juices, energy and juice drinks category accounted for just under a third (33.2%) of this (British Soft Drinks Association, 2014)
- In terms of value, the bottled water market saw an 8.1% rise in 2012, before more significant growths of 13% and 9.3% were seen in 2013 and 2014, respectively (British Soft Drinks Association, 2014)

The UK food and drink manufacturers introduce over 8,000 products on the shelves every year. For example, UK was the first to introduce first frozen food, ready meals and instant coffee (GOV.UK, 2015). Achieving the innovation goals is particularly challenging in the UK as 80% of food and drink companies are medium to micro sized (FDF, 2016). Brands are the main drivers of innovation, their share is 58% of the packaged grocery market with retailers simply monitoring their success. However, less than half of the new products survives more than 3 years. The chances of surviving are highest among beverage innovations and private label products (Institute of European and Competitive Law, University of Oxford, 2015).

The major food and FMCG companies such as Unilever, Mars, General Mills, Heineken and PepsiCo are constantly searching for collaboration with researchers, technology developers, spin-outs and start-ups. These had a chance to pitch their 50 innovation areas identified by the companies at the Open Innovation Forum Food & FMCG Pitching Event. FMCG companies were particularly interested in products and technologies enhancing food preservation and extended shelf-life, reduced sugar in beverages and food as well as searching for natural/ clean label ingredients especially colours and preservatives (Management Technology Policy, 2015). According to The Economic Impact of Modern Retail on Choice and Innovation in the EU Food Sector (2015) report, the brand owners have both stronger incentives and abilities to innovate in comparison to retailers (Food Drink Europe, 2015). The main reason for innovating is the fact that new products warrant companies to charge higher prices and achieve value sales growth even though volumes keep decreasing (European Commission, 2014). Moreover, based on Mintel Academic report (2015) 17% of consumers tend to shop at a different supermarket if they get bored of products in their usual supermarket. This supports the need for constant NPD of the food and drink brands.

The UK grocery market has also seen several private label innovations, as consumers are constantly searching for ways to reduce the cost of grocery shopping. For instance the seven new farm brands range by Tesco and brands like the Waitrose are clearly trying to differentiate their own-label offering, charge premium and boost the margins (Leyland, 2016). The number of own label products on the supermarket shelf witnessed an increase of 38.7% over the past 5 years (this number includes toiletries and household essentials). The increasing sales of the private label products have also been partly influenced by the discount retailers that have convinced consumers their products were of a better quality than branded goods via word-of-mouth and focused marketing. Due to a high unemployment rate and increasing inflation, all of the major supermarkets have been introducing tiered ranges of ‘good’, ‘better’ and ‘best’ products. For instance, essential Waitrose and Simply M&S targeting the price conscious consumer, on the other hand discounters introduced premium private label ranges (Euromonitor International, 2015).

The increasing competition between private label and branded products led to practices such as delisting branded products to exchange them for own-label products by the supermarkets. For example, Waitrose delisted most of its Tropicana and Capella juices and replaced them with their own brand product. Another instance of such practices was when Sainsbury’s displayed their own label Easter eggs in the front shop area just before the Easter instead of the branded products (Spary, 2014). Furthermore, in the long term the dual role of the retailers as being the customer as well as competitor could raise concerns. In cases when the power of the retailers or the dominance of private label will become too strong it may lead to innovation suffering. This issue is particularly important in countries with highly concentrated retail markets such as the United Kingdom. A food retail sector inquiry was undertaken in Germany pointing to the positive relationship between the market share of the retailer and their bargaining power. Moreover, the leading retailers were found to have significantly higher bargaining power in comparison to their smaller competitors and manufacturers (AIM Food Drink Europe, 2015).

The most common way of NPD remains development of new variety or new extension. New packaging is becoming more important by an increase from 9.5% from 2009 to 20.45% in 2014. This provides further evidence that packaging can be responsible for the success of a product (Rundth, 2005; Simms and Trott, 2014; Simms and Trott, 2010). See Figure 3. for the NPD in the UK Food market by share of new launches and launch type 2009-2014. Some revolutionary examples from the beverage sector include the crown cork patented by Crown Holdings Inc., 2 litre polyethylene terephthalate (PET) bottles patented by Pepsi, the Dean's milk chug by Dean Foods (Risch, 2009). Consumers are particularly looking at the packaging that is easy to open, resealable and keeps the food fresh for longer. The aim is to keep reducing the food waste, but also to respond to the needs of the older generation and benefit from its growth. There still remains a belief that food products have too much packaging, and manufacturers should be focusing on minimising this. The benefits of food packaging in terms of preservation and protection of food against contamination are still underrepresented (Soininen, 2015). On the other hand food and drink manufacturers continue utilising packaging innovations to differentiate and enhance the performance of their products (Mahalik and Nambiar, 2010).

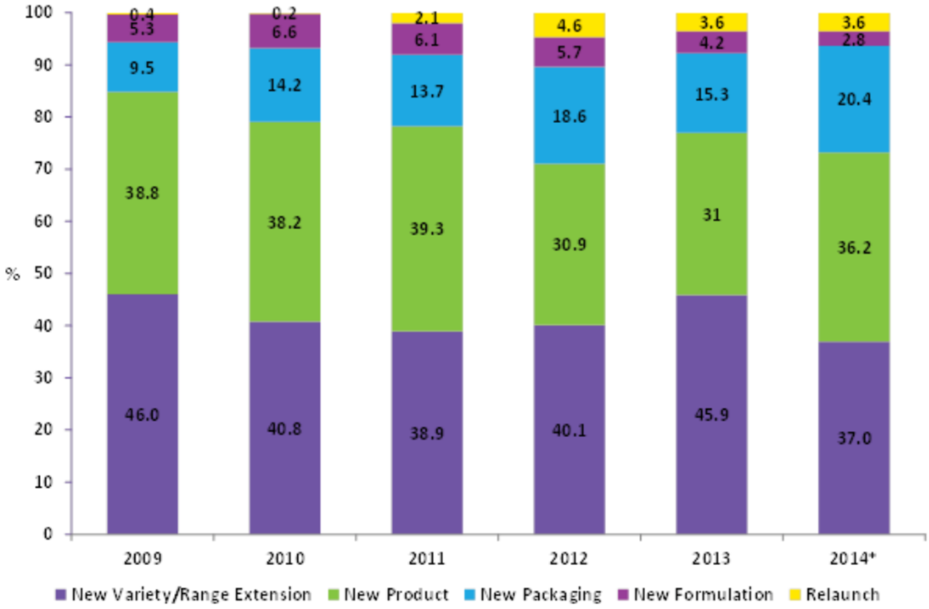


Figure 3. NPD in the UK Food market by share of new launches and launch type 2009-2014. Adapted from Soininen (2015)

According to the Mintel research (2015) conducted among 1,756 internet users aged 16+, consumers are the most open towards NPD when they are buying treats for themselves, suggesting a lot of NPD potential for brands operating in these categories in order to prevent consumers switching to competing brands. Another category where food shoppers are open to experimenting is when buying a gift. The report suggests manufacturing companies to focus on new flavours and formats to be more appealing in the gifting context. See Figure 4. for the preference of food shoppers for new vs. familiar products, by occasion (Soininen, 2015).

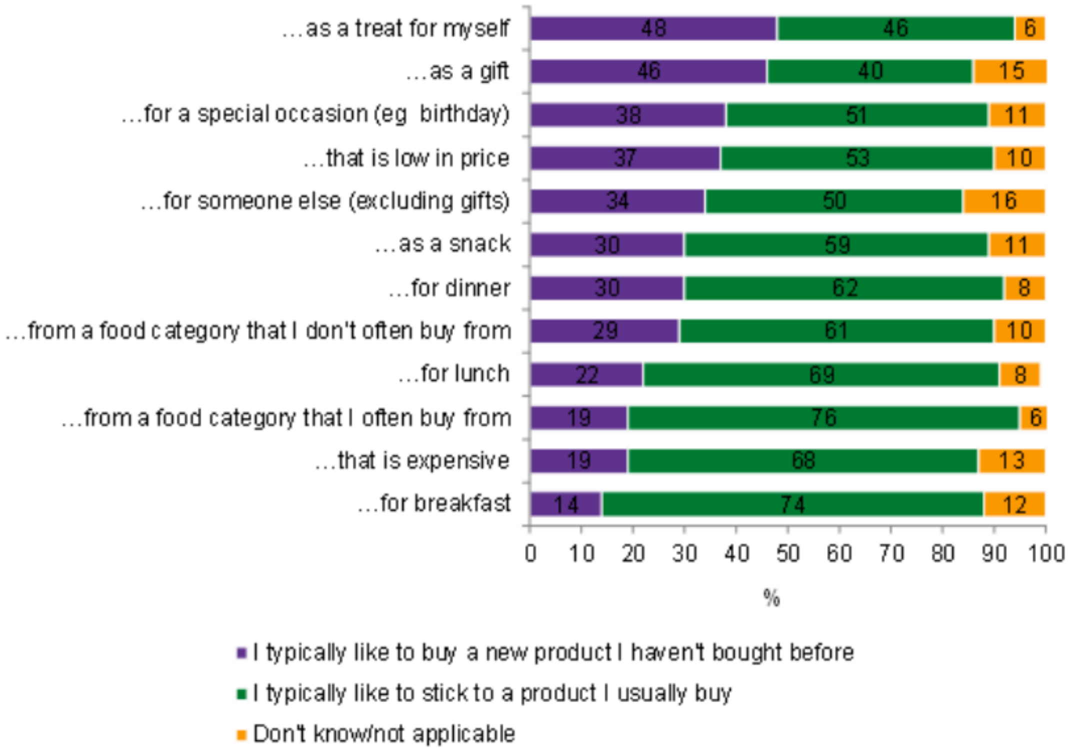


Figure 4. Preference for new vs. familiar products, by occasion, May 2015 (Soininen, 2015)

Figure 5. demonstrates the factors that prompt people to buy a new food product. The brand loyalty plays the major role in consumer's decision making when faced with a new product on the shelf. This highlights the necessity for brands to constantly innovate in order to remain competitive, but also a lot of scope for brand extensions. The category of small/trial sized packs opens opportunities for new brands as the lower price is likely to appeal in this low-involvement purchase. Among the top three factors remains the new flavour from consumer's favourite brand the most common way of NPD in the food industry.

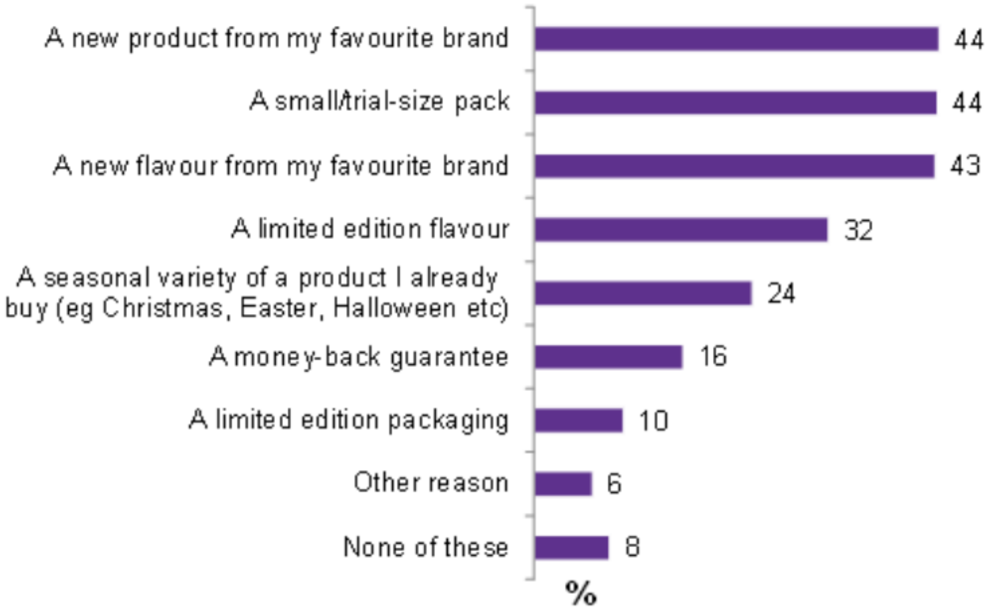
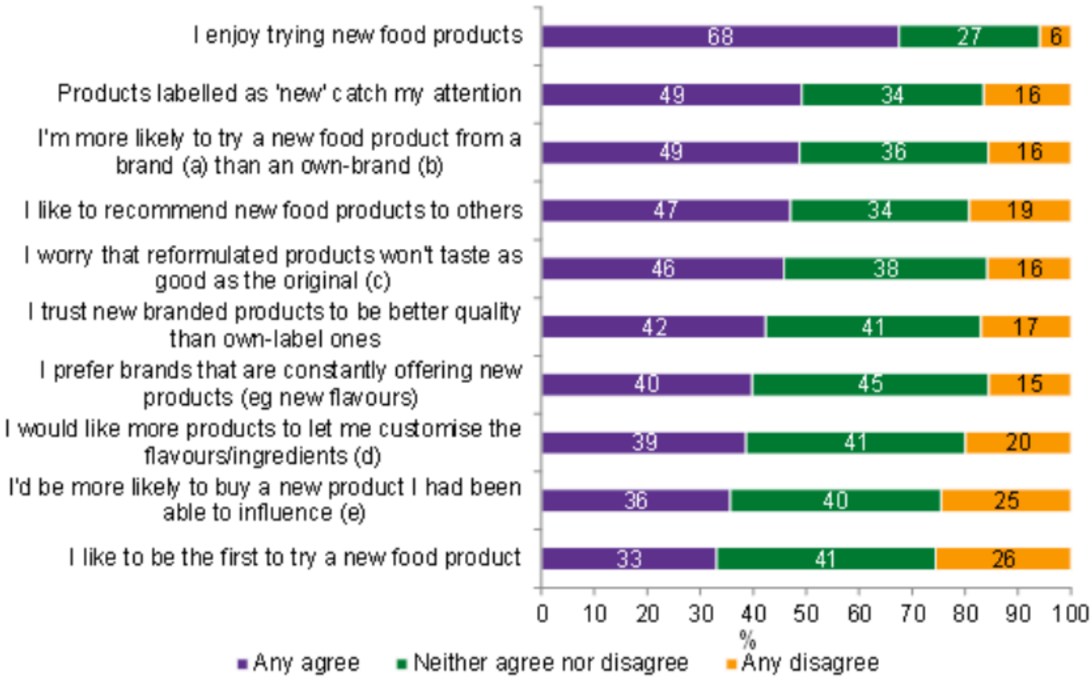


Figure 5. Factors that prompt people to buy a new food product. Adopted from: Soininen (2015)

The Figure 6. shows that consumers still enjoy trying new food products, highlighting the importance of NPD and preference for brands that are constantly offering new products. There still remains a trend to prefer branded products in comparison to own-brand as they are perceived as those of a higher quality. An interesting finding is also that consumers would like to get involved in the NPD process and customise the flavours and ingredients (Soininen, 2015).



a) eg Cadbury's, Walkers

b) eg Tesco Finest, Sainsbury's Basics

c) eg 'new and improved recipe'

d) eg order a granola mixed how I like it

e) eg vote for a flavour

Figure 6. Further attitudes towards food innovation. Adopted from: Soininen (2015)

2.5 Importance of Process innovation

Food and drink manufacturing is the UK's largest manufacturing sector worth £81.8 billion, accounting for 15.7% of UK manufacturing (FDF, 2016). The food and drink sector is at the edge of the Fourth Industrial Revolution, or Industry 4.0. This term has been coined to refer to *"the increasing connectivity of the customer, product, process and the factory through the use of emerging technologies"* (Smethurst, 2016). Countries all over the world are already making investments into the Industry 4.0. Therefore, the UK in order to stay competitive has to also step up the game in adopting emerging technologies and production automation.

The UK Food and Drink manufacturing industry has been traditionally known as the one lagging behind other industries in terms of adoption of new technology. The features of food products are variable in terms of shape and size and therefore majority of companies is still using low-skilled labour for this repetitive job. This often results in a low quality product and health and safety issues. It is expected that in the coming years there will be a shortage of workforce willing to work for minimum wages and therefore automation of food processing and installation of robots is seen as one of the major growth areas in the food industry. This situation could be further intensified by the UK leaving the European Union, as 130,000 of employees working for the food and drink industry are from the Eastern Europe. Some of the benefits from automating the manufacturing are improved productivity (quantity of end products manufacture per unit) and improved profitability that has allowed companies other strategic investments, i.e. into further product lines or expanding plant operations (Gander, 2016).

The Food Manufacture State of the Industry Survey 2015, a survey based on Food and Drink industry manufacturing professionals, has highlighted several areas about the current state of the manufacturing industry in the UK that are causing the most concern:

- A high number (70%) of respondents agreed that the prices of raw materials will be an increasing concern in the coming year
- Only 20% of respondents agreed that the Groceries Code Adjudicator, Christine Tacon, is being effective in preventing supermarket chains to impose their power over suppliers

- 87% of respondents believed that the current pricing pressures from retailers will force them to decrease the quality of their own-label products
- Even though 69% of respondents stated that they are planning to increase the investment into NPD, they believe that their consumers would prefer a lower price instead of radically new products
- There is also expected increase in regulations in composition and marketing of foods high in fat, salt and sugar (Pendrous, 2015).

According to the results of the Automation Study (2010) UK SMEs are generally not aware of the benefits of automations as well as knowledge about other companies that have been already successfully automated. This could have been caused by lack of technical expertise but also fear of changing the existing manufacturing systems, investments and payback times when purchasing new equipment (Engineering and Machinery Alliance, 2010). Moreover the estimated worldwide annual supply of industrial robots at year-end by industries between 2012 and 2014 has shown that the food industry is the worst performing industry with below 10,000 units and only minor increase between the years. However, when combined with the estimated operational stock of multipurpose industrial robots in the United Kingdom is 23,800 units, one of the lowest numbers in the world, just behind Africa with 6,500 units and Brazil with 18,300 units (International Federation of Robotics, 2016).

The Annual UK Manufacturing Report 2016 investigated the automation and productivity across UK manufacturing companies, recognising that automation is key to achieving parity. (Annual Manufacturing Report, 2016). Around 83% of investigated companies invested into some kind of automation during the past five years, with the annual spend on automation equipment ranging from below £50k (28%), between £100-£250k (28%) and between £1m-£10m (22%). The key objectives of the project were improving business efficiency, reducing production time as well as improving quality. However, the importance of introduction of new products has been gradually increasing, from 18% in 2013 to 44% in 2015.

Despite of these benefits, companies are facing a range of barriers that prevent them from implementing any form of automation. These are the return on investment (ROI) that is perceived as too long, lack of investment budget, poor experience with automation in the past, but also being too busy with the day-to-day operations to consider automating. In regards to ROI, the majority of companies that implemented automation was able to have their investment back within 1-2 years (42%) or between 2-3 years (25%). A way of solving this issue could achieved by a promotional programmes based on success stories from UK SMEs and highlighting the benefits these companies have achieved through automation investment programmes. Government institutions such as BIS, Defra, TSB and EPSRC could provide advice and assistance to these companies (Engineering and Manufacturing Alliance, 2010). As a response to the results of the Automation Survey, the British Government initiated the Automating Manufacturing Programme providing the British Automation and Robotics Association with £600, 000 in order to collaborate with UK manufacturers to help them implement manufacturing automation solutions (British Automation and Robotics Association, 2013).

Further advantages of increase in adoption of robots in the food manufacturing industry may lead to a higher number of skilled workforce and greater job satisfaction, replacing the need to complete the same activity manually during the entire shift. High number of low skilled labour is particularly evident among food manufacturing companies, where there are usually fewer engineers and they often have to concentrate on daily production rather than thinking about new equipment. HM Government (2015) found that UK manufacturing generally lacks engineering skills in order to apply automation systems, at all levels; apprentice, technician and engineer level. Moreover, the Food and Drink Federation has identified three key categories that need urgent attention within the food and drink sector, in order to achieve the 20% growth vision by 2020, See Figure 7. (FDF, 2016). These apply both towards product innovation and manufacturing process innovation.

Figure 7. A pre-competitive vision for the UK's Food and Drink Industries. Adopted from FDF (2016)

2.6 Summary of the Context Chapter

The Context Chapter provided an overview of the key challenges facing the food and drink sector in the UK. In addition, the importance of product and process innovation within the sector was highlighted.

The following Chapter will provide an overview of the five streams of literature on complementarities between product and process innovation. The key models, empirical and conceptual studies will be described and critically evaluated. This will lead to into conclusions about limitations of the current understanding of complementarity between product and process innovation.

CHAPTER 3. LITERATURE REVIEW 1

3.1 Introduction

This Chapter will start by defining the key concepts in the research project. It will provide an overview and critical evaluation of the existing streams of literature on the complementarity between product and process innovation. Based on key models, conceptual and empirical studies in the Innovation Management literature, the following streams were identified:

a) Product innovation creates a need for process innovation (Abernathy and Utterback, 1978; Damanpour and Gopalakrishnan, 2001; Utterback, 1994)

b) Process innovation creates a need for product innovation (Barras, 1986; Kurkkio et al., 2011; Novotny and Laestadius, 2014)

c) Product and process innovation are interdependent (Kim et al., 1992; Martínez-Ros, 2000; Lim et al., 2006; Lager, 2010)

d) Companies adopt a portfolio of complementarities between product and process innovation (Evangelista and Vezzani, 2010; Hayes and Wheelwright, 1979; Pisano and Shih, 2012; Wheelwright and Clark, 1992)

e) Product and process innovation are two separate types of innovation (Anderson and Tushman, 1990; Ettlie et al., 1984; Traill and Meulenberg, 2002)

3.2 Defining the key concepts

In order to provide a stronger theoretical foundation (Ennen and Richter 2010; Lichtenthaler, 2009), this research project will classify innovations based on their type and degree. Further, it will explore different innovation types and complementarity that occurs between them during New Product and Process Development Projects.

Firstly, this research project will segregate product and process innovations based on their degree of novelty (newness) into radical and incremental innovations (Baregheh et al., 2012). Radical innovations refer to fundamental changes in product and/or process while incremental innovations relate to modifications to the existing product or production process (Bessant and Tidd, 2007).

Secondly, this project refers to the outcome of the innovation process as the type of innovation. A range of classifications of innovation types has been proposed over the past decades (Oke et al., 2007; Francis and Bessant, 2005). In order to avoid this limitation, this research will adopt definitions from The Organisation for Economic Co-operation and Development (OECD) and the first version of the Oslo Manual (1992). The Oslo Manual sets down the guidelines for gathering and interpreting data on technological innovations, with an aim to provide a framework within which research on innovation can evolve and achieve comparability among studies. These definitions have been commonly used in studies investigating a relationship between product and process innovation in the food industry (Bigliardi et al., 2009; Brewin et al., 2009).

3.2.1 Defining process innovation

The OECD defines process innovation as *"A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software."* (OECD, 2015). Apart from the widely accepted definition of process innovation adopted from the OECD. The research project will follow the guidelines of assessing process development from Lager (2010)'s book called "Managing Process Innovation". Thomas Lager is one of the most well-known researchers examining process innovation among the process industry sectors in the Innovation Management literature (Lager and Frishammar, 2010; Lager and Frishammar, 2012; Lager and Storm, 2013; Lager et al., 2013). Lager (2010) differentiates between two types of the newness of process technology (process development); newness to the world and newness to the company. Newness to the world refers to how known or proven the process technology is outside of the company. Three degrees of process technology newness exist;

1. **Low**; the process technology is proven and can often be purchased

2. **Medium**; the process technology is a significant improvement of the existing technology

3. **High**; a breakthrough process technology development

The newness of the process technology (process development) to the company refers to extent to which such development will affect the existing production plant/line/unit in terms of investment. Three degree of such newness can be distinguished;

1. **Low**; the new process technology can be implemented in the existing process plant

2. **Medium**; the new process technology requires significant plant modifications

3. **High**; a completely new process plant/production unit is required

Lager (2002; 2010) proposed a simplified typology of process development projects that can be adopted for strategic project selection as well as portfolio balancing, See Figure 8.

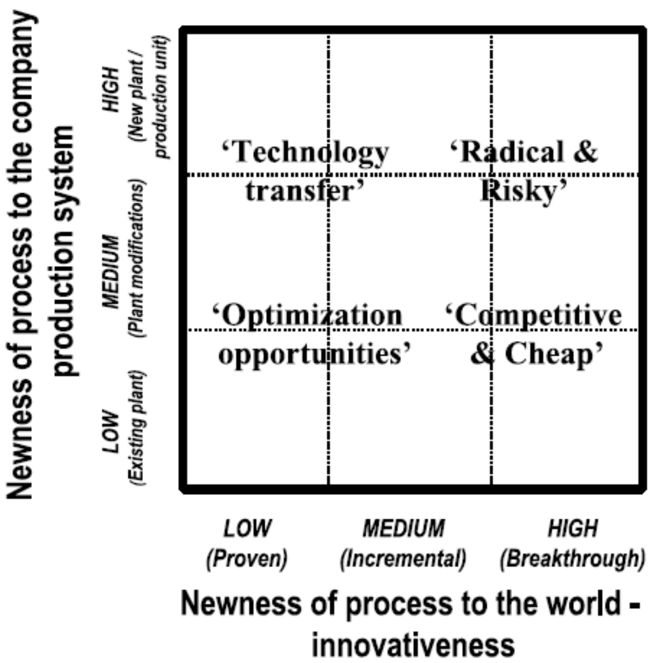


Figure 8. The process matrix for classification of the development of process technology in process industries. Adapted from Lager (2010, p.76)

In the context of a food and drink processing company process innovations will include cost saving changes such as settings adjustments of the production processes, introduction of new technology or improvements of the existing equipment to produce a new product (Grunert et al., 1997). See Figure 9. for a process of a new production system development.

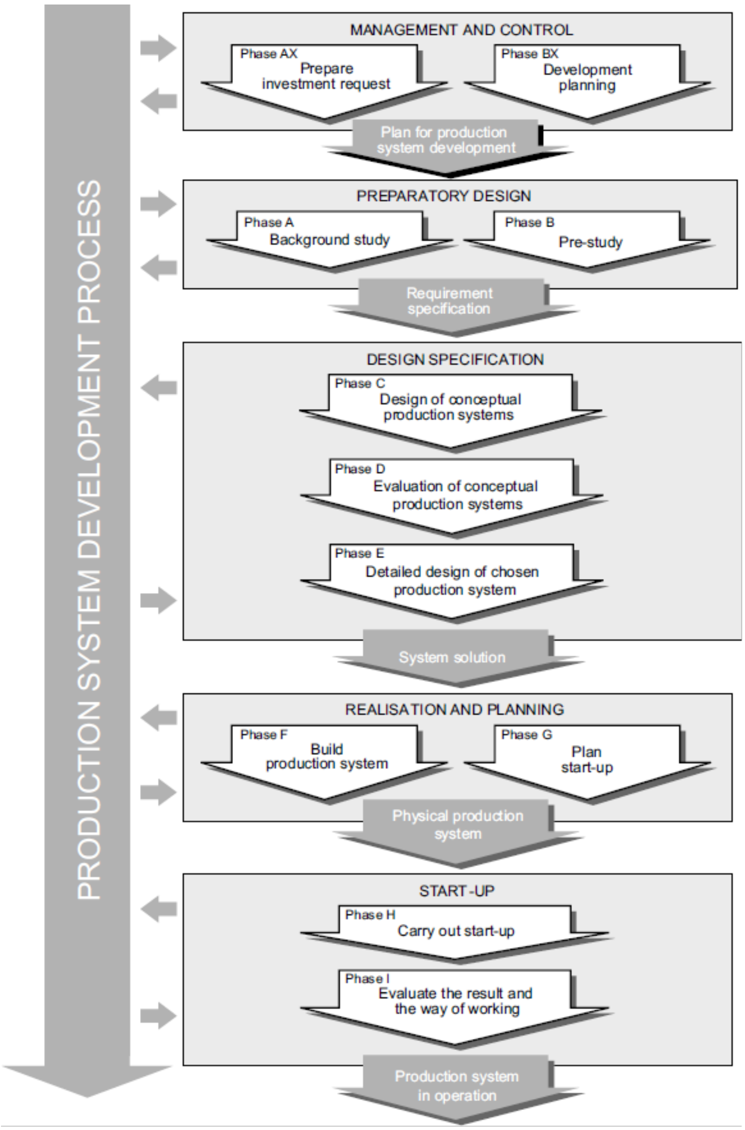


Figure 9. A process for new production system development. Adopted from Bellgran and Säfsten (2010, p.167)

The production system development model is a stage-gate model commonly applied by practitioners to reduce the cycle time and improve the new product ‘hit rate’, enabling them to closely monitor and control development process (Belgran and Säfsten, 2010). The main phases of the production system development model are:

- *Management and control*; the scoping of the project regarding the resources, time and financing
- *Preparatory design*; detailed investigation required to achieve a good production system
- *Design specifications*; the actual design and evaluation of conceptual production systems, including detailed design of the chosen concept
- *Realisation and planning*; realisation of the production system and the planning of the start-up
- *Start-up*; the start of production phase preceding serial production carried out with the speed and quality that is desired

3.2.2 Defining product innovation

The OECD defines product innovation as *"a good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics."* (OECD, 2015). In the context of a food and drink processing company innovation as defined by the OECD will include enhancement of the quality of product, changes to the recipe or a development of novel product technology. Technological newness of products arises from two types of innovation; generational and architectural. Generational innovation stands for application of a new technology, previously unknown to the company or the industry. On the other hand, architectural innovation refers to a novel combination of previously used technologies or components (Gatignon et al., 2002). See Table 7. for a generic product development process. The generic product development process developed by Bellgran and Säfsten (2010) provides a holistic overview of the NPD process, taking into account the role of Marketing, Design and Production departments in each of the key NPD phases. This process has several advantaged in comparison to the Stage-gate process developed by Cooper (1985) that portrays sequential NPD process with the fuzzy front end followed by product definition, product development phase, testing and launch of the product. Each of the phases is followed reviews 'gates' where the phase has to assessed on the basis of specified criteria.

Phase/Key Function	Marketing	Design	Production
Planning	Articulate market opportunity Define market segment	Consider product platform Assess new technologies	Identify production constraints Set supply chain strategy
Conceptual design	Customer needs Lead user Competitive products	Feasibility of product concepts Industrial design concepts Build and test experimental prototypes	Estimate production costs Assess production feasibility
System-level design	Plan product options and extended product family Set target sale price	Alternative product architectures Define major subsystems and interfaces Refine industrial design	Identify suppliers for key components Make/buy analysis Define final assembly scheme Set target cost
Detail design	Marketing plan	Define part geometry Choose materials Assign tolerances Complete industrial design documentation	Define piece-part production process Design tooling Define quality assurance process Begin procurement of long-lead tooling
Testing and refinement	Promotion and launch material Facilitate field test	Reliability testing Life testing Performance testing Obtain regulatory approvals Implement design changes	Facilitate supplier ramp up Refine fabrication and assembly processes Train workforce Refine quality assurance process
Production ramp-up	Place early production with key customers	Evaluate early production output	Begin operation of entire production system

Table 7. The generic product development process. Adapted from Bellgran and Säfsten (2010, p.133)

The current study will be extended to include packaging innovation as a form of product innovation (Earle, 1997; Kühne et al., 2010). Packaging plays an essential role particularly in the fast-moving consumer goods (FMCG) industry, including the food and drink sector (Mahalik and Nambiara, 2010). In many case, packaging is an integral part of the product and therefore should be considered holistically during the New Product Development Process (Simms and Trott, 2010; Simms and Trott, 2014; Wells et al., 2007). Due to the lack of commonly agreed definition of packaging (Olsson and Larsson, 2009) this projects adopts a definition formulated by the European Parliament and Council Directive 94/62/EC: *"Packaging shall mean all product made of any materials of any nature to be used for containment, protection, handling, delivery and presentation of goods from raw materials to processed goods, from the producer to the user or the consumer"* (European Commission, 2016). Vidales Giovanetti (1995) classify the packaging system into three layers:

a) **Primary**- packaging layer that is in direct contact with the product (e.g. plastic bag containing cereals)

b) **Secondary**- packaging layer that protects the product in the primary packaging, identifies the contents and communicates with the consumer (e.g. cereal box)

c) **Tertiary**- packaging layer that contains the primary and secondary packaging and protects the product in the distribution channel.

The packaging (product) innovation cases that will be referred to in this research will focus on the primary packaging layer. Simms and Trott (2014, p. 2018) were first to classify packaging changes (innovation) in a typology of three different levels of packaging change FMCG companies typically undertake:

a) **Skin deep**- predominantly changes to packaging reprographics and artwork (e.g. new labels for a can of soup)

b) **Body modification**- non-technical specialist design and styling aesthetics (e.g. easier bag opening)

c) **Format change**- changes to the existing format requiring high industrial design and technological capabilities (e.g. can, pouch)

Throughout this study, the skin deep and body modifications are regarded as incremental packaging (product) innovations. The format change of packaging is considered to be a radical packaging (product) innovation.

Furthermore, this research project differentiates between patterns in which the product and process innovation take place within New Product and Process Development Projects. For instance, dominant focus on product innovation in the project is followed by consequential process innovation. The emphasis on product and / or process innovation within one project ranges from a low to high extent, depending on the amount of resources and capabilities required to be employed throughout this project.

Moreover, this project will be investigating different types of complementarities occurring between product and process innovation in the New Product and Process Development Projects. The concept of complementarity and its role in managing organisations is gaining an increased attention (Ballot et al., 2015; Ennen and Richter, 2010; Porter and Siggelkow, 2008). Generally, complementarities occur when two activities reinforce each other in such a way that doing one thing increases the value of doing the another (Matsuyama, 1995). This argument is central to the Resourced Based View, which argues that companies are able to achieve a competitive advantage based on combining resources in an unique ways (Adegbesan, 2009).

3.3 Inequality in the research on Product and Process innovation

"Product innovations are for show whereas process innovations are for dough."

(P. Krason NPD Manager at UK Food manufacturing company; personal communication at Live Food Matters, July 17, 2015)

Process innovation is often perceived in the industry as a second-order innovative activity and an unchallenging cousin of the "more glamorous" product innovation (Rosenberg, 1982), or "the most primitive form of innovation" (Tushman and Rosenkopf, 1992, p. 313). Even though, there can be few, who doubt the importance of process innovation to the firm (Kurkkio et al., 2011; Reichstein & Salter, 2006). Famous examples such as Ford's Model T production line, Pilkington's float glass production process and rolling mills technology in metals processing have clearly shown that when it comes to delivering benefits to the firm it is process innovations that can generate enormous wealth for the firm (Utterback, 1994).

Generally, the innovation research tends to focus on the product, while relatively little academic attention is directed towards process innovation (Frishammar et al., 2012; Reichsten & Salter, 2006). Product innovation has been found to help companies strategically differentiate their offering in the marketplace, increase customer loyalty and improve overall company's performance (Damanpour and Gopalakrishnan, 2001; Edquist et al., 2001). Partly, this is due to the fact that innovative processes are intermediately related to a delivery of the actual product; thus perceived to generate lower revenues than new products (Damanpour & Gopalakrishnan, 2001). Another reason could be that the reduction in production costs by introducing a cost efficient process innovation is relatively small in comparison to revenues that can be generated from new products (Pisano & Wheelwright, 1995). The commonly cited objectives of process innovation are cost reductions, efficiency and improved product quality (Lager, 2002; Lim et al., 2006; Pisano, 1997). However, changes in production processes often influence product development, manufacturing strategy as well as operations strategy (Pisano, 1997). Process innovation could also significantly improve company's productivity and product quality (Vivero, 2002).

Process innovation could take place by the means of input materials, task specifications, work and information flow mechanisms and equipment used to produce a product (Utterback and Abernathy, 1975; Utterback, 1994). Process development projects often take place without any formal project, while the front end of more radical projects tends to be rather formalised. On the other hand incremental product development projects are more formalised than radical projects (Kurkkio et al., 2011; Reid and de Brentani, 2004). Kurkkio et al. (2011) further pinpoint that organisation of the relevant tasks should not be oversimplified because they depend on specific situation, internal and external environment of the process development project; i.e. degree of novelty, state of existing knowledge, sources of ideas to process development and the scope of project. Moreover, cross-functional collaboration (CFC) in the front end is crucial to facilitate the efficient alignment between product and process development. The CFC helps to identify objectives and requirements of the new project before investing into allocation of resources.

3.4 Synthesising major studies investigating complementarities between Product and Process innovation

Complementarity studies have applied two different approaches to measure and understand linkages between product and process innovation. Ballot et al. (2015) term these *complementarities-in-use* and *complementarities-in-performance*. Studies belonging to the first approach searched for relationship in product and process innovation with an aim to prove a link (e.g. Damanpour and Gopalakrishnan, 2001; Martínez-Ros and Labeaga, 2009). The second approach investigated the effects on performance when combining different innovation activities (e.g. Kotabe and Murray, 1990; Pisano, 1997). For the purposes of this research the main focus is on studies that identified *complementarities-in-use.* These can further be divided into five sub-categories (literature streams). The project is firstly concerned with an area of past research that identified only a one-way relationship, either *product-process pattern* of relationship or *process-product pattern (stream 1 & 2)*. This is followed by a third stream of research, which argued that *product and process innovation are interdependent* and any distinction between them is arbitrary. The fourth literature stream identified a *portfolio of different relationships* that may occur between product and process innovation across and within companies. Lastly, and the most significant in terms of volume is the fifth stream that examined product and process innovation as *two separate types of innovation*.

3.4.1 Product innovation creates a need for Process innovation

Abernathy and Utterback's (1975) 'A dynamic model for process and product innovation' is the starting point in the *product-process pattern* research area. The PLC model is a three-stage model that suggests changing rates of product and process innovation depending on the developmental stage of the industry. The authors combine their prior research and synthesise two distinct but complementary conceptual models of innovation; the relationship between competitive strategy and innovation (Utterback, 1974; Utterback, 1975), relationship between production process characteristics and innovation (Abernathy and Townsend, 1975; Abernathy and Wayne, 1974). The authors have introduced the Innovation and stage of development model, See Figure 10. This model brings together the frequency of innovation on the vertical axis and this is plotted against the stage of process and product development on the horizontal axis. The model addresses three important issues in managing innovation:

1. The natural locus of innovation that shifts with the stage of development
    - The critical input in the unconnected stage are the new insights about the need
    - In the systemic stage these needs are well-defined and lend themselves to complex technological solutions
2. The most appropriate type of innovation
    - In the uncoordinated stage majority of technological applications to products, process applications are rare and tend to be simple
    - During the systemic stage the assessment of the type of innovation that will be successful depends on the understanding of the productive process

3. The array of barriers to innovation

    - In the unconnected stage the resistance centres around perception of irrelevance
    - During the systemic stage the resistance originates from the disruptive nature of innovation

The feasibility of the proposed conceptual model has been tested using the data from Myers and Marquis' study of 567 commercially successful innovations from five different industries, covering 120 firms. This database included small firms that were characterised as a single product firms. The authors intentionally avoided inclusion of large companies, as the reported data usually reflect characteristics of a single division within the company. Moreover, researchers excluded companies that failed to exhibit a coherent pattern of innovation, particularly multidivisional firms with data about segments in different stages of development. The model and associated propositions have been supported, providing original insights at the firm level rather than individual successful innovations. One of the major contributions of the model is the interrelated nature of decisions within the form, as capabilities of the company to innovate have to be linked with achieving efficient operations.

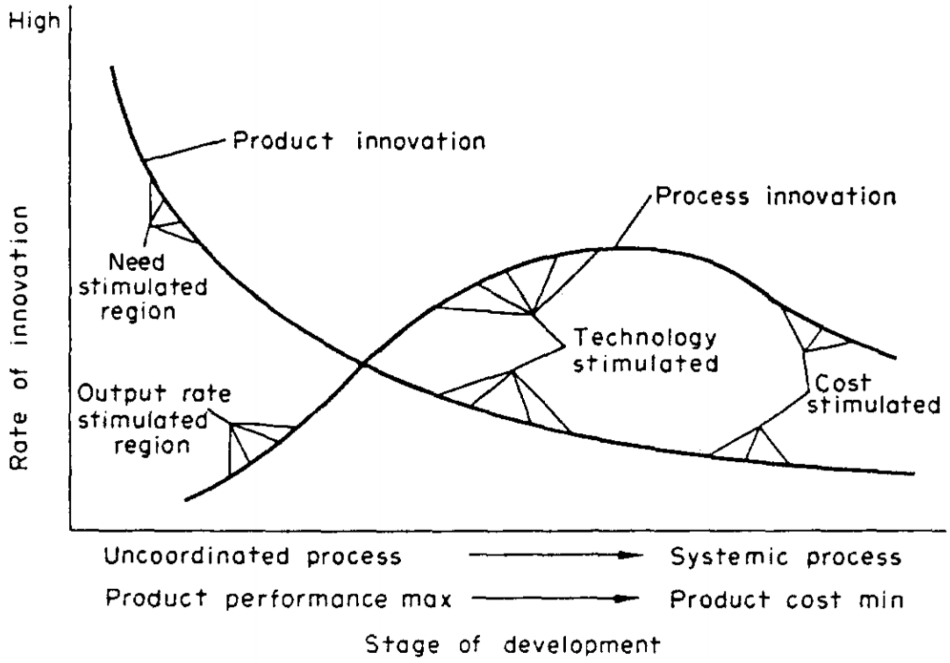


Figure 10. Innovation and stage of development. Adopted from Abernathy and Utterback (1975)

Abernathy and Utterback (1978) Patterns of industrial innovation - the second publication of Abernathy and Utterback (1978). Despite its focus on a specific industry (semiconductors), the authors identified clear differences between companies operating within this market. For example, new entrants to the semiconductors market were heavily focused on product innovation, being responsible for more than a half of the major product innovations within this market. The established companies often responded to this increasing competition by focusing on process innovation. This practice has brought further change to the market - a move towards effective process innovation that became critical for everyone in the semiconductor market.

The initial model was further confirmed by a range of cases. For example, the DC-3 that changed the character of innovation in the aircraft industry by bringing a dominant design that focused on leveraging the existing designs. Another example cited in the article was the electric light bulb that experienced a range of evolutionary improvements, but only a few major innovations until it became a commodity-like product, reducing the price from $1.60 to $ 0.20 cents per each. The heavy reliance on the skills of labor has been replaced by a single production machine operated by a few workers.

Abernathy and Utterback (1978, p. 46) predict that "units in different stages of evolution will respond to different stimuli and undertake different types of innovation." They further argue that this could be influenced by barriers to innovation as well as patterns to success and failure in innovations done by different units. Moreover, the most worthwhile application of the Innovation Life Cycle model is to situations in which the product innovation is crucial for maintaining competitiveness. They position the Innovation Life Cycle model as a means for identifying a range of issues that the company could be confronted with during the period of growth. The model could be also applied for comparing the existing conditions at the company with conditions defined in the model to support advances at each stage of development process. Managers could seek answers to questions such as:

- *Can a firm increase the variety and diversity of its product line while simultaneously realising the highest possible level of efficiency?*
- *Is a high rate of product innovation consistent with an effort to substantially reduce costs through extensive backward integration?*

Reichstein and Salter (2006) criticised models that stress the importance of the industrial context in shaping the type and rate of innovation (Abernathy and Utterback, 1978; Klepper, 1997). They argued that these models fail to explore the importance of the various firm-level inducements for individual firms to introduce product and process innovations. Furthermore, the models do not account for the relationship between product and process innovation at the firm level. This provides little managerial guidance in the decision making process, except from the most general level.

Utterback and Suárez (1993) investigated the relationship between product and process technology with competition and industry structure as a key for achieving long-term success or failure of companies or even industries. They criticised existing product lifecycle models for not dividing the data on innovations between product and process innovation. This consequently resulted in the inability to provide a deeper understanding of industry's technological evolution and inability to test whether the "locus of innovation changes over time" (Abernathy and Suárez, 1993, p.4). Their work aimed to examine the evolution of technology through independent sources, avoiding the above mentioned limitation.

The authors' propositions do not take into an account the size of a company, a common practice of previous models, but rather argued that innovative companies often originate from different industries. Abernathy and Suárez (1993, p. 2) claim that "creative synthesis of a new product innovation" by either one or several companies will culminate in a monopoly situation (high unit profit margins and process), similarly to the Schumpeter's notion of "creative destruction." (Schumpeter, 1934). This will be followed by other companies entering the market with diverse variations of the product. After establishment of the dominant design, companies will be able to achieve a competitive advantage through skills in process innovation and through the development of the internal technical and engineering skills. The shake-out created within the industry due to emergence of the dominant design will eliminate those companies that are unable to shift towards a greater product standardisation and process innovation. At the end of the life cycle, the market reaches stability with a few companies having largely standardised products, stable sales and market shares. This scenario will continue until a major technological discontinuity will take place, by starting a new cycle (Abernathy and Suárez, 1993).

Utterback (1994) Mastering the dynamics of innovation proposes that the major rate of innovation in products and processes follows a general pattern over time at the industry level. See Figure 11. Moreover, there is an important relationship between product and process innovation.

The model starts with a fluid phase during which, the rate of product innovations, be it on the industry or product class level, is the highest during the formative years. Utterback (1994) relates this scenario to automobile industry and the variety of electric and steam cars produced by manufacturers in order to bring a novel design to the public. During this phase the main attention is paid to product innovation, while the rate of process innovation is significantly lower.

This phase is followed by the period of fluidity, called transitional phase. Standard designs that satisfy consumer needs, legal and regulatory standards come into place and companies' major focus is on the process innovation and manufacturing at lower cost. Car companies would have in this stage developed technologies and consumers expectations, which together formed the new automobile.

The last phase, specific, is entered only by some companies and is characterised by incremental product and process innovation while the main focus is on cost, volume and capacity.

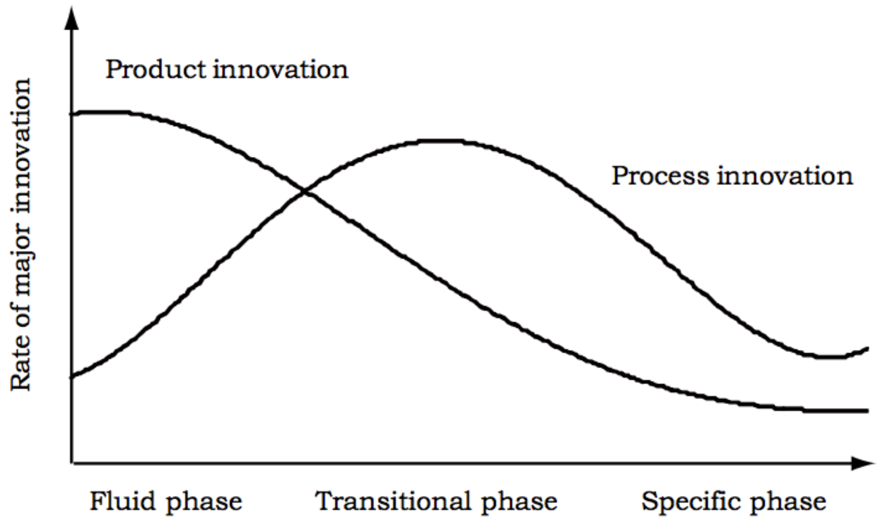


Figure 11. Dynamics of Innovation. Adopted from Utterback (1994, p.130)

Hobday (1998) characterises the above mentioned product life cycle models as "conventional." As all of the above mentioned models aim to stress the similarities in the innovation process, arguing that product and process technologies follow a certain life cycle pattern from birth to maturity (Abernathy and Utterback, 1975; Abernathy and Utterback, 1978; Utterback and Suárez, 1993; Utterback, 1994). Moreover, they are related to the production paradigm of mass market commodity goods (e.g typewriter, automobile, television set) (See Table 8. for an overview of dominant designs). Incremental process improvements play a crucial role in the competitive performance of such products (Hobday, 1998). Hobday (1998, p.17) defines a "simple" mass producible product as:

a) having few, mainly standardised components

b) they are produced by a single firm

c) having stable properties

d) the user involvement is mediated via arms-length market transactions

Industry	Dominant design	Date
Typewriter	Underwood's model 5 Hess's innovations	1906
Automobile	All steel, closed body	1923
Television	21-inch set, adoption of RCA's technical standards	1952
TV tubes	All-glass, 21-inch tube	1956
Transistor	Planar transistor	1959
Electronic calculator	Calculator on chip	1971

Table 8. A list of dominant designs by industry. Adapted from Utterback and Suárez (1993, p.8)

Kraft (1990) in his study 'Are product- and process- innovations independent of each other' confirmed the pattern of the first two phases (fluid and traditional phase). A central study by Kraft (1990, p.1029), undertaken in the context of medium sized German metal-working firms, points to a recursive model of only a one-way relationship, while the reverse effect cannot be proven. Kraft (1990) questions the dominant assumption of product and process innovation being independent of each other, but determined by the same variables. The author argues that manufacturing of a new product will not not be possible without new process implementation. Even in situations when the existing production equipment might be used to produce the product, company could take this as an opportunity for improvement of its current process technology. On the other hand, a process innovation that leads to product improvements might be a side effect, but product innovation is unlikely to be determined by the used technology. The data was collected among metal-working (belongs to process industries), West German companies in 1979. Results of a simultaneous equation model provide evidence for product innovation stimulating process innovation, but these findings are showing no evidence of the reverse effect (e.g. process innovation stimulating product innovation).

Damanpour and Gopalakrishnan (2001) investigated the dynamics of the adoption of product and process innovation in organisations. The authors conducted their investigation with a sample of commercial banks in the United States. They argued that studies on product and process innovation were mainly conducted in the manufacturing sector. Hence, these studies investigated the applicability of the product-process model solely to the service sector. According to their findings, one of the reasons banks tend to first introduce product innovation (e.g. credit cards) over process innovation is greater *appropriability*. Product innovations are based on technologies, which can be more easily protected by patents and other legal mechanisms. Damanpour and Gopalakrishnan (2001) criticise the existing research that explored the patterns of product and process adoption across industries rather than focusing on the patterns within specific firms. The authors further criticise the existing studies for predominantly focusing on the manufacturing sector, even though, product and process innovations are equally important in the service sector (Pisano and Wheelwright, 1995; Ettlie et al., 1984). Therefore, their study aims to answer the question: "Does the adoption of one type of innovation lag or lead the adoption of the other type at the firm level?" among commercial banks in the United States between 1982-1993. Damanpour and Gopalakrishnan (2001) stress the need for innovation adoption at the firm level due to changes in the environment or a way of adapting towards them. They have identified rate and speed of adoption as the two key measures of company's readiness to innovate and refer to the situation when one type of innovation lags or leads the adoption of another type as a *lag pattern*. The results show that in the service sector companies emphasise the adoption of product innovation over process innovation similarity to the approach used in manufacturing sector. One of the main reasons for this was a higher *appropriability* of the product innovation over process innovation. Product innovations can be protected by patents and are perceived to provide a first mover advantage to the company, while process innovations are predominantly based on technologies that are readily available on the market. The results of the study are based on patterns of product and process innovation at the firm level in response to the environmental changes, demonstrated by series of products and processes to maintain or enhance their competitiveness. Therefore, they are not reflective of the patterns illustrated in the industry based models (Abernathy and Utterback, 1978; Barras, 1986). Even though the results have proven that the product-process pattern is more likely than the process-product pattern, the key finding was the synchronous adoption of product and process innovation that has positive implications on bank performance.

3.4.2 Process innovation creates a need for Product innovation

Barras (1986) Towards a theory of innovation in services The *process-product pattern* is seldom seen in the literature on evolution of innovation. It followed the logic of the 'Reverse product cycle model' proposed by Barras (1986) for service industries. The paper introduces a Reverse Product Cycle arguing that within the service industries the cycle operates in an opposite direction to the Product Lifecycle within goods industries. The main reason for this is that in the user industries companies adopt the technology developed in the goods industries; therefore, in the first phase of the Reverse Product Cycle, this technology is used to increase the efficiency of the existing services. During the second phase, this technology is applied to improve the quality and effectiveness of these services and only in the third phase of the cycle it assists in generating new or wholly transformed services. This leads to an incremental process innovation and improvements of efficiency, radical process innovation to improve effectiveness and these are followed by radical product innovations, in the means of services (See Table 9.). The theoretical model is further developed in Barras (1990), where the author uses the vanguard sector of financial and business services as a case study example of the way innovation operates as an interactive process. The Reverse Product Cycle is elaborated by stressing the interactive nature of innovation process reflecting; technological opportunities, market conditions and industry structures within the adopting sectors. The author has offered a discussion of the optimal industry structure for innovation, arguing that large companies are likely to dominate the early stage of incremental process innovation. However, later in the Reverse Product Cycle, small entrepreneurial firms are responsible for an introduction of more radical product and process innovations.

Growth cycle phase	**Capital sector**		**Consumer sector**	
	Stage in the innovation cycle	**Products**	**Stage in the innovation cycle**	**Products**
Prosperity	Transition	Emergent	Growth	Improved
Recession	Introduction	New	Maturity	Cheaper
Depression	Growth	Improved	Transition	Emergent
Recovery	Maturity	Cheaper	Introduction	New

Table 9. The phases of growth cycle. Adapted from Barras (1986, p.169)

One of the few studies proving this relationship was a multiple case study of process firms conducted by Kurkkio et al. (2011). Authors have indicated that process development practices may be necessary to achieve high product development performance. Most recently, Novotny and Laestadius (2014) have identified, based on case studies among pulp and paper process-based industries in Sweden, that when a significant change occurs in process technology, the product subsequently changes. The authors argued that within process-based and natural resource-based industries, process innovation is tightly coupled with product innovation in the inter-industry linkages, forming a development block. The large-scale process industries are commonly characterised by established technological trajectories, focusing predominantly on incremental innovation.

3.4.3 Product and Process innovation are interdependent

The synergistic benefits of reciprocal complementarity have been identified by the *complementarities-in-performance* stream of research. Researchers, who specialised in this field, focused on identifying different economic benefits of combination of different practices within the organisation, proving that the joint application of these practices leads to greater advantages than benefits that can be achieved through their individual parts (Ballot et al., 2015). Development of relationship between product and process innovation may lead to long lasting competitive advantage (Clark and Wheelwright, 1993), overall improvement of company's performance (Damanpour and Gopalakrishnan, 2001; Pisano, 1997; Collins and Hull, 2002; Martínez-Ros & Labeaga, 2009; Ballot et al., 2015) as well as protection of the company from imitation by creating complex innovation strategies (Rivkin, 2000). The realised reciprocal complementarity capability may also result in a smoother launch of new products (Kotabe and Murray, 1990) and reduced development time (Adler, 1995; Nobelius, 2004; Liker et al., 1999). Achieving relationship between product and process innovation has also several financial benefits such as improvement of a net cash flow over time (Kim et al., 1992), improvement in manufacturing unit costs (Swink et al., 2006) and establishment of economies of scale (Martinez-Ros & Labeaga, 2009). Last, but not least, there is a range of efficiency related *complementarities-in-performance*, for example, ease of production ramp-up process (Pisano & Wheelwright, 1995; Pisano 1997), ability to control product mix and acquire process equipment (Kim et al., 1992) and facilitation in implementing innovative strategies (Turkulainen and Ketokivi, 2012). Studies investigating the *complementarities-in-use* go further by claiming that congruence between these two types of innovation is especially important during competitive times (Ettlie, 1988).

Kim et al. (1992) in their article 'Linking Product planning and Process design decisions' analytically tested two extreme alternatives between product planning and process design decisions and their impact on the manufacturing strategy;

a) The Unlinked decision (non-integrated, sequential) scenario, when product planners determine which products to offer based on demand, process, cost and existing technology

b) The Linked decision (strong two-way relationship in both directions) scenario, similar to the concept of simultaneous engineering

The results have proven that the Unlinked decisions offer a larger proportion of products (60% of all possible products) than Linked with only 53%. The main reason for this is that the Linked decision considers also the changes in the process requirement mix before introducing a new product. It linked the offerings of new products more tightly, unlike the Unlinked decision. On the other hand, the Unlinked decision model in the process decisions also creates a more unstable process requirement mix due to the myopic decision making of this model. The authors further tested the impact of three clusters of environmental characteristics: environmental complexity (size and difficulty of product and process decisions), environmental uncertainty (degree of error in forecasting demand and technology's process efficiency) and environmental tightness (how strong is the competition on the market). Kim et al. (1992) concluded that integrated decision-making of product planning and process design performs better than non-linked decisions when the environment is more complex, less uncertain and tighter. Moreover, there are several additional benefits of the close integration between product and process decisions that help to control the product offerings, stabilise process requirements, improve process technology choices and increase net cash flows.

This finding is supported by Martínez-Ros (2000) who found strong complementarities between product and process innovation among Spanish manufacturing firms. The knowledge accumulated through product innovation increased the profitability of process innovations by 36%. Furthermore, companies that innovated in their processes were 27% more likely to be product innovators. Lager (2002) analysed a wide spectrum of sectors in European Process Industries and concluded that development of a new product is related to the introduction of an improved process. He argues that this characteristic is specific to process industries. In other manufacturing industries a new product can be developed in the design office and the manufacturing of the product can occur later. Lager (2000) was one of the first studies to mention the combination between product and process development within a project. He argued that: "process development project can give opportunities for product development, just as the development of new products can be combined with process development and cost reduction in the production process" (Lager, 2000, p. 323). The study further points to the shift in the innovation strategy among companies operating within mature process industry sectors from being simply commodity producers to aiming to produce more functional products, that not only provide more benefits to the customers, but also bring higher profit margins to the company. Commodity producers tend to predominantly focus on the process development in order to be able to compete on price, however, the functional products can often benefit from product developments. Hence, companies willing to produce more functional products would require capabilities in both product and process development.

A more recent study by Reichstein and Salter (2006) considers product innovation and process innovation separately at both industry and company level. This study focuses on the different behaviour of companies engaging in each activity (product and process), using the data from Community Innovation Survey (CIS) 2001. Ultimately, the authors have concluded that at both industry and firm levels, product and process are interdependent, not only in theory but also in practice. Hence, theories of innovation need to account for the mutual interaction between product and process innovation. Authors further suggest that radical product innovators will be also radical process innovators and vice versa. Therefore the innovation types should be viewed as “brothers” rather than “distant cousins” (Reichstein and Salter 2006, p.677). In contrast, Lim et al. (2006, p.31) build on the research within process industries, specifically in biopharmaceuticals, and show that product and process innovation cannot be viewed as “discrete entities” due to the unique development path that consists of untried techniques that make the development process iterative.

Lim et al. (2006) in their Multi-phased development path model criticise the applicability of conventional models that address product and process innovation at the industry level (e.g. Innovation Life Cycle Model) in the biopharmaceutical industry. Instead, they define product and process innovation categories in the biopharmaceutical industry as ‘fuzzy sets’. Authors postulate that distinction between these two types of innovations is less distinguishable in comparison to engineering-based industries. They claim that the “process development and production of a new biological entity are significantly more complex, context specific and difficult to specify than those for small molecule drugs” (Lim et al., 2006, p. 31). Therefore, they present a new perspective on management of the product and process development through the conceptual model that shows how product and process innovation happen in multiple phases and in conjunction with each other, see Figure 12.

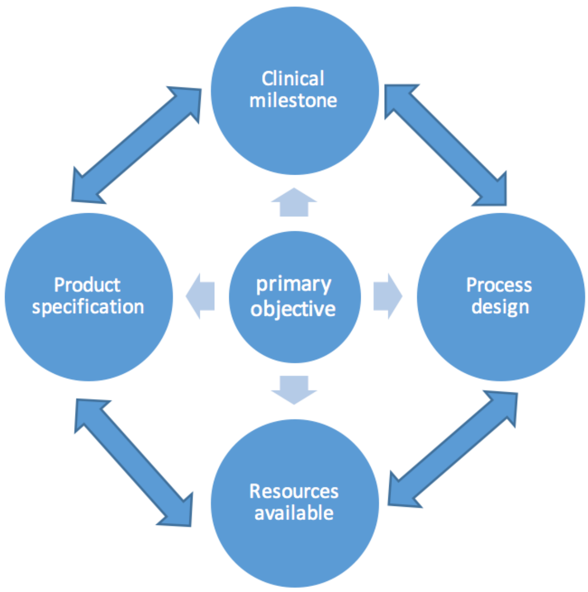


Figure 12. A multi-phased development path. Adapted from Lim et al. (2006, p.33)

In working to understand this relationship, Martínez-Ros and Labeaga (2009) using a the Spanish Ministry of Science and Technology database, including information from manufacturing firms between 1990-1999. This data have acknowledged persistence in a company’s commitment to implement product and process innovation as important for both types of innovation. Authors argue that managers have to consider whether the knowledge base gained through one type of innovation can be reutilised by the introduction of the alternative innovation. The innovation performance of the company will improve significantly, appropriating the gains through economies of scale from engaging in complementary activities. Brewin et al. (2009) examined the mechanics of adoption of product and process innovation in the food processing industry using a survey of Western Canadian food processors. Their findings have provided an evidence that the interrelationship between product and process innovation was stronger in cases when both types of innovation were developed in-house. The authors call for a recognition of this interdependence from policy makers, leading to a more effective capturing of innovative spillovers from the in-house innovations.

Lager (2010) The never-ending product development cycle is one of the most recent attempts to visualise the interdependence between product and process innovation. See Figure 13., adopted from Lager (2010, p. 43), which shows the interaction between customers and suppliers in the product development cycle. One of the main reasons for its development was the unique characteristic of the tight correlation between these two innovation types among the sectors in process industry such as chemicals, metals, food and beverage, pulp and paper.

Lager (2010) assigns importance to collaboration with customer in order to determine the way in which supplier's own products could be utilised in the customer's production process, called "application development." This encourages further co-operation to understand how to translate customers current and future demands into measurable product properties, called Voice of the Customer. The cycle is followed by an appreciation of how the knowledge could be applied into a new or improved product concepts. Further, it is crucial to appreciate how the new product functionalities could be produced ensuring qualitative and cost-efficient production systems.

Therefore, it can be argued that process development project can offer opportunities for product development, while at the same time the introduction of a new product could be combined with a new, more efficient production process. In cases when supplier and customer are able to integrate these two parts of innovation, they will find themselves in a “highly desirable position in the world of innovation in the process industries” (Lager 2010, p.43).

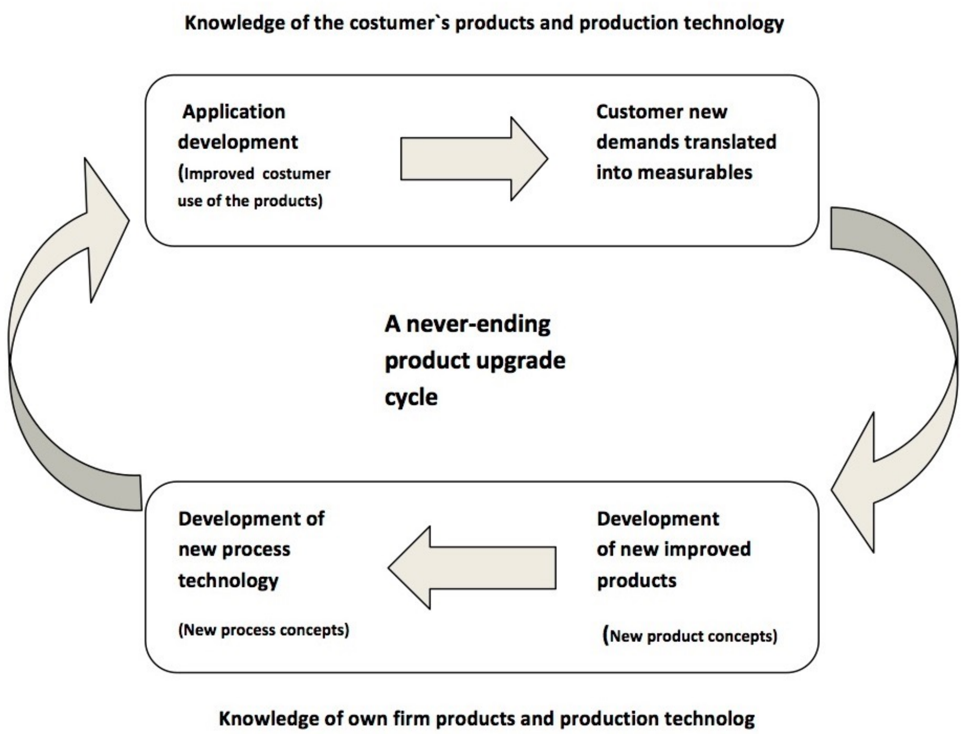


Figure 13. The never-ending product development cycle in process industries. Adapted from Lager (2010, p.43)

3.4.4 Towards a portfolio of relationships between Product and Process innovation

The following sections will focus on a range of conceptual models and empirical studies that identified a variety of different relationships occurring between product and process innovation. These relationships were suggested to occur at the industry (Evangelista and Vezzani, 2010), company (Hayes and Wheelwright, 1979) or project level (Pisano and Shih, 2012; Wheelwright and Clark, 1992).

Hayes and Wheelwright (1979) Product-process matrix are first to separate the concept of product life cycle from what they call "process life cycle" in order to aid the understanding of strategic options available to the company. In their study, authors present The Product-process matrix in which a company or a business unit can be portrayed as taking place in a certain region depending on the interaction stages of these two life cycles. They argue that integrating marketing and manufacturing organisation with a common strategy could lead to main competitive advantage. Moreover, the proposed matrix could help with more accurate predictions of changes in a particular industry. Furthermore, this matrix encourages creative thinking about organisational competence and competitive advantage and it includes manufacturing managers in planning process.

Referring to the Figure 14. below, the upper left-hand corner refers to a company that could be characterised with low level of standardisation and therefore, a job shop process is seen as the most effective in meeting product requirements. Equipment is general, rarely used at 100% capacity and workers have a wide range of skills (e.g. commercial printer). Further down the diagonal axis, increasing economies of scale lead the manufacturers to produce several basic models, with a possible customisation. The production structure is known as "disconnected line flow", where batches of a given model proceed irregularly through series of work stations (e.g. heavy equipment). This scenario could be further specified by production of few models in a relatively interlinked process (e.g. automobiles, home appliances). Finally, company could take place in the far right-hand corner and here the products are commoditised and production processes continuous. Even though, production is highly specialised and inflexible, the cost of production is low (e.g. sugar refinery). Moreover, authors portray two areas; the upper right-hand corner and the lower left-hand corner, as areas that are not economical and flexible, assuming that no industries or companies are located there. However, authors accept the possibility that the company may seek a position off the diagonal axis in order to achieve its competitive advantage (Rolls-Royce Ltd.) (See Figure 14.). The Matrix was aimed at the company level and it generalised company's product lines into a certain area of the Product and Process Lifecycle without recognising the possibility of variation in Life-cycles of different products.

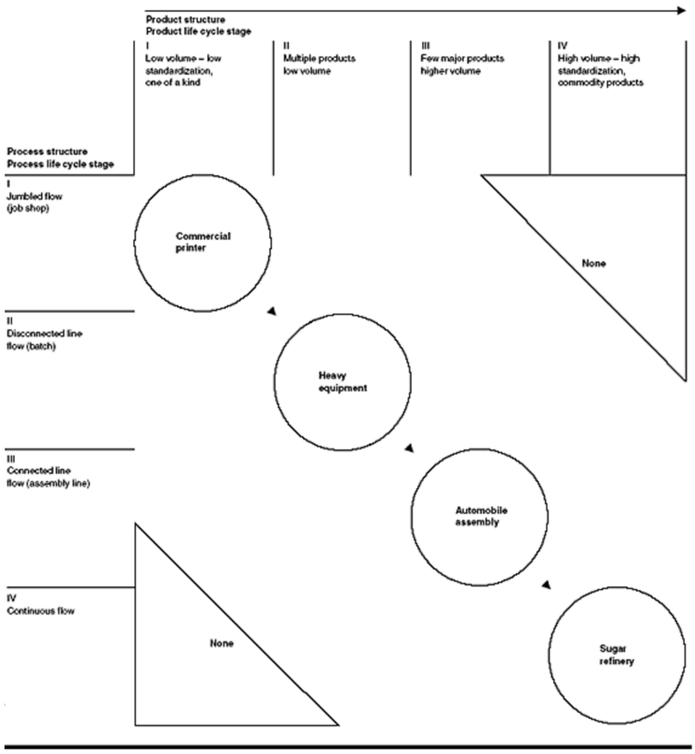


Figure 14. Matching major stages of product and process life cycles. Adopted from Hayes and Wheelwright (1979, p.135)

Dermott et al. (1997) criticise the applicability of Hayes and Wheelwright model (1979) in the 1990's , due to the need of a trade-off between low-volume, flexibility, high-quality, customised production through job shop facilities and on the other hand high-volume, standardised, low-cost production through flow shop. This model could have been applicable in the 1970's and 1980's when the high volumes of orders taken by the main market firms often allowed companies to provide limited amounts of responsiveness at only slightly increased costs. Flexible machinery that was crucial to change lot sizes efficiently and at a low cost was unavailable, allowing companies to perform only a limited number of product-specific tasks. There was no cross-functional collaboration, workers were utilised only to achieve economies of scale through repetitive manufacturing and the product development was rather sequential without any overlap between functional areas. McDermott et al. (1997) argue that the model was more suitable at describing the industry (what plants and equipment looked like) than at explaining the relative strategic options companies had.

During the 1990's the competitive landscape has changed and the level of competition in the power tools (investigated industry), has increased due to the new entrants and the increasing prominence of the mega-merchandisers (e.g. Home Depot; Home Quarters). The power of these large discount chains has increased so much that manufacturers had to dramatically change their production practices and techniques to remain competitive. Companies started to adopt flexible production methods, advanced information systems, cross-functional teams and they started to utilise workers and customers as sources of valuable feedback and ideas. All of these practices question the applicability of the Hayes and Wheelwright's model (1979) to describe manufacturing strategy. The industry does not operate by the means of trade-offs anymore, but rather transformed these into strategic combinations, allowing companies a much richer set of choices (McDermott et al., 1997).

Clark and Wheelwright (1993) in the article 'Creating Project Plans to Focus Product Development' criticise the way companies approach the New Product Development process, particularly the lack of an "aggregate project plan", allocation of resources between projects and contribution to the product line. They argue that the management needs to work on a portfolio of projects that is aligned with their development strategies, instead of selecting individual projects 'ad hoc.' With an aim to help companies manage the portfolio of projects they work on, the authors propose to use a map for allocating different types of projects which then allows companies to allocate resources accordingly. The projects are plotted on the map using two main dimension; degree of changes to the product and degree of changes to the process (the greater the change the more resources are required). These projects have been further divided into five types (See Figure 15.):

a) **Derivative projects**- cost-reduced versions or add-ons of existing products

b) **Breakthrough projects**- significant changes to the existing products and processes

c) **Platform projects**- include more product and/or process changes than derivative projects, but do not include novel technologies or materials

d) **Research and development**- development and understanding of novel technologies or materials that could be commercialised

e) **Alliances and partnerships**- formed to pursue any of the above mentioned projects

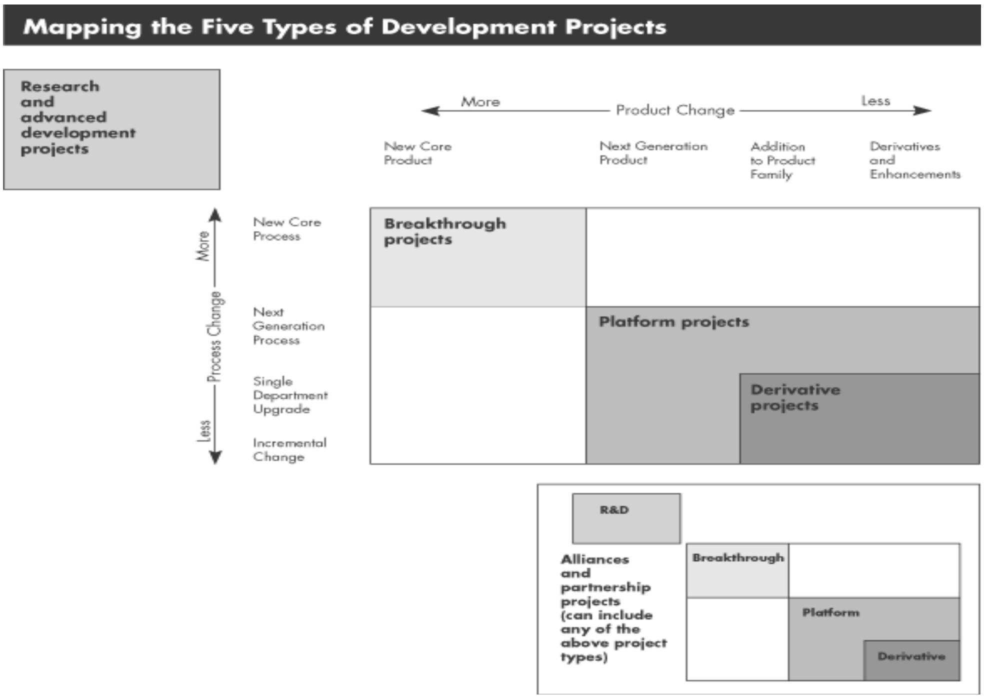


Figure 15. Mapping the Five Types of Development Projects. Adopted from Wheelwright and Clark (1992, p.4)

Pisano and Shih (2012) in their Modularity-Maturity Matrix help business leaders and government policy makers to identify when it is suitable to outsource manufacturing of a product and when it is critical to innovation and should be kept in-house. Companies often do not consider manufacturing to be an integral part of company's innovation system and this is often hindering their capabilities to transform inventions into a high quality and cost-competitive products. The matrix illustrates four innovation strategies based on the Low/High Modularity - a degree to which information about product design can be separated from the manufacturing process, and the Process maturity - a degree to which process has evolved (See Figure 16.). Even though the matrix has been developed for American companies to help them with strategically approaching separation of their R&D and manufacturing when considering outsourcing. This matrix has been also adopted by UK governmental organisation, UK Trade and Investment (UKTI) in order to help companies that are willing to increase their exports and enter new markets (GOV.UK, 2015).

Figure 16. The Modularity-maturity matrix. Adopted from Pisano and Shih (2012, p.4)

Evangelista and Vezzani (2010) further argue that product and process innovation are often closely interrelated. However, authors accept that despite the blurred boundaries between product and process innovation, it is useful to identify the dominant type of innovation strategy utilised by companies in different industries and technological regimes (Pavitt, 1984; Edquist et al., 2001). Therefore, on the basis of Italian CIS4 survey Evangelista and Vezzani (2010) identified four "innovation modes," with an aim to synthesise the highly heterogeneous nature of firm's innovative behaviours into a set of typologies. These are product oriented, process oriented, organisational and complex innovation modes.

They argue that the complex innovation modes are practiced by the most dynamic and technologically advanced companies. These companies are also characterised as large companies with a high amount of resources devoted to innovation as well as share of revenue related to introduction of products and services. Moreover, they perceive product and process innovations, organisational structure changes and innovative marketing strategies as equally important and this leads to the true competitive advantage. This practice is particularly common across manufacturing industry, particularly in the science based and specialised supplier industries. Product innovation mode is more relevant in the manufacturing sector, specifically science based industries, in comparison to service sector. These companies focus predominantly on introduction of product innovation (increasing range of goods, entering new markets, increasing market share) which is often complemented by marketing innovation. Process innovation (acquisition of new equipment, computer hardware and software) is also more common across manufacturing industries. These findings could be related to different contexts and technological regimes in which these companies operate and hence, both product and process oriented innovation strategies can be effective.

However, due to limited information provided by the CIS questionnaire, the underlying strategies characterising the innovation mode could not be fully explored. Evangelista and Vezzani (2010) conclude that further conceptual and empirical research is required to advance the research in the field that combines technological and organisational innovation.

Further, Säfsten and Aresu (2000) have conducted a study among 15 companies and identified three different forms of cooperation between product and production development:

1. Traditional approach- over-the-wall engineering with minimum cooperation and integration between the processes. Product and process development are independent process, carried out sequentially.
2. Parallel and iterative- production is involved in the early stages of product development. There is some level of collaboration, but the development processes are not fully integrated.
3. Concurrent engineering- product and process development processes are involved in a close collaboration and team work. The focus is on the time-to-market introduction (Bellgran and Säfsten, 2010).

3.4.5 Product and Process innovation are two separate types of innovation

The majority of existing academic and practitioner literature has perceived product and process innovation as two separate stages of innovation process (Damanpour and Gopalakrishnan, 2001; Ettlie and Reza, 1992; Lager, 2002; Reichstein and Salter, 2006). A common consequence of this discrete view was that designs were "thrown-over-the-wall" to the manufacturing department, and subsequently found to be non-producible or requiring several modifications to improve the quality and cost of production (Adler, 1995; Collins and Hull, 2002; Säfsten et al., 2014).

Tushman and Anderson (1990) Technological discontinuities and dominant designs: A cyclical model of technological change Schumpeter (1942, p. 84) argued that in every industry such innovations appear that "command a decisive cost or quality advantage and that strike not at the margins of the profits and the outputs of the existing forms, but at their foundations and their very lives." Tushman and Anderson (1990) term these a technological discontinuities that dramatically departs from the norm of continuous incremental innovation, affecting underlying processes or products. Process discontinuities refer to the significantly new ways of producing the product, enhancing the cost or quality of the product (e.g. catalytic cracking of petroleum, genetic engineering using restriction enzymes). Product discontinuities refer to significantly different product forms related to cost, performance or quality advantage compared to the prior product (e.g. jet vs. piston engines, CT scanners vs. x-rays). Anderson and Tushman (1990) introduce a revolutionary model of technological change, a Cyclical Model of Technological Change (See Figure 17.) This model is comprised of three parts; era of ferment, dominant design and era of incremental change. The era of ferment is characterised with an introduction of a radical advance either in product or process. Even though it is purely experimental the competition between the old and novel technology is fierce. However, the new technologies are often underestimated as they still do not work well and are based on competencies that are inconsistent with existing technological order. The dominant design is the second part of the technology cycle, marking a development of a single architecture and establishment of a dominance in a product class. Throughout this stage , the new product or process become part of a larger system, allowing it to achieve system integration. The third and last part of the cycle is the era of incremental change. The focus here is on incremental improvements of the dominant design and achieving lower cost and differentiation through design variations (Tushman and Anderson, 1990).

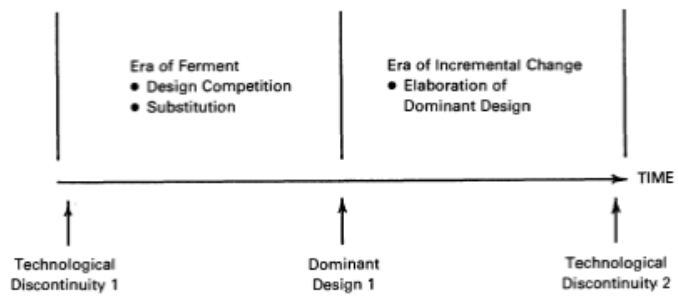


Figure 17. The Technology Cycle. Adopted from Anderson and Tushman (1990, p.606)

Following a similar logic as proposed by Anderson and Tushman (1990), the majority of studies have focused on studying product and process innovation as two separate phenomenon. Researchers have claimed, particularly in the manufacturing sector, that product and process innovations are two different types of innovation contributing to the competitiveness of the company, which is influenced to different degree by environmental and organisational factors (Damanpour, 2010). Ettlie et al. (1984) viewed the distinction between them as crucial because their adoption requires different organisational skills. Traill and Meulenberg (2002) studied food manufacturing companies across Europe and suggested that companies have a dominant orientation, either product, process or market. This determines their core strategy and the company will only keep basic standards with respect to the other two innovation types. Weiss (2003) was more specific and argued that companies will favour process innovation when products are less differentiated and there is a low level of competition. Whereas in situations with high product differentiation and intense competition the emphasis will be on product innovation.

3.5 Summary Literature Review 1

The above literature review exemplifies a limited understanding of the different scenarios of complementarities between product and process innovation. The immaturity of the field may be one of the reasons why conceptual work on the relationship between product and process innovation has not progressed sufficiently to constitute a theory that would offer specific scenarios defining different types of complementarities or conditions for their emergence (Ennen and Richter, 2010).

This chapter revealed the tendency of majority of complementarity models to portray a specific pattern of complementarity between product and process innovation; interdependence (Lager 2010; Lim et al., 2006), product-process pattern (Abernathy and Utterback, 1978; Utterback, 1994) and process-product pattern (Barras, 1986; Novotny and Laestadius, 2014). Only a few models and empirical studies have pointed to the portfolio of complementarities (Pisano and Shih, 2012; Wheelwright and Clark, 1992). However, these studies missed to portray a sequence at which the complementarity occurs, neither stated what resources and capabilities are necessary to achieve illustrated complementarities. Another limitation of these studies was the level of analysis. Majority of the existing models has referred to one type of complementarity occurring at the industry level. There were only few studies that investigated complementarities at the company and project level. Furthermore, majority of authors tended to justify applicability of these models based on an array of different NPD projects from a range of high-technology industries. Only a few models have been developed as representative of process industries (See Table 10. for an overview of the models portraying complementarity between product and process innovation).

The original idea of complementarity was that complementarities occur when two activities reinforce each other in such a way that doing one activity increases the value of doing the another (Matsuyama, 1995). However, wider dissemination of this concept shows that it is difficult to research (Ballot et al., 2015), and it has reached the point that it now became "all things to all people," particularly when investigating the complementarity between product and process innovation. According to Stieglitz and Heine (2007, p.3) companies that do not take into account complementarities results in a "loss in value creation, revenues and ultimately, in profits for the firm, because it fails to realise its full potential."

To advance the understanding of complementarities, the following chapter provides a starting point in this research area by proposing a theoretical underpinning to studying the complementarity between product and process innovation. Chapter 4. further identifies three contingencies that are likely to influence the type of complementarity in the low technology industries, referring particularly to the food and drink sector.

Model	Author(s)	Level of investigation	Industry context	Type of complementarity
Industry life cycle model	**Abernathy and Utterback (1975)**	Industry level	Semiconductors industry	Sequential complementarity
Patterns of industrial innovation	**Abernathy and Utterback (1978)**	Industry level	Semiconductors industry	Sequential complementarity
Product-process matrix	**Hayes and Wheelwright (1979)**	Company/Business unit level	Referred to a broad range of industries	Portfolio of complementarities
Reverse product cycle	**Barras (1986)**	Industry level	Service industry	Sequential complementarity
Mapping the five types of development projects	**Wheelwright and Clark (1992)**	Project level	The Map is demonstrated on a large scientific instruments company	Portfolio of complementarities
Mastering the dynamics of innovation	**Utterback (1994)**	Industry level	The model related to automobile industry, electronic and steam cars	Sequential complementarity
Multiphased development path	**Lim et al. (2006)**	Industry level	Process industry (biotechnology sector)	Reciprocal complementarity
The never-ending product development cycle in process industries	**Lager (2010)**	Industry level	Process industries	Reciprocal complementarity
The modularity-maturity matrix	**Pisano and Shih (2012)**	Project level	Referred to a broad range of industries	Portfolio of complementarities

Table 10. An overview of the key models portraying the complementarity between product and process innovation: Analysis of the level of investigation (industry/company/project); Industry context and type of complementarity proposed.

CHAPTER 4. LITERATURE REVIEW 2

4.1 Project Management

Given the limitations of the existing literature in terms of incorrect level of analysis in examining the complementarity between product and process innovation, stated in Chapter 3. This Chapter will introduce theoretical underpinnings that will be used to examine the issue of complementarity between product and process innovation at the NPPD level.

The beginnings of the Project Management and its recognition as a distinct contribution grounded in the management discipline trace back to 1958. In this year were introduced the first types of planning techniques such as Programme Evaluation Review Technique (PERT) and the Gantt Chart. At those times PERT was calculated by specialised programmers, also known as 'brokers of information' employed to work on government projects (Klein and Meckling, 1958). These brokers were in essence schedulers and estimators managing large budget and schedule driven projects.

However it took further three decades to realise that projects are often undertaken beyond the hierarchical lines of authority, hence they require unique coordination mechanisms and leadership skills (Shenhar and Dvir, 2007). This lead to development of a comprehensive set of tools, procedures and standards for management of project portfolios as well as single projects in the 1990s (Project Management Institute, 2015). Only then, the research on project management has increased in prominence and projects were acknowledged as value-creating business processes (Schwab and Miner, 2008). However, the research was predominantly centralised around explaining project success or failure, missing to provide insights into project management foundations and development of theory (Söderlund, 2004). For instance, Pinto and Prescott (1990) identified planning and tactical factors in the project implementation process. These included; clarity of goals, top management support, clear project plans, client relationships and communication. Furthermore, Söderlund (2004) criticises the universal theories of projects for their inability to appreciate the heterogeneous nature of projects influenced by contextual and contingency factors. There can be significant differences among the success factors due to differences among industries and project types. The author calls for future research to answer questions such as; Why do project organisations differ? How do project organisations behave? What determines success or failure of project organisations? On the other hand, Shenhar and Dvir (2007) stress the lack of commonly accepted paradigms in project management that hinder development of the discipline. To provide a starting point in this area, the authors integrate theoretical perspectives from other fields and propose three project management perspectives, See Table 11. Project Management is viewed as an integrating function rather than a discipline on its own and therefore combining the knowledge from Project Management with areas such as technology and strategy can significantly improve the perception Project Management research field in academia and practice (Maylor and Söderlund, 2015). The field is also largely fragmented. The authors continue to publish articles that re-define the existing concepts and propose new conceptual models without questioning whether their work adds up or builds upon the existing research (Maylor and Söderlund, 2015; Young, 2015). This research project will follow the practices of the Scandinavian School of Project Management by viewing the projects as temporary organisations (Lundin and Söderholm, 1998). Shenhar and Dvir (2007) categorise such projects under the Strategic/Business View founded on the principles of the Resource-based View. Furthermore, this School tended to adopt the contingency perspectives (Engwall, 2003).

Project Management Perspectives	Definition	Foundations
The Strategic/Business View	Defines projects as strategic activities supporting or implementing corporate goals. The single project or project portfolio are the primary unit of focus.	Strategic Management Contingency Theory Resource-based View Economics
The Operational/Process View	Views projects and sub-projects as a composition of processes executed to achieve single tasks that will contribute to achievement of the overall project goals.	Process Theory Optimisations Process Theory
The Team/Leadership View	Focuses on the human issues, i.e. leadership, motivation towards achieving a common goal, coordination among team members. The units of study are teams, often from different functional/organisational units.	Psychology Behavioural Theory Leadership Organisational Theory

Table 11. Three Project Management Perspectives and their foundations from other theoretical approaches. Adapted from Shenhar and Dvir (2007, p.96)

4.2 Combining Project Management with well-established theories to uncover the complementarities between product and process innovation

The Project Management is a broad subject that can be examined from different perspectives via a range of lenses. When looking at the management theory we observe that it is a multidisciplinary area that builds upon borrowed concepts and theories from biology, engineering, law and philosophy (Ostwick, Flemming and Hanlon, 2011). Gioia and Pitre (1990) argue that theory development which builds upon multiple theoretical lenses has an important role to play in providing a relevant critique of the management practice. Adoption of multiple theoretical lenses can also lead to bridging of silos across disciplines and stressing the relationships or complementarities among them. Thus, providing novel contributions to the theory.

Parallel to the Literature review and Data collection, the search for complementary theories continued. Towards this search contributed also numerous presentations of the research project at the Conferences (PhD Student Conference at the Portsmouth Business School; 22nd International Product Innovation Conference in Copenhagen 2015) as well as research seminars (i.e. Research Seminar at the Delft University in Netherlands 2015, 24th European Doctoral Summer School on Technology Management in Belgium 2014). A particularly useful theories were perceived those that would solve the problem of differences in how is the complementarity between product and process innovation managed at the NPPD level.

For the purposes of the current research the Project Management literature was complemented with perspectives from Resources-Based View and the Contingency Theory.

These two theories are well-established in the fields of Strategic and Innovation Management. They are perceived as the most suitable given the findings of the Literature Review. By adopting these perspectives, the research project will overcome one of the main criticisms of the Project Management research and projects being viewed as tools, often missing to build upon established theoretical disciplines. The project will contribute to the existing literature in the Contingency School of Project Management by categorising the project types on the basis of differences in the focus on product and process innovation. The adoption of the Contingency Theory in the Project Management field was a necessary development in order to answer the existing critique of "one size fits all" approach of the traditional Project Management (Ortt and van der Duin, 2008; Thompson, 1967; van de Ven et al., 2013). The theory was necessary to identify the differences amongst the projects in terms of a range of complementarities between product and process innovation (Shenhar and Dvir, 2007). Furthermore, the adoption of Contingency Theory provided a starting point in research of the complementarity between product and process innovation beyond the industry level of analysis portrayed by the Abernathy and Utterback's (1978) and Barras's (1986) models.

The Resource-Based View has been adopted following the Strategic View on the Project Management. Each project is perceived as a temporary organisation with its unique aims and characteristics (different complementarities between product and process innovation). Therefore, each project requires identifying or acquiring of different resources and capabilities. These can already exist within the company or will have to be sought for in the external environment (Ballot et al., 2015; Storm et al., 2013;Van Looy et al., 2005). The Resource-Based View also significantly contributed to development of the initial and the final Conceptual Framework. Moreover, both theoretical perspectives were utilised throughout the course of undertaking the research project and acted as tools to view the theoretical and empirical world.

4.3 Combining Project Management with Contingency theory

Following the classical management theory, known as 'scientific management', academics started to question the assumption of 'the one best way' and application of 'the golden rules' of managing organisations (van de Ven et al., 2013). They started to proclaim the idea that companies do not follow the best practices that were given by the dominant model of the time, but carefully select their innovation practices on the basis of the specific context in which they operate (Ortt and van der Duin, 2008). This stream of research has evolved into contingency theory. Contingency theory represents one of the most well-known theories of organisational integration. It has been applied in many areas of management, for example: Strategic Management (Semadeni and Cannella, 2011), Production Management (Kim et al., 1992) and Innovation Management (Bergfors and Lager, 2011; Van der Duin et al., 2013). Scholars, who belong to this stream of research argue that firm-to-firm variances in structure and strategy are the result of environmental demands (e.g. market, competition, technology) (Duncan, 1972; Miles and Snow, 1978). Donaldson (2001, p.1) defines the essence of the contingency theory as *"organizational effectiveness that results from fitting characteristics of the organization to contingencies that reflect the situation of the organisation."* According to Pennings (1992, p. 268) contingency theory suggests that *"there is no optimal strategy for all organisations and posits that the most desirable choice of strategy variables alters to certain factors, termed contingency."*

One of the limitations of the prior research on complementarities is that most of the investigations done in this field were ‘ad hoc’, meaning that the aim of the investigations was merely to gather and examine data, rather than to explore the interdependence in the context of well-structured models (Ennen and Richter, 2010). According to Durand (1992) in reality the product innovation does not always necessarily have to be followed by process innovation, but it can be also in a reverse sequence when process changes may affect product designs. Moreover, different companies possess different dynamic capabilities within which has been accumulated knowledge from previous projects.

The study of organisation and the study of innovation have always been closely related. Some of the early studies have already discussed the relationship between the organisational structure and innovation. Nadler and Tushman (1997) defined the basic function of an organisation to be bringing individuals and groups together in order to create benefits of scale via specialisation, shared support and control of shared resources. Hence the structure of an organisation is often described using different groupings, such as “internal differentiation and patterning of relationships” (Thompson 1967, p. 51). For example, Burns and Stalker (1961) argued that less formalised organisations are better suited for innovation, while more hierarchical companies maximise task efficiency. On the other hand, Lawrence and Lorsch (1967) claimed that the integration between differentiated departments is necessary requirement for a successful innovation.

The single most important reference found during the literature review process was “Organizations in Action: Social Science Bases of Administrative Theory” by Thompson (1967). The concepts and classification of complementarities between subunits of an organisation identified by Thompson (1967) contributed to the initial development of the

Conceptual Framework. Another important reference that influenced researcher's theoretical thinking was Lawrence and Lorsch (1967)'s theory of differentiation-integration showing that a one best way of managing organisations does not exist and organisation system in order to be efficient has to be tailored to the context of the company (environment, strategy, size etc.) (Lawrence and Lorsch, 1967).

Significantly, Child (2005) stressed the importance of expanding the boundary conditions in applying the contingency theory in order to address changes in organisations that occurred throughout the past 20 years. Van de Ven et al. (2013) argued that due to the organisational complexity applying the organisational contingency theory is a way to uncover it. Evangelista and Vezzani (2010) stress the limitation of the current research using aggregated analyses that are not able to take account of the heterogeneity of innovation behaviour of companies. They accept the challenge in advancing the micro-level studies at the firm level due to the multiform dimension of firm's 'organisations' and the differences at the firm and industry level, in regards to organisational strategies and assets.

Academics have characterised different innovation modes composed of different mixes of product, process and non-technological innovations (Hollenstein, 2003; Tether & Tajar, 2008). The better performance is related to more complex and economically consistent innovation strategies (Brynjolfsson & Hitt, 2000). For the purposes of the current research the contingency perspective is perceived as the most relevant as prior studies have argued that the complementarity between product and process innovation does not resemble a common pattern across organisations, even when they belong to the same industry. Due to the differences in organisational contingencies the fit between product and process innovation may be unique, even across types of organisations (Damanpour, 2010).

Building on the contingency approach, there seems to be a broadly shared view for a need to understand contingencies that may influence the type of complementarity between product and process innovation evident inside a company (Lager, 2002; Lim et al., 2006; Damanpour, 2010; Storm et al., 2013). This can be further supported by a recent empirical study conducted by Ballot et al. (2015), who identified great firm-to-firm variances in different complementarity strategies among UK and French companies based on the Community Innovation Surveys (CIS). The authors concluded that there are no *ex-ante* and empirical reasons to find a one best complementarity strategy for all companies (Ballot et al., 2015). Furthermore, other innovation studies have pointed to the heterogeneous nature of innovation as well as differences among industries in the process of innovation (Hobday, 1998; Pavitt, 1990). Studies have also distinguished between several main groups of products for production, stressing out that process innovation is dependent on unit volume of throughput (Hayes and Wheelwright, 1984).

This research project builds upon the above mentioned arguments of the 'no one best way' of managing the complementarity and argue that the five streams of research on complementarity between product and process innovation (See Literature Review 1.), based on either industry models or the 'optimal scenario' of synchronising radical product and process innovation, are not sufficient to understand differences in management of complementarities across companies (Wischnevsky et al., 2011). Due to the differences in organisational contingencies the fit between product and process innovation may be unique, even across different types of organisations (Damanpour, 2010). The following section will explain the importance of the project portfolio perspective in identifying the correct level of analysis when investigating the complementarity between product and process innovation.

4.3.1 Defining project portfolio management

Killen and Hunt (2013, p. 132) define the project portfolio management as “a high-level capability in which managers engage with a range of processes, methods and tools for ongoing resource allocation and reallocation among a portfolio of projects to maximise their contribution to the overall welfare and success of the enterprise.” The holistic approach to Product Development, including the project management perspective, has been proposed by Takeuchi and Nonaka (1986). They have criticised the sequential models within Product Development management, such as the stage-gate® model by Cooper (1979) and called for a change from such linear approach to an integrated approach, termed as ‘rugby approach’. The stage-gate® model is divided into a number of sequentially dependent stages with well-defined gates between them. The main weakness of the model is the sequential mode that does not allow for bypassing of gates neither repeating of the former stages, crucial especially when working on more radical projects (Gomes, 2003; Browning and Ramasesh, 2007). Roussel et al. (1991) identify four key reasons why portfolio management is key for a successful business performance:

1. It is a way senior management operationalises their business strategy
2. The product and technology choices company makes now, will influence success of the business in the next 5 years
3. It aids company with allocation of scare resources (R&D, engineering, marketing, operations)
4. Helps to establish a balance between available resources and number of projects

However, companies often struggle to achieve a balanced project portfolio and often allocate majority of their attention and resources towards incremental projects and only a small portion towards radical long-term projects (Cooper et al., 2001).

4.3.2 Understanding the complementarity between Product and Process innovation by applying the project portfolio approach

Ortt and van der Duin (2008, p. 534) state that "the historical development of innovation management has stopped and been replaced by a portfolio-approach that offers companies a wide range of ways to manage their innovation processes." This research project argues that to understand complementarity between product and process innovation, industry, company and project levels of analysis are required. Nonetheless, research has predominantly favoured the perspectives portrayed in the two industry level models (Abernathy and Utterback, 1978; Barras, 1986) that argued for sequential complementarity between product and process innovation. However, it was soon noticed that these models oversimplified the industrial reality (Pisano, 1997; Lager, 2011). 'The fallacy of the wrong level' has been recognised by Utterback (1994) in his book Mastering the Dynamics of Innovation, where he also referred to the company level. Models such as The Product-process matrix (Hayes and Wheelwright, 1979a; Hayes and Wheelwright, 1979b) and The Modularity-maturity matrix (Pisano and Shih, 2012) published in the Harvard Business Review, also moved away from the industry level and tried to portray the different complementarity options at the company level. Furthermore, studies based on the Community Innovation Survey (CIS) tended to classify the complementarity innovation strategies of companies (Battisti and Stoneman, 2010). For example, Evangelista and Vezzani's (2010) study identified four innovation modes with an aim to synthesise the highly heterogeneous nature of firm's innovation behaviour (*product oriented/process oriented/organisational and complex innovation modes*).

All of these classifications fail to take account of the possibility that companies within a single industry sector could differ in the types of complementarities they adopt in their New Product and Process Development Projects. This research project builds upon the arguments of Bruch and Bellgran (2014) and Cooper et al. (1997) and argue that companies can be working on a portfolio of projects. In these portfolios more breakthrough innovations with a high degree of risk, but a potential for development of a competitive advantage, are combined with 'safer' projects with a higher success ratio. Perhaps the most commonly cited model in this area is the typology of development projects by Clark and Wheelwright (1992) where they differentiate between New Product Development (NPD) projects based on the extent of product change and manufacturing process change, but failed to uncover the pattern in which the product and process innovation take place within these projects. Wheelwright and Clark (1992) criticise the management and the way companies approach their development projects. They argue that management directs too much attention towards micromanagement of 'ad hoc' individual project developments, rather than a mix of projects and suitably allocates resources towards them. Moreover, they also point to the complementarity between product and process changes for effective portfolio management. The authors of the "Five Types of Development Projects" call for a more 'aggregate project plan'. This would enable companies to effectively categorise projects based on the amount of resources they require and what is going to be their contribution to the company's product line. By mapping this portfolio of projects, management will be able to identify gaps in their development strategy and decide on additional projects as well as identify weaknesses of company's development capabilities.

4.3.3 Managing Product and Process innovation in the project portfolio

Effective portfolio management also depends on managing the relationship between the manufacturing and R&D (Clark and Wheelwright, 1993). Riedel and Pawar (1991) is one of the early studies pointing to the fact that the literature has not established a relationship between the product design and manufacturing sufficiently. Moreover, authors argue that simultaneous engineering between different parts of New Product Development Process is more beneficial than the sequential model. The integration could positively influence multiple performance dimensions; volume flexibility, manufacturing unit cost as well as adoption of innovative strategies (Turkulainen and Ketokivi, 2012). Bruch and Bellgran (2014) criticise the lack of integration between manufacturing operation and R&D among manufacturing companies and this is mainly due to interdepartmental differences. Manufacturing is often described as output oriented, including well-established technologies and routine tasks. In addition, R&D is solution focused with a long-term planning of advanced projects (Vandevelde and Van Dierdonck, 2003). Although, practitioners have a good understanding of how to design a product, the production system development involves a range of different interpretations and definitions. This often results in production system being considered close to its introduction and hence the introduction of new product generations requires costly changes to the production system (Bruch and Bellgran, 2014).

Bruch and Bellgran (2014) propose matching the strategic planning of the product with strategic planning of the corresponding production system. The authors argue that production system generations should be considered in the same way as product generations and updates. As portrayed in the Figure 18. companies could manage a portfolio where new product and production technology (star) are both developed as part of the so called Engineering in Advance portfolio (AE). This would consequently provide “new and verified solutions that can be used in a NPD project for new generations of products and corresponding production systems (circle) or for product or production system updates (triangle) (Bruch and Bellgran, 2014). The integrated portfolio illustrates a clear link between product and process development among a range of projects within a portfolio of products and production systems. Manufacturing companies and their managers should perceive the production system development process as an integral part of product introduction to the market. Therefore, it should receive the same amount of attention and resources as product development.

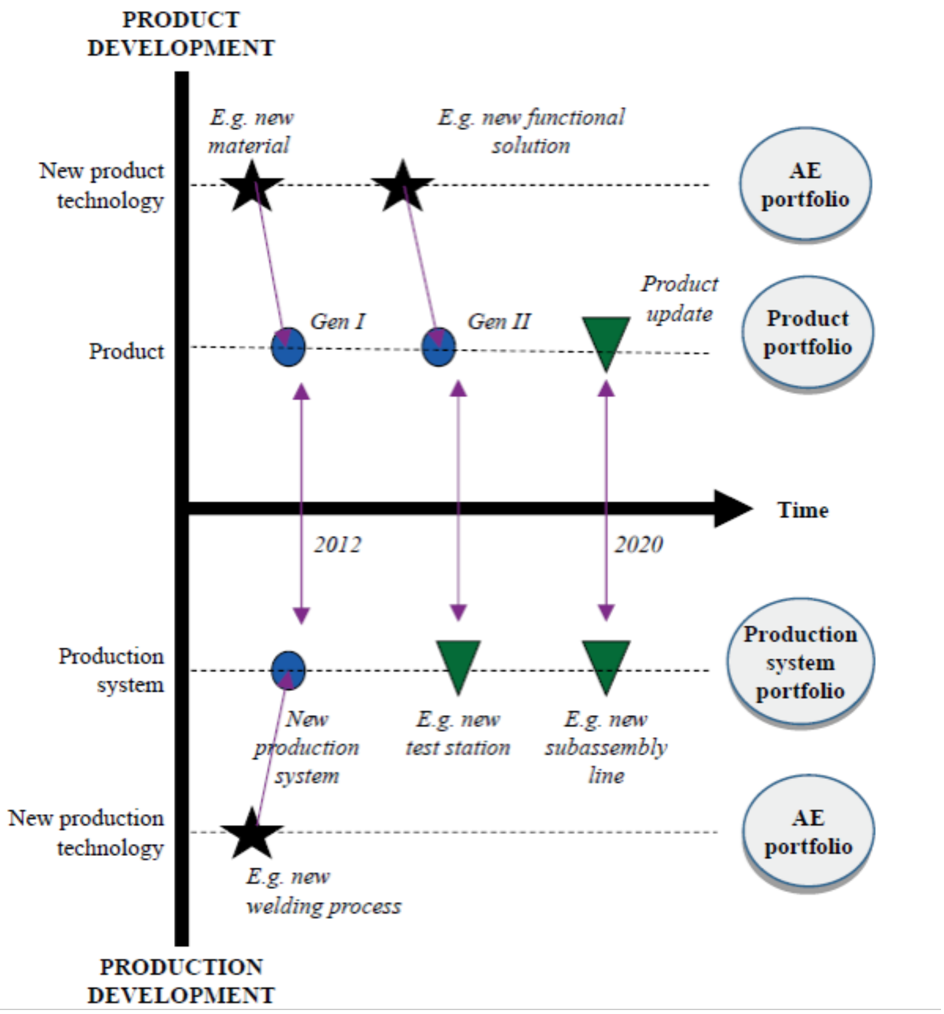


Figure 18. A principle model of an integrated portfolio planning of products and production systems including the AE development. Adopted from Bruch and Bellgran (2014, p.170)

However, not every company can take upon this opportunity in an effective manner- deliver the innovation and utilise all of the opportunities available to the company. Managers often perceive projects as fundamentally similar "a project is a project" (Hobday, 1998, p. 693). According to Loch and Kavadias (2007) the generation and prioritisation of project variants are the key areas to be controlled by portfolio managers. Klingebiel and Rammer (2014, p. 248) criticise the existing literature for primarily focusing on conceptual contributions about the "performance effects of heterogeneity in firms' strategies in allocating resources to innovation projects”, while providing limited empirical research. The following section will explore the second theoretical perspective the current research project relates the Project Portfolio Management literature to and it is the Resource- Based View. This well-known theory will provide the reasoning for a need to understand contingencies necessary to achieve different types of complementarities in the New Product and Process Development projects.

4.4 Combining Project Portfolio Management with Resource-Based View

Within the contingency approach, there seems to be a broadly shared view that we need to understand those contingencies that may influence the types of complementarities evident inside the company (Lager, 2002; Lim et al., 2006; Damanpour, 2010; Storm et al., 2013). For instance, Ennen and Richter (2010) criticise the existing literature for providing little prediction regarding conditions under which complementarities are likely to emerge as well as for the missing attention to factors among which complementarities exist. The contingency perspective does not follow the notion of “best practices,” which assumes that complementarity enhances company’s performance despite the circumstances and context of the company (Battisti and Stoneman, 2010). Instead, it assumes that each company develops a complementarity that is specific to its internal and external conditions and then adopts the combination of innovations. To uncover these contingencies (conditions) the research project will build upon perspectives from the Resource-Based View (RBV). It is a dominant theory in organisational research and suggests that different tangible and intangible resources and knowledge of the company contribute to its competitive advantage, as long as they are rare, difficult-to-replicate and have no substitutes (Barney, 2001). The RBV contends that resources across companies are unevenly distributed and there are considerable differences in the ways companies deploy them to achieve organisational strategies (Fredericks, 2005). Moreover, it is being increasingly argued that companies do not achieve success only by their superior resources, but rather due to their distinctive capabilities that enable them to utilise organisational resources in order to achieve a specific end result (Helfat & Peteraf, 2003; Mahoney, 1995). Innovation managers are often faced by scarce resources, and hence have to make trade-offs in their resource- allocation between different projects, while keeping in mind company's overall strategy. According to Eisenhardt and Martin (2000) Innovation managers, who are able to make foresightful allocation decision making will provide their company with a competitive advantage. This line of thought is related to the effective portfolio management that is also critical in gaining/sustaining company's competitive advantage (Cooper et al., 1999).

Porter and Siggelkow (2008) argue that researchers aiming to investigate complementarity should take into account contextual factors such as industry context, social and political factors, which often influence the context in which they operate. A recent empirical study conducted by Ballot et al. (2015), identified great firm-to-firm variances in different complementarity strategies among UK and French companies based on the Community Innovation Surveys (CIS). The authors further argued that companies tend to adopt the type of complementarity that best suits the given operating contingency, rather than what is said to be the best practice of combining all forms of innovation. They concluded that *"the effectiveness of the various combinatorial strategies is dependent on the institutional context and firm characteristics in which these combinatorial strategies are embedded"* (Ballot et al., 2015, p. 13). See Table 12. for a list of contextual and organisational factors identified to influence the complementarity between product and process innovation.

Contextual factors influencing complementarity between product and process innovation	**Organisation specific factors influencing complementarity between product and process innovation**
Social and industrial relations in the country (Ballot et al., 2015; Roper et al., 2010)	R&D intensity (Battisti and Stoneman, 2010)/R&D expenditure (Ballot et al., 2015)
External conditions (Battisti and Stoneman, 2010)	Resources and capabilities (Evangelista and Vezzani, 2010)
Market obstacles (Ballot et al., 2015)	Orientation towards product or process innovation (Evangelista and Vezzani)
Industrial context (Lager, 2002; Lim et al., 2006; Schiedeberg, 2008)	Concentration of specialists in manufacturing (Ettlie, 1995)
Market competition (Damanpour, 2010)	Management practices (Evangelista and Vezzani, 2010)
Complex, less uncertain and tighter environment (Kim et al., 1992)	Financial and knowledge obstacles (Ballot et al., 2014)
Sector specific (Evangelista and Vezzani, 2010)	Different phases of product and process development (Lager, 2002)
	Degree of novelty of product and process innovation (Reichstein and Salter, 2006)
	Firm characteristics (Lim et al., 2006; Storm et al., 2013)

Table 12. Contextual and organisation-specific factors influencing complementarity between product and process innovation

The majority of the studies summarised in the Table 11. were based on the results of Community Innovation Survey, a questionnaire among manufacturing and service companies that takes place every two years in all EU member countries (e.g. Ballot et al., 2015; Battisti and Stoneman, 2010; Evangelista and Vezzani, 2010). Due to the differences among a range of high- and low-technology sectors investigated within the survey, its results are difficult to generalise. Furthermore, the contingencies identified were based on the assumptions and propositions that were developed without a clear guidance towards the type of complementarity likely to result. This research project builds upon the above arguments and proposes a new stream of research that should focus on understanding *why* and *under what* conditions firms utilise different complementarities in their New Product and Process Development Projects. It is termed as the *Contingency complementarity*.

The following sections will provide further reasoning for the focus on the low-technology process industries, particularly the food and drink sector. Further, three contingency factors playing a crucial role within the sector in terms of influencing product and process innovation will be explained.

4.5 Towards understanding contingencies in the low-technology process industries (focus on food and drink sector)

Given the theory-building purposes of this research, the project is positioned within the context of process industries in order to demonstrate the relationship between product and process innovation. Previous research has emphasised that within these industries product innovation is related to process innovation (Kurkkio et al., 2011; Lager, 2002; Lim et al., 2006; Storm et al., 2013). A few studies have taken place in high-technology industries (e.g. pharmaceutical, biopharmaceutical industry), in which both product and process technology are rapidly evolving and therefore must be well synchronised (Feldman and Ronzio, 2001; Pisano and Wheelwright, 1995; Pisano, 1997). There is, however, a lack of academic attention to low-medium-technology (LMT) sectors of process industries (e.g. food and beverage, metal, mineral, pulp and paper). A systematic literature review conducted by Keupp et al. (2012) identified the large gap in the academic literature on strategic management of innovation paid to low-and medium-low technology (LMT) industries in comparison to medium-high technology industries. This gap is particularly interesting because in most developed and developing countries, LMT industries account for more than 90% of the economic output and are more likely to contribute to economic growth (Robertson et al., 2009). Consistent with this concern, the R&D Management Journal published a special issue dedicated to 'Managing Innovation and Technology in the Process industries' (2013, issue 3) and Research Policy featured a special issue aimed at 'Low- and Medium-Technology Industries' (2009, issue 3).

4.5.1 Reasoning for the choice of three contingencies from the food and drink sector

Various studies point to the research gaps on innovation in the food and drink sector (Avermaete et al., 2004; Traill and Meulenberg, 2002). There are particularly few studies on the types of innovation (Baregheh et al., 2012; Lefebvre et al., 2015). This project aims to contribute to the existing literature on low-technology process industries by situating the study in the UK food and drink sector. It is the UK's largest manufacturing sector and one of the main driving forces of the European economy (FDF, 2016). Throughout the past few years the sector has witnessed a range of technological, economic and societal changes and innovation became central to sustaining companies' competitiveness (Baregheh et al., 2012; Bigliardi and Galati, 2013; Capitanio et al., 2010). These factors make understanding of factors that influence innovation in the food and drink sector a pressing issue (Fortuin and Omta, 2009).

In reviewing the literature, three discrete but inter-related themes emerged to play critical role in influencing both product and process innovation in the New Product and Process

Development projects in the food and drink sector (from the perspective of the food and drink processing companies):

- Levels of potential and realised absorptive capacity (Gatignon *et al.*, 2002; Huston and Sakkab, 2006; Knudsen, 2007; Lefebvre et al., 2015)
- Importance of established technology trajectories in product and production process (Aylen, 2013; Baker, 2013; Bigliardi and Dormio, 2009)
- Supply chain relationships between supplier of production equipment, buyer (processing company) and customer (the retailer) (Burt and Sparks, 2003; Dobson and Chakraborty, 2015; Fearne and Hughes et al., 2013; Lager and Frishammar, 2012)

Product and process innovation success relies on the ability of firms to acquire and utilise complex knowledge. Hence, absorptive capacity has become one of the most influential concepts within the innovation literature (Fosfuri and Tribó, 2008; Martin, 2012; Zahra and George, 2002). The ability of firms to manage and allocate their resources determines why and how food and drink companies develop competencies in particular areas of their business (Capitanio et al., 2010; Fortuin and Omta, 2009; Tell et al., 2016). Thus, for all firms, movement along a technology trajectory is associated with research and development. A firm's product and process technologies can become locked-in to a trajectory thus making it difficult to adopt ideas and innovation from outside (Bauer and Leker, 2013; Benner and Tushman, 2003; Tushman and Anderson, 1986). Abernathy and Utterback's (1975) industry lifecycle model reflects this challenge. The model illustrates the importance of switching and learning costs and sunk capital equipment costs and their influence on the relationship between product and process innovation. Both absorptive capacity and technology trajectories are affected by the pivotal role played by external linkages. The seminal paper by

Pavitt (1984) on industrial classification of firms underpins the role of supplier dominated firms as a significant driver or a barrier to innovation. Further, within process industries the supply chain has been found to play a particularly influential role in product and process innovation (Lager and Frishammar, 2010; Soosay et al., 2008; Storm et al., 2013). These three themes are interwoven and inextricably linked to one another when attempting to understand product and process innovation.

The following sections will provide evidence of the importance of these three contingencies in the food and drink sector and their impact on development of complementarity between product and process innovation (Bigliardi et al., 2012; Brewin et al., 2009).

4.5.2 Absorptive capacity of the processing company

Absorptive capacity is particularly relevant to the food and drink sector that is characterised with many chain and network ties (Fortuin and Omta, 2009). These play a role during both product and process innovation. However, there seems to be hardly any evidence of these practices (Costa and Jongen, 2006; Saguy, 2011). See Figure 19. for an overview of the parties commonly involved in the New Product and Process Development projects from outside and within the food company's supply chain (Bigliardi and Galati; 2013).

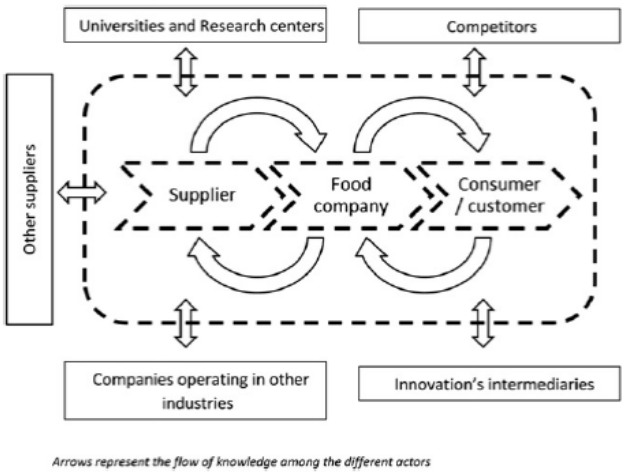


Figure 19. The open food supply chain. Adopted from Bigliardi and Galati (2013, p.19)

Prior research within the Innovation literature has established that the potential for the external collaborators to contribute to the customer's R&D is dependent upon the customer maintaining internal knowledge capabilities in order for the value of new technologies to be recognised internally (West and Gallagher, 2006; Yoeh, 2009; Huang and Rice, 2012). Cohen and Levinthal (1990) referred to such knowledge as the 'absorptive capacity' and define it as the "ability to recognise the value of new external knowledge sources in modern economies, assimilate it, and apply to the commercial needs" (Cohen and Levinthal, 1990, p. 128). Huang and Rice (2012, p. 203) illustrate this on the example of a sponge and sieve by stating that: "both are able to attract fluids, but only a sponge with strong absorptive nature can retain fluids for later use." Absorptive capacity has earned its place as one of the most significant constructs in research during the past twenty years (Camisón and Forés, 2010). One of the main reasons for this is the experiential learning derived from accumulating knowledge of the external partners (Matusik and Heeley, 2005), enabling the company to outperform its competitors in terms of innovation (Zollo and Winter, 2002).

A review of the existing literature on absorptive capacity reveals that it is necessary that firms not only focus on acquisition and assimilation of the external knowledge (potential absorptive capacity), but also on transformation and exploitation (realised absorptive capacity). This enables them to renew their knowledge stock and at the same time incorporate transformed knowledge into operations (Arora and Gambardella, 1994; Dahlander and Gann, 2010; Ritala and Hurmelina-Laukkanen, 2013; Singh et al., 2016; Zahra and George, 2002). Having more of a potential absorptive capacity does not necessarily lead to higher realised absorptive capacity and vice versa (Huang and Rice, 2009; Fosfuri and Tribó, 2008). Therefore, companies need to focus on the efficiency factor, "the ratio of realised absorptive capacity to potential absorptive capacity" (Zahra and George 2002, p. 191). The efficiency factor suggests that considering the differences in the capabilities of the company to recognise and exploit knowledge, firms will vary in their ability to create value from their knowledge base (Zahra and George, 2002). Hence, only companies that are able to maintain a high efficiency factor will be able to relate between these two components of the absorptive capacity, enhancing their performance and introducing product and process innovations (Gebauer et al., 2012).

Whilst absorptive capacity has been termed as a by-product of company's R&D activities (Cohen and Levinthal, 1990), knowledge gained from internal R&D is an essential catalyst for the development of firm's absorptive capacity (Lane et al., 2006). According to the traditional view, majority of the R&D experience inside the company is aimed at the product or service innovation (Huang and Rice, 2012). The results of the European Process Industry survey prove that 60% of the total R&D resources were allocated towards the product development and only 40% towards process development (Lager, 2002). Several arguments can be offered in support of this outcome, for example: the ability of direct commercialisation of the product (Ettlie and Reza, 1992), the fact that new products are mainly triggered by the market (Utterback and Abernathy, 1975) as well as delivery of more tangible outcomes and additional revenues in comparison to process innovation (Damanpour and Gopalakrishnan, 2001).

Therefore, companies which are aiming at process innovation tend to seek out cooperation with external actors (Gooroochurn and Hanley, 2007; Clausen, 2013). Processing companies have to be committed to finding a competitive production solution by involving several different parties. This is mainly due to idiosyncratic requirements of process technology across different processing plants (Lager and Frishammar, 2012). In cases when the external knowledge is used for adoption of process innovation, the internal R&D will become less important and negatively influence company's ability to leverage the absorbed knowledge internally. This could be avoided by involving employees from the processing company throughout the project (Huang and Rice 2012; Chiaroni et al., 2011; Zirpoli and Becker, 2011). However, in cases when process companies have a competitive advantage in the proprietary process technology, they may choose to work on the process innovations internally (Lager and Frishammar, 2012).

On the other hand, Nicholls-Nixon and Woo (2003) claim that the utilisation of various types of innovation relationships such as contracting or alliances could be used to gain different types of knowledge and will have a positive influence on the introduction of product innovations. For example, Huston and Sakkab (2006) described the development of Pringles potato crisps printed with words and images. Procter and Gamble (P&G) was able to 'in-source' the technology of printing edible images on cakes and cookies from a bakery in Italy.

This was achieved through its global network of potential sources of ideas, but also the existing know-how of P&G.

Avemaete et al. (2004) build on the work of Grunert et al. (1997) by introducing a conceptual framework that consists of dependent variable (product and process innovation) and two exploratory factors (internal capabilities and the ability to use information from external partners) (See Figure 20.). The authors argue that both in-house capabilities and the ability to utilise the knowledge from external partners are crucial in development of company's technological capabilities and its market orientation, similar to the concept of absorptive capacity (Avemaete et al., 2004).

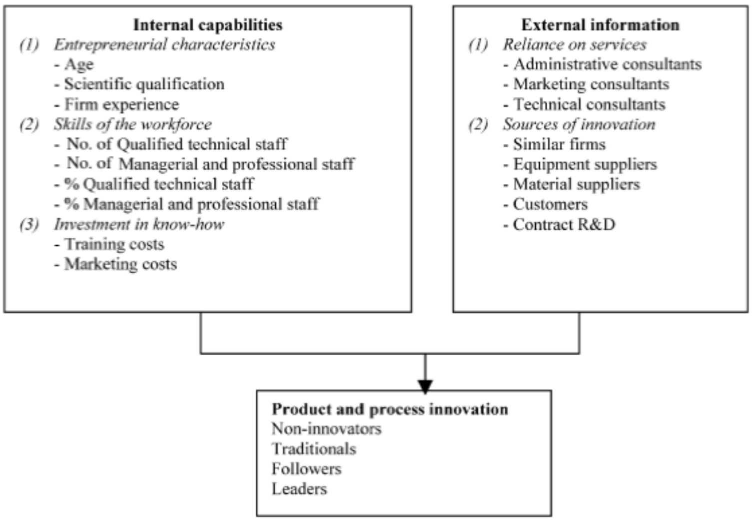


Figure 20. Conceptual framework to analyse determinants of product and process innovation in small food firms. Adopted from Avermaete et al. (2004, p.467)

4.5.3 Supply chain relationships

Companies operating within process industries are often characterised with long and complex supply chains. The supply chain may include a range of small and large production plants (owned and operated by different companies) or fully integrated in a long production chain within a conglomerate (Tottie and Lager, 1995). The supply-chain collaboration for an enhanced innovation performance has been identified by a number of studies (Lefebvre et al., 2015; Sarkar and Costa, 2008; Soosay et al., 2008). Food companies tend to develop collaborative relationships particularly with suppliers (Aylen, 2010; Storm et al., 2013; Knudsen, 2007) and with customers (Menrad, 2004; Thomke and von Hippel, 2002).

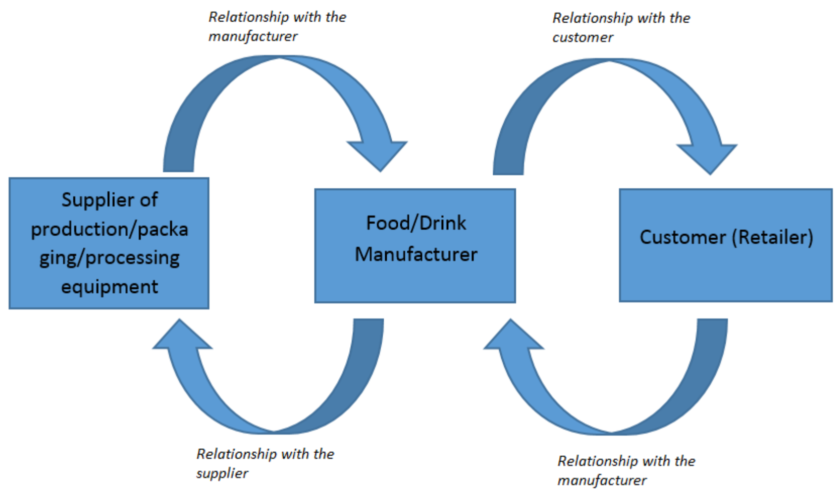


Figure 21. The supply chain relationships investigated in the present research

The three echelon supply chain (See Figure 21.) investigated in this research project is considered to play a crucial role in the New Product and Process Development projects, it is composed of:

- supplier of either production, packaging or processing equipment (in some instanced all)
- food or drink products manufacturer or packaging developer
- customer (in this research project the retailer)

The Figure 21. illustrates relationships between the supplier of equipment and the food/drink manufacturer (processing company) that is involved during process innovation, on the left hand side. While the right hand side, the Figure portrays the relationship between food/drink manufacturer and customer (retailer), assumed to be important during product innovation. The food/drink manufacturer is in the middle of these relationships as it is the key party responsible for developing a complementarity between the process innovation and product innovation.

4.5.3.1 Collaboration between the equipment supplier and the processing company in the food and drink sector

Spekman et al. (1998, p. 57) argue that collaboration between supply chain members requires “high levels of trust, commitments and information sharing.” Process industries are characterised by the collaboration of the process firm with the suppliers of new technology (Aylen, 2010; Lager and Frishammar, 2012). A major study by Hutcheson et al. (1995) points to the importance of collaboration between operating companies that provide the process expertise and equipment manufacturers that play a crucial role in refining existing technologies, improving equipment reliability and capabilities. This, however, causes that individual process firms very rarely develop their own process technology or manufacture process equipment, making them dependent on equipment suppliers in cases when they decide to further enhance their operating performance (Lager & Frishammar, 2010; Rönnberg Sjödin et al., 2011).

Lager and Frishammar (2012, p. 68) point to the "incentives of joint development efforts through mutual collaboration" between the processing company and equipment supplier as still being strong. This practice has a long tradition particularly among Nordic countries, where equipment suppliers started with a collaboration with domestic process firms and gradually established themselves in the global markets. They had the opportunity to test the prototypes and gain hands-on experience about the needs and problems processing companies are facing in their daily operations, helping them with development of new equipment. Equally, this involvement presents an opportunity for process companies to gain an early access to novel technology and equipment. When process companies are building a new plant or improving the existing one, it often could not be expected that the solution would be available off the supplier's shelf. A close collaboration between equipment supplier and the processing company is needed (Beckeman, 2013; Bruch and Bellgran, 2010).

A collaboration between the equipment supplier and process firm is also needed to find a competitive production solution, due to the firm-specific nature of process technology needed by process firms (Bigliardi et al., 2010; Frishammar et al., 2012). Despite this mutual dependency, the type of collaboration required between the processing company and equipment supplier will differ based on requirements of the New Product and Process

Development project (van Echelt et al., 2008). Bergfors and Lager (2011) argued that even though during a radical process development, a collaboration with equipment manufacturer is crucial from the early stages of the innovation process, it may not be necessary during incremental process development. Moreover, ‘newness’ and ‘complexity’ of process technology have been identified as some of the key determinants of the required form of collaboration (Lager and Frishammar, 2012).

Lamming (1993) defines four main ways in which suppliers can be involved in the collaborative product innovation (in this case the product innovation refers to production equipment):

1) The supplier provides proprietary parts to the company (standard components developed and designed by the supplier)
2) The supplier provides components whose functional/performance requirements are specified by customer (engineering done by the supplier)
3) The supplier provides parts whose characteristics are defined/controlled by the customer to a greater extent
4) The supplier provides parts whose characteristics are controlled/defined entirely by the customer

4.5.3.2 Collaboration between the processing company and the customer (retailer)

The well-established relationship between the actors in the supply chain was found to result in a more effective and efficient collaboration in the future, but it has also been found to influence their innovation capacity (Kühne et al., 2013; Lager and Storm, 2013). The field of research on involvement of suppliers in the product development has shown that it is one of the ways to enhance the product and process development process in terms of speed and product quality (Gupta and Souder, 1998; Primo and Amundson, 2002), while at the same time gaining innovative ideas and crucial technologies from suppliers (Bonaccorsi and Lipparini, 1994). According to Teichert and Bouncken (2011) only a supplier with an emergent strategy approach that is based on experimentation and creativity associated with trial and error, could lead to achieving a long term competitive advantage in the setting of low supply-chain rigidities. Suppliers should be allowed to experiment with new technologies, designs and various interfaces of components.

Despite the assumption that one of the main aims of the buyer-supplier collaboration is the maximisation of value. Kahkönen and Virolainen (2011) believe that the networks consist of different types of relationships that are not necessarily collaborative in nature. Järvensivu and Möller (2009) build on this argument, by stating that network players possess more or less equal power of influence and hence the relationships could become increasingly unstable and in danger of becoming fief-like and trussed to dominant partners (Kumar, 1996). Majority of the existing definitions of power define it as: “the ability to influence the decision-making and actions of the other party” (Kahkönen and Virolainen, 2011, p. 112). Focal companies have in general an increased power over their collaborators than lower-tier components suppliers. Moreover, company's market power has an impact on its position in the network (Sanderson, 2004). This statement is supported by Ramsay (2014), who adds that the proportion of buyer's purchases of supplier's capacity and the size of buyer have a positive influence on the buyer's control. The asymmetry of risk that is present in the vertical supply chain leads to a scenario in which losing a retailer account would be much more serious for the supplier than for the retailer losing out a supplier.

Historically, the role of retailers has been perceived as largely irrelevant within the production and distribution chain. Throughout the past decade their role as a bridge between product manufacturers and consumers has become more important across all functions most importantly innovation. In the 1970's the main area of value creation was occurring at the manufacturer's stage of the retail value chain (van Donk, 2001). Today, the distribution system in the UK is dominated by 'Big Four' (Fernie et al., 2010). Their power has been further intensified by the increasing market share of the four largest UK supermarkets; Tesco, Morrison's, Asda and Sainsbury's. During the past two decades their market share has increased from 48% in 1998 to 72.6% in 2016 (IGD Retail Analysis, 2016). Private label operator Tesco Plc is the largest supermarket out of the 'Big Four', as it holds strong positions in several categories, it leads in dairy, nutrition/staples in value terms and is ranked fourth in both bread and oils and fats. Furthermore, power of these retailer is demonstrated by a number of fresh and packaged foods that are being continuously discounted, i.e. milk and bread, causing further issues for others down the supply chain. Dairy farmers are loudly voicing their fear about their inability to maintain the price pressures on the production costs (Euromonitor International, 2016).

The nature of relationship between processing company and retailer is particularly complicated due to the dual role of retailers in commissioning private labels and also being a way through which branded products reach the consumer, See Figure 22. (Dobson and Chakraborty, 2015). This practice is referred to as ‘co-opetition’ (Bengtsson and Kock, 2000). Retailers act as gatekeepers between the food processing company and the final consumer (Burt and Sparks, 2003; Caizza and Volpe, 2013). Retailers’ key interest are consumers and their satisfaction and repeat purchase. They constantly focus on delivering products that consumers need. Retailers do not share information about sales and performance with processing companies and this often leads to lack of trust, making it difficult to collaborate (Grunert et al., 2008; Kottila and Rönni, 2008; van Donk et al., 2008). Retailers are commonly referred to as ‘barriers to innovation’, particularly radical innovations. This is caused by their dominant focus on short-term sales performance and low price (Esbjerg et al., 2016).

One of the main advantages of the retailer brand over the manufacturer brand is their ability to limit marketing expenses and achieve the economies of scope across all products because of their trusted name. However, the manufacturers have the advantage of developing brands with a common production technology/marketing technology/R&D base enabling them to establish expertise in production, distribution and marketing of these products (Cotterill and Putsis, 2000).

The retailers tend to develop exclusive relationships with a few favoured, single sourced partnerships resulting in supplier’s ‘lock- in’. Some of the reasons for this are; reduced transaction costs, fewer risks associated with quality and safety, but also fewer strategic investments (Christopher and Jüttner, 2000; Fearne and Hughes, 2013). Based on the results of a study conducted by DG Comp into the choice and innovation in the food retail sector in case when retailer's private label is able to rapidly copy manufacturer's innovations, the returns such manufacturers will be able to earn will decrease. This "free riding practice" could consequently hinder the motivation on the side of manufacturer to innovate (van de Veer, J.P., personal communication, May 22, 2016). Activities of the subordinate supply chain member, such as product and process objectives, frame specifications and target prices are confronted with pre-settings of the dominant supply chain member. While under these circumstances the subordinate member will have to accept the contractual conditions with little opportunity for disagreement.

This has led to several investigations conducted by the UK Competition Commission to determine whether the major players have been exercising market power along the supply chain, towards suppliers (Competition and Markets Authority, 2008). The dramatic change in the power of retailers can be demonstrated on the example of the fresh produce. In 1990, more than half of the UK fresh produce was sold by greengrocers, ten years later the share of multiple retailers was at 83% of sales in terms of value (Hingley et al., 2006). Supermarkets have changed their strategy from market penetration by focusing on more store openings to differentiation strategy, particularly using the own-label products (Burt and Davies, 2010; Burt and Sparks, 2002).

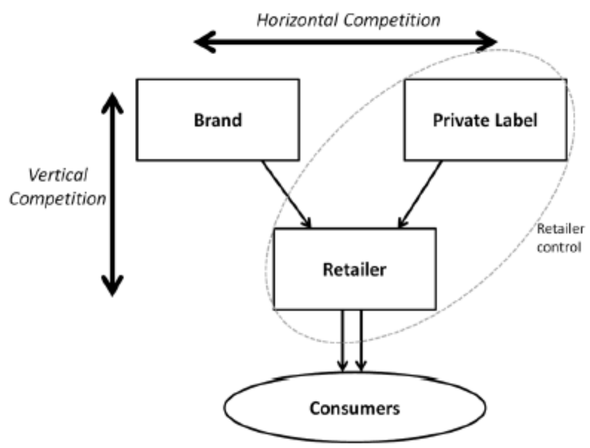


Figure 22. Brand and Private label competition (Adopted from Dobson and Chakraborty, 2015, p.77)

4.5.4 Established product and process technology trajectories in the processing company

The commonly held view of technological change is that it begins with a technological discontinuity (Tushman and Anderson, 1986). Abernathy and Utterback (1978) illustrate this in their Industry Life Cycle theory. Within this conceptualisation product and process innovation are closely interlinked with competitive environment and organizational structure through each of the three phases: *fluid, transitional and specific*. The *specific* phase is of particular relevance to low technology intensive sectors of process industries, which are characterised by a high path-dependency continuously stabilised by incremental innovation activities. The literature on technology management shows that companies tend to deploy technologies that are well-known and established, while processes and products are embedded in routines (Bauer and Leker, 2013; Benner and Tushman, 2003; Henderson and Clark, 1990; Tushman and O'Reilly, 1997). This constrains innovation and reinforces the development paths (technology trajectories) due to the high capital costs, development costs and a reluctance to pass away the preceding investments into the established technology (Bunduchi and Smart, 2010). Kauffman et al. (2000) studied how companies search for more efficient production recipes and refer to this as a “walk” on a technology landscape. They claim that once the company succeeds in finding technological improvements it restricts the search for other improvements to a local region of the technology landscape. This leads to incremental adaptation and decreasing interdependencies with other actors (Levinthal and Warglien, 1999).

The food and drink sector has traditionally been regarded as an industry with low research intensity (Bigliadi et al. 2013; Christensen et al., 1996; Martinez and Briz, 2000). It is not only the largest manufacturing sector in the UK, but also in the European Union contributing to the economic development and employment opportunities (Kühne, 2011). Research has shown that radical food product innovations are more successful than incremental innovation such as line extensions and me-too products that often provide companies with instant and short-term benefits (Knox et al., 2001). Incremental product and process innovations and exploitation of the existing product and process technologies prevail in the sector (Baker, 2013; Lagnevik et al., 2003; Lefebvre et al., 2015). For instance, Trippl (2011) points to incremental nature of innovation within Viennese food companies, while research conducted by Martinez and Briz (2000) found an incremental product-orientation towards innovation in Spanish food companies.

Moreover, companies operating in the food and drink sector tend to have less developed process innovation strategies when compared to the product innovation (Pisano, 1997). The production system development has been often underfunded, although the marginal returns of production process development are much higher than the cost of capital. This might be due to process innovation being extremely diffuse and elastic. It does not only include enhancements in manufacturing operations (e.g. new machine tools), but also includes production changes (Reichstein and Salter, 2006). Another reason for the reluctance of the processing companies towards process innovation are switching costs and unwillingness to pass away the pre-ceding investments into technology (Lager, 2011).

An efficient production process helps companies to ensure that their production costs will be aligned on maximising profit margins and less price sensitivity. According to Mahalik and Nambiar (2010) there is a range of similarities between the food and drink processing, packaging and the manufacturing industry. Therefore, for example, manufacturing principles from lean manufacturing and production systems are applicable to the food and drink sector. The pressure from large supermarkets in terms of increasing number of product lines and short lead times has led to adoption of techniques such as Just in Time manufacturing, Total Quality Management (TQM) and Computer Integrated Manufacturing Systems (CIMS) (Baker, 2013). According to Weinekötter (2009) in many companies for example, the packaging machinery is often underutilised due to frequent shorter production runs and changeovers. Therefore, Womanck and Jones (1996) argue that food companies should be focusing on the overall equipment effectiveness in order to be cost effective. This could be achieved through five lean principles that would enable companies to do more, for less; a) identify value of product/service to the customer, b) identify value-stream using Value-Stream Mapping, c) ensure continuous flow, d) ensure customers pull value using kanban systems, e) continuously strive to achieve high efficiency through kaizen. Decreasing the amount of waste and lead times is even more important in the food industry due to the perishable nature of the products (Langhauser, 2009).

Therefore, the development of production system usually occurs 'ad hoc' (Bruch, 2012; Rösiö and Säfsten, 2013). Baker (2013, p. 53) argued that "an entrenched conservatism within the food industry limits its ability to implement modern techniques and production methods employed in other sectors." According to the UK Annual Manufacturing Report (2016) some of the benefits of the purchase of automation equipment are improvement of business efficiency, reducing production time, improvements of quality as well as introduction of new products (The Manufacturer, 2016). The adoption of robots in the food industry is also very low, not only in the UK, but across the world, equaling to around 8,000 industrial robots bought by the food sector worldwide (International Federation of Robotics, 2016). Some of the known motivations for their adoption are rising labour costs, health and safety issues, primarily related to the unsafe working environment. Companies usually apply robots to produce single products such as biscuits and chocolates, as they are particularly suitable for delicate pick-and-place operations (The Manufacturer, 2016).

Process industries are characteristic with large fixed items of capital equipment and incremental innovation of the existing products and processes. However, there is a range of mechanisms that companies could apply to achieve a higher output and even development of new products from the established plants. Aylen (2013, p. 272) defines such practices as 'stretch' "the continual modification of a plant, system or service beyond its initial design specification, with the main aim of increasing capacity, but also to increase product range, quality and use new inputs." The stretch mechanism provides a proof that obsolescence does not always have to lead to replacement, but the old product and process technologies could still remain in widespread use and in shape for modern use. But this does not mean that discontinuous technological changes, requiring premature scrapping of old technology, do not take place among sectors of process industries. Float glass, oxygen steelmaking or continuous casting of steel are all examples of radical innovations (Aylen, 1980; Utterback, 1994).

Stretch is crucial for companies that aim to increase the output over time and at the same time keep up with the new technology to stay competitive. Realising the potential of existing plants and the ability to stage a price war will create high barriers for competitors to enter into the market and at the same time a strategic option to compete in mature industries. For example, the oil refineries typically run for 330 days before stoppages, float glass tanks are refined every 7 years, both create an opportunity for retrofitting equipment and expansion of individual plant items. A typical production line in the food or drink factory consists of several independent operations, with each of them serving a different function (Baker, 2013). Aylen (2013) developed a taxonomy of stretch based on five interrelated features, the taxonomy can applied across all operations:

- Improved intensity of hardware use through experience and better maintenance
- System-wide effects of improvements in material feedstock and downstream processing
- Bolt-on goodies (improved instrumentation or control systems/ incremental process improvements)
- Physical reconstruction of existing plants
- Enhancement of quality and offer of scope for making novel products

Food product innovations can be classified along seven categories (See Table 13). Accept from development of innovative and creative products all of the new product types are building upon the existing product technology. The Table further confirms the tendency of food and drink companies to build upon existing product technologies (Fuller, 2011). Fuller (2011, p. 19) mentions five key drivers of innovation in the food and drink sector;

- All products have a lifecycle (they die and must be replaced)
- New products promote growth
- New markets may be created; i.e. organic, functional food
- New knowledge and technologies may offer new opportunities; i.e. nanotechnology, electromagnetic processing, texturising techniques (Esbjerg et al., 2016)
- Changes in legislation, health regulations, agricultural policies

Type of New Product	Examples of Category
Line extensions	New varieties of a family of canned ready-to-serve soups New flavours for snack product such as potato chips
Repositioned existing product	Soft drink repositioned as main meal accompaniments Soy-containing products repositioned as dietary factors combating cancer
New form of existing product	Margarine or butter spreadable at refrigerator temperatures Instant coffees and teas
Reformulation of existing product	Low calorie (reduced sugar, fat) products Lactose-free milk products
New packaging of existing product	Single serving sizes of yoghurt Pull-top containers of snack dips
Innovative products	Frozen dinners Simulated seafood products
Creative products	Short-chain fatty acid containing products Extruded products

Table 13. Examples of different types of new products. Adapted from Fuller (2011, p.4-5)

4.6 Summary Literature Review 2.

This Chapter provided overview of the four theoretical perspectives that underpin this research project. Furthermore, three contingency factors, levels of absorptive capacity, supply chain relationships, and dependence on the existing technology trajectories were identified to influence product and process innovation in the food and drink sector.

The following section will bring together the findings from Literature Review 1. and Literature Review 2. and propose a classification of complementarities between product and process innovation as well as introduce the Typology: Complementarity-Capability Matrix. The Typology provides a starting point in identifying an overview of seven complementarity strategies (propositions) and contingencies (resources and capabilities) necessary to achieve these strategies.

CHAPTER 5. THE TYPOLOGY: COMPLEMENTARITY-CAPABILITY MATRIX

5.1 Introduction

This Chapter brings together the five streams of literature on complementarities between product and process innovation and builds upon theoretical perspectives from the contingency theory, project portfolio management and ambidexterity to introduce a Classification of complementarities between product and process innovation at the New Product and Process Development Project level. Furthermore, the Classification is combined with three contingencies identified in the Literature Review 2.; technology trajectories, supply chain relationships and levels of absorptive capacity in the Typology: Complementarity-Capability Matrix.

5.2 Investigating the complementarity between Product and Process innovation at the project level

To understand complementarity between product and process innovation, analysis at the industry, company and project levels are required. Yet, existing research has predominantly favoured the perspectives portrayed in the two industry level models (Abernathy and Utterback, 1978; Barras, 1986). Both of these models reflect sequential complementarity between product and process innovation. However, authors have argued these models oversimplify the industrial reality (Pisano, 1997; Lager, 2011). Utterback (1994) highlights the problem of the 'fallacy of the wrong level.' In his book Mastering the Dynamics of Innovation, he also recognises the need to consider the company level when investigating product and process innovation. Furthermore, models such as The Product-process matrix (Hayes and Wheelwright, 1979a; Hayes and Wheelwright, 1979b) and The Modularity-maturity matrix (Pisano and Shih, 2012), published in the Harvard Business Review also moved away from the industry level and tried to portray the different complementarity options at the company level. In addition, studies based on the Community Innovation Survey (CIS) inclined to classify the complementarity innovation strategies of companies (Battisti and Stoneman, 2010). For example, Evangelista and Vezzani's (2010) study identified four innovation modes with an aim to synthesise the highly heterogeneous nature of firm's innovation behaviour (product oriented/process oriented/organizational and complex innovation modes).

The aforementioned classifications fail to take account of the possibility that companies within a single industry sector could differ in the types of complementarities they adopt in their New Product and Process Development Projects. The project builds on the assumptions of prior research and argues that companies can be working on a portfolio of projects involving innovation of different types and scales (Bruch and Bellgran, 2014; Damanpour, 2010; Prange and Schlegelmich, 2010). In these portfolios more breakthrough innovations with a high degree of risk, but a potential for development of a competitive advantage, are combined with "safer" projects with a higher success ratio. Perhaps the most commonly cited work, following the ambidexterity approach is the typology of development projects by Clark and Wheelwright (1993). The authors differentiate between New Product Development

(NPD) projects based on the extent of product change and manufacturing process change. However, this model fails to uncover the pattern in which the product and process innovation take place within these projects. Moreover, a recent study by Beregheh et al. (2012) has demonstrated the importance of exploring organisational commitment to a range of innovation types in the food sector SMEs.

5.3 Classification of complementarities between Product and Process innovation

This research project aims to provide a starting point in this research field by bringing the contingency perspective into the area of complementarity studies. In doing so, a classification of complementarities between product and process innovation available to companies in their New Product and Process Development Projects is developed (See Table 13.). Within this Table the terminology is re-conceptualised from one of the most commonly cited publications in the contingency theory field; Thompson (1967) to describe complementarities occurring between product and process innovation. These are: *Reciprocal interdependence, Sequential interdependence* and *Pooled interdependence* (Thompson 1967, p. 54). It is argued that depending on the aims of the New Product and Process Development Projects there could occur *Product* or *Process Pooled* complementarity as well as *Product* and *Process Sequential* complementarity. Moreover, the classification contributes with two unique complementarity types that define a low extent of complementarity, *Product* and *Process Amensalism*. The Table.. also includes suggested examples of New Product and Process Development Projects from a range of process industry sectors.

The following part describes these complementarity types from high to low extent of complementarity. *Reciprocal complementarity* is the highest extent of complementarity and is defined as a synchronous adoption of product and process innovation often creating opportunities for other product and process innovations. New Product and Process Development Projects that adopt this complementarity aim to develop radically new products that require the development of new product and production technology, that is new to the company. In these types of projects, teams usually get much more freedom in choosing and developing resources and capabilities instead of using existing equipment and operating techniques. Teams work closely in all New Product and Process Development stages as every change in the product has to be tightly integrated to the production process and *vice versa*.

Product Sequential complementarity occurs when companies start the project with a dominant focus on product innovation. A clear product concept prior to development ensures that this opportunity is worth of further exploration and makes it easier to prioritise during the formal development (Frishammar et al., 2013). This subsequently necessitates (triggers) changes in process innovation. These types of projects typically follow the pattern described in the Stage-Gate NPD model (Cooper, 2008). Arguably, there is a lack of collaboration between different departments at the beginning of the project, while project's aims are dominated by the product quality.

Process Sequential complementarity takes place in New Product and Process Development Projects with a dominant focus on process innovation. The project commences with development or adoption of a new manufacturing process technology. This results in the recognition of an opportunity for a new product and its subsequent development.

The term *Amensalism* is taken from biology and is defined as “a relationship between two species of organisms in which the individuals of one species adversely affect those of the other and are unaffected themselves” (Encyclopaedia Britannica, 2015). This is applied to the investigated research context in terms of established process or product technology trajectories that companies keep for many years (Aylen, 2013; Baker, 2013). Such situations hinder the development of complementarity with the other innovation type, leading to either *Product Amensalism* or *Process Amensalism*. These types of projects are characterised by utilisation of existing resources with minimal changes to the existing products and production process with an aim to maximise return on investment. For instance, a fixed product design reduces the number of production technology options (Bellgran and Säfsten, 2010).

Product or *Process Pooled* complementarity types are characteristic with the lowest extent of complementarity between product and process innovation. The primary focus is typically either on product or process innovation and the development of resources and capabilities without any impact on the other types of the complementarity. In such situations meaningful discussions between the New Product and Process Development teams are limited. The emphasis is on using the existing resources to produce the product without any change to the process (See Table 14. for an overview with examples).

Extent of complementarity: HIGH	**Reciprocal**		Synchronous adoption of product and process innovation often creating opportunities for other product and process innovations.	**Suggested example:** Development of Guinness 'in-can' system in the 1980's, required the development of the new plastic 'widget' and new process equipment to insert the system and gases into the can (Trott, 2010).
	Sequential	**Product Sequential**	The dominant focus is on product developments. The project commences with the development of a new product concept, this subsequently necessitates (triggers) changes in process innovation.	**Suggested example:** Billerud is largely focused on satisfying their customers and developing a wider product range, e.g. malleable formable board for packaging project; subsequently leading to a focus on innovations in the production technology and processes (Bergfors and Larsson, 2009).
		Process Sequential	The dominant focus is on process developments. The project commences with the development or adoption of a new manufacturing process technology. This results in the recognition of an opportunity for a new product and its subsequent development.	**Suggested example:** The development of complex manufacturing float process enabled Pilkington to produce the float glass (Anderson and Tushman, 1991).
	Amensalism	**Product Amensalism**	A New Product and Process Development Project where the presence of a constraining factor, such as incumbent product technology or a lack of capacity to understand new technologies, could hinder process innovation.	**Suggested example:** The cork product closure for wine in its traditional form dominated industry for 100 years, because of this dominance emergence of new production technology was hindered (Pereira, 2007).
		Process Amensalism	A New Product and Process Development Project where the presence of a constraining factor, such as incumbent process technology, sunk investments, or a lack of capacity to understand new technologies, could hinder product innovation.	**Suggested example:** Extractive industry saw only about 12 revolutionary developments in the 20th century (Bartos, 2007). Rio Tinto HIsmelt® iron smelting technology for production of steel took more than 20 years and millions of dollars before the plant was constructed in Western Australia (Leczo, 2009).
	Pooled	**Product Pooled**	A New Product and Process Development Project in which product innovation takes place irrespective of process innovation. The only connection between them is that they belong to the same organization.	**Suggested example:** Ingredients changes to food products, such as flavorings used in potato chips, requiring no change to the manufacturing process (Bigliardi and Galati, 2013).
LOW		**Process Pooled**	A New Product and Process Development Project in which process innovation takes place irrespective of product innovation. The only connection between them is that they belong to the same organization.	**Suggested example:** Continuous wide strip rolling technology for steel moved through five generations of incremental process improvements from its inception in 1926, with few resulting in changes to the core product (Aylen, 2010; Aylen, 2013).

Table 14. A classification of complementarities between product and process innovation

Seven different types of relationships are described in the classification of complementarities between product and process innovation, to develop "Product-Process Complementarity Map." Mapping approaches and bubble diagrams are some of the popular project management methods. These include for example; Extensions of Boston Consulting Group portfolio models (stars, cash cows, dogs, wildcats); GE/McKinsey Model designed to allocate resources across business units in a company (Cooper et al., 1999; Roussel et al., 1991). Figure 23. shows graphically the classification of relationships in the Product-Process Complementarity Map. The vertical axis represents an emphasis on process innovation and the horizontal axis product innovation, from a low to high extent. The axis in the centre of the map represents the extent of complementarity between product and process innovation, from a low to high extent. The blurred lines between different complementarities are intended to reflect unclear boundaries between complementarities, and offer an initial conceptualisation of these complementarities within a map. The Product-Process Complementarity Map should be perceived as a map to position a portfolio of projects from which companies could choose the most suitable complementarity strategy for their current project.

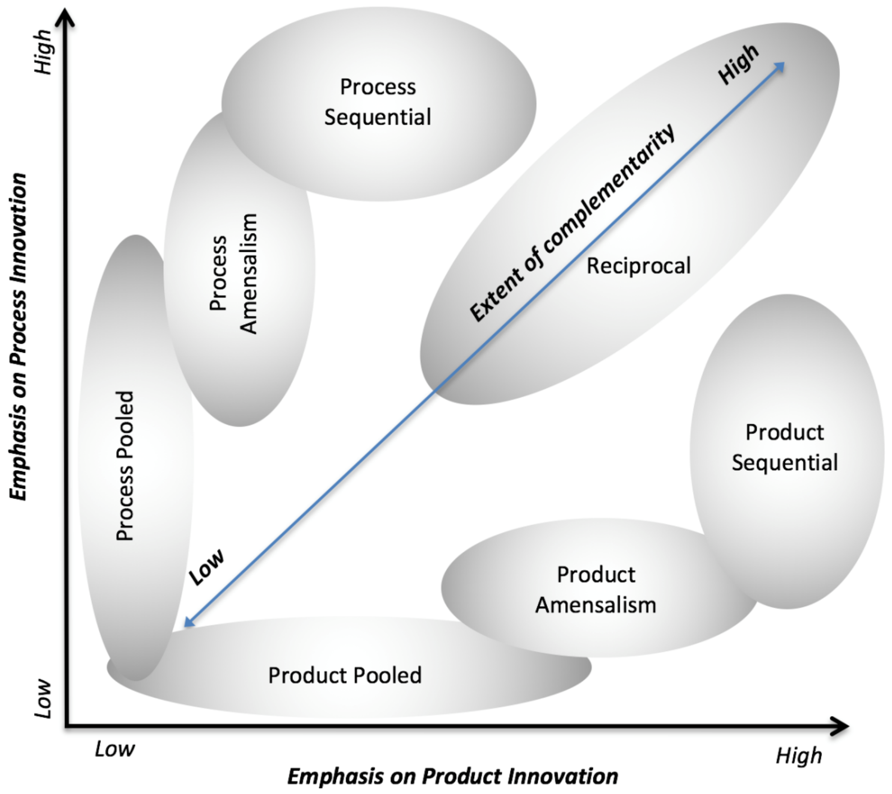


Figure 23. Product-Process Complementarity Map to position a portfolio of projects

The sections that follow demonstrate how three contingencies (company's resources and capabilities) could lead companies operating in the food and drink sector closer to a particular type of complementarity between product and process innovation, in their New Product and Process Development Projects. The conceptual approach to understand the linkages between product and process innovation is under-pinned by three contingencies described in Literature Review 2: i) Levels of potential and realised absorptive capacity; ii) Dependence on existing technology trajectories and iii) Relationships in the supply chain between the processing company and customer or equipment supplier. By combining the Classification of complementarities between product and process innovation and three contingencies, it is possible to develop a Typology of seven complementarity strategies (propositions) that identify a range of complementarity patterns between product and process innovation.

5.4 Typology: The Complementarity-Capability Matrix

This thesis builds upon prior literature that suggested a need for an established and formalised project management practices for the Project Portfolio Management (PPM) implementation to succeed (Brown and Eisenhardt, 1995; Teller et al., 2012). However, to create value it has to be tailored to a specific environment (Cooper et al., 2001; Crawford et al., 2006). The existing literature provides little guidance or understanding about the different complementarity types that may exist between product and process innovation within organizations' New Product and Process Development Projects. Further, it lacks guidance on the allocation of resources and capabilities that are necessary to achieve them in the food and drink sector. The aim in this research project is to overcome these limitations and provide academics and managers with a useful tool for analysis and decision making, within the context of the process industry sectors.

The research project builds upon the definition of contingency approach that claims "the effect of one variable (X- product innovation) on another variable (Y-process innovation) depends upon some W" (Donaldson, 2001, p.5). Instead of presenting the impact of factor W as dichotomous (low or high). In this research project the aim is to point to a spectrum of types of technology trajectories, degrees of supply chain rigidities and levels of absorptive capacity (W) that will influence complementarity between product and process innovation.

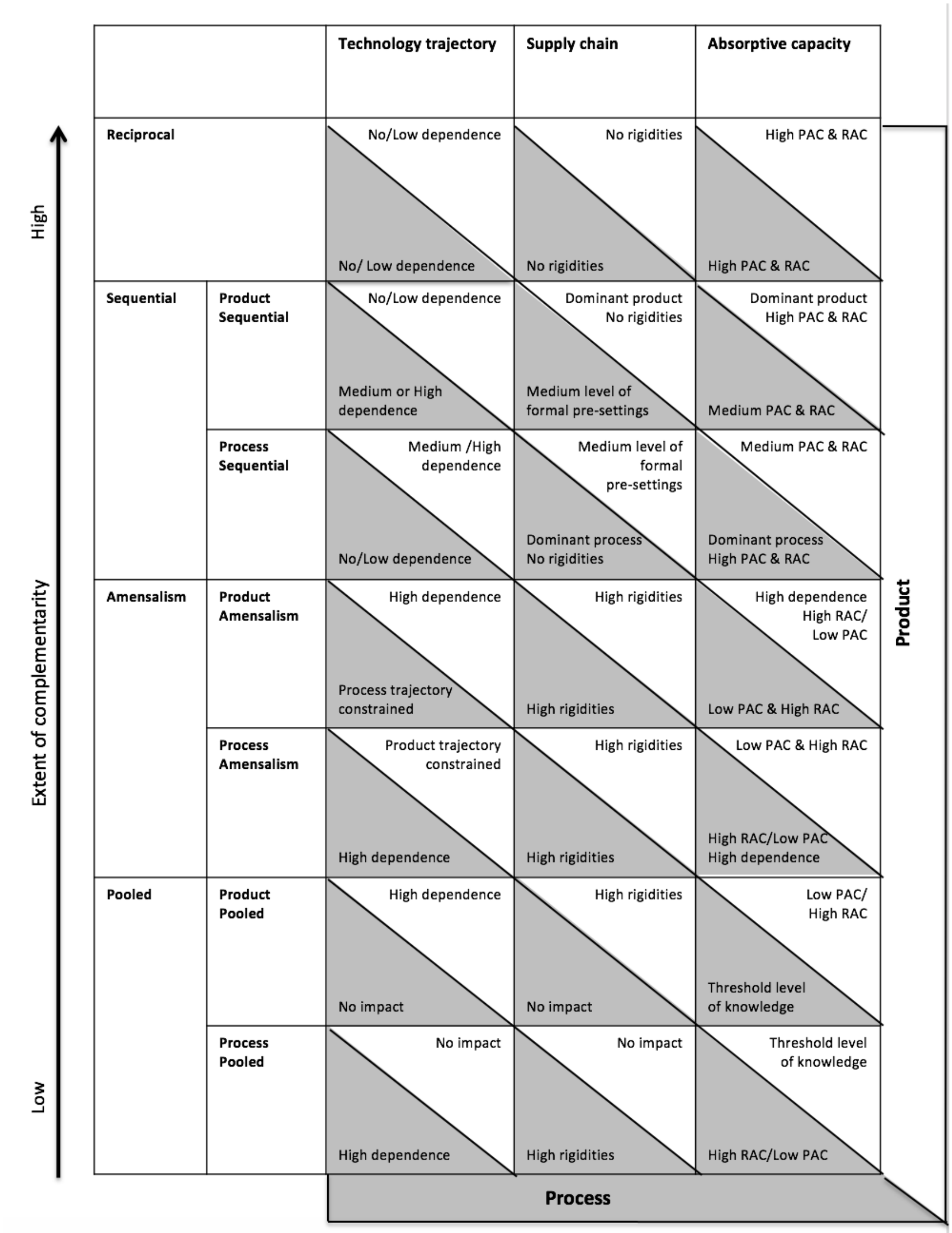
The value of the variable W is identified within a spectrum ranging from low through medium to high, defining the relationship between X and Y.

This project presents this logic in a novel typology termed as “The Complementarity-Capability Matrix” to portray the relationship between complementarity types, ranging from high to low extent of complementarity between product and process innovation. These are then related to the resources and capabilities (W) in product and process innovation required to effectively manage (move closer towards) these complementarities in the New Product and Process Development Projects (See Figure 24.). This comprehensive conceptual framework explains different innovation strategies that are available to companies operating within the food and drink sector. The framework further enables companies to understand the necessary resources and capabilities to achieve the desired strategies. The development of a complex typology has enabled the researcher to incorporate multiple levels of theory; contingency theory, resource-based view, project portfolio management. This would not be possible by building upon the traditional bivariate or interaction theories (Doty and Glick, 1994).

The far left vertical axis reflects the seven complementarity types between product and process innovation, ranging from low to high extent of complementarity. Across the top of the framework, the horizontal axis captures our three contingencies (resources and capabilities) influencing the complementarity between product and process innovation. The lower left shaded area relates to process innovation, while the upper right area relates to product innovation (the former is also reflected in the shading in Figure 24.). The Typology identifies a spectrum of different extents of technology trajectories, degrees of supply chain rigidities and levels of realised and potential absorptive capacity that are necessary to move towards achieving each complementarity type. For example, if a company is facing a New

Product and Process Development Project in which it aims to achieve reciprocal complementarity; Managers need to make sure that the New Product and Process Development Project does not depend on the existing technology trajectories in product and process innovation. There are no supply chain rigidities that may hinder innovation, and the project team has well developed potential and realised absorptive capacity in both product and process innovation. Both components of absorptive capacity are necessary in order to be able to utilise the existing knowledge inside the company and combine it with suitable knowledge in the external environment. The Typology should be perceived as seven complementarity strategies that are at this stage in the role of seven propositions. These will be empirically tested using the Proposed Case Study Methodology (Bitektine, 2007). See Chapter 6 for details on the proposed study design.

The matrix enables the identification of a portfolio of complementarities between product and process innovation and resources and capabilities necessary to achieve them in a more systematic way than has been demonstrated in the past. This matrix should be seen as a preliminary attempt at addressing an issue that has significant implications for innovation strategy at the new product and process development project level. Empirical testing of the conceptual framework and propositions that have been put forward should follow.



*Notes: Realised absorptive capacity (RAC); Potential absorptive capacity (PAC)

Figure 24. Typology: The Complementarity-Capability Matrix

5.4.2 Definitions of the constructs within Typology: Complementarity-Capability Matrix

The centre of the Matrix presents a typology of a portfolio of complementarity strategies companies can adopt in their New Product and Process Development Projects. These strategies are defined by the required resources and capabilities (contingencies) to achieve these.

Doty and Glick (1994, p. 232) define typologies as "conceptually derived interrelated sets of ideal types that identify multiple ideal types, each of which represents a unique combination of the organisational attributes that are believed to determine the relevant outcomes."

The adoption of a typological approach is driven by its ability to effectively build theory in four respects (Fiss 2011, p.393):

1. Multidimensional nature- acknowledge the complex and interdependent nature of organisations (focusing on complementarities among a range of characteristics)
2. Result in integrative theories- linking structure, strategy and environment
3. Simplify multiple causal relationships into few, easy-to-remember profiles
4. Providing a useful tool for researchers as well as practitioners.

Even though typologies have been a popular way of theory building and a widely applied tool for guiding strategic analysis over decades (DeSarbo et al., 2005; Meyer et al., 1993; Porter, 1980). They have been commonly criticised for being inadequately developed or missing to fully specify the causal processes between constructs (Doty and Glick, 1994; Fiss, 2011). Furthermore, typologies have been criticised for including trade-offs, irrelevant elements, failing to provide insights into what really matters and to what extent (Fiss, 2011). Therefore, the aim of the typology presented within the Complementarity-capability matrix was to focus on three resources and capabilities that play a critical role in driving the complementarity type adopted in the Product and Process Development Projects within the food and drink processing industry. Moreover, the typology addresses the issues of specifying the degree to which the construct matters by identifying a spectrum of the extents of dependence on the technology trajectory, different degrees of the supply chain rigidities as well as different levels of potential and realised absorptive capacity. As stated by Klingebiel and Rammer (2014, p. 248) "the success of a firm's suite of innovative activities is a function of the amount and quality of resources dedicated to the task." These constructs have been defined based on the review of literature within each field, See Tables 15, 16, 17.

The following Chapter will test the validity of Classification of complementarities between product and process innovation and The Typology: Complementarity-Capability Matrix. Both concepts will be further modified and extended using qualitative data collection techniques in the UK food and drink sector.

Construct	Product/Process technology trajectory constrained	High technology trajectory dependence	Medium technology trajectory dependence	No/Low technology trajectory dependence
Definition of the construct	A project during which the established product or process technology is being hindered by development of the other innovation type.	Company utilises the existing product and process technology trajectories making no or only incremental adaptations.	Company utilises the existing product and process technology trajectories, by making significant changes to these.	Company is facing a radical new product and process development project that requires development of a unique product/ processing technology/purchase of an existing product or process technology (radically new and complex project, new to the company).
Evidence from wider innovation and operations management literature	Based on a stream of literature on different types of dependence on the established technology trajectories: Abernathy and Clark (1985); Bauer and Leker (2013); Benner and Tushman (2003); Henderson and Clark (1990); Kauffman et al. (2000); Lager and Frishammar (2012)			

Table 15. Definitions of different extents of technology trajectories.

Construct	High supply chain rigidities	Medium level of formal pre-settings	No supply chain rigidities	No impact
Definition of the construct	A dominant player (buyer/supplier) utilises its bargaining power by prescribing formal pre-settings in product/process development, without devoting sufficient resources to the relationship.	Buyer/supplier approaches relationships in a standardised way by making suggestions on improvements of the existing production process settings or requiring some form of customisation of the product.	The supply chain members share equal rights in the relationship, often collaborate in order to contribute to or support development of product and process innovation.	The supply chain rigidities do not play a role, caused by no or limited need for collaboration due nature of the project.
Evidence from wider innovation and operations management literature	Based on the stream of literature on asymmetric relationships in the food innovation supply chain between buyer and supplier: Beckeman et al., (2013); Järvensivu and Möller (2009); Johnsen and Ford (2008); Knudsen (2007); Lamming, 1993; Teichert and Bouncken (2011); Trippl (2011); van der Valk and Wynstra (2005).			

Table 16. Definitions of different degrees of supply chain rigidities.

Construct	High RAC	Medium RAC	Low RAC	High PAC	Medium PAC	Low PAC	Threshold level of knowledge
Definition of the construct	High ability to transform and exploit the external knowledge, demonstrated by having a significant level of experience in undertaking product/ process innovation internally.	Average ability to transform and exploit external knowledge, demonstrated by experience in undertaking product/ process innovation derived from a limited number of prior projects undertaken internally.	Low ability to transform and exploit external knowledge, demonstrated by few if any experience in undertaking product/ process innovation internally.	High ability to acquire and assimilate external knowledge, demonstrated by significant experience and ability to recognize commercially valuable new knowledge and assimilate it into its innovation process.	Average ability to acquire and assimilate external knowledge, demonstrated by experience in collaboration with external parties on product/ process innovation in several projects.	Low ability to acquire and assimilate external knowledge, demonstrated by few if any experience in collaboration with external parties on product/ process innovation.	The level of internal experience in product/ process innovation or experience in collaborating with external parties plays only a peripheral role.
Evidence from wider innovation and operations management literature	Based on the stream of literature on absorptive capacity and importance of collaboration with external parties when developing an innovation: Fosfuri and Tribó (2008); Huang and Rice, 2012; Lane et al., 2006; Jurado et al., (2008); Todorova and Durisin (2007); Zahra and George (2002);			Based on the stream of literature on absorptive capacity and importance of Fosfuri and Tribó (2008); Knudsen (2007); Lefebvre et al., (2015); Swift (2016); Todorova and Durisin (2007); Zahra and George (2002)			Fiss (2011)

Table 17. Definitions of different levels of potential and realised absorptive capacity.

CHAPTER 6: RESEARCH METHODOLOGY

6.1 Introduction

The preceding Chapters highlighted the importance of investigating the complementarity between product and process innovation at New Product and Process Development Project level, and reviewed the literature on two key aspects of this study. Firstly, this involved examining five streams of literature on complementarities between product and process innovation. Secondly, the different contingencies (resources and contingencies) influencing adoption of different complementarities in process industries, particularly the food and drink sector were addressed. The preceding discussions have also outlined the lack of academic attention towards this topic, particularly within the last decade (Damanpour, 2010). As well as "the fallacy of the wrong level" at which this topic has been investigated (Bruch and Bellgran, 2014; Cooper et al., 1997; Hullova et al., 2016). The theory introduced in Chapter 5 in the form of the; Product-Process Complementarity Positioning Map and the Typology: Complementarity-Capability Matrix, influenced design of the methodology and serves as a basis for theory testing and refinement. Due to the richness of the two theoretical constructs, theory testing through qualitative explanatory study is perceived to be a useful step before undertaking pure theory testing using quantitative research design. Quantitative methodologies are a commonly applied approach for theory testing (Bitektine, 2007; van Echelt et al., 2008).

The methodology in this research is divided into two phases of qualitative data collection. Phase 1 follows an inductive exploratory approach to address the first research question related to the ways food and drink companies manage the complementarity between product and process innovation. This phase also tests the validity and extends the Product-Process Complementarity Positioning Map. Phase 2 follows an abductive approach with an aim to test and extend the Typology: Complementarity-Capability Matrix, addressing the second research question.

The inductive approach in Phase 1 using semi-structured interviews with key informants was perceived as appropriate due to theory building purposes of the project. This phase also enabled researcher to identify 'illustrative' case studies of complementarity types in the Revised Product-Process Complementarity Map. Phase 2 tests and refines propositions of seven complementarity strategies from the Typology: Complementarity-Capability Matrix with single 'illustrative' cases studies using definitions of the key constructs from the Matrix (See Figure 25. in Chapter 5). Moreover, the research benefited from a sponsorship and collaboration with a packaging machinery company that aided researcher in gaining access to some of the research participants.

6.2 Research theory and design

Prior to undertaking primary data collection, the researcher had to consider appropriate research philosophy, research approach, strategy, method of data collection as well as techniques and procedures of data collection and analysis (See Figure 25.) (Saunders et al., 2009).

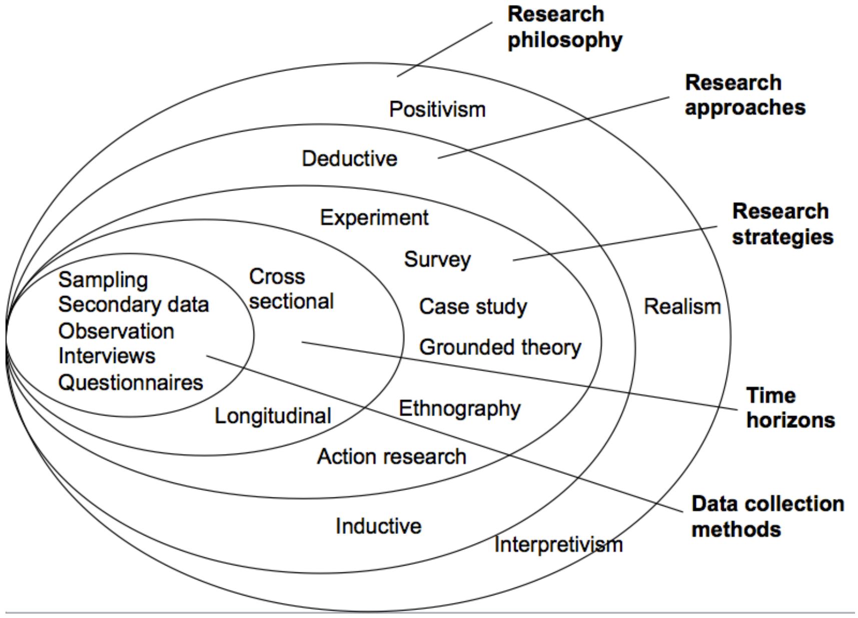


Figure 25. The research onion. Adopted from Saunders et al. (2009, p.138)

6.2.1 Ontological, epistemological and axiological stances

The ontological and epistemological stances influenced the methodological nature of the research project. The ontological stance (researcher's view on nature of reality) belongs to the category of subjectivism, as the researcher views the reality as socially constructed in which the actors engage in social interactions and the investigated phenomena are in a constant state of change. The perception of reality is a product of individual's cognition rather than being simply given 'out there' in the world (Burrell and Morgan, 1994). The human beings (respondents) are perceived to play a creative role, being viewed in the role of creators of the environment rather than being products of the environment.

The epistemological perspective is concerned with the way the researcher may understand the world and start to communicate this understanding as a knowledge to others. It is associated with the types of knowledge that can be collected as well as with a provision of a border line between what is 'true' and what is 'false' (Burrell and Morgan, 1994). The Project

Management research field is dominated by the positivist epistemology, focusing on causality and law-like generalisations (Smyth and Morris, 2007). However, Pollack (2007) identified a new trend towards a focus on details of situation and its reality. Therefore, despite a long tradition in the positivist view, the area is becoming more diverse in terms of the paradigms providing contrasting viewpoints, instead of re-stating assumption of prior research. This research project will follow the Interpretivist epistemology. Saunders et al. (2012) defines Interpretivism as too complex to develop law-like generalisations. The researcher has to understand the differences between the social actors. The aim of the research project was to uncover ways the complementarity between product and process innovation was managed in the NPPD projects. The Interpretivist researcher aims to embrace the complexity and dynamic quality of the social world holistically, by getting closer to the participants and their realities, while interpreting this appropriately (Leitch et al., 2009). This research was building upon criticism of the existing knowledge for producing industry models that were simplifying the reality. The research followed a belief that the social world can only be understood from the perspective of the managers and other parties that were directly involved in organisation of NPPD projects. The epistemology at the same time influences the axiology of the research, that is the role of researcher's values in the research. In Interpretivism the researcher is part of the investigation and cannot be separated from it. Hence, also the researcher's view on the role of values in the project was subjective. See Table 18. for an overview of the main philosophies compared by the assumptions.

	Pragmatism	Positivism	Realism	Interpretivism
Ontology *(researcher's view on nature of reality)*	External, multiple, most appropriate view chosen for answering the research question.	External, objective and independent of social actors.	Objective, exists independent of human thought or knowledge about their existence (realism) but is interpreted through social conditions (critical realism).	**Subjective, socially constructed, may alter, multiple.**
Epistemology *(researcher's view on acceptable knowledge)*	Depending on research question, either or both, observable phenomena and subjective meanings can provide acceptable knowledge.	Only observable phenomena enable the production of facts and credible data. Focuses on causality and law-like generalisations.	Observable phenomena provide credible data and facts. Insufficient data means inaccuracies in sensations (realism) or phenomena create sensations which are open to misinterpretations (critical realism). Focuses on explanations within a context.	**Subjective meanings and social phenomena. Focus on details of situation and its reality, subjective meanings motivating actions.**
Axiology *(researcher's view on role of values in research)*	Large role of values in interpreting results. A researcher takes both an objective and subjective view.	Value-free research with the researcher being objective and independent of the data.	Value-laden research because the researcher is biased concerning worldview, cultural experiences and background, which affect the research	**Value-bound and subjective. The researcher is part of what is researched and cannot be separated.**

Table 18. Four main philosophies compared by assumption (Adapted from Saunders et al., 2012; p. 146)

6.2.2 Research approach

The research project followed guidelines of an abductive research approach. Abductive research is said to overcome the weaknesses of purely inductive and deductive research. The abductive research requires an integrated approach rather than following one of the extremes described by induction or deduction. This approach relies on the existing theory and literature and intertwines these with the data collection (Dubois and Gadde, 2002). Dubois and Gadde (2002) argue that a standardised conceptualisation of research process as several sequential phases, does not provide the potential to utilise the advantages of a case study research. The researcher is able to make the most out of the theoretical and empirical phenomena by going 'back and forth' across different research activities, known as matching; e.g. theoretical framework, existing literature, theories and empirical data. The initial theoretical framework served as a guidance for the research project or in other words as 'preconceptions' and was continuously developed over time following the findings in the empirical world. The main logic in the research was that the theory cannot be understood without observations in the empirical world. The above described process is termed as Systematic combining. Please see Figure 26. for an illustration of Systematic Combining proposed by Dubois and Gadde (2002).

According to the authors any research project aims to compare the theory with empirical world. However, abductive research that builds upon Systematic combining does this continuously throughout the research process. The way this process develops is directed by the evolving conceptual framework and the evolving case study. The aim of the research method was not to force the findings onto the preexistent categories, but rather to develop and adjust these categories on the basis of collected data and chosen theoretical perspectives (Dubois and Gadde, 2002).

Miles and Huberman (1994) assigned the theoretical frameworks into two distinct categories; tight and pre-structured/ loose and emergent. Both types have their advantages and disadvantages. For instance, having a tight framework might "blind the researcher to important features in the case or cause local informants' perceptions" (Miles and Huberman 1994, p. 16). On the other hand a loose framework may lead to data overload or indiscriminate data collection. In the present research the conceptual framework acted as a cornerstone, functioning as a guidelines during the data collection. This approach is in line with the adaptive theory approach that also portrays theorising as a continuous aspect of the research process (Layder, 1998). The adaptive theory "focuses on the construction of novel theory in the context of an ongoing research by utilising elements of prior theory in conjunction with theory that emerges from data collection and analysis of data" (Layder, 1998, p. 27). This approach further contributed to achieving the overall goal of the research project to produce a cumulative knowledge rather than add to the fragmentation of the research field. The researcher viewed the extant theory as important as discovery of theory (Layder, 1998).

Another important characteristic of systemic combining that was adopted in the research project were the direction and redirection of the study. In particular, the impact of different data sources and methods on data collection. These enabled the researcher to uncover new dimensions of the research problem. The Phase 1 of data collection sought to uncover the different types of complementarities between product and process innovation utilised in the NPPD projects among food and drink companies. In the Phase 2 of data collection, the NPPD projects identified in Phase 1 (case studies) were considered as tools or in other words pieces of jigsaw puzzle. Every single additional interview, observation or reading of a secondary data source about the NPPD project under investigation such as annual reports or press releases facilitated researcher's ability to observe clear complementarity patterns in the data. Consequently, the initial Conceptual Framework (Typology: The Complementarity-capability Matrix) was continuously modified based on the unanticipated empirical findings.

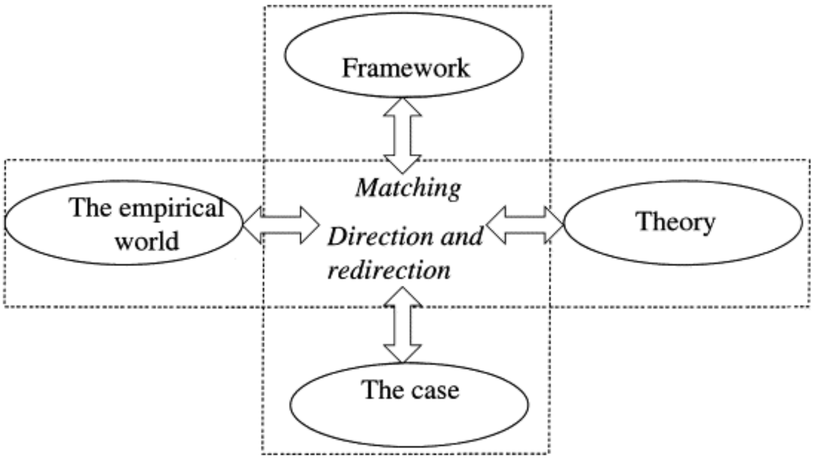


Figure 26. Systemic combining. Adopted from Dubois and Gadde (2002, p. 555)

6.3 Overview of research design

The primary data collection will be conducted in two phases; exploratory Phase 1 and explanatory Phase 2. The qualitative data collection will include semi-structured interviews and single 'illustrative' case studies (See Table 19. for an overview of the two phases).

	Phase One	**Phase Two**
Research Aim	To extend the Product-Process Complementarity Map in the food and drink sector.	To refine the Typology: The Complementarity-Capability Matrix based on case studies of New Product and Process Development Projects in the food and drink sector.
Research Approach	Qualitative interviews with key informants from the food and drink sector.	Case study research based on in-depth analysis of New Product and Process Development Projects among food and drink companies using interviews and secondary data collection.
Research Questions	1) How do food and drink companies manage the complementarity between product and process innovation in New Product and Process Development Projects? 2) How different contingencies, in terms of resources and capabilities influence the adoption of different complementarity strategies?	
Objectives	To examine the innovation strategies applied across food and drink companies and the role that is played by the complementarity between product and process innovation in their strategic decision making. To identify factors that influence company's choice of innovation strategies in their projects.	To extend the Typology Complementarity-Capability Matrix by pattern-matching with findings from illustrative case studies of New Product and Process Development Projects in the food and drink sectors.

Summary of key research questions to be addressed within each phase	1. How many incremental/ moderate/radical product innovations had the company launched in the past 5 years? 2. How many incremental/ moderate/radical process innovations had the company launched in the past 5 years? 3. What is the relationship between product and process innovation? 4. Is it possible for both product and process innovation to occur in NPD project? 5. What advantages and opportunities does this bring? 6. What are the barriers/ challenges to this? 7. Did the company develop/ implement any structures in order to coordinate product and process development? (e.g. design for manufacturability, concurrent engineering) ***Additional part (Introduction of the Product-process positioning map)*** *Can you give me an example of a case of New Product and Process development project within the past 5 years when such complementarity innovation strategy was applied?* *Can you think of any other complementarity innovation strategies utilised within your company, but not mentioned on the Product-process positioning map?*	1. How was the project influenced by the requirements of the customer/supply chain members? 2. How was product/process technology innovation perceived within the project? 3. Who were the key collaborative partners in product and process developments? 4. What internal product/ process capabilities (knowledge) were present within the company? 5. Were there any other resources/capabilities that facilitated development of relationship between product and process innovation? 6. Were there any other factors (not mentioned until now) that negatively influenced development of the relationship between product and process innovation? 7. What were the further opportunities, gained during execution of this project that you were able to utilise in the follow-up projects?
Research Strategy	Interviews	Single case studies
Sample	Innovation, NPD, technology and production managers within food industry.	Innovation, NPD, technology and production managers within food industry.
Research instrument	Semi-structured interviews	Semi-structured interviews and secondary data.

Table 19. Summary of Phase 1 and Phase 2 of data collection.

6.4 Summary of research strategy, design and links to the research questions

The research design was informed by the research questions (See Table 19.). The data was collected in two phases (Figure 27.). Each provided rich in-depth qualitative insights into this under researched topic. Phase 1 identified cases of Product and Process Development Projects that could be further investigated in Phase 2 to test the Typology: Complementarity-Capability Matrix.

The following section will briefly outline the purpose of the research sponsorship from a distributor of a premium packaging machinery. The sponsorship has provided the researcher with a range of valuable insights into the food and drink packaging industry and contacts to several food manufacturing/packaging companies. The aims of the sponsorship did not, influence the results or biased the data collection.

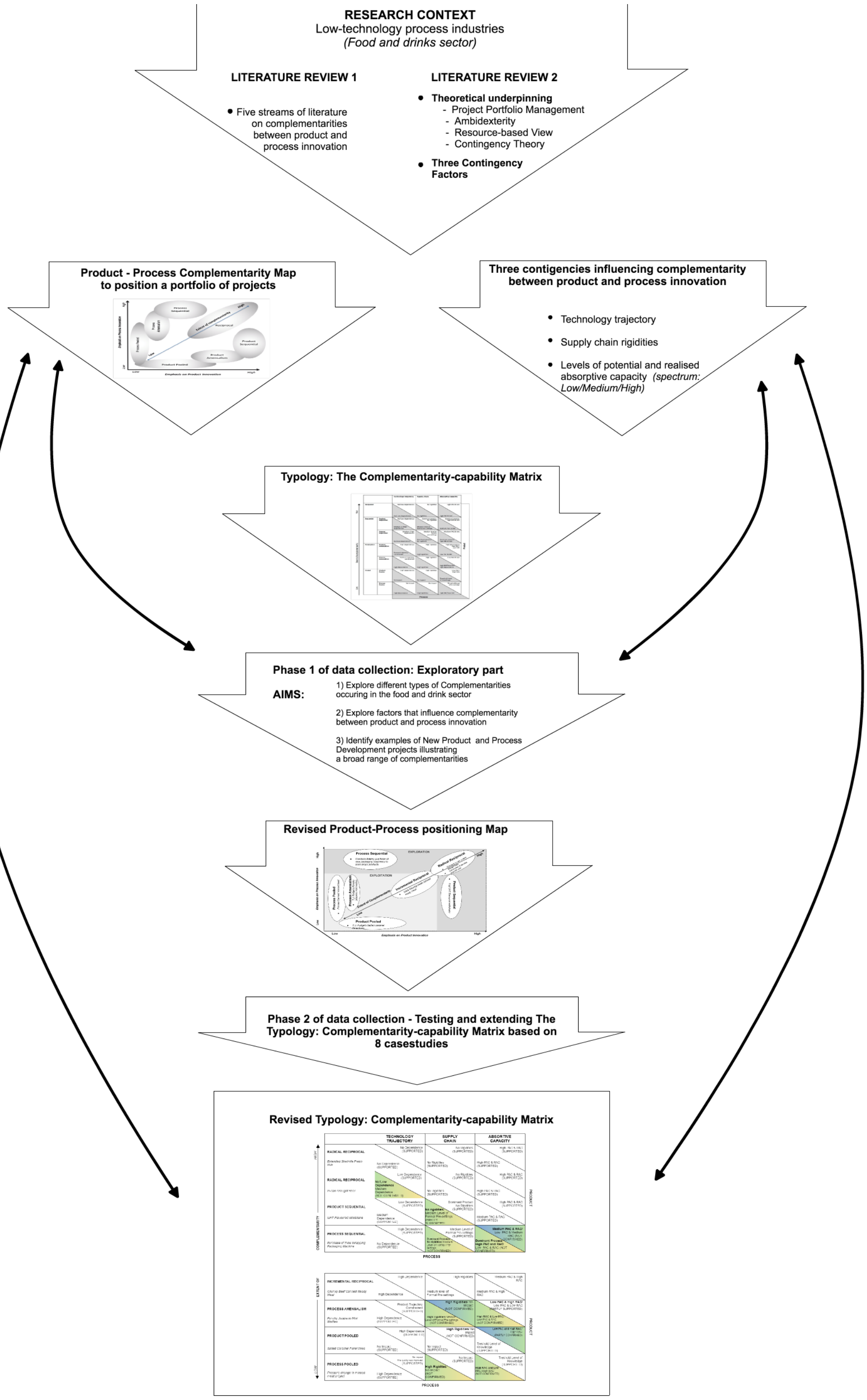


Figure 27. Summary of the structure of data collection.

6.5 Research Sponsorship

The research project has been sponsored by KernPack, a part of Kern Ltd. UK. This sponsorship received a significant trade media coverage (Packaging news, Food and drink technology, Food Manufacture). KernPack largely sells and distributes mail inserting and sorting machines. In this industry it has established a reputation for high quality machinery, after sales maintenance and support. Kern's entry into the UK Packaging market, valued at £11 Billion, has thus far had limited success. KernPack aims to be expert in packaging machinery solutions and automation. The company has over 60 years of experience with precision systems, and a strong reputation in other industry sectors. Currently the company sells high quality packaging machines produced by other third party machinery manufacturers. The main part of KernPack's sales has until recently been targeted at mailing companies. However, due to shift in the market towards electronic communication, the company had to identify further industries for which their machinery would be suitable. This has proven to be the food and drink industry. KernPack's aim in the next four years is to reach a 50/50 ratio between their mailing and food/drink business. Moreover, it wants to increase the number of sales force selling the packaging equipment to food manufacturers. For KernPack the success of their customers is a crucial part of their business. As a result the company emphasises on innovation to develop new technologies, products and services. To deliver this the company also employs in-house experts to focus on the packaging needs of their diverse customer base. In order to deliver better value to their clients, and assist their selling of new machinery, the company recognises the need to provide evidence of the returns on investment the equipment can deliver to the client in the future. This will help KernPack to promote the need to invest in new machinery, beyond simple replacement of outdated equipment, and direct cost savings.

The company has decided to sponsor the present research project to develop a better understanding of the benefits companies can obtain through establishing closer interrelationships between product and process innovation. Thus assisting in a justification for machinery investment by their customers. A greater understanding of these factors; how their customers can take advantages of the opportunities for product and process innovations, and a framework to help salespeople to market these benefits, would aid KernPack in their selling process. Particular attention will be given to how food firms manage their production process, and their product development processes, in order to enable them to take advantage of the potential benefits.

6.6 Data collection methods

Taking into an account the exploratory nature of Phase 1 and explanatory nature of Phase 2, a phased approach was considered as appropriate. Hence, the researcher adopted a mixed method approach, both qualitative in nature, to provide in-depth insights when answering the research questions. Table 21. provides a summary of the approach adopted.

Research Philosophy: Interpretivism	
Research Strategy: Semi-structured interviews and Single case studies	
Data Collection: Phase 1	• Eighteen semi-structured exploratory interviews with key informants analysed for key themes
Data Collection: Phase 2	• Eight cases of New Product and Process Development Projects) were collected using semi-structured interviews. • This phase aimed to test and refine the Typology: Complementarity-capability matrix, developed on the basis of literature review • Research aims to gain in-depth understanding of the complementarity phenomenon and factors influencing it using multiple sources of data (primary and secondary in some instances) to achieve triangulation (Yin, 2009) • Data analysis includes in-depth summaries of individual cases and pattern-matching between propositions and outcomes from case studies, interweaved with direct quotes (Bitektine, 2007).

Table 21. Summary of adopted approach

6.7 Key guidelines for the data collection

There are four main guidelines that will be followed during the primary data collection;

1. The present study will cover technological innovations related to products and processes. Therefore, other types of innovation such as organisational or administrative innovations, as well as entry to new markets will not be considered

2. To be considered the product and/or process innovation must have been implemented or used within a production process. Hence aborted innovations or innovations in progress will be excluded.

3. According to Grunert et al. (1997), there are three groups of actors that may perceive product as new; consumers, distributors and producers. For the purposes of the current study only the newness to the producer (processing company) will be considered. Because, even the product that might not be perceived as new by the

consumer and distributor, it is likely to be considered new by the producer that is involved in development of this product and/or process innovation (Fuller, 2011). Such innovation will require development of new skills and resources (not previously available to the company).

4. The innovation process can be analysed at three different levels: supra company (industry), company and project level (Grunert et al., 1997). This study will aim to contribute to the general knowledge about the types of complementarities at the industry level by investigating the complementarity strategies utilised by the food and drink manufacturing companies at the project level. This strategy is based on the theoretical grounding of this research project 'the contingency theory' that assumes companies adopt different complementarity strategies based on the type of New Product and Process Development Project they are facing. Instead of adopting a 'single best' complementarity strategy at the industry level.

6.8 Methodology for Phase 1: Exploratory Expert Interviews

The first phase of this research took the form of an exploratory semi-structured interviews using expert sampling technique, during 2015/2016. This exploratory phase enabled the researcher to develop insights into the management of the complementarity between product and process innovation in the New Product and Process Development Projects in the UK food and drink sector. The design of this phase was based on answering Research Question 1:

Q1: ***How do food and drink companies manage the complementarity between product and process innovation?***

Overall, this phase enabled the researcher to gain insights into companies' attitudes towards product and process innovation as well as their understanding of complementarity between these types of innovations. The existing findings about the subject were mainly conceptual contributions based on investigations of mass market commodity products (Abernathy and Utterback, 1978; Pisano and Shih, 2012; Utterback, 1994) or quantitative analysis of CIS survey (Ballot et al., 2015; Evangelista and Vezzani, 2010). The results from Phase 1 informed Phase 2 of data collection, these results were also used to confirm the complementarities identified in the Product-Process Complementarity Positioning Map. Any further complementarities that occur in the UK food and drink sector identified in this phase will be further investigated in the Phase 2 as case studies (Edmondson and McManus, 2007).

6.8.1 Semi-structured interviews

Phase 1 employed expert sampling, as a sub-category of purposive sampling. The participants were chosen because they were likely to generate useful information for the research project (Bitektine, 2007). The sample was based on 18 semi-structured interviews with key informants within the food and drink industry (i.e. senior managers, process development managers, product development managers, innovation managers, packaging experts and consultants from food and drink industry). The aim was to encourage participants to talk as freely as possible and discuss their own perspectives by providing rich and in-depth insights on the issues that have received limited attention in the existing literature (Yin, 2009).

Furthermore, the selected participants were chosen based on their expert knowledge and experience in development of new products, packaging, production as well as packaging processes within the UK food and drink sector. The first contact was initiated with the company through gatekeepers from the Product Innovation Research Group at the Portsmouth Business School and their existing industry contacts. Moreover, a high number of respondents was recruited using contacts developed while undertaking research for the PhD sponsor during the interviews with the past clients. Interviewees were also recruited at the industry trade shows; Speciality and fine food and drink exhibition 2015 in London; Food Matters Live in London in 2015; Food and Drink Expo in Birmingham in 2016. Thus, whilst the sample size is relatively small, the expertise and experience of the participants significantly contributes to the validity and reliability of this research.

6.8.2 Choice of interview questions

The interview guides utilised in this project focused on the same areas, however, they were slightly modified to be relevant for different areas respondents worked within. The first four questions of each interview were focused on the incremental and radical product and process innovation that have been introduced in their company within the past 5 years. The aim was to gain insights into companies' attitudes towards product versus process innovation. Although, the answers to these questions would rely on the subjective judgment of the respondents, it is a technique that has performed consistently well in previous studies (Romijn and Albaladejo, 2002; Avermaete et al., 2004). This section was followed by questions about management of complementarity and interviewees awareness of different types of complementarities that could exist in their organisation. The next part focused on reasons why they adopted different strategies within different New Product and Process

Development projects and whether they had any structures in place to co-ordinate these strategies. These were followed with a question on opportunities gained from achieving a complementarity and possible barriers that may prohibit this (See Appendix 2. for Phase 1 questions).

At the end of interviews, those respondents who worked at positions perceived to have sufficient knowledge in the product portfolio of their companies (i.e. Production Manager, NPD Manager, Owner). Interviewees were shown the Product-Process Complementarity Positioning Map and asked to identify projects that utilised complementarities described within the developed constructs. Participants were also encouraged to suggest any additional complementarities occurring within their company's product/process portfolios that are beyond those portrayed within the Map.

6.8.3 Interviewee sample selection

Building upon the expert sampling technique, the key informants were selected for the Phase 1. Each participant was chosen due to his/her expert knowledge and experience in the food and drink sector. Even though accessing these types of informants is often difficult, they are known to be a very credible and knowledgeable (Baker et al., 2012). The research design sample was developed to incorporate informants from a range of organisations (see Table 20. for further details). The aim was to get a broader representation of members within the whole supply chain, as they all play a considerable role in the product and process innovation. For instance, the sample consisted of large and medium-sized branded and own label food and drink companies (e.g. bakeries, dairies, brewery, snacks manufacturer, processed food manufacturer), packaging and processing equipment suppliers.

The sample of interviewees can be summarised as follows:

1. Food and drink private and own label manufacturers
2. Food and drink industry consultants
3. Food packaging companies
4. Processing/Packaging equipment manufacturers

In this phase, the organisation for which the respondent worked remained anonymous. It was assumed that this would result in questions being answered more freely and have less impact on gaining permission for conducting the interviews. Each of the key informants was heavily involved either in the New Product or Process Development or both. The incorporation of this variety of interviewees aimed to capture the 'population' of those involved in the New Product and Process Development Projects across the supply chain. The interviews were conducted either face-to-face or by telephone and lasted between 45 minutes to 2 hours. The interviews were not recorded and the interviewer took detailed notes, including key quotes. This choice was based on the commonly stated disadvantages of recording on validity of responses. Within twenty-four hours following the interview the notes were transcribed. The transcripts and summaries made from them will be stored securely on the university's digital N drive and physical copied documents will be stored in locked filing cabinets.

	Interviewee	Type of organisation	Primary type of products sold	Turnover and number of employees based on information available	Length of time organization is in existence	Length of interview
I1	Consultant	Packaging manufacturer	Consultancy	Not available	Not available	1.5 hours
I2	Consultant	Range of food and drink private label brands	Consultancy	Not available	Not available	1.5 hours
I3	Sales Director	Development, production and supply of integrated processing and filling lines	Food, juice and dairy processing and filling lines manufacturer	Not available	86 years	2 hours
I4	Production manager	Packaging company for the main retailers	Fresh produce packer	£54.4mil Over 1,000 full time staff	64 years	1 hour
I5	Material supplying manager	Development and delivery of diverse solutions including freezing and chilling, modified atmosphere packing and transport , cooling and dry ice applications.	Food and drinks Non-food (including non-food items) raw materials supplier	€11,387mil 30,000 employees	130 years	2 interview s each approx. 50 mins
I6	Engineering Manager	Private and own label manufacturer.	Food and drinks Manufacturer and packer	£1.74bil. 8,000 employees	135 years	50 mins
I7	NPD Manager	Private and own label manufacturer.	Food and drinks Manufacturer and packer	£1.74bil. 8,000 employees	135 years	2 interview s each approx. 1.5 hours
I8	Production Manager	Manufacturer and supplier for retailers, manufacturers, food service customers and brand owners.	Food and drinks Manufacturer and packer	£31.93mil 200 employees	Not available	50 mins
I9	Director	Manufacturer of packaging for FMCG	Food and drinks Non-food	£345,2mil	77 years	1 hour
I10	Consultant	Range of food and drink private and own label brands	Consultancy	Not available	Not available	1 hour
I11	Production Manager	Own and private label food manufacturer.	Food Manufacturer and packer	£10.5mil	36 years	50 mins

I12	Managerial meeting	Packaging manufacturer	Food and drink packaging manufacturer	£393 mil 24,238 employees	124 years	1.5 hours
I13	Sales manager	Producer and seller of Packaging machinery	Food (Non-food) Packaging machinery producer and distributor.	Not available	60 years	1 hour
I14	Owner	Producer and packer of brand label product	Food Manufacturer and packer	Not available	5 years	1.5 hours
I15	Director	Producer and seller of Packaging machinery	Food (Non-food) Producer and seller of machinery	Not available	60 years	2 interview s each 1 hour
I16	General manager	Manufacturer and packer of private label product	Drink Manufacturer and packer	£44 mil.	253 years	1.5 hours
I17	Commercial Director	Manufacturer and packer of private and own-label product	Food Manufacturer and Packer	£13mil. 180 employees	100 years	1 hour
I18	Manufacturing Manager	Manufacturer and packer of private and own-label label products	Food Manufacturer and packer.	£50 million	81 years	1.5 hours

Table 22. List of participants involved in Phase 1 of data collection

6.8.4 Analytical procedure

To analyse the data collected during the semi-structured interviews researcher used an abductive approach. This approach relies on intertwining the existing theory and literature with the data collection (Kirkeby, 1994; Dubois and Gadde, 2002). Abductive approach builds upon Systemic combining, which aims to compare the theory with empirical world constantly through the research process. The aim of the research method is not to force the findings onto the pre-existent categories, but rather to develop and adjust these categories on the basis of collected data and chosen theoretical perspectives (Dubois and Gadde, 2002).

Once the interviews were transcribed, they were analysed using procedures described by Miles and Huberman (1984). Each interview transcript was read several times by the researcher. Each transcript was organised into 'chunks of text'. Each chunk covered one coherent statement or an idea. These chunks were assigned with a first category label (code), briefly describing the statements in researcher's own words. After this, the data analysis shifted to collation of codes into second order themes and over-arching themes. After this exercise all themes were reviewed in relation to the two research questions stated in the Introduction Chapter. Afterwards, the themes were labeled and refined to fit with the questions of How do food and drink companies manage the complementarity between product and process innovation? and How different contingencies influence such complementarity? Finally, the researcher returned to the literature, the findings were written up pointing to the similarities and different with the existing literature. See Appendix 3. for an example of a coding scheme.

Adoption of the above approach enabled the researcher to discover subtle meanings and gain new insights into the topic of managing complementarity between product and process innovation in New Product and Process Development projects in the UK food and drink sector.

6.9 Methodology for Phase 2: Single case study approach

The Phase 2 of data collection subjects the Typology: Complementarity-Capability Matrix to validation using abductive theory extending approach through 'illustrative' single case studies. According to van Echtelt et al. (2008) due to the richness of the conceptual framework, theory testing and its extension using qualitative explanatory approach are useful step before conducting pure theory testing. This methodology was considered appropriate based on the aims of the research and the need to test the conceptual typology. The main reason for adopting the Typology: Complementarity-Capability Matrix for theory testing is its first attempt to combine different types of complementarities with resources and complementarities necessary to achieve these, while firmly grounded in existing theories (i.e., contingency theory, project portfolio management, ambidexterity and resource-based view). To summarise, the choice of methodology was particularly based on:

- the desire to understand how companies manage the complementarity between product and process innovation in different types of New Product and Process Development Projects
- to gain an understanding into the reasons why a specific complementarity strategy was chosen (ended up) and what resources and capabilities were necessary to achieve this
- to provide insights into a phenomenon that did not receive the deserved attention at the correct level of investigation
- the desire to test and refine the propositions within the theoretical typology, as well as gain further insights into the New Product and Process Development Projects identified in Phase 1

Q2: How different contingencies, in terms of resources and capabilities, that influence the adoption of different complementarity strategies?

6.9.1 Case study methodology

Studies using the case study methodology have provided Innovation and Strategic management scholars with some ground-breaking insights (Burgelman, 1983; Eisenhardt, 1989). Despite this, the case study methodology is applied very rarely. According to Gibbert et al. (2008) there were only 22 case study articles published within the top management journals; Academy of Management Journal, Administrative Science Quarterly, Strategic Management Journal, in 6 years. Within the literature, case studies are the most commonly applied method for the purposes of theory building (Corley and Gioia, 2011; Eisenhardt, 1989; Eisenhardt and Graebner, 2007; van de Ven, 2007). A lack of adequate quantitative measures and a need to investigate unique phenomena make the use of qualitative methods often necessary (Bitektine, 2007; Flyvjberg, 2006). One of the key differences from the other research methods, and at the same time benefits of this approach, is that case studies investigate the phenomenon of interest within their context. Therefore, they often provide managerially relevant knowledge (Amabile et al., 2001). Case study research has been proven to be particularly effective when testing complicated issues, such as strategy implementation (Boyer and McDermott, 1999). See Table 23. for an overview of different types of case study methodologies including their advantages and disadvantages.

Choice	Advantages	Disadvantages
Single cases	Greater depth	Limits on the generalisability of conclusions drawn. Biases such as misjudging the representativeness of a single event and exaggerating easily available data.
Multiple cases	Augment external validity, help guard against observer bias	More resources needed, provide less depth per case.
Retrospective (historical) cases	Allow collection of data on historical events	May be difficult to determine cause and effect, participants may not recall important events.
Longitudinal cases	Overcome the problems of retrospective cases	Have long elapsed time and thus may be difficult to do.

Table 23. Choice of number and type of cases. Adapted from Voss et al. (2002, p. 203)

The Phase 2 of data collection aims to set a starting point in the empirical research on complementarities between product and process innovation in the food and drink sector. The objective is to provide empirical evidence for the Product-Process Complementarity Map to position a Portfolio of Projects and to test the adoption of contingencies listed in The Typology: Complementarity-Capability Matrix. For the theory testing purposes a single case study methodology was selected as the research strategy for several reasons.

Firstly, the complementarity between product and process innovation in the New Product and Process Development Project is a complex phenomenon with a range of iterative activities. Secondly, a case study allowed for contextual assessment of this phenomenon within a real life environment, allowing the researcher to identify different levels of importance played by concrete resources and capabilities (contingencies) within the investigated projects (Yin, 2009). Thirdly, case studies provided detailed insights into the management of complementarity between product and process innovation at the project level (beyond the industry and company level). Lastly, case study methodology was chosen due to lack of existing studies building on qualitative data collection techniques, especially case studies that would investigate complementarities between product and process innovation in a real-life environment.

Majority of the contribution in this research area were either conceptual or based on the CIS survey (Ballot et al., 2015; Evangelista and Vezzani, 2010). Some of the exceptions are Kurkkio et al. (2011) and their multiple case studies of mining and mineral companies, Lim et al. (2006) and their single case study of biopharmaceutical virus vaccine and Novotny and Laestadius (2014) and the case of pulp and paper industry. However, majority of studies have developed only conceptual contributions to the literature (Abernathy & Utterback, 1978; Barras, 1986; Hayes & Wheelwright, 1979; Kim et al. 1992) or conducted a quantitative data analysis of statistics from different streams of the Community Innovation Survey (CIS) (Battisti & Stoneman, 2010; Evangelista & Vezzani, 2010; Reichstein & Salter, 2006; Wischnevsky et al., 2011).

The case studies were selected for their intrinsic value (Stake, 1995) in order to provide illustrations of the New Product and Process Development Projects through portraying different extents of complementarities between product and process innovation, evidenced within Phase 1 of the data collection (Patton, 2002). See Table 24. for an overview of different types of research purposes linked with research questions and structure.

Purpose	Research question	Research structure
Exploration (uncover areas for research and theory development)	Is there something interesting enough to justify research?	In-depth case studies; unfocused, longitudinal field study
Theory building (identify/describe key variables; identify linkages between variables; identify "why" these relationships exist)	What are the key variables? What are the patterns or linkages between variables? Why should these relationships exist?	Few focused case studies; in-depth field studies; multi-site case studies; best-in-class case studies
Theory testing (test the theories developed in the previous stages; predict future outcomes)	Are the theories we have generated able to survive the test of empirical data? Did we get the behaviour that was predicted by the theory or did we observe another unanticipated behaviour?	Experiment; quasi-experiment; case studies; large-scale sample of population
Theory extension/refinement (to better structure the theories in light of the observed results)	How generalisable is the theory? Where does the theory apply?	Experiment; quasi-experiment; case studies; large scale sample of population

Table 24. Matching research purpose, research question and research structure. Adapted from Voss et al. (2002, p.204)

6.9.2 Primary data collection Phase 2: Case study sample selection

The results of Phase 1 have identified seven different types of complementarities between product and process innovation occurring in the New Product and Process Development Projects in the food and drink sector.

The eight case studies from six food and drink companies operating in the UK, were chosen to fill theoretical categories in the early stage of theory testing with an aim to answer the second research question. Theoretical sampling technique was chosen to identify the 'illustrative' case studies. Theoretical sampling is particularly suitable for highlighting the patterns of relationships among constructs and the embedded knowledge across cases in their rich, real-life context that provides a stronger base for theory testing in comparison to a single 'extreme case study' (Eisenhardt & Graebner, 2007). Fewer cases were chosen based on their validity and rich insights in comparison to randomly picked cases (Flyvberg, 2005). Cases were chosen to fill theoretical categories as the area of interest was “transparently observable” that increased the likelihood of developing a unique theoretical vision (Eisenhardt, 1989). In the theoretical sampling the key aim was to arrive at “an appropriate matching between reality and theoretical constructs” (Dubois and Gadde, 2002). The sampling was a continuous process over the course of Phase 1 of data collection.of 18 semi-structured interviews with knowledgeable informants. These informants enabled the researcher to identify NPPD projects that followed different complementarity strategies between product and process innovation and these were further examined in Phase 2 of the data collection (case studies). The process of systematic combining is often described as “messy, idiosyncratic and difficult to articulate” (Van Maanen, Sorrensson and Mitchell, 2007, p. 1149). Due to the nature of a traditional UK PhD format, it was difficult to illustrate this process throughout the research project. Therefore the researcher decided to use the Methodology section to describe the processes involved in the present study.

Dubois and Gadde (2014) criticise the approach adopted by Yin (2003) and Eisenhardt (1989) that are particularly useful for multiple case studies that rely upon replication logic. The positivist epistemology of such research is defined as a linear process with clearly identifiable phases and recommendations for the best practice at each stage. The authors following the research of Dyer and Wilkins (1991) stress the benefits of single case study research due to its ability to uncover new theoretical relationships and question old ones. The story the case study has to say is seen as crucial in developing better theoretical constructs.

These case studies were selected following detailed discussions with the key respondents in the exploratory Phase 1. There were three main criteria in the case selection:

a) Explore a broad range of complementarities from the Revised Product-Process Complementarity Positioning Map

b) Select cases based on common type of projects from the company's product portfolio

c) The complementarity type was transparently observable, this further enabled the researcher to test the validity of The Complementarity-capability Matrix (Eisenhardt, 1989).

As stated by Siggelkow (2007) seeing concrete examples of theoretical categories enables the reader to imagine the application of conceptual arguments to empirical settings. Providing the case study evidence for purely conceptual argument that the relationship between A and B is moderated by XYZ is regarded as a powerful use of case studies. Theoretical sampling has provided richer insights in comparison to randomly selected cases and facilitated theoretical generalisation (Flyvberg, 2005; Hildebrand et al., 2001; Yin, 2009).

Phase 1 has identified that the majority of the projects investigated within the food and drink companies involved in this research are predominantly located within the exploitative part of the Map (Product/Process Pooled; Process Amensalism; Incremental Reciprocal complementarity). The projects primarily involved incremental product and process innovation utilising existing product technologies (recipes/packaging) and processing (packaging) equipment. The interviewees were able to identify only a few projects with a more radical nature (Product/Process Sequential; Reciprocal Complementarity), indeed these projects had often been undertaken more than 5 years ago. This emphasis on exploitative innovation is consistent with other studies within the food and drink sector and prior researchers have attributed this to consumer inertia or conservative consumer behaviour (Capitanio et al., 2010; Grunert et al., 1997). Indeed, companies operating within the food and drink sector are commonly described as focusing on incremental product and process innovation, with limited number of disruptive innovations (Baker, 2013; Knox et al., 2001; Lefebvre et al., 2015). Considering this, of the eight case studies selected for the Phase 2; six were undertaken within the past 5 years (C; D; E; F; G; H), whilst the other two (A; B) were historic case studies (See Table 25.).

In the case of the historic cases, these provided an additional benefit to the researcher, as it was possible to observe the evolution of the innovation. Indeed, this approach is becoming a popular qualitative data collection method (Featherson, 2016; Slayton and Spinardi, 2016). Arguably this method has been overlooked by Innovation scholars, who have tended to study managerial practices at different stages of projects. Hence, they have failed to consider the historic and organisational embeddedness of investigated projects when trying to explain the reasons for project's success, and how this success can contribute to long-term strategic benefits (Marsh and Stock, 2003). In order to increase the validity of using historic case studies to demonstrate radical product and process innovations, two case studies were selected (instead of one as in the other complementarity types).

Given the aims of the present research; to provide an overview of complementarities occurring within the food and drink industry, the researcher believes that a combination of case studies from both, large as well as medium sized companies, will not influence the representativeness of the data (See Table 26. for an overview of companies involved in the research project). This is due to the 96% of companies operating within the UK food and drink sector are SMEs. Innovation is becoming an important strategic tool for SMEs to achieve competitive advantage in the increasingly competitive markets (Avemaerte et al., 2004; Gellynck et al., 2007). The industry includes only a small number of large companies these, however, dominate the food and drink sector (FDF, 2016). Moreover, the aim of the present research is to provide an overview at the industry level of complementarities occurring between product and process innovation in the New Product and Process Innovation Development projects in the food and drink sector.

The cases were also selected to provide insights into management of complementarities between product and process innovation within two contrasting types of products: own brand products (manufactured on the basis of retailer's order) and branded products (initiated internally) (See Phase 1). The sample of the companies includes producers of bakery and snack products (which form one third of the 6100 SMEs in the UK) (FDF, 2016). The drinks sector is represented by two dairy companies and a brewery and a well-known British processed food manufacturer with a product portfolio of 700 products is also included. As mentioned in Chapter 2, the packaging plays a crucial role in New Product Development, therefore a case of radical packaging innovation was also selected.

Details of firm and project			Details of case and rationale for its selection		
Case company	**Project(s)**	**Project identifier**	**Classification of the extent of complementarity**	**Project type**	**Rationale (justified by illustrative quotes from interviewees)**
Daily Dairy	Extended Shelf-life Fresh Milk	A	Radical Reciprocal complementarity	Development of radical product and packaging innovation synchronised with development of new processing equipment.	*"The project would fall into category of high extent of complementarity"…"radical product innovation synchronous with process innovations"…" (I3)*
Best Brewery	In-can system Draught Beer	B	Radical Reciprocal complementarity	Development of radically new product technology synchronised with innovation in packaging equipment.	*"We could not have come up with a solution for the widget without a tight relationship between packaging and process innovation." (I16)*
Fresh Dairy	UHT flavoured milkshake	C	Product Sequential	Radical packaging and closure innovation resulting in processing and filling innovation.	*"The project started with a need to develop UHT version of the existing milkshake product…this has led to development of a new bottle followed by processing changes." (I3)*
Cornish Bakery	Purchase of flow wrapping packaging machinery	D	Process Sequential	Radical process innovation resulted in incremental packaging innovation.	*"The purchase of flow-wrapping machine enabled us to pack all 5 products requested by the customer." (I11)*
Food Co.	Chunky Steak Canned Ready Meal	E	Incremental Reciprocal complementarity	Incremental innovation in the existing production process synchronised with incremental innovation in the product recipe.	*"Product and process innovation had to be synchronised, however we were seeking an appreciable improvement of an existing process to manufacture the product"…"we had to satisfy customer's product specifications." (I7)*

	Canned Minced Beef	H	Process Pooled	Incremental process innovation (enhanced overall quality of the product would not be noticed by consumer).	*"Lowering the bar pressure from 4 to 2 bars in the canned minced meat project enabled us to improve efficiency by 30%"…"speed and efficiency are key." (I7)*
Dorset Bakery	Jalapeño Mini Wafers	F	Process Amensalism	The existing production equipment constrained development of the product to incremental changes.	*"The existing machinery is a constraining factor"…"we collaborated with a small local engineering company to help us come up with a simple solution to produce a mini version of the Jalapeño wafers." (I17)*
	Salted Caramel Florentines	G	Product Pooled	Incremental product innovation.	*"The flavour changes of our florentines would fit into the Product Pooled area. We often do these because of the production line constraints." (I17)*

Table 25. Summary of case studies selected including the project identifier, classification of complementarity type, project type and quotes from interviewees providing rationale for categorisation of complementarity.

Companies	Summary of essential information
Daily Dairy	• Largest European dairy co-operative, owned by 12,700 dairy farmers (3,000 based on the United Kingdom) • Employs 19,600 people in 30 countries around the world • In the UK, it is the largest supplier of milk and cream reaching 2.2 billion litres of milk every year. • The profits of the manufacturer reached £250 million in 2014 (UK buying more products than any other country) • Recently announced an investment of $48 million into new global innovation centre
Best Brewery	• One of the most prestigious dark beers with 250 years heritage and consistency in quality • Brewed in 50 countries and sold in more than 150, with 2 billion pints sold each year • Merged with Grant Metropolis and developed a multinational alcoholic drinks producer in 1997 • Operating profit in Europe was £804 million in 2015
Food Co.	• Found in 1880 and made up of 3 ambient companies (Group) with the head office in Liverpool that is dealing with all orders • Bought by a large car manufacturer in 1989, since the company has made 22 mergers and acquisitions in the food industry all over the world • The manufacturer produces a range of branded and customer own brands • One of the Europe's fastest growing food and drink Groups • Global turnover of 1.61 billion in 2015
Dorset Bakery	• UK turnover of £13 million • Employs 180 people • Founded in 1916 in Dorset • Largest production of Florentines in the UK market
Cornish Bakery	• An award winning baker of own and private label products • Turnover of £10.5 million in 2015 • Established 36 years ago in Cornwall
Daily Dairy	• Dairy has grown from a division of the Milk Marketing Board into a leading British owned dairy business via flotation in 1996 • Manufacturer and processor of a range of market-leading products • Achieved revenues of £422.3 million and profit before tax of £57.7 million in 2016 • The flavoured milkshake brand represents over 50% of flavoured milk market share

Table 26. Case study companies with summaries of essential information on each companies, based on information accessible from internal documentation. For the purposes of anonymity the name of each organisation has been changed.

6.9.3 Primary data collection: Choice of respondents, Interview type and conduct

According to Yin (2009) the validity and reliability of the case study research can be further enhanced by a well-designed research protocol. Moreover, it is necessary to ensure that the researcher possess required skills to undertake the investigation and that the project follows the ethical guidelines (See Appendix 6. for the Case study protocol). Prior to data collection the researcher had a well-established knowledge on the subject based on; the literature review, findings from the Phase 1, regular attendance of industry trade shows (e.g. Speciality and fine food and drink exhibition 2015 in London; Food Matters Live in London in 2015; Food and Drink Expo in Birmingham in 2016) and conferences in the field of innovation and technology management (e.g. International Product Innovation Conference 2015 in Copenhagen; R&D Management Conference 2016 in Cambridge; Groceries Code Adjudicator Conference 2015 in London; Trends in Retail Competition: Private labels, brands and competition policy 2016 in Oxford). Prior to undertaking interviews, the researcher designed questions to test the validity of the Typology: Complementarity-Capability Matrix (See Tables 14-16.) and conducted secondary data collection on the investigated project, including background information on each investigated company. Semi-structured interviews were undertaken for each case study with key informants from multiple functional areas, who worked on, or were significantly involved in the specific New Product and Process Development project (See Table 27. for an overview of respondents). In addition, in some cases, suppliers of production equipment or the key external collaboration parties who were involved in the projects were consulted to obtain partial verification of case data, or to provide further insights and greater understanding of the particular case. In total thirty-four interviews were held, with an average of three interviews per case study. The interviews lasted between 30 minutes and 2 hours. Majority of the interviews were conducted face-to-face, however some of them were conducted over the telephone. During each interview, the interviewer kept extensive notes and transcribed them within 24 hours after the interview. By involving more than two interviewees for each case study, which was often complemented with secondary documentation (e.g. coverage of the company's activities in the media, annual reports), the researcher was able to achieve principles of triangulation (Yin, 2009). This practice has further improved the reliability of the study and decreased its subjectivity.

The questions were based on three contingencies adopted in the Typology: The Complementarity-Capability Matrix. They had an open-ended character, as researcher's aim was to uncover How? Who? and When? of the development of complementarities between product and process innovation and contingencies influencing these choices (van Echelt et al., 2008). The impact of contingencies (resources and capabilities) was measured based on the stated definitions in the typologies (See Chapter 5.) and the degree of attainment of the three key constructs; technology trajectory dependence, supply chain rigidities and levels of potential and realised absorptive capacity. The format of interviews was adapted and slightly amended to identify new and potentially fruitful points about the project (Nag et al., 2007). Please see Appendix 1. for the list of questions. Since the questions related to the Typology: The Complementarity-Capability matrix might have failed to reveal other important factors, open questions about presence of other factors that might have influenced development of complementarity were asked. Additionally, documentary studies were performed regarding secondary sources to validate the information collected in interviews (i.e. patents, books published about the company, written reports and journal articles) (Amaratunga & Baldry, 2001).

The eight 'illustrative' case studies were chosen to fill theoretical categories in the early stages of theory testing (Eisenhardt, 1989). This enabled the researcher to provide an overview of different types of complementarities occurring between product and process innovation at the food and drink sector level. For each Product and Process Development Project, a key informant was identified during Phase 1. The key informants identified further knowledgeable respondents involved in the execution of the project using a snowball sampling technique (Sjödin et al., 2016). The familiarity of the respondents with the Product-Process Complementarity Positioning Map from the qualitative pre-study further increased the construct validity. Indeed, using the same set of respondents from the Phase 1 to identify further knowledgeable informants (who worked/were involved/ has significant amount of knowledge about the project) could be perceived as a weakness, in the present study, this methodology was used to obtain theoretical saturation.

This strategy enabled the researcher to provide insights into a broad range of New Product and Process Development Projects occurring in companies that operate in the food and drink sector in the UK. Overall, the interviewees were able to identify examples of each of the proposed complementarities, accept from Product Amensalism complementarity. Moreover, a further complementarity portraying a synchronous product and process innovation by making only incremental changes to the existing production equipment and product was identified. Interviewee 7 termed this complementarity as 'Incremental Reciprocal Complementarity.' In comparison to the Reciprocal complementarity, project teams have less freedom in developing resources and capabilities, and have to work with what is available inside the company. The synchronisation between the two innovation types is required due to the unique product nature. Due to the retrospective nature of case studies, the data collection was at a possible risk of interviewees not recalling all the details, over-simplifying as well as being influenced by post-hoc attributions. The author aimed to overcome this limitation by triangulation, and interviewing a range of respondents per case as well as through the use of secondary data collection (van Echelt et al., 2008). By building upon multiple sources of information and where necessary the researcher was able to validate the collected data through comparison and discussion with interviewees independently (Yin, 2009).

Company	Interviewee identification	Job role	Number of interviews	Length of interview(s)
Daily Dairy	I3	Sales Director of processing and filling lines	2	Approx. 2 hours each
	I19	Manufacturing Manager	1	Approx. 1 hour
	I20	NPD Manager	1	Approx. 50 mins
Best Brewery	I16	General Manager	2	Approx 1.5 hours (1st interview) 30 mins (2nd interview)
	I5	Gas supplying Manager	2	Approx 1 hour each
	I23	Plastics Specialist	1	Approx 40 mins
	I24	Packaging expert	1	Approx 1 hour
	I25	Brewing Specialist	1	Approx 50 mins
Food Co.	I7	NPD Manager	4	Approx. 1.5 hours each
	I27	Operations Manager	1	Approx 1 hour
	I28	Processing equipment supplier	1	Approx 1 hour
Fresh Dairy	I3	Sales Director of processing and filling lines	2	Approx. 2 hours each
	I30	Packaging Supplier	1	Approx 1 hour
Cornish Bakery	I11	Production Manager	2	Approx. 50 mins (1st interview) 30 minutes (2nd interview)
	I31	Engineer from packaging equipment supplier	1	Approx 40 mins
	I32	Product Innovation Manager	1	Approx 50 mins

Dorset Bakery	I17	Commercial Director	2	Approx. 1.5 hours (1st interview) 20 mins (2nd interview)
	I33	Company owner	1	Approx 45 mins
	I34	Production Manager	1	Approx 1 hour

Table 27. Job title of interviewees, number of interviews and their approximate duration.

6.9.4 Primary unit of analysis

Prior studies portrayed and examined the complementarity between product and process innovation at the industry and firm level (Utterback and Abernathy, 1978; Hayes and Wheelwright, 1979; Lim et al., 2006; Lager, 2010). These levels of analysis were not able to provide insights into differences among NPPD projects. Mainly because companies are working on a portfolio of projects, all of them having different aims, characteristics and requiring different resources and capabilities. By adopting perspectives from the Contingency theory to investigate the complementarities between product and process innovation, it is argued that projects within company's project portfolio differ in their aims, characteristics as well as resources and capabilities that consequently affects the complementarity choices.

Therefore, the primary unit of analysis of this research project is the New Product and Process Development project. The project is defined as "a temporary organization and process used to create novel and outcomes, such as new and improved product and services tailored to individual customer requirements" (Davies, 2015, p. 635). When compared with permanent organisations such as firms, projects are 'time-limited' organisations. They can be either a standalone team or be part of a larger organisation. Davies (2015, p. 649) defines three different forms of projects;

1. **standalone projects**- are temporary organisations where individual participants and organisations join a new project

2. **hybrid projects**- organisations where the formation and coordination of a project is influenced by a combination of participant and centrally controlled organisations

3. **fully embedded projects**- centrally controlled at a higher level and fully incorporated in a permanent organisation of the company (i.e. internal R&D, product development projects)

The current research project will investigate predominantly fully embedded NPPD projects. However, there will be a few examples of hybrid projects in which food manufacturers collaborated with external parties to be able to deliver a new product or process innovation. In the Methodology Chapter and Analysis of Phase 2 of data collection will be briefly described the organisations that initiated the NPPD projects. These descriptions will be used only to set the scene for the case study, but also because the resources and capabilities that were utilised within the NPPD projects often resulted from firm’s existing capabilities and internal knowledge.

6.9.5 Data analysis strategy

The data analysis of Phase 2 followed the procedures for outcome evaluation in Purposive Case Study design developed by Bitektine (2007). The aim was to evaluate the seven propositions (seven complementarity strategies) with eight case studies identified by interviewees at the end of Phase 1 of data collection. These were;

A. Formulation of research questions, selection of theories to be tested and development of testable propositions based on the literature review
B. Identification of the case study, where the theories can be tested
C. Selection of the data collection and analysis methods (justification for the case study selection for the stated research purpose)
D. Formulation of criteria for outcome evaluation at Step 2, e.g. What outcomes will be considered to support/disprove propositions?

The definitions of spectrum of contingencies (dependence on technology trajectory, presence of supply chain rigidities and levels of absorptive capacity) in Chapter 5 were used as a reference point when evaluating the case studies. The evaluation between the seven propositions (seven complementarity strategies portrayed in the Typology: Complementarity-Capability Matrix) and eight case studies from the food and drink sector was performed using the pattern-matching technique. According to Trochim (1989, p. 360) all that the pattern matching technique requires is "a theoretical pattern of expected outcomes, an observed pattern of effects, and an attempt to match the two."

The Incremental Reciprocal complementarity was identified only during the Phase 1and therefore findings from the case study that illustrated this complementarity will be added to the existing Typology. Future research should therefore test its validity and generalisability.

The process of data analysis was divided into two parts;

Stage 1: The development of in-depth descriptions of individual cases, based on undertaken interviews and secondary data to provide a 'rich story'. The case studies covered eight New Product and Process Development projects, particularly focusing on the sequence of adoption of product and process innovation and the role of three contingencies on the type of innovation strategy. These were further supported with quotes. Missing to provide quotes has often lead to inability to make informed judgements about the researcher's findings (Valk and Wynstra, 2005).

Stage 2: Testing of seven propositions (seven complementarity strategies) proposed within the Typology: Complementarity-Capability Matrix. It is important to note that the primary interest of the current research project was to develop and test the typology of complementarity strategies occurring between product and process innovation at the New Product and Process Development Project level. Generalising these findings to further case studies in the food and drink sector and other process industry sectors was of a secondary concern. The proposed typology is a unique and complex contribution to the literature on complementarities between product and process innovation. Therefore, deducing a testing the essential contingencies influencing different complementarity strategies, in the form of theory-based propositions (typology), is an appropriate and necessary initial test (Lee et al., 1996). It is important to note that the focus of the research project is not to compare different complementarity strategies with cross-case comparisons, but on testing and extending each developed proposition with outcome from case study identified to ‘illustrate’ such complementarity. This method is consistent with the logic of the contingency theory that assumes there is ‘no one best complementarity between product and process innovation.’ Instead, companies prefer to adopt a portfolio of complementarities based on aims and particular objectives of each New Product and Process Development Project.

Firstly, the eight case studies were summarised within a complex table at the beginning of Chapter 9 (two cases of Reciprocal complementarity are analysed to increase the validity of the data due to use of historic case studies). Then, propositions for each complementarity strategy were compared with findings from the ‘illustrative’ case study using a pattern-matching technique. According to Yin (2009), pattern-matching can be performed using variation on either dependent or independent variables. For instance, when a set of a non-equivalent independent variables is predicted and found to result from a particular process, the researcher can be relatively confident that proposed effect has occurred (Ross and Stow, 1993). In the present study, the independent variables are in the means of spectrum of contingencies influencing complementarity strategy. The criteria for evaluation of the outcome of case studies was as follows;

- **Supported**- the evidence from the case study supported the proposition from the Typology: Complementarity-Capability Matrix
- **Not supported**- this contingency factor is not supported in the case study analysed, however the evidence within the case does not disprove the factor - it is not clear whether this may occur in other cases.

- **Partly supported**-some evidence from the case study supported the proposition from the Typology: Complementarity-Capability Matrix
- **Disproved**- the evidence from the case study disproved the proposition (provided contradictory evidence) from the Typology: Complementarity-Capability Matrix
- **Insufficient evidence**-evidence from the case study was not sufficient to evaluate applicability of the contingency factor

The analysis was based on independent judgements of the researcher and supervisors, who both read and analysed the transcribed interviews and case studies. Also separately, the researchers categorised interviewee's responses in respect to the definitions of contingencies proposed within the Typology: Complementarity-Capability Matrix. After all materials were reviewed and independent judgements made, the evaluating researchers verbally summarised to each other the findings. There was some disagreement on approximately 10 per cent of the contingencies, but the disagreements were resolved via further discussion. The findings were complemented with supporting interpretation that was interweaved with direct quotes throughout the analysis to further support validity of the data analysis (Beverland et al., 2006).

6.9.6 Assessment of Phase 2: Quality Criteria and weaknesses

There is a range of criteria to assess the rigour of field research. The current research is grounded in the Interpretivist tradition and hence uses four commonly applied criteria to assess the case study rigour; construct validity, internal validity, external validity and reliability. Such criteria were previously adopted by some of the key contributions to the case study research (Yin, 2009; Eisenhardt, 1989) (See Table 28.).

Quality Criteria	Meaning	Design of Research
Construct Validity	• Order to ensure that the research investigated what it claims and consequently leads to accurate observations of reality (Creswell and Miller, 2000)	• Research project therefore aimed to establish a clear evidence the way researcher started with the research question to the conclusions stage (See Research Summary Figure 27.) (Yin 2009, p. 102) • Secondary data collection that was combined with semi-structured interviews with various managers working on the New Product and Process Development projects, the researcher was able to look at the same phenomenon from different angles, triangulate (Creswell and Miller, 2000) • Reviewing draft case studies with interviewees
Internal Validity	• Related to the data analysis phase and is concerned with providing achievable causal argument and logical reasoning that is strong enough to defend the research conclusions	• Abductive approach to data collection and analysis was adopted to overcome the limitations of purely inductive and deductive research • This approach relies on the existing theory and literature and intertwines these with the data collection • Pattern-matching technique enabled the researcher to evaluate the propositions (typologies) with outcomes of case studies (Lee et al., 1996)

External Validity	• Establishes the domain to which a study's findings can be generalised	• Researcher did not intend to develop generalisations, but rather to provide a starting point in the research area • Justification for the choice of single 'illustrative case studies' was used • Further testing of the Typology is required to test the external validity
Reliability	• Demonstrates that the data collection procedures can be repeated by subsequent researchers and arrive at the same insights	• Achieved by transparency and use of a case study protocol, specifying the way the entire case study was conducted

Table 28. Assessment of quality criteria of Phase 2

6.10 Summary of Methodology Chapter

This Chapter discussed the methodology adopted in this research project, the rationale for choice of methodology in Phase 1 and Phase 2, research design and provided details about the collection of primary and secondary data. The researcher has also pointed to the weaknesses of the chosen data collection techniques as well as methods to limit their impact on the validity and reliability of data (See Appendix 1 and 1.1. for details on ethics and their approval).

The following Chapters will include findings from Phase 1 and their analysis that resulted in development of a Revised Product-Process Map to position a portfolio of products and identification of 'illustrative case studies' to be further explored in Phase 2. Phase 2 tested the propositions (complementarity strategies) presented within the Typology: Complementarity-Capability Matrix with the findings of each case study, using pattern-matching technique.

CHAPTER 7. PHASE 1 FINDINGS

7.1 Overarching dimensions, second order themes and first order categories

Sections within this Chapter will be organised into main categories identified through analysis of interviews collected during Phase 1. The following sections will also include quotes from interviewees to further support proposition and to provide in-depth insights into the management of product and process innovation in the food and drink sector.

7.2 Complementarity between Product and Process innovation

The interviews revealed that despite the managers' awareness of the existence of complementarity between product and process innovation, managers did not recognise the range of complementarity types that were available to them. Prior to being shown the Product-Process complementarity map to position a portfolio of projects, the majority of participants stated with high level of certainty that there is a complementarity between product and process innovation in their New Product and Process Development Projects. Yet, they struggled to specify a particular type of complementarity.

Although, interviewees acknowledged the existence of complementarity, from their responses it was obvious that the choice of complementarity strategy was not an integral part of portfolio management and they were not actively considering and managing it. An exception was observed among companies that utilised a range of management techniques such as cross-functional collaboration or Quality Attribute Sheets.

The interviews provide evidence that the complementarity between product and process innovation is influenced by five factors;

- Management of complementarity
- Attitudes towards changing the existing product and process technologies (equipment)
- Impact of supply chain members on firm's innovation
- Collaboration with external parties
- Existing knowledge (experience) within the company

Except from these five key themes, there were several sub-themes identified as possible causes and consequences of their existence. Figure 28. provides an overview of the overarching dimensions, second order themes and first order categories. The following section explores the key findings in each of these areas.

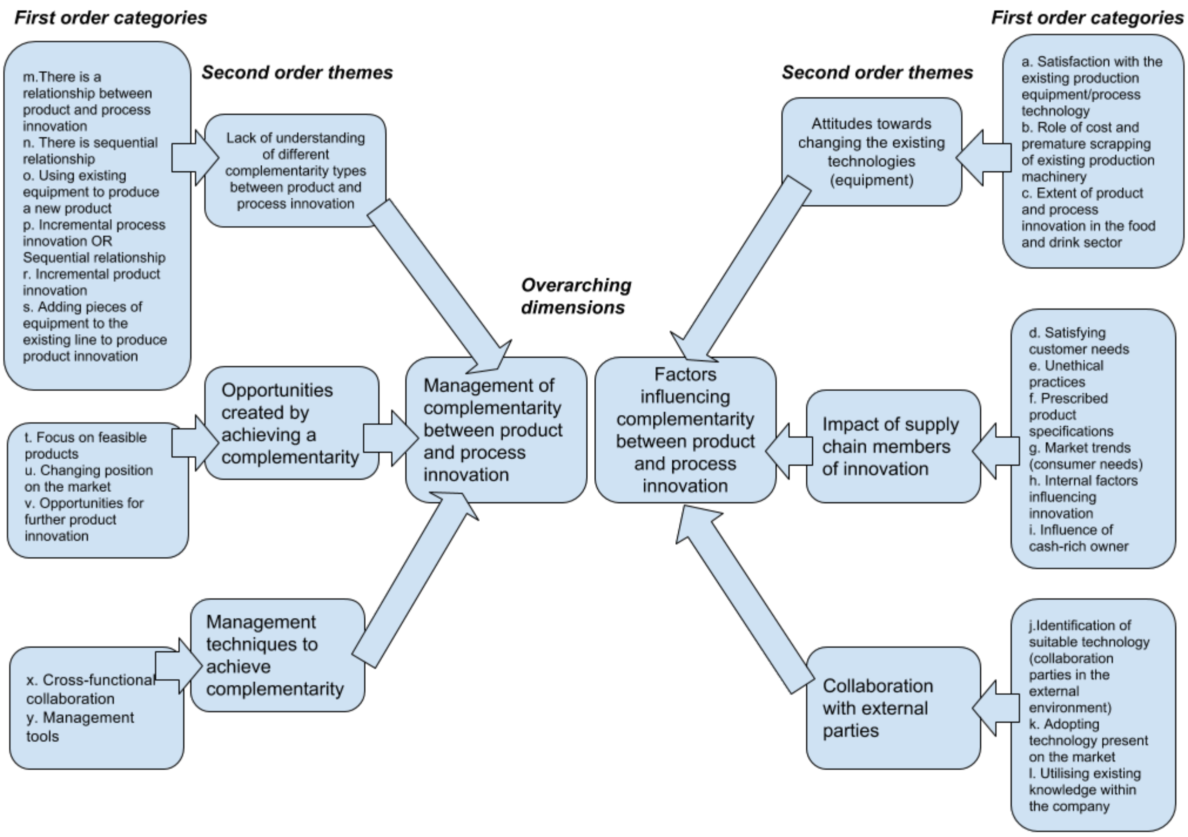


Figure 28. An overview of findings from Phase 1

7.3 Lack of understanding of different complementarity types between Product and Process innovation

The majority of respondents recognised the importance of the relationship between product and process innovation and argued that there is a relationship between product and process innovation in any product (revealed by I1; I2; I10; I16; I17). Yet, they were unable to identify any clear patterns between these two types of innovation. For example, in the case of I7 it was suggested that *"product and process go hand in hand…in essence, as the product formulation changes, the process changes as well."*

Only a limited number of interviewees referred to any specific pattern in the relationship between product and process innovation (particularly revealed in interviews with I3; I8; I11; I4; I10). These included;

- Sequential (product-process complementarity; process-product complementarity)
- Use of existing production equipment to produce a product
- Incremental product or process innovation
- Adding pieces of equipment to the existing machine to produce incremental packaging innovation

However, interviewees tended to associate complementarity to any product in the food industry: *"there is an interaction between product and process in any product"* (I2). Or, associating innovation to the changes at the industry level, for example: *"in the food industry it is usually about optimising the process… or something happens in the market and new processes are developed that means, you can enhance the flavour of the milk"* (I3). The above evidence has not only demonstrated that companies do not actively manage and consider the complementarity. But it has also uncovered "the fallacy of the wrong level" in their understanding of complementarity management. The themes identified in these responses are summarised in Table 29.

Management of complementarity	
Lack of understanding of different complementarity types between product and process innovation	
There is a relationship between product and process innovation	*"Product and process go hand in hand"…"in essence, as the product formulation changes the process changes as well." (I7)* **(there is a complementarity- no clear pattern)** *"There is an interaction between product and process in any product." (I2)* **(there is a complementarity- no clear pattern)** *"It is hard to pinpoint what it is they started with, it is almost like photo-finish, product just being first before process." (I1)* **(there is a complementarity- no clear pattern)** *"Most companies tend to have a link between product and process innovation, especially from the cases that I was involved in there were not that many cases when companies preferred to do product innovation rather than process innovation." (I10)* **(there is a complementarity- no clear pattern)**
There is sequential relationship	An interviewee commented on the tendency to adopt synchronous relationship between product and process innovation in the food and drink industry: *"you do not always have to change both, an exception would be if a new processing technique becomes available on the market that would provide companies with opportunities for product development." (I3)* **(process- product complementarity)**
Using existing production equipment to produce a new product	*"The challenge in the food industry is doing the biggest product change with the smallest process change." (I10)* **(existing process limiting product change)** *"You could say that in every SME manufacturing company the existing process is constraining the development of product, we are using the assets we have and start to look for new production machinery opportunities only once the capacity of the existing machinery is filled."(I8)* **(existing process limiting product development)**
Incremental process innovation OR Sequential relationship	Interviewee 3 commented on the extent of process innovation among dairy companies, stating that this basically applies to the entire food industry: "*It is usually case of optimizing the process or a new technology arrives in the market and new processes are developed that mean you can enhance or retain the flavour, the current technology has to be replaced because of this new technology that arrived in the market." (I3)* **(only incremental process innovation OR process-product complementarity)** An interviewee commented that the only innovation that occurred at their company was process innovation *"There is no relationship between product and process innovation." (I9)* **(process innovation only)** *"We often follow lean improvements and go for line efficiencies"…we are often able to improve process capability by making small changes"…as small change as 0.5% in filling speed will increase the efficiency." (I7)* **(only incremental process innovation)**

Incremental product innovation	*"There were about 80 changes to the flavours in the past year…we were using the existing process kit to change the flavours." (I8)* **(only incremental product innovation)**
Adding pieces of equipment to the existing line to produce incremental packaging innovation	An interviewee argued that the collaboration with the packaging machinery supplier enabled them to realise the opportunities and flexibility of the machine: *"by adding an additional part to the newly purchased flow wrapping machine, worth £300, we were able to pack 20 different products. Our customers offer an increasingly wide range of individual bakery items to consumer and change their menus regularly, this small adjustment of packaging machinery has enabled us to meet these demands perfectly" (I11).* **(process-product complementarity)** *"Incremental process innovations, usually results from change in the product initiated by the customer (one of the retailers)…our customer started to use new shelves, all the herbs used to be in the box and the box on the shelf... the customer requested to include hooks on which the herbs will be hanging…we had to include euro slot on the top of the packaging, it was only one upgrade on the machine, it is done at the time when the packaging is cut… we had to buy an additional part from the machinery provider- it was a couple thousand pounds." (I4).* **(process-product complementarity)**

Table 29. Management of complementarity: Lack of understanding of different relationship types

7.4 Opportunities created by achieving a complementarity

Interviews provided evidence of some understanding of the benefits that could be attained by achieving relationship between product and process innovation in New Product and Process Development Projects (revealed by I1; I9; I16; I7). These included the ability to realise the knowledge and experience developed for the purposes of the current innovation in further projects. According to Interviewee 16: *"Packaging technology used in Best Brewery Draught In-can project was later utilised in development of the rocket system for Draught In-bottle project."* Further two opportunities identified were ability to focus on physically and scientifically feasible products and ability to change company's positioning on the market from follower to the leader. As stated by Interviewee 9: *"We would have intellectual property and patents that could be extremely advantageous."* The first opportunity pointed to the internal focus and exploitation of the current expertise within the company, common in projects developing incremental innovations. The second opportunity identified benefits of developing a relationship in a radical project that provides companies with significant advantages in the long term. Again, a lack of understanding of different types of complementarities between product and process innovation and their consideration in new projects led to an inability to articulate different types of opportunities.

Interviewees identified several techniques used for managing the relationship between product and process innovation. Perhaps the most commonly identified technique was cross-functional collaboration between R&D (Production) department and NPD department (I7; I11). However, several interviews identified the importance of involving a range of other departments during the innovation projects including; Operations, Technical, NPD, Packaging and Suppliers (revealed by I7; I18; I17; I16).

There was also a range of management tools that several interviewees referred to as useful in helping them to manage the relationship: Quality Attribute Sheets, Quality Contracts, Statistical Process Control (SPC) and Quality Function Deployment (I7; I1). Interviewee 7 argued that within their company they use Quality Attribute Sheets to assess whether they have the right equipment to produce the product: *"This enables us to get ideas of capabilities of the line for each product as early as possible"… "So if there are any issues we share them with the customer."* Reference to the customer (retailer) implies a considerable pressure imposed by retailers on manufacturers to produce ever increasing number of product lines and different packaging formats. Interviewee 1 referred to the Quality Function Deployment to help the company to identify "what" they want to produce and "how" they could produce it using the same production equipment: *"we are using Quality Function Deployment [and] this management technique is used in the ideation stage of every project, aiming at development of new product, using the existing production or incremental changes to the existing* *production lines due to the cost involved in adoption of new machinery."* Adoption of the above mentioned techniques demonstrate that food and drink companies are reluctant to pass away the preceding investments into the production machinery and try to utilise machine's capabilities to its full potential through incremental changes. See Table 30. for an overview of key themes and associated quotes.

Management of complementarity	
Opportunities created by achieving a complementarity	
Focus on feasible products	*"Companies do not waste money on ideas that are not going to be feasible, physically, scientifically." (I1)* *"We can match the existing production capabilities with the changes to the product." (I17)*
Changing position on the market	*"We would have intellectual property and patents that could be extremely advantageous"…"we could become market leader rather than a follower." (I9)*
Opportunities for further product innovations	Interviewee 3 mentioned that the radical product innovation of extended shelf life was later utilised in other liquid product categories *"Introduction of extended shelf life milk led to NPDs in the juice market where the product technology (a slight variation of it) was adopted in various juice products."* *The knowledge from Best Brewery draught from can project was later applied in development of the rocket widget technology. (I16)* Interviewee 7 argued that after achieving 30% efficiency improvement in the canned minced meat project: *"We applied lower pressures across all products."*
Management techniques to achieve complementarity	
Cross-functional collaboration	An interviewee argued that within their company it is crucial to ensure that new products will be producible: *"We often collaborate together with R&D department as we need to make sure that we would be able to produce the product on the shop floor" (I11).* *"Cross-functional working with people from different departments is important." (I18)* *"In the project for own-label product of our main customer everyone was involved. Engineers started the project, but cross-functional people from Operations, Technical and NPD and Packaging were involved." (I7)*

Management tools	Interviewee argued that Quality Attribute Sheets are used to assess whether they have the right equipment to produce the product: *"This enables us to get ideas of capabilities as early as possible." "We have to identify any changes at the beginning everything has to be approved by the retailer."* The interviewee further continued: "*We also apply Quality Contracts and Statistical Process Control (SPC) to identify capabilities of the line for each product. So if there are any issues we share them with customer." (I7)* Interviewee 1 responded about management technique applied by Crown Cork based on "what" they want to produce and "how" they could produce it using the same production equipment: *"Crown is using Quality Function Deployment, this management technique is used in the ideation stage on every project, aiming at NPD using the existing production or incremental changes to the existing production lines due to the cost involved in adoption of new machinery."*

Table 30. Management of complementarity: Opportunities and management techniques to achieve complementarity

7.5 Factors influencing the complementarity between product and process innovation

The researcher classified the factors that were identified to influence innovation strategies of food and drink companies into three main themes. The following section will describe these themes and their underlying sub-categories using quotes from the interviews.

7.5.1 Attitudes towards changing the existing product and process technologies (production equipment)

The first important internal factor that was identified to influence companies' innovation strategies was satisfaction with the existing processing technologies and production equipment. Interviews revealed that companies in the food and drink sector, to a large extent, rely on the existing processing equipment and process technologies used to produce existing products (particularly revealed in interviews with I9; I2; I3; I17; I18: I13). It was uncovered that in some instances, despite being aware of the limitations associated with the same processing technology, there was reluctance to undertake radical change. As argued by one interviewee, who referred to using the same processing technology in their company for the past 40 years: *"I would almost call it a complacency, machines are more efficient, but the fundamental process technology did not change in the past 40 years…we have been resting on our history, we are not seen as market leader but rather as a follower"* (I9). Another interviewee argued that such practices apply to all SMEs in the food and drink sector: *"you could say that in every SME manufacturing company the existing process is constraining the development of product, we are using the assets we have and start to look for new production machinery opportunities only once the capacity of the existing machinery is filled"* (I8).

This characteristic also applied to a large multinational companies that were heavily focused on efficiencies, margins and on-time deliveries of the existing products (revealed by I1; I2; I10; I9). One of the Interviewees described the initial attitude of a large multinational company towards adoption of a novel product technology that would improve the ease of spreading their margarine: *"the multinational company we worked with was not interested in investing into new technology as it has already had an asset base of spread machines…and preferred to do it 'the old way'"* (I2). Similar argument came from another interviewee who argued: *"Yes, the injection moulding restricts our product (packaging) innovation options… blow moulding technology would be needed to produce bottles for vitamins, powders, tablets"* (P9).

However, a few respondents identified plans to invest into automation of production in the years to come. They realised the limitations of having the production equipment spread all around the production floor, added cost of involving low-skilled manual labour as well as decreased product quality by using outdated production, processing and packaging equipment (I17; I18; I13). As interviewee 17 said: "*The Bakery is planning to invest into automated production, within the next three to five years… at the moment packaging and chocolating are done manually.*"

The biggest factor influencing companies' tendency to utilise their existing equipment is the cost of new production machinery, as well as the cost of its premature scrapping (particularly revealed in interviews with I7; I3; I8; I10). Interviewee 7 argued that: *"we are constantly constrained with what we have and we aim very few investments into renewing the processing machinery."* Another interviewee (I3) described the existing equipment as one of the main challenges facing their company in a radical Product and Process Development project of the UHT milkshake with an extended shelf-life: *"the main barrier within the project was the need to change the existing packaging and processing equipment, it has been used for the past 20 years and it suddenly needed changing."* The importance of this issue was further demonstrated on the renewal periods of the machinery in the food and packaging sectors that was commonly between 15 and 25 years. As argued by interviewee 10: *"Even though there might have been suppliers of new processing equipment knocking on their door, these companies were not able to realise the flexibility of the machine…the food industry is well known for incremental changes…when being faced with a purchase of new piece of equipment, companies are looking for cost efficiency rather than looking for the most suitable equipment with the most opportunities"*.

Instances when a new production machinery was purchased for a certain project were often cost oriented and focused on getting the best price. Companies were buying the equipment to produce or pack a certain product ordered by their customer, rather than considering long-term opportunities and flexibility of the machine (I11; I15). This was demonstrated by interviewee who described his view on the reasoning behind the purchase of new packaging equipment among food and drink companies: *"majority of our customers are short-term oriented…they have a product in mind that they need to pack and are looking for efficiency in speed and cost…they do not realise the flexibility of the machine."* One of the main reasons for the inability to understand the range of opportunities that could be achieved through adoption of a novel production machinery was the sales team. Several interviews identified that sales people themselves frequently did not understand/realise the flexibility of machine, beyond the commonly referenced benefits of improved efficiency, cost and speed of production. This could have been an outcome of the lack of communication between sales team and engineers - sales team did not have any knowledge of what was going on in the R&D department. This resulted not only in inability of the machinery customer to make the most out of the machine purchased, but also hindered learning opportunity for both; machinery producer and seller (revealed by I13; I15; I17; I18).

Innovation in the food and drink sector was generally characterised by incremental changes in products and processes. The sector was commonly referred to as very traditional and very hard to change (particularly demonstrated in interviews with I10; I3; I1; I4; I7). Interviewee 11 argued that in their company they spend most of their time working on recipe tweaks on a weekly basis: *"We have over 250 lines so it usually takes about 2 years to get to every recipe."* This statement can be further supported by incremental process innovations such as lean improvements and line efficiencies initiatives that are often deployed and prioritised. According to an interviewee: "*as small changes as 0.5% in filling speed will increase the efficiency"* (I7). The same perception of the industry had interviewees from different sectors, i.e. in the fresh herbs segment: *"We are trying to improve our product through use of new packaging, but herbs are not an innovative segment"* (I4). From dairy sector: *"There are not many radical innovations occurring in the dairy industry, fresh milk is a commodity"* (I3) as well as canned food sector: *"canned food is a declining market"* (I7).

Several interviewees referred to the attempts to introduce new packaging concepts to improve the consumers' perception of their product. However, these trials were often unsuccessful and never introduced on the market due to an increased cost and lower speed of production (particularly identified in interviews with I7; I4; I10; I1). For example, one interviewee (I4) mentioned trials to introduce new packaging for a new line of soft herbs: *"we had some trials of new packaging…however, the innovation has proven to be 5p more than the original packaging, therefore it was not accepted."* Interviewee 7 demonstrated an initiative to change the low-cost perception of canned food products by changing its packaging: *"we wanted our products to be perceived as higher-end and [we have] decided to change the packaging format to pouches…however this has proven to be very costly and slow (15 units per minute) in comparison to cans (200 units per minute)."* Table 31. provides an overview of key themes and quotes.

Factors influencing complementarity between product and process innovation
Attitudes towards changing the existing product and process technologies (equipment)

Satisfaction with the existing production equipment/ process technology	Interviewee described the initial attitude of a large multinational company towards adoption of a novel technology that would improve the ease of spreading their margarine: *"This multinational company was not interested in investing into new technology as they have already had an asset base of spread machines….and preferred to do it 'the old way'." (I2)* Interviewee 3 described the attitude towards process innovation of dairy companies as*:" Once you have a process that works, the equipment that makes the product does not wear out, the final life is very long." …"For commodity products such as milk temperature treatment works well and everybody is familiar and comfortable with it."* Most of the time it is the case of optimising the processes or there are new technologies introduced in the market place. An interviewee realised the weakness of using the same processing technology for 40 years: *"I would almost call it a complacency"…"we have been resting on our history, we are not seen as market leader but rather as a follower." (I9)* *"The Bakery is planning to invest into automated production, within the next three to five years… at the moment packaging and chocolating are done manually. (I17)*
Role of cost and premature scrapping of existing production machinery	*"We are constantly constrained with what we have and we aim very few investments into renewing the processing machinery. However, our equipment has 10 years renew period that is in comparison to other plants that are using 50 years old machinery still on the better end." (I7)* *"You could say that in every SME manufacturing company the existing process is constraining the development of the product. We are using the assets we have and start to look for new production machinery opportunities only once the capacity of the existing machinery is filled." (I8)* Interviewee argued that companies in the food and packaging industry have not considered a change of machinery for 15-25 years, even though there might have been many suppliers knocking on their door, however they were not able to realise the opportunities of the process innovation: *"The food and packaging industry is well known for incremental changes. When faced with a purchase of new piece of equipment, companies are looking for cost efficiency in comparison to looking for the most suitable equipment with the most opportunities." (I10)* Interviewee commented on the development project of the UHT milkshake with an extended shelf-life: *"The main barriers within the project were the existing packaging and the processing change…the equipment has been used for more than 20 years and you suddenly needed to change it." (I3)* Interviewee claimed that it is often difficult to develop a relationship between product and process innovation: *"The main barrier to development of the relationship is the financial barrier. The new products are at risk themselves…the speed of return on investment is key." (I8)* An interviewee commented about an unsuccessful initiative within company to improve the perception of their product by changing the packaging due to cost: *"canned food products are perceived as low cost"...,"we wanted our products to be perceived as higher end and decided to change the packaging format to pouches." "However this has proven to be very costly and slow (15 units per minute) in comparison to cans (200 units per minute)." (I7)* *"We know that robots are a way forward, but we need to prove the return on investment to our Managerial Board. One year return is no problem…for a two year return we will need a business plan…for a three year return the robot will need to generate a good contribution in the years to come." (I18)*

Extent of product and process innovation in the food and drink sector	*"We are always trying to improve our product through use of new packaging"…"however herbs are not an innovative segment." (I4)* *"We are more of a follower than leader"… "we tend to sit in our comfort zone"…"90% of our product innovations are incremental, only 10% of projects create new knowledge…"these are out of our comfort zone." (I7)* *"Our production site is half automated… we are still using 7 people on average at each line"…"At the moment we are discussing opportunities for complete automation of the production with several equipment suppliers"… By removing 2 people from the line we will be able to save £52,000 plus a year."(I18)* Interviewee from a manufacturing equipment company (I3) described the place of radical product innovations in the food industry as "*Food industry is very traditional and it is very hard for it to change*." Consultant working with a range of FMCG companies argued: *"From my experience companies in the FMCG industry are less interested in radical innovations. They focus more on packaging and design changes." (I10)* An interviewee argued that in their company they are working on recipe tweaks on weekly basis: *"we have over 250 lines so it usually takes about 2 years to get to every recipe." (I11)*

Table 31. Factors influencing complementarity between product and process innovation: Attitudes towards changing the existing product and process technologies (equipment)

7.5.2 Impact of supply chain members on innovation

The results of interviews revealed that one of the key parties influencing innovation strategies of processing companies were the 'Big Four' retailers. Retailers do not produce their own label products themselves, but rather partner with processing companies to produce it for them. Instances when the retailer makes a joint investment with the processing company further increases willingness of the processing company to consider undertaking an innovation (I9; I10). Interviewee claimed that when being approached by a customer to bring a solution to their problem they would consider a purchase of a new production machinery, however: *"we would need to have at least 25% margin, and it would need to be a long term contract… 99% of what we do are orders from customers, we do not initiate any innovation ourselves"* (I9). However, food companies producing own label products were also willing to purchase new packaging or production equipment if they received new contract from the retailer, even if they had to purchase the equipment themselves (often one of their biggest customers) (I11; I4). Interviewee 4 stated: *"we are keen on investing into new machinery if we get a contract for a new product from one of our key customers."*

Despite this, the majority of innovation requirements from retailers were incremental changes to the existing products based on consumers' complaints (revealed by I1; I7; I8; I12; I10). Interviewee 7 claimed: *"70% of our NPD projects is coming from our biggest customer… they are usually improvements to existing products based on consumer complaints."* This provides processing companies with a limited space to consider more radical innovations. As even quality improvements of the existing products did sometimes take several months or years.

The incremental changes included product and packaging specifications, particularly for retailer's own label products. These included;

- levels of salt and sugar
- preferred suppliers of raw materials
- packaging size and design
- levels of meat in the product
- types of starches to be used in a product

Interviewee 7 commented on the constant pressure their company is facing from their main customers (retailers): *"we are pushed by our main customers to meet the quality, nutrition and stability of the product as well as their meat sourcing requirements…we are allowed to source meat only from nominated suppliers … retailers are putting extremely high pressures on Key Performance Indicators (KPI)."* There were even tighter specifications when manufacturers produce and pack own label products for retailers. For example, one of the interviewees stated that: *"our cut herbs are not branded, therefore all the biggest supermarkets have their own specifications and standards that we have to obey"* (I4). This can be further supported by a statement of an interviewee who noted: *"we receive a brief from the supermarket, for example for a steak pastry…the recipe is allowed to have only a certain amount of salt, have specific packaging requirements and design"* (I11).

Furthermore, the interviews revealed a range of unethical practices utilised by the 'Big Four' (particularly demonstrated in interviews with I10; I1; I7; I14; I3) these included;

- Requests for the cheapest price on the market in order to buy from a supplier
- Copying popular branded products and consequently stopping to stock the branded product and replacing it with an own label product
- Bribery to get stocked by the supermarket
- Imposing price pressures on commodity producers

Smaller companies, even though producing high quality products, are facing difficulties in getting listed by the major retailers. Interviewee 14 argued that: *"we could not get into supermarkets, there is a lot of bribery going on, and we cannot compete with companies that are providing a similar product, but using a powder to give it the required flavour…we are using the traditional recipe and using real ingredients."* A further interviewee built on the issue of bribery in order to get listed by one of the major retailers: *"you have to pay them tens of thousands pounds to stock your product, of course behind the closed door"* (I4). Some of the interviewees mentioned to report these practices to the Groceries Code Adjudicator to help manage the imbalance in relationship between the powerful buyers and suppliers in the food and drink sector.

The evidence from interviews revealed that retailers did not influence innovation when companies were working on their own NPD projects. These were usually initiated by a market need, identified through consumer research (revealed by I17; I10; I1; I4). As stated by Interviewee 4: *"due to the increasing trend of the healthy life style, we have introduced several product innovations."* A further interviewee stated: *"We read a market report on the baked snacks category that highlighted the rising on-the-go market with mini pack sizes… based on this we decided to introduce mini jalapeños and mini macaroons"* (I17). However, the number of such projects was significantly lower because companies are prioritising their day-to-day operations and duties.

An interesting finding was that the managerial attitude towards product and process innovation within the food and drink companies themselves often hindered any potential change (demonstrated in interviews with I7; I2; I18; I7; I8). For instance, interviewee 7 defined the organisational culture of their company as 'orthodox': "*The way our company works is often orthodox- on one-to-one basis…you give someone several solutions and then they choose… and try to sell your pitch to the wider audience."* There were also different perceptions of innovation by R&D department and the managerial board. Interviewee 2 pointed out that during the Pulse Electrofields technology project that the production process changed from batch process to a continuous R&D process. This was perceived as an innovation by R&D department, while the managerial board argued that: *"there was not much of an innovation."*

Being a part of a large conglomerate was often one of the key enablers to undertake 'exploratory' projects. An interviewee mentioned some of the advantages of being owned by a global giant: *"we are owned by 'cash-rich' global conglomerate…anything that looks like it will have some kind of return or payback, they help us to pay for it"* (I6). Similar benefits were identified in another interview: *"we are part of a larger Swedish owned group that has established a plant to focus on innovation and R&D, helping us to improve…moreover, being part of the group enabled us to work on more expensive projects as we are sharing the cost of every project 50/50 with the head office"* (I9). An interviewee mentioned that creating a joint venture with a large conglomerate enabled them to develop a strong focus on their dry powder products and invest into new products and processes: *"we have combined our technical and manufacturing capabilities to deliver high quality products"* (I8). See Table 32. for an overview of underlying themes with associated quotes.

<table>
<tr><th colspan="2">Factors influencing complementarity between product and process innovation</th></tr>
<tr><th colspan="2">Impact of supply chain members on innovation</th></tr>
<tr><td>Satisfying customer needs</td><td>"70% of our NPD projects is coming from our biggest customer… they are usually improvements to existing products based on consumer complaints." (I7)

One interviewee explained that an important consideration influencing the extent of product innovation was whether the products were branded or own brand. The reason was that whenever retailers wanted to develop an own label brand they would partner with company that is producing the products for them and make joint investments. "The joint investment helped the production companies to be more willing to consider change." (I10)

Interviewee argued that the main reason for the purchase of new flow wrapping machine was their "customers who wanted a larger product and our old machine could not pack it." (I11)

Interviewee argued "we are keen on investing into new machinery if we get a contract for a new product from one of our key customers." (I4)</td></tr>
</table>

Unethical practices	Interviewee described the inequality between the packaging supplier and large customer (well-known cereal brand), who required the cheapest price on the market in order to buy the packaging: *"For example to large FMCG packaging companies sell their boxes at a loss…they do that so they can get a production line for their premium niche products and achieve the turnover to buy and run the equipment." (I10)* Interviewee stressed the power of Big Four retailers by giving an example of a branded ready soup product that was launched in a new packaging, which proved to be very successful among consumers: *"the major retailer liked this, copied them and stopped stocking them…they almost took ownership of that product in the category." (I1)* An interviewee said that their company is constantly pushed by one of the main retailers to meet the quality/nutrition and stability of product criteria: *"It was especially intense during the time when retailer was running a "Better for your health" campaign."…"Retailers do not like change"…"you are giving them headache if you have to report on NPD"…"they have so many different products in the supermarkets that they do not have time to spend on each of them." (I7)* An interviewee commented on the difficulties their product faced when trying to be listed by retailers: *"We could not get into supermarkets, there is a lot of bribery going on, and we cannot compete with companies that are providing similar product, but using just a powder to produce it"…"we are using real ingredients and the original recipe." (I14)* Interviewee commented on the decreasing prices of commodity product milk due to changes in the dairy industry from being local to being dependent globally and the big retailers taking advantage of this: *"Mr Tesco and Mr Asda do not think locally now, but they can think what they buy globally."* …*"Milk is very fresh product consumed locally, but the price pressures on the milk are global."* Moreover adding… *"The decreasing prices of milk have a devastating impact on farmers, also production and processing companies in the middle get squeezed and the retailers are the only ones who are making money." (I3)*
Prescribed product specifications	An interviewee commented on the constant pressure their company is feeling from their main customers (retailers): *"We are pushed by our main customers to meet the quality, nutrition, stability of the product, meat sourcing requirements from retailers"…" we have to source meat from nominated suppliers"… retailers put extreme pressures on Key Performance Indicators (KPI)." (I7)* *"We have to identify any changes at the beginning everything has to be approved by the retailer" (agents, approved sources of meat). (I7)* *"Cut herbs do not have their own brand, all the biggest supermarkets have their own specifications and standards that you have to obey." (I4)* Interviewee did not perceive the specifications given by their customers (main retailers) as limitations towards innovation: *"When we receive an order from a supermarket there is quite a lot of specifications…such as salt content or packaging requirements… but I would not say that it limits the innovation on our side to any extent"…"we are producing them for the supermarket, who is our customer so we need to adjust to what our customer needs." (I11)*
Market trends (consumer needs)	Interviewee described how changes in consumer preferences influence product innovation: *"due to the increasing trend of the healthy life style, we have introduced several product innovations." (I4)* *"Our Managing Director read a market report that identified the major growth opportunities in the baked snacks category. This was the starting point for development of mini Jalapeño. The Bakery is planning to build upon this trend in the future."(I17)* *"We started to produce gluten free wraps to target gluten intolerant consumers." (I11)*

Internal factors influencing innovation	*"The way our company works is often orthodox- on one-to-one basis…you give someone several solutions and then they choose… and try to sell your pitch to the wider audience." (I7)* An interviewee commented on different approaches within a company towards the extent of process innovation during adoption of Pulse Electrofields (PEF) technology to help with shelf-life extension of fruit juices: *"The process has changed from batch process to continuous R&D process."* However, R&D department perceived this as *"an innovation."* The managerial board argued *"there is not that much of a difference to what we did previously." (I2)* *"When the NPD team comes up with a product idea, the operations people often say it is not producible with the existing equipment…We often have to make compromises." (I18)* *"Everything is done on tight margins and evaluated on increase in labour and slow down of machine…the key question is: How many units can you produce per minute?" (I7)* *"The innovation projects of the drive brands are prioritised and the smaller companies are "put into queue"…the company is focusing on the top pay back and marketing opportunities." (I8)*
Influence of the cash-rich owner	*"Food Co. has been since 1989 owned by multinational corporation, enabling the company to renew the equipment much more often than competitors." (I7)* *"The process innovation is more radical when the packaging company is working on their carrot projects."* However, *"before developing a new machine, they tried to use the piece of machinery they already had and add new parts to it." "These process innovations could often increase the cost of packaging by 40-50%."* These changes are often too expensive for own label companies, but for large multinational branded companies it is worth the money. *(I1)* An interviewee commented about the advantages of being owned by a global giant: *"We are owned by a 'cash rich' global company"… "anything that looks like it will have some kind of return or payback, they help us pay for it." (I6)* An interviewee commented on the benefits of being part of large group: *"We are part of a larger Swedish owned group that has established a plant to focus on innovation and R&D, helping us to improve." "Moreover, being part of the group enabled us to work on more expensive projects as we are sharing the cost of every project 50/50 with the head office." (I9)* An interviewee mentioned that creating a joint venture with a large conglomerate, has enabled them to develop a strong focus on their dry powder products and invest into new products and processes. *"We have combined our technical and manufacturing capabilities to deliver high quality products."(I8)*

Table 32. Factors influencing complementarity between product and process innovation: Impact of supply chain members on innovation

7.5.3 Collaboration with external parties and existing knowledge (experience) within the company

The evidence from interviews suggests that food and drink companies collaborate with a range of external parties. The collaborations were mainly initiated when the company was facing a problem with the existing production equipment and the solution was not available internally. Close collaboration relationships with a number of external parties were build when companies were working on a radical product or process innovation projects. Interviewees referred to the following external parties (particularly revealed in interviews with I2; I3; I6; I7; I8);

- Links with outside spin-offs such as university spin-offs and collaboration with students, who were building upon their PhD projects
- Packaging machinery suppliers, who developed customised solutions for manufacturing companies
- Production machinery suppliers were involved when developing a customised production equipment, but also when utilising the potential of existing machines
- Licensing of product or process technology that already existed in the food and drink industry, but also from unrelated industries
- Design agencies to help companies to make their products' packaging stand out on the shelves
- Collaboration with Food research institutes

The interviews revealed that although food and drink companies rarely search help when developing incremental product innovations. They almost completely rely on equipment suppliers in both radical and incremental process innovation projects (particularly revealed in interviews with I3; I13; I6; I10). This was caused by lack of experienced engineers working on the 'shop floor', outsourcing of the production process development work to the external supplier as well as unique nature of each product that resulted in customised production processes. Therefore, food and drink companies require well-developed research techniques to identify the most suitable sources of knowledge their project requires. This was for instance demonstrated by Interviewee 2, who referred to the project of development of cold pressed orange juice for Starbucks by a manufacturing company: *"The high pressure machine was already on the market, the challenge for the company was to identify amount of pressure and time the product had to be inside the machine."… "The manufacturer collaborated with producer of bater soy meat that used the same processing technology to identify these"…"with this knowledge the manufacturer was able to produce the cold pressed juice and soon after introduced a guacamole dip that built upon the same technology, but again required changes to time and temperature when processing."*

In projects that required a new production line to manufacture a slightly enhanced product, collaboration with the external supplier of the production equipment enabled the company to customise it specifically to the needs of their production (I11; I6; I13; I18). Interviewee 6 stated: *"the machine was designed in Netherlands, we went there three times to ensure the machine was developed exactly to the needs of our production"* (I6). One further interviewee demonstrated the mutual benefit of collaboration: *"one of our packaging machinery suppliers is working a lot with us as packaging company…they are working on development of an improved technology to be able to compete with their main competitor"* (I4).

There were also instances when collaboration with external parties was not required because companies were focusing predominantly on incremental improvements to the existing products and processes. The time pressure to keep up with the daily orders and delivery of high-quality products has resulted in working with the existing knowledge and experience. For instance, Interviewee 8 stated: *"our NPD team is composed of 6 people from cross-*

functions of NPD, operations, marketing…people are trying to do what they can but there is less time for clever ideas.” The themes identified in these responses are presented in Table 33.

Factors influencing complementarity between product and process innovation	
Collaboration with external parties	
Identification of suitable technology (collaboration parties) in the external environment (PAC)	One interviewee commented about the common practice of outsourcing production/ packaging plants by retailers. Internally, retailers had 2-3 people with PhDs, who were looking for packaging opportunities and more environmentally friendly solutions. *“The retailer had very good knowledge of food manufacturers, as when required, he could have just changed the supplier who would have produced the product for them.”(I10)* One interviewee described a case of new packaging development for a wine glass by a major UK retailer: *“They saw this technology on Dragon's Den and they contacted the person who came up with it and he made the packaging for them.” (I10)* *“If a retailer is working on a new premium product, they will go to the agency and ask them to make the design of the packaging look luxurious, so they will come up with 4-5 designs and the retailer would pick one.” (I1)* Pulse Electrofields micro pulses process innovation used for conservation and shelf-life extension were developed by collaboration between juice manufacturer and university “Vahinger” in Netherlands: *“The University approached Unilever to work with them on the case of optimization of an ingredient (super-critical CO2 treatment).” (I2)* Interviewee argued that the company does not do much development work inside the company, *“we are relying on the outside sources of ideas and knowledge.” “We are using links with outside spinoffs such as university spin-off and collaboration with students, who are building upon their university projects and focusing on the idea generation and further product opportunities with companies.” (I8)* An interviewee argued that a well-known design agency helped them to make their product stand out on the shelf: *“the agency helped us to create a new, more attractive packaging that brings over the local type of product.” (I14)* Seller of packaging machinery stated: “*Radical process innovation would usually come from customer, who would come up with an innovation on laboratory scale and then come to us to take it semi-commercial or fully-commercial.” (I3)* Interviewee argued that their packaging machinery is tailored to their customers' needs: *“We are not selling an off-the-shelf solution…we offer them a proper technical change… it usually takes us about one month.”(I13)* An interviewee commented on development of a complete solution providing filling and packing in one line for specific needs of their production: *“The machine was designed in Netherlands, we went there three times to custom make it.” (I6)*

Adopting existing technology	Interviewee 2 noted that during the cold pressed orange juice project for Starbucks, the manufacturer required help with product processing: *"The high pressure machine was already on the market, the challenge for the company was to identify amount of pressure and time the product had to be inside the machine."… "The manufacturer collaborated with producer of bater soy meat that used the same processing technology to identify these"…"with this knowledge the manufacturer was able to produce the cold pressed juice and soon after introduced a guacamole dip that built upon the same technology, but again required changes to time and temperature when processing."* Interviewee argued that their company saw a gap in the market in the use of micro pots packaging. These were supplied by RBC pots manufacturer that were used for composite meals, soups and sauces**:** "Food Co. *was one of the first companies to trial this packaging in the UK market about 10 years ago. The same pots were already used 30 years ago by Heinz and Campbell's soup in USA." (I7)* *"At the site we are starting to use new cold-wetting technology, it was in use previously in the food industry for example for coffee whiteners." (I8)*
Existing knowledge and experience within the company	
Utilising existing knowledge within the company	*"Our NPD team is composed of 6 people from cross-functions of NPD, operations, marketing...people are trying to do what they can but there is less time for clever ideas"* leading to *"low levels of success."(I8)* During the project of improvement of consistency of chunky steak canned ready meat the processing company utilised the existing processing and product knowledge: "*We had sufficient knowledge and experience from previous projects in understanding how the product forms."(I7)*

Table 33. Factors influencing complementarity between product and process innovation: Collaboration with external parties

7.6 Examples of Product-Process positioning maps from Phase 1

The Additional, final part of interview that built upon Product-Process positioning map enabled the researcher to gain insights into the variety of different complementarities adopted by food and drink companies in the UK. It has also helped to identify 'illustrative' case studies that would be further analysed in Phase 2.

Researcher adopted the Product-Process positioning map to assist interviewees in understanding the different types of complementarities, at the end of each interview. The aim was to support interviewees in identifying any further types of complementarities that are utilised within their project portfolios. Furthermore, the second part aims to identify complementarities that were illustrated within the map, but did not occur within the portfolio.

The complementarity map was developed to graphically visualise the classification of complementarities between product and process innovation in the New Product and Process Development Projects. It is meant to be perceived as a map to position a portfolio of projects companies work on. This will enable companies to see the range of opportunities that are open to them and allocate resources and capabilities accordingly. Moreover, it can also be applied as a re-consideration whether the company works on a well-balanced portfolio of exploratory and exploitative projects.

This part of the interview provided some further interesting insights. Once each of the different complementarity types in the map were described by the researcher, interviewees realised the number of complementarities that took place within New Product and Process Development Projects in their companies. Their understanding of the complementarity concept was much clearer than at the beginning of the interview and they were more confident in identifying and discussing different types of complementarities. Interviews revealed that majority of companies' projects were located within the lower extent of complementarity (particularly revealed by I1; I2; I7; I9; I17). As argued by Interviewee 7: *"we have a lot of projects in the Product and Process Pooled area as well as Process Amensalism complementarity…I would also position some in the lower end of Reciprocal complementarity as we often utilise the knowledge from more radical projects in further product developments and process developments."* An extreme answer came from Interviewee 9, who argued: *"our projects are positioned in the Product and Process Pooled complementarity area, we recognise there are other complementarities and surely there is a range of benefits associated with these, but our products are selling well…we are happy with our sales."* The interviewees suggested that the map helped them to realise all of the different options that were open to them in the projects, but also helped them to visualise/realise whether their portfolio of projects maintains a balance between exploratory and exploitative projects - an important characteristic in order to stay competitive. The feedback received from interviewees enabled the researcher to visually enhance the The Product-Process Map to position a portfolio of projects by dividing the areas of exploitative projects from areas portraying exploitative projects (See Figure 29.). In addition to this, a further complementarity was added based on the comments of Interviewee 7. The complementarity portrays an instance of synchronous product and process innovation, while making only incremental changes to the existing production equipment and product, termed; "Incremental Reciprocal Complementarity" due to its similarity with the Reciprocal complementarity in terms of synchronous adoption of product and process innovation. In comparison to the Reciprocal complementarity project teams have less freedom in developing resources and capabilities, and have to work with what is available inside the company. The synchronisation between the two innovation types is required due to the unique product nature.

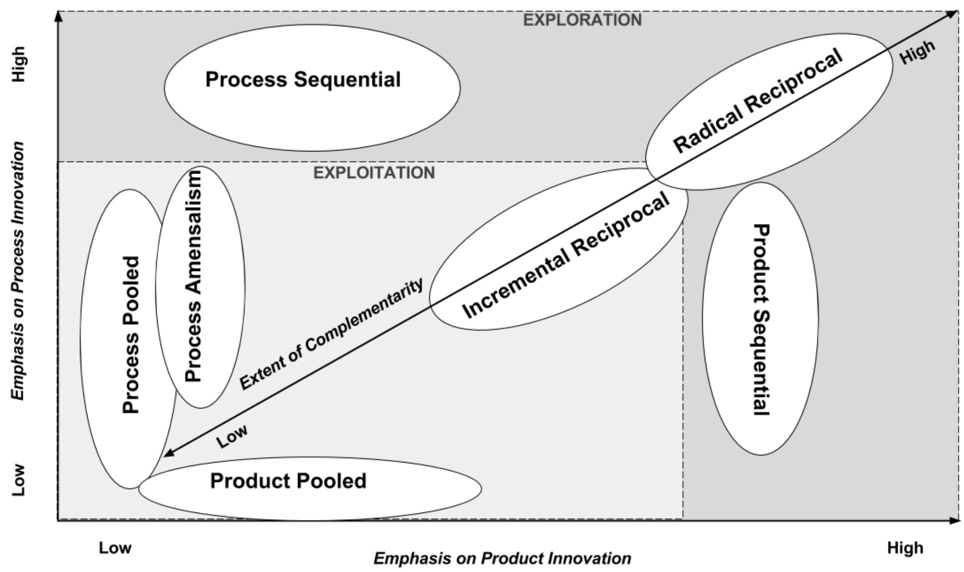


Figure 29. Revised Product-process complementarity map to position a portfolio of projects based on the findings from Phase 1

The following Figures 30. and Figure 31. are meant to serve as demonstrations of Product-Process positioning maps of New Product and Process Development projects undertaken within the past 5 years at the Dorset Bakery and Food Co. . Dorset Bakery complementarity portfolio relies on flavour changes of the existing products. The Bakery aims to utilise the existing production equipment to its maximum potential, despite realising the disadvantages of this practice. Only a single project, development of Jalapeño wafers was located in the explorative part of the Map.

Food Co., also relies predominantly on incremental changes to the existing production processes. Company's aim is to enhance the production efficiency and provide consumers with a wide choice of existing product variants. The Additional part of Phase 1 confirmed all of the proposed complementarities between product and process innovation, accept from Product Amensalism complementarity. Figure 32. includes the case studies that were chosen to 'illustrate' the portfolio of complementarities between product and process innovation occurring in the food and drink companies in the UK.

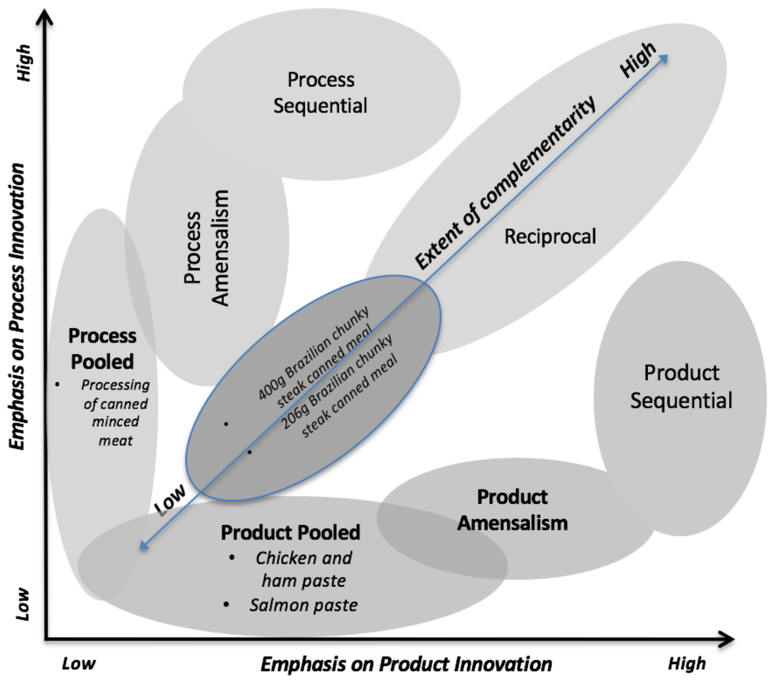


Figure 30. Portfolio of New Product and Process Development projects at the Dorset Bakery undertaken within the past 5 years.

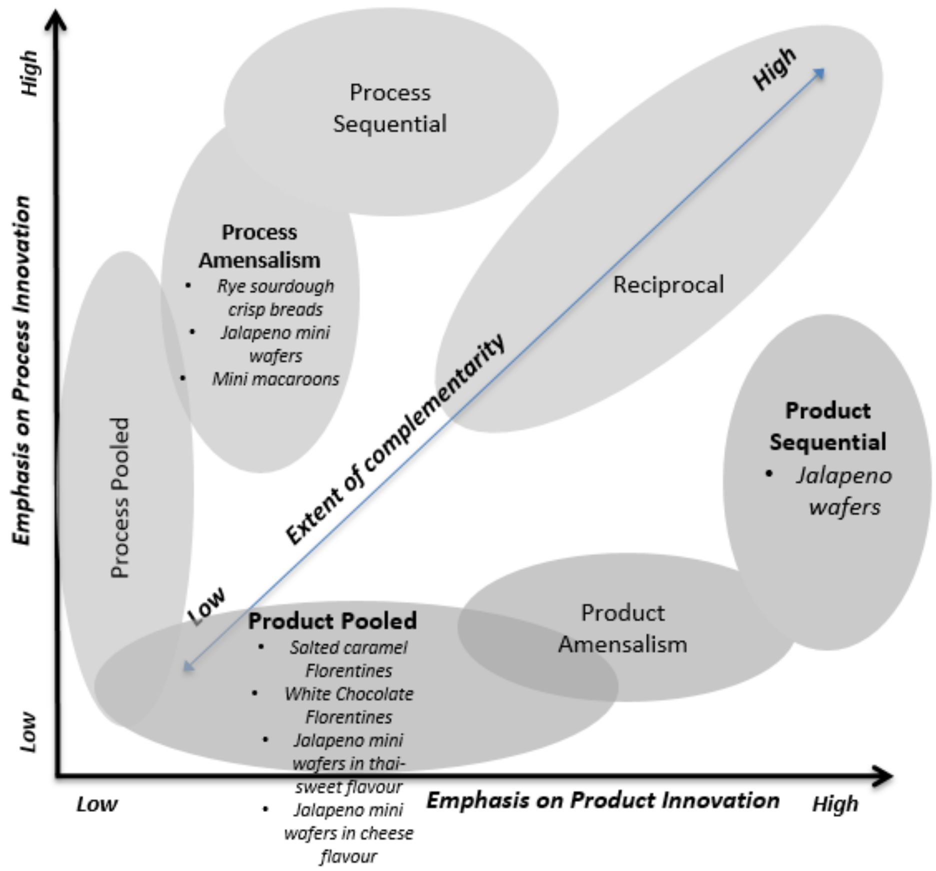


Figure 31. Portfolio of New Product and Process Development projects at the Food Co. undertaken within the past 5 years.

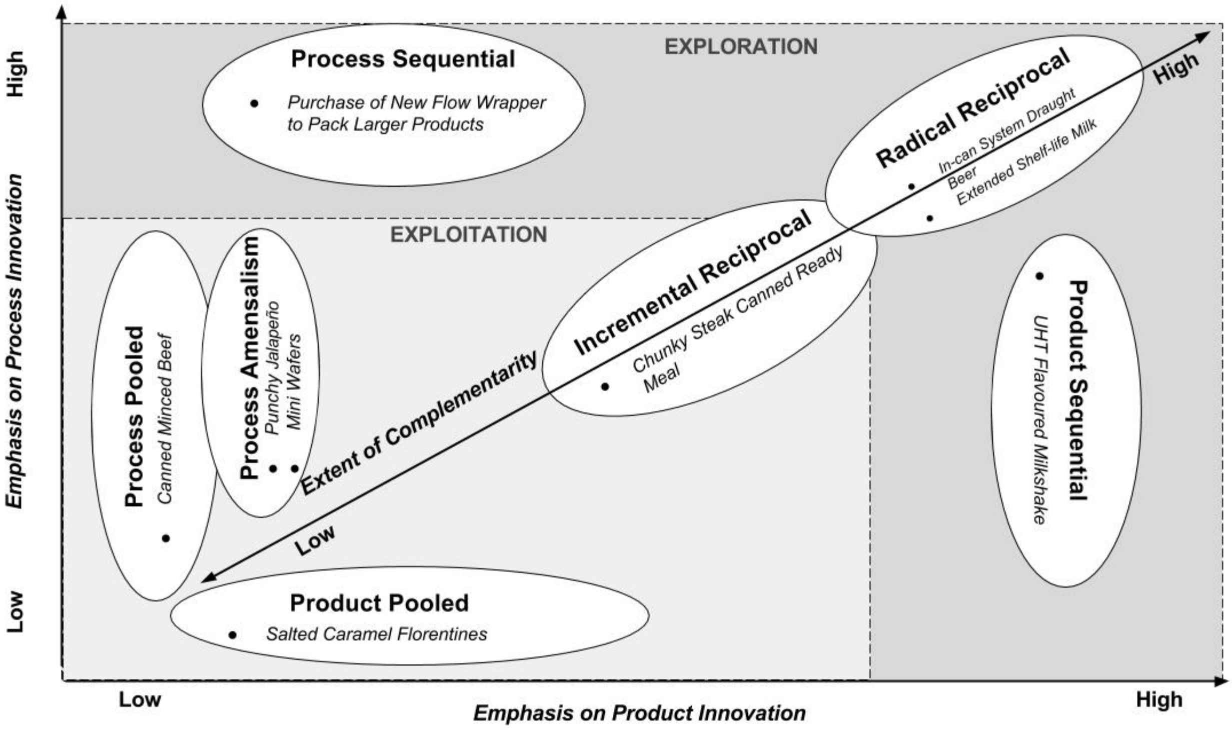


Figure 32. Visualisation of New Product and Process Development projects identified during the Phase 1 within the Revised Product-process complementarity map to position a portfolio of projects

7.7 Summary of Phase 1 findings

Results from the interviews conducted with the key informants in the food and drink sector have identified a lack of understanding within manufacturing companies in terms of different types of complementarities that may occur between product and process innovation in the New Product and Process Development Projects. The two examples of Product-Process Positioning Maps have further demonstrated that investigated companies had tended to undertake projects within a few areas in the map, i.e. the Premium Snacks Manufacturer in the exploitation part of the map focusing primarily on flavour changes of the existing Florentines products, while trying to make the most out of the existing production equipment (despite being unreliable and outdated) in the Process Pooled and Process Amensalism complementarities. Moreover, based on the interviews the Product-Process Complementarity Positioning Map was slightly adjusted (See Figure 32.). Radical reciprocal complementarity was divided into two complementarities; Reciprocal and Incremental Reciprocal. Incremental Reciprocal complementarity was identified by Food Co. as a common practice at their company. It was characterised by synchronous integration of incremental changes to the product recipe and production process throughout the New Product and Process Development Project, using the existing resources and capabilities of the company.

CHAPTER 8. CASE STUDIES

8.1 Introduction

The purpose of this Chapter is to introduce nine 'illustrative' case studies identified by interviewees in Phase 1 of primary data collection. Case studies portray a portfolio of complementarities utilised by food and drink companies utilise in their New Product and Process Development Projects. Each case study begins with a brief introduction of the company within which the case(s) are being studied. This is followed by description of complementarity strategy between product and process innovation, particularly focusing on the role of three contingencies from the Typology: Complementarity-Capability Matrix. A single case study is used to describe each of the seven complementarities. Two case studies are used only to demonstrate instance of Reciprocal complementarity. Both cases are historic case studies, therefore to increase the validity of the collected data such methodology was perceived as appropriate. Figure 32. visually portrays the New Product and Process Development projects that will be described. The Chapter starts with case studies illustrating the highest extent of complementarity Reciprocal complementarity, and finishes with Product and Process Pooled complementarities, which represent the lowest extent of complementarity. The following Chapter will test and extend the Typology: Complementarity-Capability Matrix using the findings from 'illustrative' case studies.

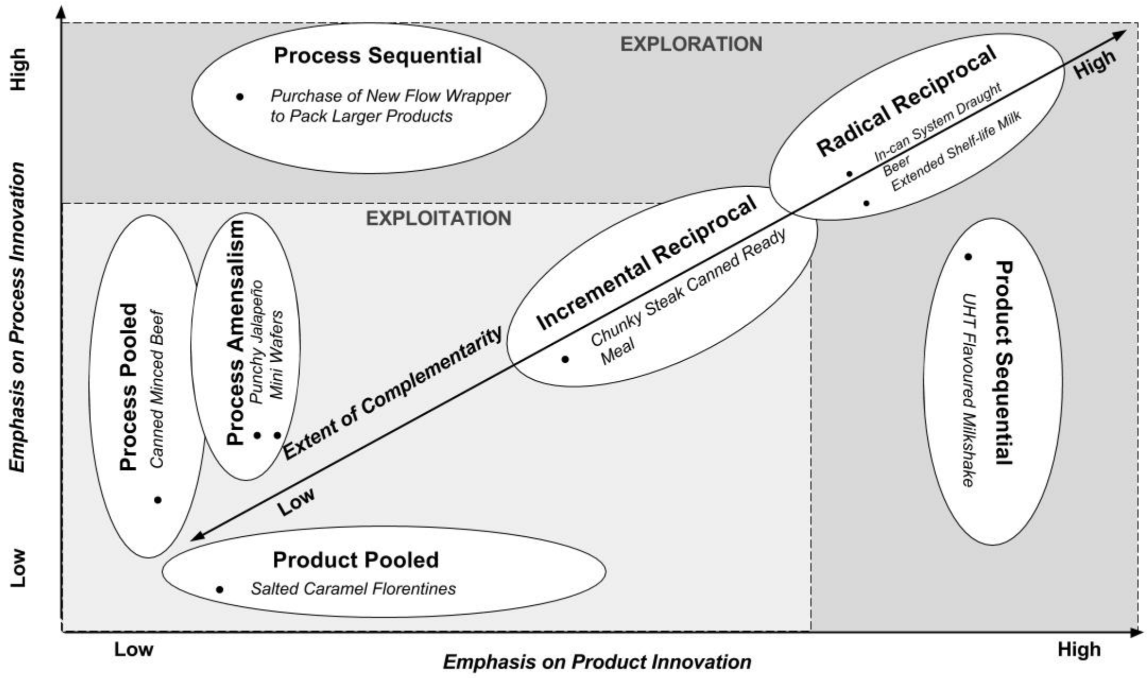


Figure 32. Visualisation of New Product and Process Development projects identified during the Phase 1 within the Revised Product-process complementarity map to position a portfolio of projects

8.2 Daily Dairy- Extended Shelf-life Fresh Milk (Reciprocal complementarity)

The following case study will explore an example of a Radical Reciprocal complementarity that illustrates a radical product innovation involving the concurrent management of significant changes to the processing and packaging equipment.

Extended shelf-life fresh milk was introduced in the UK market in 2001 as one of the biggest innovations in the milk sector. The main driver of this project was a clear market need for a longer shelf-life milk that tasted fresh. Right at the beginning of the project the company was facing a critical challenge in development of this product: How to process a product to give it a longer shelf-life that would not detract from the fresh taste of the product? There were three options that were open to the company:

1. **Pasteurisation-** 73 degrees for 23 seconds providing the taste of a fresh milk, and killing the bacteria (providing shelf life of 12-14 days by being distributed in the cold supply chain of 4-8 degrees)

2. **UHT sterilisation-** 124 degrees for 2 seconds leaving no bacteria or spores inside, but having an impact on the taste of the milk making it slightly oxidises and caramelised (providing shelf life of 90+ days by being distributed ambiently)

3. **Ultrafiltration process-** separating the whole milk into the skim and cream and putting it through ceramic membraning to filter out the bacteria (the final product will never be sterile)

Daily Dairy aimed to develop an extended shelf-life product without compromising the taste, and was willing to make significant investments into this project. The company believed that this initiative could significantly strengthen its brand. The project team identified an already existing product technology and decided to license the PurFiltre™ technology from Food Ltd. in Canada. This provided a starting point in the extended shelf-life fresh milk project. The milk processing technology of cold micro-filtration used to eliminate bacteria in milk before being pasteurised was introduced in Canada by Foods Ltd. through product called Lactantia PurFiltre™ milk. It has been said that this technology was the biggest breakthrough since Louis Pasteur developed pasteurisation. According to Interviewee 3: *"If you give spor bacteria the right environment they will grow again, with the microfiltration process you get*

99.9% of spors out." Several years of R&D and $8 million led to development of processing technology that led to;

- The extended shelf-life milk tasted better than regular milk as it required less heat for pasteurisation
- Consumers were willing to pay a premium for the milk due to the fresh taste and improved quality
- The milk had double the shelf-life of the regular milk
- Production of pure milk that contained 92 times less bacteria than pasteurisation alone

Daily Dairy understood the number of further challenges they would face throughout the project therefore, they started with a risk assessment process, addressing all the factors that could cause product contamination. These included filling machines and operations filling them, packaging equipment and the bottle with closure.

Firstly, the microfiltration plant was supplied by Packer, Sweden. "Microfiltration is a well-established laboratory technique for the removal of microorganisms (both vegetative and spore forms) and hence the production of sterile fluids, without the application of heat" (Britz & Robinson, 2008, p. 61). Microfiltration was a suitable option to extend the shelf-life of the milk as a replacement for the heat treatment. The extended shelf-life milk, currently available in the UK, is a semi-skimmed product that is claimed to remove 99.7% of bacteria by the use of microfiltration. This product has an extended shelf-life of 20 days.

Secondly, the dairy collaborated with Krones of Germany that supplied the bottling lines, the equipment was specifically designed for the extended shelf-life milk project. The hygiene requirements for this product were much higher than in the production of normal milk. The new equipment was able to;

- work on a weight filling basis and fill the low density polyethylene (LDPE) bottles with a cold aseptic process
- the injector, filler and capper were ordered in a Bloc arrangement in a cleanroom environment ensuring the enhanced hygienic filling (EHF) throughout the bottling process
- the bottling line had to be adapted to include an induction sealing technique (a process to make sure the foil was hermetically closed onto the top of the bottle)
- an ultraviolet light was used to ensure the top was completely sterile (milk is very light sensitive and when exposed to natural light it will degrade the quality of the milk, largely the vitamins inside)

Except from considering the production process, the diary had to consider the milk packaging. There were two options in managing the presentation of bottle and closure in the filling environment:

1. The Bottle could be closed and produced sterile in 100 degrees (this option is a high in cost but a low contamination risk option)
2. Produce the bottle, leave it open and sterilise it prior to filling (same cost as option 1., but there is no need to decontaminate the bottle)

Considering these two options are used equally in the market, there are a few disadvantages associated with the closed bottle option (option 2) and chose option 1. Firstly, when the sealed bottle is subject to temperature changes it will change its shape, if storing the bottles after producing them, it is required to store them in a controlled temperature. Secondly, closed bottles are difficult to move around as they have very different characteristics than an open bottle. According to Interviewee 19: *"We understood that throughout the distribution chain the bottle will be stressed and warmed up that would create an environment for spores and bugs to grow, hence we chose the second option…the issue of degrading the milk through contact with light came up during the design of the bottle itself."* This is the reason why extended shelf-life milk bottles have white pigment on them to keep the light out. Moreover, for this project another layer had to be added to the bottles, the aluminium foil, to protect it from the light. These were further developments that had to take place and the manufacturers of the bottle got involved. Extended shelf-life fresh milk is packed in white bottles from Packer, complete with ITW-Auto-Sleeve stretch sleeve labels.

The dairy was aware of the Packer carton packaging format would have been suitable for this project, however the problem was with the perception of UK consumers about the milk in cartons. Even though in Scandinavia it is common practice, in the UK, consumer would not accept it at those times. The milk bottles were manufactured and filled inside the diary to provide a sterile environment throughout the production. After 2 years of R&D, and development of the plant to be able to produce the extended shelf-life milk, the PurFiltre started its production exclusively at Hatfield Dairy. The significant success in the UK market, has led to a construction of a new dairy. The entire production has shifted completely to 'Super Dairy' to Wiltshire in 2002. The new plant cost £70 million in investment, while £20 million from this budged has been financed by the increasing sales of extended shelf-life fresh milk (the brand grew by 23% in 2004) as well as thanks to receiving a major contract as a sole supplier of liquid milk to one of the major retailers in the UK.

8.2 Best Brewery In-can System Draught Beer (Reciprocal complementarity)

The case study of the Best Brewery in-can system project illustrates an instance of Reciprocal Complementarity, when development of a novel product technology was synchronised with radical reconstruction of the bottling and packaging line to accommodate the technology.

The success story of the Draught beer begun in 1964 with the Best Brewery Draught dispensing from a bulk container (keg) that revolutionised the brand and brought a new experience to consumers at local pubs. This project was led by a former mathematician who became a brewer and developed the "Easy Serve" system that created the "serve and settle effect" the first nitro beer, Best Brewery became famous for. This product technology was based on a single metal cask, which combined two sections: one for the stout and the second one correctly pressurised mixture of carbon dioxide and nitrogen (Mansfield, 2009). This invention identified that a solution having a mixture of gases will provide the desirable qualities for the head to develop. The commercial success of the Best Brewery Draught beer inspired the brewing director at Best Brewery, to begin looking into a solution for inserting Draught beer into cans, through an initiation mechanism that would stimulate the formation of bubbles. Throughout the following 17 years, Best Brewery devoted a significant amount of investments into research and development and patented several different versions of the widget. However, all of these attempts were short-lived and proved not to be commercially viable as extremely high costs were incurred in their development. The Best Brewery Draught in can project started to gain considerable attention in the 1980's, when a new R&D director was appointed, who brought life to the project. This was combined with the increasing take-home market and popularity of canned beer. The Best Brewery brand was facing fierce competition from international brands, who were growing in prominence. Lager producers that were enjoying growing success, due to the fact that lager tasted much the same whether it was canned, bottled or on draught. Best Brewery believed its current headless beverage was regarded by consumers as unattractive, particularly when drank from the container (e.g. can).

In this project, however, the brewery realised that such a radical product innovation requires resources and capabilities that are not present within the company. Best Brewery decided to complement their existing knowledge in froth formation and canning processes with the expertise of several companies. The majority of these were from outside of the beverage industry. These included Plastic Components Co. from automotive sector to help them design and develop the small plastic widget, Gases Company that supplied nitrogen and carbon dioxide as well as National Engineering Laboratory and their physicists and mathematicians to conduct modelling work in order to understand all technologies and processes involved in the project. Interviewee 5 argued: *"everyone knew Best Brewery was coming up with this new product"…"it was a public project and people wanted to collaborate and help with the innovation."*

At the beginning of the project Plastic Components Co. did not want to get involved in the project. According to Interviewee 16: *"There was a high amount of risk involved in the project and at the beginning Plastic Components Co. was reluctant to do it"…"we had to* *convince them that the project will be feasible and has the potential on the market."* It was important to choose the best technology to use in plastics to produce the widget. At those times it was common to use heat thermoplastics and injection moulding. Blow moulding techniques was chosen in the end as a new technology to produce small widgets. A further challenge was drilling and controlling the size of the hole on the widget with the laser. The development of the widget was also influenced by people from Marketing department, who wanted the widget to have wings on it rather than to be freestanding. Interviewee 25 argued that: *"the collaboration with Engineering Laboratory was critical to do and we have learned a lot from it"…"it was not only used for modelling, but we also wanted to solve the different weaknesses and questions we had in mind about the way the widget is going to work."*

The canning plant was already owned by Best Brewery. The plant did not want to invest into a completely new canning line and therefore another challenge was to make sure that the new technology will be compatible and easily integrated with the packaging line. New features such as taking out the oxygen before inserting the widget and development of a new packaging system and re-engineering of the lidding system in order to keep the speed and efficiency of the machine to what is was before widget was used were necessary.

The project was supervised by three General Managers with cross-disciplinary knowledge. They were responsible not only for the cross-functional collaboration within the company but also for the collaboration with external parties supervising the development of the product technology as well as its synchronisation with the production/packaging process (canning line). The high system complexity between the product technology and packaging processes required equal devotion towards both. In 1989 was introduced a hollow insert (pod) which had a 15ml chamber that linked with the beverage through a 0.3 mm restricted aperture. The pod was developed as a discrete insert rather than an integral part of the container from food grade plastics using a blow moulding technique. The insert contained a liquid that comprised of beverage containing gases, with a pressure greater than atmospheric in the headspace of the container. Even though the knowledge about the possibility of doing this has been present within the company for more than 30 years, this was the first time a mixture of liquid nitrogen and oxygen was used in beverage packaging.

Once opened to the atmosphere this resulted in pressure differential causing the pressure in the insert to eject fluid (this could include gas, beverage or froth) from the insert in the way of restricted aperture. This caused stout being "ripped apart" and generating extreme minute bubbles that left "vapour trails" of larger initiated bubbles which developed within the headspace leading to the desired froth. The entire product technology had to be synchronised with filling, packing and sealing. A conventional canning line used for packing Best Brewery lager was heavily modified to include the additional steps to keep the speed and efficiency. According to the Master Brewer at Best Brewery: *"The introduction of the widget meant that consumers could now enjoy the perfect pint both in the pub and at home. It was a long journey but every step was a masterful experiment and the end result is considered one of the major innovations in the evolution of the beer industry*."

After the development of the original Draught in can, various companies have introduced different forms and structures of hollow inserts to their own beverage packaging (Turner, 2001), See Table 34. However, many of the competing widgets relied upon a complex technology (e.g. sophisticated arrangements of individual chambers and interconnecting passages or use of displaceable ballasting arrangements) were very costly and hence ceased several years after development.

Brewer	Widget name	Year introduced/ after Best Brewery	Brief description
Worthington	Bass In-Can-Draught	1995	The system was very different from others currently on the market and was based on bubble trapping technology using non-woven polypropylene fibre sheet folded to give a concertina. It is held in place by a locating ring to ensure that the sheet does not float.
Carlsberg-Tetley	Smoothflow	1993	The system consisted of an extruded polypropylene tube that was curved in the can base and held by holding the ring, a separate injection moulded component.
John Smith	Courage Cask pour	1993	The System is manufactured using injection moulded polypropylene to create two separate components; one component forms a cavity to hold the system tight in the can and the second is a cap that forms a chamber. This chamber has a jetting hole on its underside and a standpipe above it.
Theakston Draught Best Bitter	Scottish & Newcastle Tapstream	1994	The most complex system on the market consisted of 5 components; three moulded polypropylene, machined plastic ball and a ring of metal knives. The system was assembled and pre-pressurized in a lengthened fashion and dropped into the can in expanded form.
Boddington	Whitbread Draughtflow	1992	The system consists of two injections moulded plastic components; body and a cap. The body holds the system at the base of the can, it also has a cavity that forms a chamber when the snap fitting cap is applied. Both components are flushed and pressurized with nitrogen on assembly.

Table 34. Examples of Draught in can systems commercialised after introduction of in-can system by Best Brewery

Continuous improvement and innovation are the ‘life blood’ of organisations that do not want to fall into complacency with current practices. Food and drink sector is well- known for strong learning effects that are driving the reductions in the manufacturing costs. After the introduction of Best Brewery Draught can range the company continued working on reducing the cost of the plastic insert, processing costs for fitting the inserts into the container and developing more effective product technology. A result of the following eight years was the introduction of the current version of floating widget; a small white plastic sphere 1.5 inches in diameter used in the Best Brewery Draught cans. The new widget benefited from a simpler structure that enabled it to be efficiently produced and dropped into the container, limiting any possible beer wastage and allowing the use of thinner cans.

Moreover, the knowledge developed during the original widget project has led to further product opportunities. In 1999 the Best Brewery Draught range was extended to bottled beer by the development of the 'rocket widget technology', with a hollow longitudinally extending body of the circular lateral section with the stepped bottom end, restricted aperture and four fins located midway along the body. Within this project, the development of a new froth forming product technology was optimised for drinking straight from the bottle and its insertion added to the conventional bottling line, leading to a further investment of £15 million. Recently, Best Brewery had developed the 'surger', which consisted of a separate surging plate, employing ultrasonic excitation to create or increase the head and 'fizz' on the product. This innovation was aimed at bars that were not able to store kegs due to lack of space or cost. The glass of Best Brewery is simply placed on an electronic plate and its excitation leads to cavitation of the liquid encouraging the gas in the liquid to come out and form tiny bubbles.

Furthermore, according to the GB patent the invention could have been equally applied to soft drinks such as fruit juices, squashes, milk and milk based drinks. This opportunity has led to collaboration with Ball packaging Europe in 2003 and the development of the 0.53 litre can that made it possible to apply the widget technology to milkshakes, mixed drinks, yoghurt based drinks and coffee drinks.

8.4 Fresh Dairy - UHT (Ultrapasteurised) Flavoured Milkshake (Product Sequential complementarity)

The following case study will describe a high extend of complementarity between product and process innovation that was necessary to deliver an UHT (Ultra-pasteurised) version of the existing milkshake dairy product.

The flavoured milkshake has been on the market for at least 20 years since 1993. The company was going through a time of restructuring. The plants the milkshake was manufactured in were old and the Dairy was planning to do a re-brand and re-launch. Therefore, the managerial board decided to build upon the popularity of the existing short shelf-life flavoured milkshake and develop its UHT version that would be sold to petrol stations and parking places. As stated by Interviewee 30: "*If you are gonna deliver to the supermarket, you are gonna deliver a lot, but if you going to deliver to Shell garage on M27, they may sell 20 per day"…"they will order in hundreds, you need a product that will last longer."* The main reason was the fact that petrol stations would sell much less than for example supermarkets and a delivery once a week would be much cheaper than delivering free times a week. The aim was to retain the original product that everyone is familiar with, so the UHT version is the same as the fresh version. However, the UHT version would have a shelf-life of 90 days without the need to be refrigerated and could be put into distribution channel that is longer. On the other hand the fresh milkshake had shelf-life of 20 days and had to be refrigerated and distributed through a cold distribution channel. According to Interviewee 30: "*Processing, filling as well as packaging had to be changed to meet the criteria of the UHT milkshake."*

There were several issues that the Fresh Dairy was facing during the Product and Process Development Project:

1. Milk processing had to be changed as the Dairy was producing a sterile product and a higher temperature to kill the bacteria. Milk was very viscose product and hence it was more difficult to process.

2. New packaging had to be developed, because the UHT was very light sensitive and the existing packaging was using high density polyethylene that had a poor light barrier and it had only a moderate oxygen barrier.

3. New hermetic closure that is easily re-closable and lid the the seal could be taken off at the same time (the original short shelf-life milkshake had a normal seal).

The Dairy has collaborated with a range of external parties to help them tackle the above mentioned challenges. Firstly, it was a bottle manufacturer that has developed a unique three-layered bottle (white/black/white layers) to prevent any light going through the bottle. Secondly, a closure manufacturer solved the issue with opening, as the Dairy wanted closure to be not only hermetically sealed, but also wanted the foil and lid to be taken off at the same time. The closure manufacturer came up with a sophisticated solution by heat sealing the lid on the top of the bottle and once opened it would cut off the foil and still be kept inside the lid. The dairy was able to utilise the existing processing and filling machinery as the filling machine would not recognise the difference between the UHT or short-life milk. However, a new custom made packaging line was required, as the closure solution was not available on the market before. It was further necessary to collaborate with liquid food processing equipment supplier in order to get the temperature and time right during processing and filling to make the full UHT product possible. The last challenge that the Dairy had to face was sleeving the bottle. The full bottle decoration with HD graphics was tightly fitted on the bottle before it was filled up, while making sure that the filling process did not damage the sleeve.

8.5 Cornish Bakery- Purchase of a new flow wrapping machine to pack different sized products (Process Sequential complementarity)

Following case study describes a high extent of complementarity between product and process innovation, the Process Sequential complementarity. This case is an example of a dominant focus on the process innovation that has led to several opportunities in incremental product innovation. The Cornish Bakery manufactures a wide range of savoury products such as pasties, sausage rolls and turnovers for company owned convenience stores as well as major retailers and wholesalers

The Bakery has started production with an 'old style' type of flow wrapping machine that was slow and unreliable. However, once the bakery received a new large contract from one of its customers, a major retailer one of the 'Big Four', a need for more up-to-date packaging equipment arose. Usually when the bakery receives an order for a new or improved product from the retailer, it includes a high number of specifications. However, the bakery does not perceive this as a rigidity, because they want to satisfy the needs of their customer. During this order, apart from receiving specifications on the reduced salt content, the order also required increasing the size of five products. Since pasties were all handmade the change in the size of the product did not involve any additional investments in terms of production the pastry itself. The only automated part of the production was the packaging part. The existing flow wrapping machine has been used for the past 15 years in the bakery with only minor maintenance. The packaging team was aware that the machine was slow and inefficient, causing a lot of disruption during the process. Cornish Bakery has their own, in-house, R&D department where they are working on product innovation projects. But, developments are primarily focused on the core product, predominantly regular recipe tweaks of their 250 product lines. Additionally, they introduced at least two new products every month.

The production and packaging teams soon realised that the required increase in the packaging size would not be possible with the existing machine. Therefore, the packaging manager had to start looking for packaging machinery suppliers that would be able to offer them a solution. Following a quick market research, the most suitable offer came from KernPack, a local supplier, who offered Technopacking flow wrapping machine as the ideal solution, able to pack all 5 products requested by the retailer. After installation, the machine was packing two days per week for about 12 hours a day, not fully utilising the new machinery, using it to pack only 5 products it was originally bought and adjusted for. Only a few months later the company was again being faced with an order for a new, smaller product that needed to be packed and again, had two options:

1. To Buy a new flow wrapping machine
2. To Adapt the existing machine

Due to the significant investments related to the purchase of a new packaging line, the Cornish Bakery chose the second option and decided to collaborate with engineers from the packaging machinery supplier. Because the purchased machine was not primarily designed for packing smaller products it had to be adjusted. The solution was identified by two engineers, who were able to achieve this by adding parts to the machine that were worth £300. According to Interviewee 11: *"We did not realise how flexible the machine was, since the help from KernPack's engineers we have made modifications to maximise its potential."*

Interviewee 31 explained: *"We did not come across a product that we would not be able to wrap on our adjusted machine. The machine is easily modified to pack our increasing range of 40 different wrap products ranging from mini cakes and brownies to giant size pasties."* Today, the machine is running almost all day, six days per week. The stretch of the flow wrapping machine has increased the production from 70,000 units per week to 400,000.

Interviewee 11 pointed out that: *"The new machine from Technopackaging enabled the company to win new contracts from the major retailers, travel and convenience retailing, not only because of its capacity but also the ease with which it can wrap new products."* A year after installation of the flow wrapping machine the bakery is already considering opening of the second site in Cornwall. Moreover, during a 52 week period the turnover grew from £9.8mil to £10.5mil.

8.6 Food Co. - Chunky Steak Canned Ready Meal (Incremental Reciprocal complementarity)

The following case study will describe a case study portraying an Incremental Reciprocal complementarity. Within the Chunky Steak Ready Meal project it was necessary to synchronise both incremental changes to the product recipe and adjust the production processes in order to deliver the desired consistency of the final product.

The project was initiated by one of the biggest customers of the manufacturer and at the same time, one of the "Big Four" retailers in the UK. The retailer required improvement of the existing Brazilian beef canned product due to constant complaints from consumers, over 200 complaints a month. The reason behind the complaints was inconsistency among different products in terms of amount of meat present within the can. The original product used to be a single shot, 1 homogeneous solution (minced meat and the slurry mix including stock, tomato and seasoning) all mixed up in preparatory tanks, heated and deposited as a single shot into cans. During this process 'bridging' occurred at an unacceptable frequency, this being where beef would not fall into the can but 'bridge' the can top. As such, the can would fill with gravy, and when the filler head was removed from the can, the meat would be sucked back up. The manufacturing company had no quality control process to prevent this. According to Interviewee 27 the above reasons have resulted in: *"a lack of normal distribution of meat. In reality we were producing cans with 90% of meat, on the other hand the last 20% of the batch included a very low amount of meat (below 70%). This made customers feel they were not getting the value for money."* Another issue with the current product was the build up at the bottom of the can that had to be transferred to the meat. Consistency was being perceived as quality. The product was highly successful in the Brazilian market, therefore the manufacturer's aim was to achieve the same result in the United Kingdom. The customer requested that the manufacturer seeks to ensure that each can would contain a guaranteed beef content of 75%. This was an important metric because this was a premium product and the meat content was much higher than in the average product of this kind.

The main technological advance the manufacturer was seeking was the appreciable improvement of an existing process to manufacture the product, in order to deliver increased consistency of the meat to gravy ratio in each can. The aim was to achieve this without increasing the cost of production or altering the organoleptic profile (without affecting the taste, colour, odour or feel) of the product. This required redevelopment and improvement of the existing process that the manufacturer was using to produce and package the product as well as changes to the product recipe. Interviewee 7 argued: *"We wanted to start off with a simple solution and only in case this would not work, look for other options. The way our company works is often orthodox, on one-to-one basis, you give someone several solutions and then they choose. We often start with one-to-one and then try to sell your pitch a wider audience."*

The Brazilian Corned Beef project was cross-functional, including people from operations, technical, NPD and packaging, who had sufficient knowledge and experience from previous projects in understanding how the products form. Moreover, engineers from the equipment suppliers helped to achieve optimisation of settings and supplying the corned shaped head to the end of the nozzles on the vacuum filler to prevent sucking up of the meat.

At the beginning, the first 10% of the project was started by the manufacturer's engineers. They have identified that the inconsistency in the amount of meat (inability to get a normal distribution) has been caused by a single shot filling with one homogeneous mix deposited as a single shot. Such cooked beef was more diluted, the aim of the project was to concentrate solids as much as possible. Manually filling the cans with the cooked product would achieve the required meat to gravy ratio, but the cost would be prohibitive. To solve the problem with inconsistency of the amount of corned beef in the can the manufacturing company has changed the production process from a single shot fill to two shot cold fill. In this process, the raw solid components of the product would be added to the can followed by the raw liquid components. The final product was then cooked within the can. This process was a significant divergence from the existing method and also different to any equivalent product, in which cooked meat and gravy were added to the can in a single shot. The high content of meat, beyond the typical composition of canned ready meals made the process much more difficult. As stated by Interviewee 27: *"There was no readily available or deducible knowledge in the public domain about how to transform a process from 'one shot' to 'two shot', or even how to automate the 'two shot' canning process.*" Therefore, the manufacturer had to redesign the existing manufacturing process to be able to use the two shot canning process. The main issues that the manufacturer had to tackle were:

1. How to change 'one shot' fill that used cooked ingredients to 'two shot' fill that used uncooked ingredients. For example, using raw ingredients, in itself, was a significant area of technological uncertainty because of the additional water content of the beef. The more flexible and sticky nature of the raw products impeded the delivery of the ingredients into the can.

2. How to fill cans with raw beef effectively, so that it dropped to the bottom of the can easily and avoided the issue of bridging and minimised the risk of cans being knocked over (this

issue was further intensified by the larger volume occupied by raw meat and its decreased rigidity in comparison to cooked beef as a result of its greater water content.

3. What should be the size of the beef required to drop into in the can to still retain the appearance of the canned ready meat from the previous method.

4. How to reformulate the product and the order in which to add various components of the second fill.

5. How to best cook the final assembled raw ingredients in the can.

According to Interviewee 7: *"There are available different kinds of production equipment, Ishidas, multi-head weighers. But you have to work with what you have. It is not difficult to buy a new machine for a product that you need to produce. We out of here produce 700 different lines, so it gives you an idea…you could imagine the challenges that you might have even though it is a small plant."* In collaboration with equipment suppliers, the manufacturer redesigned the existing manufacturing equipment and split the recipe into two different parts. Throughout the process the process innovation had to be tightly linked with the changes to the recipe. Firstly, the delivery of the meat into cans has been resolved by identifying the best combination of coatings on the raw beef to create slip and place the raw beef at the bottom of the can. The xanthan gum was used as a lubricant for meat to be transferred from tanks to filler. Furthermore, consideration of improving handling of the meat resulted in the meat fill stage occurring at reduced temperature (0°C to 2°C). Secondly, to compensate for the extra water in the raw beef, raw gravy in a concentrated form and a further slipping agent was added to the stock. Thirdly, the manufacturer had to improve the rotary process in the vacuum filler, because as the can was going round on the filling heads it was drawing a vacuum and sucking up the meat. This has resulted in inconsistencies in the amount of meat inside cans. Different variables were investigated including redesign of the dispensing nozzles in different configurations and with sieves or caps as well as pressing down of the beef within the can proved ineffective. To tackle this issue the equipment suppliers helped the manufacturer to develop a pointed nozzle with a coarse sieve. It was a small pipe leading down with a rubber gasket. The corned shaped head to the nozzle was pushing down the meat. It was drawing out the vacuum and releasing the sauce on the top. Through improving the valve the company was able to change the tolerance from 8grams standard deviation of beef content to only 2grams, ensuring a higher consistency among cans. Fourthly, experimental investigation to identify the most suitable way of cooking the product inside the can resulted in rebalancing the starches used in the product and rotation of the cans at five revolutions per minute during cooking to avoid an undesirable inconsistency.

Steps in the production process of the Chunky Steak Canned Ready Meal:

The meat goes into the Hema filler in the most concentrated form possible. 75% meant and 10% of slipping agent and that slipping agent is water and xanthan with disperse it in oil that acts as a lubricant. It is able to handle the raw meat throughout the line. Planetary mixer is a preparation mixer, with rotating motion. The meat goes over the Luma weight check system, anything that is outside required amount of meat is rejected. The other shot happens at the CFT vacuum filler and again the xanthan is used. Cold sauce is added to the meat, rather than hot, because otherwise the meat solution would be sealed and the aim was to add something that will mix within the raw meat. Therefore, a very concentrated sauce is made including starches, stock, some tomato puree, seasoning and that gets deposited at the end of the line. Right at the end of the line this concentrated sauce gets deposited. Each can passes through an X-ray system that checks the density of product and detects any bones or metals. As stated by Interviewee 28: *"The secret is that the meat is cold when it is capped. After seaming the cans they are put into baskets and go through a rotary process in the cookers, as the water is released the starch absorbs that as it is rotated in the can."* At the end of the project, consumers would definitely notice the difference and complaints have decreased from 200 to 2 per month. Moreover, they were able to utilise the knowledge gained in this project during their following projects.

8.7 Dorset Bakery- Punchy Jalapeño Mini Wafers (Process Amensalism complementarity)

The following case study will describe a low extent of complementarity between product and process innovation, the Process Amensalism complementarity. Projects adopting such complementarity are common within the investigated bakery, as the existing production equipment is perceived as a barrier to any radical product innovations.

The main driver for the idea of producing mini Jalapeño wafers was a market report read by the managing director of the Premium Snacks Manufacturer that identified the major growth opportunities in the baked snacks category. The report highlighted increasing growth within the savoury snacks market and the on-the-go market with mini pack sizes. The Snacks Manufacturer had already been producing mini florentines that have proven to be a successful concept. Therefore, the next logical step seemed to be to produce a mini version of the Jalapeño wafers, the company's best-selling savoury product. Interviewee 17 stated: *"We wanted to come up with a cheap and a quick way of coming into the minification market and* *target the young, casual consumer."* Originally the manufacturer's entire production was manual, only 10 years ago the bakery automated some parts of production. The remaining production steps are still compensated with processes that require manual handling.

The entire product portfolio of the manufacturer was predominantly focused on producing incremental product innovations through minimal or no changes to the production equipment rather than radical product and process innovations. As stated by Interviewee 34: *"The existing machinery is a constraining factor. We always find that there are certain areas that stop us from doing something. For example, we often have to make compromises with the product design."* The existing production process used to produce the Jalapeño Wafers consisted of three main steps. Firstly, the batter mix has been deposited. Secondly cheese, thickened cream and butter were added. Thirdly, such mix was deposited into all the tray holes to create wafers. According to the Interviewee 34: *"The trick is in setting wafers quickly, this gives the product a unique taste."* Originally, the process was purely manual, however ten years ago half of the production became automated to increase the efficiency of production.

This project involved cross-functional collaboration between: the Commercial Director, NPD team that proposed the idea, Portfolio Manager (who converted the idea into a product), Bakery Manager, Technical Manager (who ensured they are using the right ingredients) and was responsible for checking the shelf-life as well as the Supply Chain Manager (who sourced the finest ingredients from all around the world). However, following the internal discussions the bakery realised the need to invite an external collaborator to help them with utilising the existing machine in producing the mini Jalapeño wafers. The bakery chose to collaborate with a small local engineering company that was perceived as having sufficient knowledge and experience in this area. Another reason for this choice was the production equipment that was sourced from United States, and therefore it would be difficult to cooperate with the supplier. The result of the collaboration was a new plastic tray with a higher number of holes and smaller sizes, than the existing tray for regular wafers, to produce a mini version of the original wafer. This simple solution enabled the company to utilise the existing production process and simply replace the original tray with the new one, when producing the mini wafers product. As stated by Interviewee 33: *"This project cost the bakery only a couple of thousands of pounds and provided us with a range of further benefits in terms of new products and a possibility to approach the on-the-go/airline/coffee shops market"*.

The line stretch has led to several incremental product innovation opportunities such as the mini wafers in cheese and thai-sweet flavour. Moreover, following the completion of the project and further collaboration with the local engineering company, the team identified an opportunity to utilise the same equipment in the next project to produce macaroons. The product was well accepted by the retailers mainly due to increasing savoury snacking market. As stated by Interviewee 17: *"We have never felt any restrictions from retailers, they are always welcoming new innovations from us."*

8.8 Dorset Bakery- Florentines with Salted Caramel flavour (Product Pooled complementarity)

The following case study will describe adoption of the Product Pooled complementarity by a Premium Snacks Manufacturer when adding a new flavour to the existing florentines product range.

Dorset Bakery primarily focuses on regular flavour changes in their florentine products. This is due to the production line constraints and the associated investment required during more radical product innovation projects. The existing range includes Dark Chocolate, Milk Chocolate and White Chocolate Florentines. The company also ensures that only the best ingredients are used in their florentines products, e.g fruit is sourced from Turkey and almonds from California. After visiting a Fine Food and Drink Fair in London in 2015, the Commercial Director came up with an idea of adding a new "trendy" flavour to the florentines, the salted caramel. This flavour has been increasingly used by many confectionery producers and a caramel supplier contact from Northern Ireland developed at the exhibition made the sourcing process even easier.

Originally, all florentines were hand made. Before deciding to include some automation in the shop floor, the company owner who led the automation project, had meetings with several machinery providers, seeking for opportunities to collaborate on development of machine that would suit their requirements. However, this option has proven to be too costly. Therefore, the Snacks Manufacturer decided to buy a machine from United States that was originally developed to deposit sesame seeds on burgers. Despite a range of limitations of this machine, the company has been using it for 10 years without any changes or developments to it, apart from regular maintenance. One of the limitations of the current system is inadequate amount of nuts and fruits in the florentines, but the manufacturer received only a small amount of complaints from their customers. A tight management is required during depositing of nuts for Florentines as +1/-1 gram can in overall mean 13% more or less of the product. Moreover, some issues are arising with the nuts depositor that was originally used as sesame seeds depositor, as the depositor is crushing the nuts when opening and closing. The Interviewee 34 acknowledged the need to invest into a new depositor as *"it decreases the quality of product and the way it looks inside the packaging. The product varies also in terms of baking and would require more consistency."*

One of the main weaknesses of the production system, is that it is scattered all over the production that is very inefficient. Even though they would be able to produce 10,000 products they are able to pack only 5,000. This is due to depreciation of the product quality on the air for too long. Interviewee 17 realised that: *"in an ideal case, the entire production line would need to be built from scratch. It is not smooth, sometimes the product is waiting there for 3-4 hours before it gets to be packed. Compromises always have to be made between the operations people and marketing/NPD people."* Operations people often claimed it is not possible to produce the new product idea given the production equipment that they have. Therefore, a simple flavour change on the coating of the Florentine that is being done off-the production, manually, is an easy extension of the existing portfolio of flavours.

Company's plan is to invest into further automation within the next 3 to 5 years, for both chocolating and packaging. As stated by Interviewee 17: *"We are aware that a fully automated production line would be able to speed up the production processes such as dipping Florentines into chocolate as well as packaging, and make it more cost efficient. However, even in the current circumstances the company is able to produce far better product* *at a lower cost than the competition."* The Snacks Manufacturer is also planning to introduce Coffee Mocha Florentines in September, and mini Florentines in packs of free for Airlines such as British Airways and Virgin, but also coffee shops.

The process of making Florentines;

1. Dry mix, mix of nuts and fruits, is deposited into large trays with 40 holes and deposit exact amount into each hole.

2. Caramel wet mix is deposited into the holes.

3. Florentines are baked for 15 minutes, while workers manually insert the trays into ovens.

4. Trays are manually taken out and Salted Caramel is added by dipping the Florentines into the Salted Caramel and turning them to one side to achieve the desired waves structure (it is crucial that the Salted Caramel is heated at the correct temperature and prepped along).

5. The Florentines are left to chill, manually taken out and packed.

8.9 Food Co. - Pressure Change in Production of Canned Minced Beef (Process Pooled complementarity)

The canned minced meat case study will portray an example of the Process Pooled complementarity, in which the manufacturer was able to significantly improve the efficiency of the production line by adjusting the setting of the machine, without an impact on the product.

The manufacturing company was using minced beef in products such as Bolognese sauce and Chilli Con Carne, these were all high volume products. Minced meat was treated gently, delivered from the supplier at +2/-2 temperature. The manufacturing company was usually using off-cuts for batching with an aim to achieve 90vl with 19-50% fat. The production of minced meat had to be free flowing as it had a very short shelf-life of 4 days. The 200 litre cookers in the main line were using the steam injection at the bottom of vessels that was highly efficient as it was breaking things down from starches, using 4 bar pressure. But, at the same time negatively influenced the quality of the product. Operations were required to achieve efficiency of 200 cans per minute and therefore they were reluctant to make any changes to the pressure, even though the quality of the product could be significantly improved. According to Interviewee 7: *"Everyone in the company is working towards their own KPI's therefore it is very difficult to make any changes. The company is facing a constant financial pressure, with £4 per kilo of meat and rest of the ingredients £4,000- 5000. Therefore the company has to be mindful all the time about the cost of production."*

Pressure processing was well-known by production engineers for its impact on the quality of minced meat in comparison to the conventional processing methods. However, the treatment conditions (bar pressure/time) had to be carefully defined and tested. The minced beef project was led by the Factory Manager and NPD Manager with an aim to improve efficiency using a simple solution. Interviewee 7 admitted that: "*Even though everyone realises the benefits of cross-functional collaboration in a project and including people from operations, technical and NPD, would be the ideal scenario. We are constantly tossed to get improvement through different departments to sell the pitch. Throughout the project there were many individuals who supported, but also did not support the project and our aim was to find a link between them.*"

The opportunity for a process improvement was identified by the front R&D personnel in the kitchen through various cooking methods. Moreover, the manufacturer often collaborated with starch companies and the British Food Research Institute, while applying their expertise and support. Engineers were aware that when gelatinising the starch, the higher the pressure the higher sheer effect on the colour, starches and vegetables was achieved. Moreover, the filling aid starches were breaking down more readily. But by going to a lower pressure the engineers could control the gelatinisation of the starches better and keep the piece integrity of the meat and vegetables. Reducing the pressure to 1 bar would result in a perfect product, however beating up the meat would take too long. Everything in the production was coming on tight margins, therefore increase in labour and slowing down of production would have influenced the number of units produced.

By lowering the bar pressure from 4 to 2 bars, the project was able to achieve efficiency improvement of 30%. This at the same time led to the Overall Equipment Efficiency (OEE). Despite this, it took quiet a long time to get the project signed by everyone working on-line as well as off-line. An important factor in the project was efficiency in heating, as high temperate could damage starches. In the project were used physically modified starches. The heating time was slightly extended, however only by a few minutes rather than 20 to 40 minutes, common when decreasing the pressure within vessels. According to Interviewee 7: *"The use of high pressure is a common way of improving a microbiological quality of meat"…"most meat products have a very high pH, such conditions create an ideal growth environment for most microorganisms, particularly pathogens."* The microbiological safety of the cooked meat was the key reason for heat processing.

As stated by Interviewee 27: *"Since this project we have applied lower pressures across almost all products"…"across 137 different products"……"previously we tended to use different pressures for different products that has led to problems within the productions, due to different shifts changing on a regular basis."*

Steps in the production process of minced beef in a single shot fill;

1. Minced meat is put into 200 litre tanks (most of the tanks are 70% meat). The company generally uses 90vl minced meat in other words it has up to 15% fat.

2. Than the minced meat is steam injected to seam the meant in order to retain the moisture within the meat.

3. Starch slurry with beef stock, salt and small amount of caramel are added on top. This is done on the slurry tank. There are 4 tanks next to each other, slurry tank and a high speed mixer.

4. The entire tank is than heated up to 78 centigrade which is used to optimise the cook, to develop maximum viscosity without extracting water from meat (taking too much water from the meat will lead to problems in stabilising it)

5. The contents of the tank are added to the cans as one shot fill process.

The following Chapter will evaluate the findings from nine case studies with the propositions (complementarity strategies) from the Typology: Complementarity- Capability Matrix. Definitions of the spectrum of extents of dependence on existing technology trajectories, different degrees of supply chain rigidities and different levels of potential and realised absorptive capacity will be used as the basis for evaluation.

CHAPTER 9. PHASE 2 ANALYSIS

9.1 Introduction: Testing and extending the Typology: Complementarity-Capability Matrix with case studies applying a pattern-matching technique

The typology illustrated in the Complementarity-capability matrix identified seven complementarity strategies between product and process innovation and associated resources and capabilities required to achieve them. The constructs (extent of dependence on technology trajectories; degrees of supply chain rigidities; levels of potential and realised absorptive capacity) identified in the typology are 'ideal types' that are intended to "provide an abstract model, so that deviation from the extreme or ideal type can be noted and explained" (Blalock, 1969, p. 32). Two of the main virtues of the Typology lie in its potential to:

- guide more focused and systematic investigations into the complementarity between product and process innovation
- serve as a strategic decision making tool, providing the Project Managers with an overview of different complementarity types and associated resources and capabilities they could choose from when facing a New Product and Process Development project

Prior efforts to examine complementarity occurring between product and process innovation were limited by the absence of a holistic theoretical framework. Moreover, existing studies failed to provide guidelines on how to achieve these complementarities and hence, the direct further investigation into this area is needed (Ballot et al., 2015; Battisti and Stoneman, 2010; Evangelista and Vezzani, 2010). The following sections will analyse the extent to which the eight cases identified by interviewees in Phase 1 as 'illustrative examples of complementarity types' provide evidence to support the proposed typology (seven propositions). Findings from the case study illustrating the new addition to the Product-Process positioning Map; Incremental Reciprocal complementarity, will be included in the Revised Matrix. These complementarity types should be perceived as a starting point to guide future research.

The analysis within these sections will be focused around a spectrum of three contingencies (resources and capabilities) that are further specified within each complementarity strategy (propositions) in the Typology: Complementarity-Capability Matrix (See Chapter 4 for definitions of the contingencies).

Bitektine (2007) stressed the importance of formulation of criteria for outcome evaluation when evaluating a theoretical framework with case outcomes. For the purposes of the present study the following criteria for outcome evaluation were used;

- **Supported**- the evidence from the case study supported the proposition from the Typology: Complementarity-Capability Matrix
- **Not supported**- this contingency factor is not supported in the case study analysed, however the evidence within the case does not disprove the factor - it is not clear whether this may occur in other cases.

- **Partly supported**-some evidence from the case study supported the proposition from the Typology: Complementarity-Capability Matrix
- **Disproved**- the evidence from the case study disproved the proposition (provided contradictory evidence) from the Typology: Complementarity-Capability Matrix
- **Insufficient evidence**-evidence from the case study was not sufficient to evaluate applicability of the contingency factor

These findings will be drawn together in the final section that will aim to summarise the key findings. This section will also include;

- The Typology: Complementarity-Capability Matrix versus Findings from eight case studies (highlighting propositions that were not confirmed or were disproved)
- Revised Complementarity-Capability Matrix with propositions for further research based on the Phase 2 findings

Table 35. summarises the cases centred around different New Product and Process Development Projects. These cases are grouped based on the extent of complementarity between product and process innovation (from a high to low extent). The data is organised into categories, corresponding with the sections identified above.

Case	A- Extended Shelf-life Fresh Milk	B- Draught In-can Beer	C- UHT Flavoured Milkshake	D- Purchase of flow wrapping packaging machine	E- Chunky Steak Canned Ready Meal	F- Mini Jalapeño wafers	G- Salted Caramel Florentines	H- Canned Minced Beef
Company	Daily Dairy	Best Brewery	Fresh Dairy	Cornish Bakery	Food Co.	Dorset Bakery	Dorset Bakery	Food Co.
Type of complementarity	Radical Reciprocal	Radical Reciprocal	Product Sequential	Process Sequential	Incremental Reciprocal (New Complementarity)	Process Amensalism	Product Pooled	Process Pooled
Reason for undertaking the project	Consumer demand for longer shelf life milk	Consumer demand for the same experience as in the pub/ Increasing competition	Part of the re-brand and re-launch strategy Sell UHT to garages and parking (savings on the delivery of fresh product- 90 days shelf life)	Order from one of the major retailers for a different sized products	Customer required improvement of the existing product due to consumer complaints.	Baked savoury snack becoming a growth area providing space for product innovation combined with the new trend of minimization	Provide more flavour options for consumers using a popular ingredient	Improvement of the efficiency of the line
Product developments required	Development of new bottles made of low density polyethylene (LDPE) and closure	Designing and developing the in-can system in the form of a hollow insert (pod)	Development of 3 layered bottle Development of a unique technique to open the seal and lid together	Producing different sized pasties (handmade) Larger packaging sizes required	Slipping agent was added to the stock to compensate for extra water in raw beef. (production process innovation enhanced the quality of the product)	Producing a mini version of the existing product	Change of flavour (ingredient) added on the top of Florentine Identification of the correct temperature to melt caramel	Quality of the product is positively influenced

Process developments required	Cold microfiltration process technology licenced from Ault Food Limited in Canada (new processing technology enabled product innovation) Filling machines and packaging equipment had to be specifically developed for the project including ultraviolet light and hermetically closed top Microfiltration plant sourced from Tetrapack, Sweden	Drilling of the restricted aperture Placing the pre-formed stack of pods at the bottom of the can Filling stage with 440ml of stout supersaturated with nitrogen and carbon dioxide Flushing stage to remove oxygen from the top of can Packaging and Pasteurization for 20mins at 60 degrees	Adjustments to the existing processing and filling machines to get the temperature and time right. Development of a new custom made packaging line.	New flow wrapping packaging machine	The manufacturer redesigned the existing manufacturing equipment and split recipe into two shots. Xanthan gum was used to place the raw beef at the bottom of the can. Pointed nozzle with a coarse sieve was developed to prevent sucking up of the meat during the rotary process in vacuum filler. Rotation of the cans at five revolutions per minute during cooking was added.	Production of a new plastic container with a higher number of holes and smaller sizes	No changes to the production process	Decreasing the bar pressure during the steam injection at the bottom of vessels from 4 to 2 bars
Importance assigned to product/process/ both	Both considered since the beginning of the project	Both considered since the beginning of the project	The starting point was building upon popularity of the short-life Frijj that led to adjustments of the processing line	The adoption of a new packaging machinery led to opportunities for product innovation	Both were considered throughout the project.	The existing production equipment constrained opportunities in NPD Stretch mechanism was applied	The focus was on providing more options for consumers though additional flavours (Florentines manually dipped into caramel)	The focus was on efficiency improvement of the processing line with a positive (limited) impact on the quality of the product
External parties involved in the development	Supplier of cold micro-filtration technology, supplier of bottling lines, supplier of microfiltration plant, bottle manufacturer	Plastic components company, National engineering company, gas company	Liquid food processing supplier, bottle and closure manufacturer, packaging machinery supplier	Machine bought adjusted to pack 5 requested products, later collaborated with the same machinery supplier to improve the flexibility of the machine	Equipment suppliers	Local engineering company	Internal project	Internal project

Further opportunities	Success of the project led to development of a new plant financed by increasing sales followed by receiving of a major contract from one of the "Big Four" retailers	Ability to simplify the product technology and achieve more efficient packaging process Ability to utilise developed knowledge in the rocket widget project and surger project	Information not available	Ability to pack 20 different products on the same machine after installation	The new 'two shot' process was utilised in the following projects	Ability to identify further product opportunities in terms of different flavours (e.g. cheese and thai-sweet flavour) Utilising the same equipment for production of mini macaroons	The same technique was applied in the following project of Caffe Mocha limited edition	The lower bar pressure was applied across almost all products

Table 35. Summary of the New Product and Process Development Projects. Grouped based on the extent of complementarity between product and process innovation.

9.2 Radical Reciprocal complementarity illustrated in the Extended Shelf- Life Milk Product and Best Brewery In-can System project

The radical reciprocal complementarity was defined as the highest extent of complementarity between product and process innovation. A range of benefits can be achieved by the integral consideration of product and process innovation (Damanpour, 2014; McNulty & Ferlie, 2004; Piening & Salge, 2015). These include ability to control product mix more tightly and acquire flexible process equipment (Hayes and Wheelwright, 1979a; Kotabe and Murray, 1990), smoother launch of new products, achieve more rapid penetration of new markets and ease of production ramp up process (Pisano and Wheelwright, 1995; Pisano 1997).

Dependence on the existing technology trajectory Within the extended shelf-life fresh milk case was no evidence of established technology trajectories in product and process innovation. The milk processing technology of micro-filtration was new to the firm and had to be licensed from Canada. Moreover, the bottling lines, operations filling them and the packaging equipment had to be specifically designed for the unique needs of this project. Team working on the project also had to develop a new bottle that included two additional new layers to protect the milk during its lifecycle (milk is very prone to degradation caused by light). The packaging played several different roles within this project; it protected, preserved, facilitated the distribution and promoted hygiene and safety of the product, instead of being purely a marketing tool (Simms and Trott, 2010; Rundh, 2005). Since the early beginnings of the project both, processing and product innovation had to be continuously considered. As Interviewee 19 stated: *"product was the process…it was impossible to differentiate between them."*

Case B (Best Brewery In-can Draught Beer) provided further support for low dependence on the product technology trajectory when aiming for reciprocal complementarity While in this case, proposition was not confirmed as there was a medium dependence on the process technology trajectory. The existing knowledge gained from prior projects (i.e. Easy Serve system and froth formation properties when mixing gases) led the team to realise the need for new technologies and knowledge in order to achieve their aims. Hence, the development of the in-can system technology required many years of R&D and extensive collaboration with external parties. Open innovation is a key priority to achieve product and process innovation in the food industry (Erickson, 2008; Huston and Sakkab, 2006), but still rarely used (Fortuin and Omta, 2009). In the case of process technology the brewery was able to introduce a radical packaging innovation without developing a new customised canning line. Instead, it made significant changes to the existing filling, packaging and sealing parts of the canning line to enable insertion of the in-can system. Interviewee 16 argued: *"the development of the* *froth forming technology had to be synchronised with a heavy modification of the conventional canning line used for packing lager."* This finding reflects a reluctance to pass away the pre-ceding costs in the production equipment - a commonly stated characteristic of companies operating within process industries (Gellynck and Vermiere, 2009; Novotny and Laestadius, 2014). Another possible reason for medium dependence could be that only a packaging development was required instead of development of a new product with packaging (as demonstrated in the extended shelf-life project).

Impact of the supply chain rigidities There was no evidence of the presence of supply chain rigidities within either project. Whilst internal staff of both companies had to collaborate with a range of external parties in order to contribute to development of the innovation, both projects were initiated internally. Project B was characteristic with collaboration with external parties that did not belong to the existing supply chain. Combination of knowledge and technologies utilised were stemming from different sectors (i.e. automotive, gases, engineering laboratory). Connected relationships between companies (network) enabled the network actors to share complementary capabilities and resources, maximising their innovation potential (Kähkönen, 2014). For instance, in project B the developer and supplier of the in-can system technology was operating in the automotive industry. There was a high risk involved in the project and at the early beginnings, the plastic components company was reluctant to get involved. Best Brewery had to convince the company that the project will be commercially feasible. This type of collaboration was previously associated with more radical product and process innovation (Fitjar and Rodríguez-Pose, 2013; Fitjar and Rodríguez-Pose, 2011). According to Teichert and Bouncken (2011) only suppliers with an emergent strategy approach that is based on experimentation and creativity associated with trial and error, experiments with new technologies, designs and various interfaces of components, could lead to achieving a long term competitive advantage. Evidence from case studies can be further supported by findings of Lager and Frishammar (2012). The authors identified 'newness' and 'complexity' of process technology to be directly related to the type of collaboration required between supplier of process technology and the customer.

Levels of potential and realised absorptive capacity Achieving reciprocal complementarity in Projects A and B required a well-developed Potential absorptive capacity (PAC). The PAC enabled companies to identify possible sources of external knowledge to help them with development of the product as well as competitive production solutions (von Hippel, 1988; Lager and Frishammar, 2012). The cases also provided evidence that PAC would not have been sufficient if the company did not have existing experience in product development, processing and packaging techniques (Realised absorptive capacity - RAC). Existing knowledge aided companies to understand the absorbed knowledge, assimilate it and co-ordinate this skill-sets with the existing knowledge base within the company (Kogut and Zander, 1992; Cassiman and Veugelers, 2006; Lane et al., 2006). For example, in case B, the brewery was trying to internally develop the froth forming technology for 17 years. Despite the different patents filed; the brewery was not able to introduce the innovation. They were short-lived (i.e. syringe that required effort and time from the consumer), while others were perceived by the brewery as costly and commercially unviable. The brewery succeeded only once it had identified suitable collaborative parties with capabilities that were not present in the brewing industry at that time (i.e. development of 100,000,000 small plastic in-can systems using a blow moulding process).

To manage the cross-industry collaboration the brewery employed three integration managers with cross-disciplinary expertise and these supervised not only the internal cross-functional collaborations, but also those with the external parties. Appointment of general managers, also known as integrators, to supervise complex projects as an effective tool for synchronisation of product and process development was identified in prior research (Wheelwright and Clark, 1994; O'Connor and McDermott, 2004). This managerial practice also contributed to the internal knowledge in product and process development - Best Brewery collaborated with mathematicians and physicists in order to understand every single step in the project. The well-developed PAC and RAC further helped the brewery in the following new product and process development projects. Jensen et al. (2007) defined these learning modes as the STI and DUI modes of firm learning. STI stands for 'Science, Technology and Innovation' and refers to use of scientific knowledge in the development of new technologies that are applied in development of new products or processes." DUI refers to 'Doing-Using and Interacting'; an ongoing problem solving that relies on exchanges of experience and know-how. According to Jensen et al. (2007) and Fitjar and Rodrígues-Pose (2013) companies that combine both STI and DUI types of learning are more likely to introduce new products and processes than those focusing only on one of them.

The case study of the extended shelf life milk also provided evidence for the necessity of high levels of experience in acquiring and assimilating knowledge, as well as the ability to transform and exploit the external knowledge to achieve Reciprocal complementarity. Due to the radical nature of the innovation, the dairy had to collaborate with experts in processing equipment, invest into development of a custom-made bottling line and source the micro-filtration plant from Sweden. According to Desouza et al. (2005), in the future, one of the key capabilities companies will have to develop will be excellent competencies in identifying innovation-relevant knowledge. The evidence further supports the high level of dependency of companies operating within the food sector on the external sources of information in order to innovate (Soosay et al. 2008). The dairy is part of a largest European dairy cooperative and is constantly active in product innovation. As stated by Interviewee 20: *"Radical innovation is at the heart of our company…we always want to surprise our customers with new categories of dairy products."* Such levels of experience enabled the company to benefit from the established experience in the processing techniques and product development in the future innovation projects. Prior research provided evidence that radical food product innovations are more successful on the market than line extensions and 'me-too' products (Knox et al., 2001; Lagnevik et al., 2003; Lefebvre et al., 2015).

9.3 Product Sequential complementarity illustrated in the UHT flavoured milkshake project

Product Sequential complementarity was characterised with a product idea (concept) being the starting point within a project that consequently required significant adjustments of the existing production process. This complementarity type reflects the Stage-Gate NPD model (Cooper, 2008).

Dependence on the existing technology trajectory The UHT flavoured milkshake case provides support for a low dependence on the existing product and medium dependence on the established process technology. The dairy was already producing a short-life version of the flavoured milkshake and was therefore building upon substantial level of knowledge in product development. Despite this, the UHT version required development of a unique three-layered bottle and closure that was hermetically sealed but once opened the lid and sealed foil were taken off at the same time. The company was able to utilise the existing processing and filling lines that had to be adjusted for a correct blend of time and temperature. A new custom made packaging line was added to the existing production equipment.

Impact of the supply chain rigidities In the Product Sequential complementarity there were no retailer rigidities imposed, as proposed within the typology. The rationale for the project of UHT flavoured milkshake was built internally, upon popularity of the existing short-life flavoured milkshake. According to Interviewee 30: *"There was a range of different parties involved in the project…particularly the bottle manufacturers and the developer of the closure technology significantly contributed to the introduction of the product."* The impact of supply chain rigidities upon the process innovation was only partially supported. Even though, a medium level of pre-setting has been demonstrated by collaboration with the food processing equipment supplier which set up their existing equipment with the correct time and temperature during the processing. The new bottle and closure required development of a new custom-made packaging line that was added to the existing production process. The collaboration between equipment supplier and process firm is often needed due to firm specific nature of process technology needed by process firms (Bigliardi et al., 2010; Frishammar et al., 2012).

Levels of potential and realised absorptive capacity The case study further confirmed the need for high levels of potential and realised absorptive capacity in product innovation. The dairy had already developed and was producing the short-life milkshake. This level of knowledge and know how served as an advantage in development of its 90 days shelf-life version. Moreover, the dairy successfully collaborated with bottle and closure manufacturer to be able to provide tailored solutions for their customers. This innovation was new to the market and required development of a new packaging line. The company was able to utilise the existing processing and filling machines with help of the food processing equipment supplier. As stated by Interviewee 30: *"the processing and filling machines would not be able to recognise the difference between the short life and UHT product."*

9.4 Process Sequential complementarity illustrated in the case of flow wrapping machine purchase by Cornish Bakery to produce and pack larger pasties

Process Sequential complementarity reflects projects that start with purchase or development of a new custom-made processing/packaging equipment that then results in identification of future possibilities for product innovation.

Dependence on the existing technology trajectory The case study of Process Sequential complementarity provided support for both propositions about dependence on the existing technology trajectories. The bakery (case D) purchased a new flow wrapping machine to be able to pack larger pasties for the project - an incremental product innovation. The size of pasty itself had to be increased, however, as pasties were hand made, it did not have any influence on the production process. The high dependence on the existing product technology was demonstrated by the increase of the size of pasties and their packaging.

The impact of supply chain rigidities The proposition was not confirmed in regards to the presence of no supply chain rigidities towards process innovation in projects adopting Process Sequential complementarity. The case of purchase of a new packaging machinery to pack larger own-label products provided evidence that the packaging equipment supplier sold a flow wrapping machines that were adjusted to pack only requested 5 different products. The Bakery did not require any further equipment modifications that it could benefit from in the future. The reasons for this rather short-term / immediate orientation were linked to limited financial resources and strong focus on the return on investment. Bakery relied upon retailer's orders and was considering process innovations only after having secured further orders. The flow wrapping machine solved only an immediate problem, leading to a medium level of formal pre-settings.

The relationship between the bakery and the provider of packaging equipment improved in the long term when the bakery was facing further orders for own-label products requiring additional packaging sizes. The bakery did not possess the internal knowledge and expertise to adjust the existing packaging lines to be able to achieve requested packaging specifications and therefore decided to collaborate with the equipment supplier to develop a solution. Food and drink sectors are characteristic with their significant reliance on technologies developed by upstream industries (Aylen, 2010; Martinez and Burns, 1999). However, in order to leverage these resources to its maximum potential, they have to develop a relationship that is high in breadth and depth. As emphasised by Rosell et al. (2012), an increased level of knowledge integration between buyer and supplier can provide input to align supplier's manufacturing process and product technology expertise to the buyer's product development requirements. This type of joint learning represents a 'coupled knowledge integration process' that often precedes, but also follows the R&D/manufacturing interface. On the other hand, end-users of production equipment are highly knowledgeable about the production environment and could be a valuable source of innovation ideas about the operational requirements of the equipment (Hutcheson et al., 1995; Rönnberg Sjödin, et al., 2011). The transactional relationship (arm's length relationship) that has developed between the bakery and its equipment supplier led to missed opportunities for mutual collaboration (Parker and Hartley, 1997).

In relation to the product innovation, one of the "Big Four" retailers initiated the project and imposed a medium level of formal pre-settings on the supplier - supporting the proposition. According to Interviewee 36: *"…apart from receiving specifications on reduced salt content, the order also required increasing the size of the existing product."* Prior literature stressed the common practice of imposing such specifications by retailers on manufacturers, particularly when producing own-label products (Kähkönen, 2014; Lindblom et al., 2009).

Levels of potential and realised absorptive capacity The case study of Process Sequential complementarity, even though identified a suitable supplier of a new flow wrapping machine to pack larger pasties, did not confirm presence of a highly developed realised absorptive capacity in process innovation. Companies operating within process industries often lack the internal knowledge and resources to design and develop new process equipment internally (Aylen, 2010; Reichstein and Salter, 2006). Moreover, a lack of internal knowledge and experience in process innovation (keeping the same production equipment for 15 years) and a lack of experience in undertaking market research resulted in choosing convenient supplier on the basis of price. This illustrated a low level of potential absorptive capacity. Interviewee 11 said: *"Technopackaging was a local supplier, who gave us the best deal…machine had the* *flexibility to pack all five products."* Although, these capabilities were sufficient in this specific project, such low levels of absorptive capacity within the company might have several disadvantages in the long-term and further increase manufacturer's dependence on the packaging equipment suppliers (Järvensivu and Möller, 2008, Kumar, 1996). The importance of customer maintaining the internal knowledge capabilities to recognise the value of new technologies internally was highlighted by prior research (Huang and Rice, 2012; West and Gallagher, 2006)

Additionally, the proposition about presence of medium levels of potential and realised absorptive capacity in product innovation was only partly confirmed. The Bakery had experience in making the pasties, however was dependent on the packaging equipment supplier to identify suitable packaging options. In this case the packaging equipment supplier not only brought process innovation to the Bakery, but also solved the issue with packaging of pasties.

9.5 Incremental Reciprocal complementarity illustrated in the case of Chunky Beef project by Food Co.

The new complementarity type added to the Product-Process project portfolio Map is the Incremental Reciprocal complementarity. This complementarity was identified in the Phase 1 by Interviewee 7. It is characterised with a high dependence on the existing product and processing technologies, which are inseparable during the project and have to be considered synchronously throughout the project. The literature on technology management highlights, that despite employing a broad range of search strategies, companies predominantly engage in 'local search' that enables them to utilise the established product and process technology (Henderson and Clark, 1990).

Dependence on the existing technology trajectory The manufacturer depended on the existing product and process technologies to a high extent. The three key aims of the project were to utilise the existing production equipment to change the process from a single to two shot cold fill. But, at the same time ensure that the taste, colour, odour and feel of the product remained the same, so the consumer would not notice the change. Moreover, the customer requested a consistent final product containing 75% beef content (avoiding the build up at the bottom of the can). According to Interviewee 27: *"We were very confined not to touch the recipe. You have to work within the recipe, you cannot alter the specifications, because the customer ordered the recipe."* According to Leonard-Barton (1992) there are four dimensions that constitute the core capabilities of a company: employee knowledge (1) and skills that are embedded in technical systems (2), which are guided by managerial systems (3) and associated with values and norms (4). All four dimensions reflect accumulated beliefs from previous organisational successes that form an interdependent knowledge system that is difficult to imitate by future competition (Chisea et al., 2004).

The impact of the supply chain rigidities The Incremental Reciprocal complementarity demonstrated a high level of supply chain rigidities towards the product innovation. As stated by Interviewee 7: *"You are giving retailers a headache with every product innovation…the product recipe had to remain the same, as specified by the retailer…the organoleptic profile had to stay the same…we had to ensure that each can contained a guaranteed beef content of 75%."* The shelf space gives retailers a strong bargaining power during the negotiations with food companies. This, at the same time, leads to their significant power in the supply chain

(Hingley and Hollingsworth, 2003; van der Walk and Wynstra, 2005) and serves as a destructive force towards innovation (Hingley, 2005). Anselmsson and Johansson (2009) identified a significant negative relationship between increasing market share of retailers in a product category and the level of innovativeness. An example of this could be the common copycatting of the market leading brands, so-called 'me-too products' by the leading retailers. This often leads to product innovations that are exploitative in nature (Laaksonen and Reynolds, 1994; Steiner, 2004).

Food and drink companies perceive the installation of new equipment and the use of novel materials as a 'big risk'. This is due to potential lead times caused by the complexity of change, as well as fear of insufficient demand and loss of potential sales (Simms and Trott, 2014). The case study demonstrated medium level of formal pre-settings in the process innovation. This was mainly due to the development team's requirement to utilise the existing equipment by involving the suppliers of the processing equipment to make only minor adjustments to equipment settings and supplying the corned shaped head to the end of the nozzles on the vacuum filler.

Levels of potential and realised absorptive capacity Engineers from the equipment supplier helped the ready meals manufacturer to redesign the existing manufacturing process and to achieve better optimisation of settings. Existing knowledge gained through continuous collaboration with a starch company was applied to choose a suitable slipping agent to be added to the recipe. The manufacturer further built upon knowledge from its established collaboration with universities and research institutes. Existing knowledge of food companies is commonly applied in producing own-label products (Bengtsson and Kock, 2000; Peng and Bourne, 2009). The ability to identify and assimilate such knowledge required medium levels of potential absorptive capacity in product and process innovation. The manufacturer's choice to work with the existing product knowledge and equipment was evident in a high realised absorptive capacity in product and process innovation. As stated by Interviewee 7: *"Our customer obviously wanted the products to be identical they are the same label….we needed to find a different way of filling, but if you invest £100 000 into a machine you have to think about it…you do not invest without a lot of justification, especially in this country…. You also have to think of your requirements. You have to think of line efficiency. You need to meet all your requirements not just for one line… How could you utilise the existing machine as much as you can?"*

9.6 Process Amensalism complementarity illustrated in the case of Punchy Jalapeño Mini Wafers project by Dorset Bakery

Process Amensalism is adopted in New Product and Process Development projects when the company is reluctant to pass away the preceding investments into the established technology. This restricts the project in search for radical product innovations (Bunduchi and Smart, 2010; Kauffman et al., 2000).

Dependence on the existing technology trajectory The case study of the Jalapeño mini wafers (case F) demonstrated a low extent of complementarity between product and process innovation caused by a high dependency on the existing production process. The entire scope of this project was based around utilising the existing production line. According to the Interviewee 39: *"The existing machinery is a constraining factor. We always find that there are certain areas that stop us from doing something…for example, we often have to make compromises with the product design."* Leonard-Barton (1992) argued that core capabilities that once served the company well, may become after a while suitable only for a certain type of projects and inhibit development of those more radical ones. They may affect all projects, even those that are seemingly congruent with the current core capabilities. The premium snacks manufacturer was already producing Jalapeño wafers that have proven to be a successful concept. The manufacturer simply added a new tray with small holes to the existing line and was able to introduce incremental product innovation. Both propositions included in the typology were supported through this case. The Bakery was able to introduce mini version of existing Jalapeño wafer product with a limited budget and a simple solution through incremental process improvement "bolt-on goodies" (Avermaete, 2002; Aylen, 2013). Modular items, such as the tray for mini Jalapeños, are easily attached to the existing equipment and usually developed in collaboration with equipment suppliers (Ozman, 2011; Reichstein and Salter, 2006). However, such practice constrains innovation and reinforces development of technology trajectories (Bunduchi and Smart, 2010).

The impact of the supply chain rigidities The case study did not confirm the presence of high supply chain rigidities during product innovation. Mini wafers were a branded product, rather than own label product. According to Interviewee 17: "*retailers are always welcoming new product innovations.*" One of the reasons for this might have been the popularity of the snacking product category and retailer's focus on delivering what the final consumer wants (Caizza and Volpe, 2013; Day and Moorman, 2010; Esbjerg et al., 2013). On the other hand, processing equipment was sourced from the United States and therefore it was difficult for the manufacturing company to collaborate with the supplier. As stated by Interviewee 38: *"we were looking for a quick and simple solution…therefore we chose to collaborate with a small local engineering company."* The proposition about high supply chain rigidities in process innovation was not confirmed. Medium level of formal pre-settings was present during the collaboration. The engineering company designed and produced a new tray for Jalapeño mini wafers. The tray was produced to be compatible with the existing production equipment and easily replaced with the existing tray used for the original Jalapeño wafers product.

Levels of potential and realised absorptive capacity The case study did not confirm presence of high realised and low potential absorptive capacity in process innovation. Low levels of both types of absorptive capacity were present. The case study supports prior findings about the reliance of processing and packaging companies on the expertise of equipment suppliers when introducing even an incremental innovation (Lamming, 1993). The snacks manufacturer possessed only a low level of realised absorptive capacity that was sufficient for the operations department to identify the possibility for 'line stretch' (Aylen, 2013). The proposition about the high realised and low potential absorptive capacity was partly confirmed through this case. Existing experience in development of product recipe and production of original Jalapeño wafers led to a high realised absorptive capacity. However, in this case no collaboration with external parties during the product innovation was required.

9.7 Product Pooled complementarity illustrated in the case of Salted Caramel Florentines project by Dorset Bakery

Product Pooled complementarity identifies the lowest extent of complementarity between product and process innovation. Food and drink sector is often described by undertaking incremental product innovations to provide consumers with a broader choice of flavours (Martinez and Briz, 2000; Trippl, 2011).

Dependence on the existing technology trajectory The case study supported a high dependence on the existing product technology trajectory with no impact on the processing equipment. The case of Salted caramel florentines (case G) was an example of a flavour change without the requirement to adjust the existing processing equipment. This case of Product Pooled complementarity identified a lot of limitations of the existing processing line. Ineffective layout of the factory and equipment may often lead to increased cost of production and delays (Baker, 2013). The production process was only partly automated and the florentines were dipped into the salted caramel, manually. Thus, not having any impact on the automated production. The British food and drink industry is well-known for its conservatism with modern production techniques and low adoption of robots in production (The Manufacturer, 2016). The key in this project were the experiments with the flavour and temperature adjustments to melt the caramel. As stated by Interviewee 17: *"it was an easy extension of the existing portfolio of flavours."* Company's search strategy within the existing technology trajectory can negatively influence its innovation performances (Katila and Ahuja, 2002).

The impact of the supply chain rigidities The proposition about high supply chain rigidities influencing the product innovation was not confirmed. The project was aimed at introduction of a branded product. However, it is assumed that if the project has involved an own label product, the level of rigidities would have been high. Retailers are not interested in adoption of new technologies, but their focus is rather centred around consumers' wants and needs (Esbjerg et al., 2016). Throughout the past decade, grocery retailers have significantly increased the number of own label products within their stores (Anselmsson and Johansson, 2009). However, at the same time, the number of innovative products on the shelves decreased and this is often due to retailer's focus on short-term sales performance and price (Esbjerg et al., 2016). The findings from Phase 1 have further supported this statement: *"70% of our NPD projects is coming from our biggest customer…these are usually improvements to existing products based on consumer complaints."* (I7).

Levels of potential and realised absorptive capacity The case study partly confirmed the proposition about high realised absorptive capacity and low potential absorptive capacity. This project did not require potential absorptive capacity as the snacks manufacturer was able to utilise existing experience in flavour changes and production of florentines that was already present within the company.

9.8 Process Pooled complementarity illustrated in the case of pressure change during steam injection applied on the minced beef by Food Co.

Projects that adopt the Process Pooled complementarity are focused on incremental changes to the existing production, with no or limited impact on the product (Baker, 2013; Lefebvre et al., 2015; Lienhardt, 2004). This complementarity strategy reflects the lowest extent of complementarity.

Dependence on the existing technology trajectory Process Pooled complementarity was proposed to be related to a complacent technology trajectory leading to a lowest extent of complementarity. The case of pressure change in the project of canned minced meat supported this (case H). This project was being postponed by the company for a long time due to the high production efficiency requirements (200 cans per minute). Despite this, the benefits of decreasing the pressure during meat processing on the meat quality were well-known by the company. By simple adjustment of pressure during the steam injection process from 4 to 2 bars, the ready meals manufacturer was able to increase the overall equipment efficiency of 30%. The pressure change had a direct influence on the quality of the meet, however the end consumer was unlikely to notice the difference. According to Interviewee 7: *"by going to a lower pressure within vessels we could control the gelatinisation of starches better…keeping the piece integrity of meat and vegetables."* The Production equipment was often under-utilised due to frequent and shorter production runs and regular changeovers. It can be argued that food and drink companies should be focusing on the overall equipment efficiency to be cost effective (Weinekotter, 2009; Womanck and Jones, 1996). 'Invisible innovations' such as the pressure change are not seen by the consumer, but are crucial to keep down the production costs (Beckeman, 2013).

Apart from the reliance on the existing process technology, wider adoption of the lean manufacturing techniques was often related to the considerable pressures imposed by retailers on manufacturers. Retailers demanded from manufacturers to produce ever increasing number of product lines and to introduce different packaging formats (Baker, 2013). This results in short batches and short lead times, therefore, the manufacturers are constantly trying to become more flexible and efficient (Langhauser, 2008; Mihalik and Nambiar, 2010) to meet retailers' demands for increasing product flexibility and variety.

The impact of the supply chain rigidities In the Process Pooled complementarity the proposition on the presence of high supply chain rigidities was not confirmed. The processed food manufacturer undertook the project internally and did not require any collaboration with external parties. The finding can be supported by Bergfors and Lager (2011), who argued that collaboration between the equipment supplier and customer may not be necessary during incremental process development. The product supply chain rigidities did not play a role in this project, as proposed in the typology.

Levels of potential and realised absorptive capacity The case study partly confirmed the assumption of necessity to have a high level of realised and low level of potential absorptive capacity. The ready meals manufacturer was able to introduce the incremental innovation purely through utilisation of the existing internal knowledge. As stated by the NPD Manager: "*Pressure processing is a well-known technique, particularly for its impact on the quality of minced meat in comparison to conventional processing methods.*" The case study provided evidence that during projects with a low extent of complementarity and low emphasis on process innovation companies are more likely to be building upon the existing processing knowledge within the company rather than seeking expert help outside the organisational boundaries (Bergfors and Lager, 2011). Table 34. portrays the comparison between the original Typology: Complementarity-Capability Matrix (in bold letters) and findings from case studies.

PRODUCT

	TECHNOLOGY TRAJECTORY	SUPPLY CHAIN	ABSORTIVE CAPACITY
RADICAL RECIPROCAL *Extended Shelf-life Fresh Milk*	No Dependence (SUPPORTED) No Dependence (SUPPORTED)	No Rigidities (SUPPORTED) No Rigidities (SUPPORTED)	High PAC & RAC (SUPPORTED) High PAC & RAC (SUPPORTED)
RADICAL RECIPROCAL *In-can Draught Beer*	Low Dependence (SUPPORTED) **No/Low Dependence** Medium Dependence (NOT CONFIRMED)	No Rigidities (SUPPORTED) No Rigidities (SUPPORTED)	High PAC & RAC (SUPPORTED) High PAC & RAC (SUPPORTED)
PRODUCT SEQUENTIAL *UHT Flavoured Milkshake*	Low Dependence (SUPPORTED) Medium Dependence (SUPPORTED)	Dominant Product No Rigidities (SUPPORTED) **No rigidities/** Medium Level of Formal Pre-settings (PARTLY SUPPORTED)	High PAC & RAC (SUPPORTED) Medium PAC & RAC (SUPPORTED)
PROCESS SEQUENTIAL *Purchase of Flow Wrapping Packaging Machine*	High Dependence (SUPPORTED) No Dependence (SUPPORTED)	Medium Level of Formal Pre-settings (SUPPORTED) **Dominant Process No rigidities/** Medium Level of Formal Pre-settings (NOT CONFIRMED)	**Medium PAC & RAC/** Low PAC & Medium RAC (PARTLY SUPPORTED) **Dominant Process High PAC and RAC/** Low PAC & RAC (NOT CONFIRMED)

PROCESS

HIGH ← COMPLEMENTARITY

Table 36. Typology: Complementarity- Capability Matrix (in bold) vs. findings from eight case studies.

EXTENT OF

INCREMENTAL RECIPROCAL *Chunky Beef Canned Ready Meal*	High Dependence High Dependence	High Rigidities Medium level of Formal Pre-settings	Medium PAC & High RAC Medium PAC & High RAC
PROCESS AMENSALISM *Punchy Jalapeno Mini Waffles*	Product Trajectory Constrained (SUPPORTED) High Dependence (SUPPORTED)	**High Rigidities**/ No Impact (NOT CONFIRMED) **High Rigidities**/ Medium Level of Formal Pre-settings (NOT CONFIRMED)	**Low PAC & High RAC**/High RAC (PARTLY SUPPORTED) **High RAC & Low PAC**/ Low PAC & RAC (PARTLY CONFIRMED)
PRODUCT POOLED *Salted Caramel Florentines*	High Dependence (SUPPORTED) No Impact (SUPPORTED)	**High Rigidities**/ No Impact (NOT CONFIRMED) No Impact (SUPPORTED)	**Low PAC and High RAC**/ High RAC (PARTLY SUPPORTED) Treshold Level of Knowledge (SUPPORTED)
PROCESS POOLED *Pressure change in minced meat project*	No Impact (SUPPORTED) High Dependence (SUPPORTED)	No Impact (SUPPORTED) **High Rigidties**/ No Impact (NOT CONFIRMED)	Treshold Level of Knowledge (SUPPORTED) **High RAC and Low PAC**/ High RAC (PARTLY SUPPORTED)

LOW

PRODUCT

PROCESS

9.9 Conclusion and development of further propositions

The findings from case studies confirmed presence of different allocation strategies of resources and capabilities across the examined seven case studies. The following sections will highlight the contingencies that were not confirmed or only partly supported. These will result in further propositions, providing additional guidance for the food and drink companies regarding a suitable allocation of resources and capabilities when faced with different complementarity strategies.

Technology trajectories Before presenting additional propositions that were developed based on the findings from Phase 2, it is important to note that the assumptions presented within the Typology: Complementarity-Capability Matrix, in terms of dependence on the existing process technology trajectory, had to be generalised and referred to a spectrum of High/ Medium/Low dependence.

The evidence from case studies provides insights into the complex production processes within the food and drink manufacturing/packaging companies. These often include more than 4 production stages and different types of processing equipment (i.e. filling, bottling, packaging lines). The degree of their change will differ by specific needs of each New Product and Process Development project. Therefore, medium dependence on the existing technology trajectory was argued to occur in cases when one or more parts of the existing production lines had to be significantly changed to accommodate the product innovation.

The evidence from eight case studies supported all of the propositions, apart from the case study of Best Brewery draught beer in can project. This case confirmed the commonly stated characteristic of companies operating within process industries - to make the most out of the existing production equipment, even during the radical product innovations (Bigliardi et al., 2013; Novotny and Laestadius, 2014). Moreover, the case study included a radical packaging innovation rather than changes to the core product that influenced the choice of adapting the existing canning line. Therefore, it is assumed that;

> P1: *In New Product and Process Development project following a complementarity strategy of Reciprocal complementarity, medium dependence on the existing process technology trajectory will be sufficient, if the project aims to develop a radical packaging innovation.*

The impact of supply chain rigidities The case studies demonstrated a range of different scenarios in the collaboration between the supplier of processing/packaging equipment and the manufacturer/packer. Van der Valk and Wynstra (2005) highlight a potential risk associated with this approach. They suggest that companies require a set of operational management processes to be able to identify a suitable level of involvement of supplier in a specific project. The equipment suppliers were involved only in instances when the company did not possess the necessary resources and capabilities internally, as opposed to routine procedures. These involved; adjustments to processing equipment settings (often related to the development of a new product technology, new to the company), production of 'bolt on goodies', significant reconstruction of the existing equipment or development of customised production lines (Aylen, 2013; Bigliardi et al., 2010).

On the basis of the above evidence it can be concluded that during the adoption of Process Sequential complementarity, medium level of formal pre-settings to the new packaging equipment will be sufficient to introduce incremental product innovation. However, such instance will impose several limitations to the processing company. The case study of Cornish Bakery (buying a new flow wrapping machine) portrays an example of a short-term oriented company with a focus on delivering solely what is immediately required by retailer. The manufacturer, therefore did not propose a requirement for a customised 'future proof' packaging solution at the beginning of the sales meeting with the equipment supplier. This could be supported by a statement from the International Federation of Robotics Report (2016, p. 23): "*The potential users of automation in the UK lack knowledge of automation potential and therefore cannot envisage the advantages or brief the supplier correctly.*" Hence it is argued;

> P2: *In New Product and Process Development project following a complementarity strategy of Process Sequential complementarity, medium level of formal pre-setting to the packaging equipment will be sufficient, however, will hinder utilisation of equipment's flexibility.*

The cases (F;G;H) demonstrated that a low extent of complementarity does not necessarily have to be related to a high level of rigidities in the product innovation, when the company works on a branded product. The extent of complementarity in which the projects ended up was influenced by internal organisational decision making. This finding is consistent with prior research that identified the need to maintain a competitive advantage over the large retailers that offer their own label products as one of the main motivators of food firms to innovate (Garcia Martinez and Britz, 2000). An additional reason for no impact of supply chain rigidities, and welcoming of such product innovations by retailers was the popularity of on-the-go snacking products and premium sweets among consumers. This finding can be supported by the results of market report conducted by Mintel that identified growing market trend in on-the-go categories (Mintel, 2016).

Fiss (2011) divided typologies into core and periphery. The core elements are defined as essential, while peripheral as less important. The core elements clearly indicate strong causal relationship with the outcome of interest and peripheral elements for which the evidence of relationship is weaker. This leads to a proposition;

> P3: *In New Product and Process Development projects following a low extent complementarity strategy, supply chain rigidities will not play any role in influencing branded product innovation from a popular product category.*

Case G, also did not demonstrate impact of supply chain rigidities on process innovation. The case of Process Pooled complementarity involved a simple pressure change in the setting of steam injection which was based on the knowledge already present within the company. Short batches and short lead times are becoming very common, therefore manufacturers are

constantly trying to become more flexible and efficient (Baker, 2013). Therefore, it is assumed that;

P4: *In New Product and Process Development projects following a Process Pooled complementarity strategy, supply chain rigidities will not have any impact on process innovation.*

The high level of supply chain rigidities was found to have impact only in cases when the buyer (retailer) would require an incremental product innovation by prescribing the required recipe, ingredients, and suppliers for their own label product (Dobson and Charkaboty, 2015; Wynstra et al., 2010). This instance was demonstrated in the case of Chunky Steak. Therefore, it is argued that;

P5: In New Product and Process Development projects following a complementarity strategy of Incremental Reciprocal complementarity, high supply chain rigidities will be imposed by retailer requiring own-label product innovation.

On the other hand, medium level of formal pre-settings was utilised during New Product and Process development projects (E;F) when companies decided to predominantly build upon the existing knowledge and production/processing equipment. These projects involved incremental process innovations and as stated by the Interviewee 38: *"the collaboration with the local engineering company cost us only a couple of thousand pounds."* The findings lead to the following proposition;

P6: *In New Product and Process Development projects following Incremental Reciprocal and Process Amensalism complementarities, medium level of formal pre-settings will be required in process innovation.*

However, it was possible to have a combination of relationships with different suppliers within a single project and this was demonstrated by the case study of the Product Sequential complementarity. Collaboration between two or more parties involving different collaborative relationships was referred to as 'hybrid' in the previous research. It is not only crucial to identify the suitable collaboration partners, but also to identify the appropriate level of their involvement (i.e. suppliers) within the project (van der Valk and Wynstra, 2005).

P7: *In New Product and Process Development projects following a complementarity strategy of Product Sequential complementarity, medium level of pre-settings on some parts of the production process will be combined with no rigidities towards production processes that are related to radical product innovation.*

Levels of potential and realised absorptive capacity The propositions about the levels of potential and realised absorptive capacity in process innovation were not confirmed in the case of Process Sequential complementarity. Evidence from the case study suggested that low levels of absorptive capacity in process innovation were sufficient for achieving such a high extent of complementarity. This, however, resulted in a lack of operational learning within the bakery and an inability to utilise the flexibility of adopted flow wrapping machine in the future projects. Low levels of absorptive capacity among firms operating within food and drink sectors have been identified as some of the main barriers towards innovation (Spithoven et al., 2010). Reliance on the equipment supplier will further increase their ability to impose supply chain rigidities - the bakery will only be able to introduce incremental packaging innovations, such as the size/shape changes. Therefore, it is argued that;

P8: *In New Product and Process Development projects following a complementarity strategy of Process Sequential complementarity, low levels of potential and realised absorptive capacity in product innovation might be sufficient for the purposes of the project being undertaken, but will have negative impact on the operational learning of the company.*

Case D further demonstrated medium levels of realised absorptive capacity in product innovation from existing experience in production of pasties. However, the company was dependent on the equipment supplier to adjust the machine to enable packing larger size pasties. These capabilities might be sufficient for the current project, but they can lead to a lack of internal learning and knowledge. Thus it is proposed that;

P9: *In New Product and Process Development projects following a complementarity strategy of Process Sequential complementarity, medium level of realised absorptive capacity and low level of potential absorptive capacity in product innovation might be sufficient for the purposes of the project being undertaken, but will have negative impact on the operational learning of the company.*

The case of Jalapeño mini wafers provided evidence that in projects adopting the Process Amensalism complementarity, low potential and realised absorptive capacity will be sufficient to undertake process innovation. The project was characteristic by making the most out of the existing equipment, and this was the main driving force behind the decision to undertake a "line stretch" by collaborating with a local engineering company. This was combined with a high realised absorptive capacity in product innovation, without a need to collaborate with external parties. Therefore, it is assumed that;

> P10: *In New Product and Process Development projects following a complementarity strategy of Process Amensalism, low potential and realised absorptive capacity in process innovation combined with high realised absorptive capacity in product innovation will be sufficient for the particular type of project.*

The last difference identified between the assumption in the typology of Complementarity-capability matrix and the analysis of the case studies, was that Product and Process Pooled complementarities did not require presence of a low level of potential absorptive capacity. These projects were undertaken using only internal resources and capabilities, resembling the closed innovation model (Chesbrough, 2003). According to the findings of European Regional Innovation Survey (ERIS) conducted among 116 SMEs in Germany between 1995 and 1997, product innovations of food companies are focused on application fields that are "familiar with companies." For instance, experience with similar products and production processes and own R&D activities were perceived as crucial prerequisites for successful product innovation. However, only 24% of the investigated companies collaborated with market research institutes on a regular basis and 34% of these did not employ R&D personnel (Menrad, 2004). Thus, the findings lead to conclusion that;

> P11: *In New Product and Process Development projects following a complementarity strategy of Product and Process Pooled, realised absorptive capacity in product or process (respectively) will be sufficient to introduce incremental product or process innovation.*

Propositions stated above should serve as a starting point leading future research. The propositions were included in the Revised Typology: Complementarity-Capability Matrix. See Table 37.

COMPLEMENTARITY (HIGH ↑)

	TECHNOLOGY TRAJECTORY	SUPPLY CHAIN	ABSORTIVE CAPACITY
RADICAL RECIPROCAL	PRODUCT: No / Low Dependence PROCESS: No /Low Dependence (if product technology and packaging innovation) Medium Dependence (if only packaging innovation)	PRODUCT: No Rigidities PROCESS: No Rigidities	PRODUCT: High PAC & RAC PROCESS: High PAC & RAC
PRODUCT SEQUENTIAL	PRODUCT: Low Dependence PROCESS: Medium Dependence	PRODUCT: Dominant Product No Rigidities PROCESS: No rigidities	PRODUCT: High PAC & RAC PROCESS: High PAC & RAC
PROCESS SEQUENTIAL	PRODUCT: High Dependence PROCESS: No Dependence	PRODUCT: Medium Level of Pre-settings PROCESS: No Rigidities (if need to develop a custom-made production equipment) Medium level of formal pre-settings (if adjustments to production equipment available on the market needed)	PRODUCT: Medium PAC and RAC (enables the company increase organisational learning) Low PAC & medium RAC (negative influence on organisational learning) PROCESS: High PAC & High RAC (increases operational learning Low PAC & RAC (negative impact on operational learning, might be sufficient for the particular project)

Table 37. Revised Typology: Complementarity-Capability Matrix.

EXTENT OF

INCREMENTAL RECIPROCAL	High Dependence High Dependence	High Rigidities (if own label product) Medium level of formal pre-settings	High RAC Low PAC / High RAC
PROCESS AMENSALISM	Product Trajectory Constrained High Dependence	High Rigidities (if own label product) No Rigidities (if branded product from popular product category) High Rigidities (if own label product) Medium level of formal pre-settings (if minor adjustments 'bolt on goodies' on the existing production equipment	Low PAC & High RAC (if collaboration with external parties needed) High RAC (if internal knowledge sufficient) Low PAC & RAC (might be sufficient as a 'one- off solution) High RAC / Low PAC (will increase internal knowledge in process improvements)
PRODUCT POOLED	High Dependence No Impact	High rigidities (if own label product) Rigidities not applicable (if branded product from popular product category) No Impact	High RAC (if purely internal project) Low PAC (if involvement of external party required) Treshold Level of Knowledge
PROCESS POOLED	No Impact High Dependence	No Impact Rigidities not applicable (if purely internal project) High rigidities (if own label project)	Treshold Level of Knowledge High RAC (if purely internal project) Low PAC (If internal knowledge was not sufficient)

LOW

PRODUCT

PROCESS

Chapter 10. CONCLUSION

The original idea of complementarity was that complementarities occur when two activities reinforce each other in such a way that doing one thing increases the value of doing the another (Matsuyama, 1995). According to Stieglitz and Heine (2007, p.3) companies that do not take into an account complementarities result in a "loss in value creation, revenues and ultimately, in profits for the firm, because company fails to realise its full potential." A wider dissemination of this concept shows that it is difficult to research, to the point that it has now become 'all things to all people', particularly when investigating the complementarity between product and process innovation (Bruch and Bellgran, 2014; Mohnen and Röller, 2005).

The existing literature on complementarities between product and process innovation is spread among five different streams of literature lacking a holistic theoretical framework to guide further investigations (Ennen and Richter, 2010). These streams include; product-process pattern (Abernathy and Utterback, 1978; Damanpour and Gopalakrishnan, 2001; Utterback, 1994), process-product pattern (Barras, 1986; Kurkkio et al., 2011; Novotny and Laestadius, 2014), product and process are interdependent (Kim et al., 1992; Martínez-Ros, 2000; Lim et al., 2006; Lager, 2010), portfolio of complementarities (Evangelista and Vezzani, 2010; Hayes and Wheelwright, 1979; Pisano and Shih, 2012; Wheelwright and Clark, 1992), and product and process are two separate innovation types (Anderson and Tushman, 1990; Ettlie et al., 1984; Traill and Meulenberg, 2002). The models, empirical and conceptual studies within these streams largely differ in terms of the level of analysis at which they examined the complementarity between product and process innovation. Industry, company and project levels of investigations were adopted interchangeably among a wide range of industries. Furthermore, the existing knowledge about contingencies that may influence adoption of different types of complementarities was based on assumptions and propositions that lack a clear guidance on the type of complementarity strategy they are likely to result in (Battisti and Stoneman, 2010; Evangelista and Vezzani, 2010; Ballot et al., 2015).

This research project aims to provide a starting point in developing a classification of complementarities between product and process innovation at the New Product and Process Development Project level. The project combines perspectives from contingency theory, project portfolio management, ambidexterity perspective and resource-based view to uncover the range of complementarities that occur within process industries. Furthermore, this project provides insights into contingencies (resources and capabilities) that are required to achieve and determine adoption of different extents of complementarities in projects within the food and drink sector. These two contributions are brought together in Typology: Complementarity-Capability Matrix that presents seven complementarity strategies (propositions), ranging from a low to high extent. These are further related to extents of technology trajectories, degrees of supply chain rigidities and levels of absorptive capacity required to achieve (move closer to) these complementarities.

The understanding of different complementarity types, their management and factors influencing their adoption among food and drink companies was investigated in the first, exploratory phase of data collection. This phase also identified examples of New Product and Process Development Projects that 'illustrate' a range of complementarity strategies, further enhancing and expanding The Product-Process Complementarity Map. The second explanatory phase examined the validity of the Typology with findings from eight case studies. This phase provided further insights into contingencies influencing development of complementarity in the food and drink sector. The pattern-matching analysis resulted in the Revised Typology: Complementarity-Capability Matrix.

10.2 Evaluation of the substantive findings and contribution to the literature

10.2.1 Classification of complementarities between product and process innovation at the New Product and Process Development Project level

This research project is the first study to introduce a comprehensive overview of portfolio of complementarity strategies between product and process innovation at the New Product and Process Development Project level. To achieve this, it builds upon five streams of literature on complementarities between product and process innovation and perspectives from the contingency theory, project portfolio management and ambidexterity. The project re-conceptualises the terminology from one of the most commonly cited publications in the contingency theory, Thompson (1967), to define complementarities occurring between product and process innovation. These range over a spectrum from a high to a low extent of complementarity, identifying a concrete pattern of complementarity occurring between product and process innovation. The classification of complementarities includes; *Reciprocal, Product Sequential, Process Sequential, Product Amensalim, Process Amensalism, Product Pooled and Process Pooled complementarities.*

Product and Process Amensalism complementarities were unique contribution of the present study. The existing literature streams on complementarities missed to consider the negative impact of established process technology on product innovation and *vice versa*, as a possible complementarity type (Bunduchi and Smart, 2010; Kauffman et al., 2000). This relationship is particularly relevant to low-technology process industry sectors, due to their common characteristic of reluctance to move away from established technology trajectories (Lager, 2010; Aylen, 2013). Although, Amensalism complementarity could be sufficient in a short-term, it can have negative impact on the organisational innovation in the longer term. This involves predominant focus on exploitation of the existing technology, focus on incremental innovation and a lack of collaboration with external sources resulting in reduced internal learning (Baregheh et al., 2012; Bauer and Leker, 2013; Sarkar and Costa, 2008).

The classification of complementarities was illustrated in the Product-Process Complementarity Map to position a portfolio of projects. The Map should be utilised as a project portfolio management tool to visualise the range of complementarities adopted in the New Product and Process Development Projects.

10.2.2 Management of complementarity between product and process innovation in New Product and Process Development Projects in the food and drink sector

Prior researchers highlighted the synchronous adoption of product and process innovation as the 'single one best complementarity' (Lager, 2010; Damanpour, 2010) and commonly generalised their findings at the industry level (Abernathy and Utterback, 1978; Barras, 1986; Lim et al., 2006). There is, however, only a handful of studies pointing to the project level of analysis (Bruch and Bellgran, 2014; Hullova et al., 2016; Pisano and Shih, 2012; Wheelwright and Clark, 1992). Hullova et al. (2016) highlighted the 'fallacy of the wrong level' of investigations into complementarity between product and process innovation. The authors argued that New Product and Process Development project level is the correct level of analysis. In addition, Bruch and Bellgran (2014) proposed matching the strategic planning of the product with strategic planning of the corresponding production system for organisations to consider its future needs in the early stages of the product development process. The authors argued that production system generations should be considered in the same way as product generations and updates. Kurkkio et al. (2011) called for future research to focus on how the benefits of such integration may be reaped and the risks of ineffective organisation of product and process development avoided. The research project built upon these studies and confirmed the project level as the most suitable level of analysis necessary to gain an understanding of complementarity strategies occurring among companies in the food and drink sector.

In-depth semi-structured interviews with key informants from the food and drink sector revealed that majority of companies do not actively manage and consider complementarity when faced with a new project. Although, respondents recognised the relationship between product and process innovation, majority of them was unable to identify a clear pattern occurring between the two innovation types within their innovation project portfolio.

Interviewees were aware of some of the advantages of achieving a complementarity between product and process innovation, such as ability to focus on feasible products and utilise the knowledge in further product and process development (Pisano, 1997; Pisano and Wheelwright, 1995). The most commonly adopted management techniques were cross-functional collaborations between R&D and production department and often across several other departments within the company (O'Connor and McDermott, 2004). The food and drink companies also adopted tools such as Quality Attribute Sheets and Quality Function Deployment to enable them to make the most of the existing production equipment when developing new products. This practice resembles one of the commonly cited characteristics of low-technology process industries (Aylen, 2013; Lager, 2010). Respondents referred to the sunk costs and premature scrapping of an existing production machinery as hindering factors towards product and process innovation (Baker, 2013; Bigliardi and Dormio, 2009). Respondents identified also a range of different specifications retailers impose on them when making orders for their own-label products. Furthermore, a range of unethical practices such as copy-catting branded products, imposing price pressures and bribery to stock a product from a new supplier were uncovered. These findings further contribute to the prior research on inequality in power within the food and drink supply chain and this creates the need for Groceries Code Adjudicator to better manage the relationship between suppliers and buyers. An interesting finding was that even the internal organisational perception of innovation within food and drink companies negatively influenced product and process innovation. Companies, to a large extent, were focused on efficiency and the day-to-day operations leaving limited space for exploration of new ideas (Simms and Trott, 2014). However, companies that were owned by a large conglomerate seemed to have an advantage in terms of availability of financial resources in comparison to their smaller counterparts that often tended to postpone automation of the production and avoid radical product innovations. The findings from Phase 1 further contributed to the existing knowledge on the range of external parties food and drink companies collaborate with (Bigliardi and Galati, 2013, Costa and Jongen, 2006; Saguy, 2011). Moreover, the interviews pointed to crucial role played by the existing product and process development knowledge when undertaking innovation projects (Avermaete et al., 2004; Grunert et al., 1997).

The Product-Process Complementarity Map was adopted at the end of the Phase 1 to test the validity of developed classification of complementarities among highly knowledgeable informants from the UK food and drink sector. The Map proved to be an effective management tool that enabled the interviewees to identify examples of New Product and Process Development projects of all of the illustrated complementarities, except from Product Amensalism complementarity. Moreover, a further complementarity type was identified; an incremental version of the Reciprocal complementarity. It was proposed to occur frequently, particularly when project was centred around utilising the existing product and process technologies with an aim to improve quality of the existing products. These projects were related to improvements to retailer's own label products based on consumers complaints. This complementarity was termed as Incremental Reciprocal complementarity and added to the existing Map. Furthermore, feedback from interviews enabled the researcher to enhance the visualisation of the Map by dividing the complementarity types into the two areas; exploitation and exploration. By doing this, the clarity of the Map was substantially improved.

10.2.3 Development of the Typology: Complementarity-Capability Matrix

While some of the complementarity types were referenced in previous literature (Abernathy and Utterback, 1978; Evangelista and Vezzani, 2010; Novotny and Laestadius, 2014), the conditions under which each of them is likely to emerge have never been described (Ballot et al., 2015; Damanpour, 2010; Storm et al., 2013). Building on the perspectives of the Resource-Based View (Barney, 2001; Leonard-Barton, 1992) and situating the research in the food and drink sector, the research project extends the literature by offering an original theory that specifies those conditions. In doing so, the study introduces three contingency factors commonly referenced in the literature on low-technology process industries, particularly the food and drink sector. These contingencies range over a spectrum (High/Medium/Low) of extents of dependence on existing technology trajectories in product and process (Bigliardi et al., 2013; Lefebvre et al., 2015; Trippl, 2011), spectrum of degrees of supply chain rigidities (Bergfors and Lager, 2011; Hutcheson et al., 1995; Lager and Frishammar, 2012) and spectrum of levels of potential and realised absorptive capacity (Avermaete et al., 2004; Chisea et al., 2004; Huston and Sakkab, 2006) across different complementarity strategies.

Each complementarity strategy is identified by three resources and capabilities in product innovation and three resources and capabilities in process innovation that play a critical role in driving choice and development of complementarity in the Product and Process Development Project. The pattern of the complementarity plays a significant role in allocating the resources and capabilities. For example, when undertaking Product Sequential complementarity, the dominant focus is placed on product innovation. The company has no or very low dependence on the existing technology trajectory in product, but has medium to high dependence on the existing process technology trajectory. By drawing a distinction between high, medium and low contingencies the research project elaborated on Klingebiel and Rammer's (2014) argument that the success of company's innovative activities is dependent on the amount and quality of resources allocated to the task. The Typology should be perceived as a starting point in answering the calls for future research on understanding contingencies that may influence types of complementarities evident inside the company (Ballot et al., 2015; Damanpour, 2010; Ennen and Richter, 2010; Lager, 2002; Lim et al., 2006; Storm et al., 2013).

10.2.4 Testing and extending the Typology: Complementarity-Capability Matrix with findings from eight case studies

In addition, the present study tested and extended the Typology: Complementarity-Capability Matrix using eight case studies of New Product and Process Development Projects from the food and drink sector. The aim was to evaluate the proposed contingencies (resources and capabilities) with the outcomes of these case studies. This resulted in a Revised Typology: Complementarity-Capability Matrix by extending the knowledge of contingencies influencing the choice of complementarity strategy. The Revised Typology represents the key output of this study - providing further guidance towards allocation of resources and capabilities in firms project portfolio of complementarities.

Although, the data from case studies generally supported the three proposed contingencies to influence the complementarity strategy. Several non-confirming cases revealed limitations of the Matrix and provided areas for further development. The propositions about influence of a spectrum of dependence on the existing technology trajectories were confirmed except from the Reciprocal complementarity. The case study of Best Brewery draught from can project revealed that in instances when only radical packaging innovation, rather than radical innovation including also the core product, is introduced, significant reconstruction of the existing packaging equipment will be sufficient instead of acquiring new equipment (medium dependence instead of no/low dependence).

In regards to supply chain rigidities, case studies confirmed that food and drink companies tended to rely on different forms of collaboration with equipment suppliers however, this was dependent on the extent of complementarity between product and process innovation. For instance, during higher extent of complementarity companies involved a range of external parties in development of product and process innovations. One of the exceptions was purchase of a new flow wrapping machine by Cornish Bakery that only required adjustment of settings that then enabled immediate packing of different order from a retailer. This, however, resulted in bakery's inability to utilise the flexibility of the machine in future projects. On the other hand, during projects illustrating lower extent of complementarity, suppliers of production equipment were involved in minor adjustments of settings of production equipment or in development of 'bolt on goodies.' But, for example in the case of pressure change of the minced meat, no collaboration with external parties was involved. The proposed proposition of presence of high supply chain rigidities in product innovation during projects with lower extent of complementarity was not confirmed. The case studies provided evidence that during innovation projects that are internally oriented, producing branded goods from popular product categories no retailer rigidities are imposed. Only the new complementarity type; Incremental Reciprocal complementarity, confirmed high extent of rigidities imposed by retailer towards an improvement of the existing own-label product.

The propositions about the required levels of potential and realised absorptive capacity in product and process innovation were largely confirmed in cases portraying higher extent of complementarity. The exception was again the case of purchase of packaging machine by Cornish Bakery - insufficient levels of absorptive capacity negatively influenced bakery's operational learning. Evidence from cases of lower extent of complementarity stressed the reliance of food and drink companies in their internal capabilities and knowledge learned from previous projects. Collaboration with external parties was sought only in instances when the knowledge was not available internally.

The above findings provide further insights into the allocation of resource and capabilities across a range of New Product and Process Development Projects by food and drink companies. Moreover, by situating the research within the context of process industries, the findings further contributed to this unexplored area (Robertson et al., 2009; Simms and Trott, 2014). Particularly research within low-technology sectors of process industries, such as the food and drink sector missed to provide insights into innovation types. The existing studies largely examined these two innovation types as separate phenomena (Avermaete et al., 2004; Baregheh et al., 2012; Capitanio et al., 2009). Generally, the innovation research tends to focus on the product and there seems to be relatively little academic attention towards process innovation (Frishammar et al., 2012; Reichstein & Salter, 2006).

10.3 Implications of findings for industry

The long-term competitiveness of any manufacturing company depends on its ability to deliver successful Product and Process Development Projects. Product and Process Development Managers face the important and difficult task of choosing the right innovation strategy for the needs of each New Product and Process Development project. A particular attention of Managers is required towards allocating the necessary time and resources to achieve their project aims. As such, they are required to effectively lead a portfolio of new projects and cannot follow strategies defined in the simplified product-process complementarity models developed at industry or company level.

The Revised Typology: Complementarity-Capability Matrix was developed with an aim to provide Managers working in the food and drink sector with a comprehensive resource allocation guide towards different innovation projects. The Matrix assists Managers with an application of seven complementarity types to their innovation project portfolios. Firstly, the Matrix can be adopted at the beginning of a new Product and Process Development project to enable companies choose the most suitable complementarity strategy given the aims of the project. This can benefit a company mainly by considerable time and resources savings, smoother operations and faster delivery of new products or production processes. Further, the Managers will also gain better understanding of the complementarity between processes and products within the particular project. As such, the ability to manage complementarities enables Managers to foresee the extent of complementarity and associated changes to product and process - leading to higher clarity in project's execution.

Secondly, the Matrix can be applied at the end of the project (*post-mortem*) to evaluate suitability of the complementarity strategy adopted. Equally, the Matrix can be applied to 'old' projects that did not use any complementarity strategy to identify a potential strong and weak points that then can be avoided or leveraged in the future projects. This practice will not only contribute to the organisational learning, but will also lead to a more organised choice of complementarity strategy in the future projects.

Except from providing the choice of complementarity types, the Matrix also serves as a guidance on the allocation of resources and capabilities towards these complementarity types (strategies). The identified resources and capabilities significantly influence product and process innovation in the food and drink sector and should be perceived as a crucial part of the planning process. Appropriate resource allocation strategy, based on the identified dependencies (technology-in-use, suppliers and customers, existing and acquired knowledge), prior to undertaking the project will ensure that resources are not wasted - the entire project becomes more cost efficient with smoother and quicker delivery of the end product.

Furthermore, the Matrix can be applied for an effective identification and allocation of new knowledge, resources and capabilities among different innovation projects within the company. For example, a new processing technology developed or licensed for purposes of one project can be adopted later in development of new products in the future. The same logics can be applied to incremental process innovation projects. For instance, changing the existing process to accommodate production of the new product (e.g. pressure change) can then be leveraged in developing new products that require similar process but differ from the original product for which the process was developed. This knowledge holds the potential to be applied across all product lines using the same processing technology leading to enhanced equipment efficiency. Therefore, one of the key benefits of the Matrix is its ability to help Managers to understand, plan for and leverage different complementarities within their innovation project portfolio.

The Product-Process Complementarity Map to position a portfolio of projects was developed to help Managers visualise the range of New Product and Process Development Projects that are being undertaken by the firm. This, rather holistic view of the current and potential projects enables Managers to see ‘the bigger picture’. Similarly to the widely used BCG Product Market Matrix that positions different products on the grid based on two criteria (market growth and market size), the Map positions different innovation projects based on the extent of complementarity and emphasis on product and process innovation. In addition, the Map is divided into two main parts that differentiate between; a) exploratory projects that require a high extent of complementarity between product and process innovation and b) exploitative project that require lower extent of complementarity. This visualisation enables Managers to see whether their innovation project portfolio is balanced between more radical projects and ‘safer’ incremental projects to ensure manageable distribution of risk.

10.4 Limitations of the research project

It is important to note that the primary interest of the current research project was to develop and test the typology of complementarity strategies occurring between product and process innovation at the New Product and Process Development Project level. Generalising these findings to further innovation projects in the food and drink sector and other low-technology process industry sectors was of a secondary concern. The proposed typology is an unique contribution to the literature on complementarities between product and process innovation. Due to its complexity, deducing and testing the contingencies influencing different complementarity strategies, in the form of theory-based propositions (typology), was perceived as an appropriate and necessary initial step (Lee et al., 1996). The present study therefore overcomes the limitation of the existing literature that largely focused on conceptual contributions, while providing limited empirical research (Klingebiel and Rammer, 2014).

This research project was limited to investigating food and drink companies in the UK. Each complementarity strategy, accept from Reciprocal complementarity, was tested on a single case study. Moreover, the current study was limited to three contingencies (technology trajectories, supply chain and absorptive capacity) that were identified as central to the choice of complementarity strategy. Hence, further validation of the findings using a multiple case study approach is necessary.

Finally, it has to be recognised that research into cases from other sectors of process industries may require changes to the contingencies (resources and capabilities) of the Revised Typology. Other innovation projects may be influenced by different internal as well as external factors. In other words, while this research warrants confidence in the validity of the Revised Matrix within the food and drink sector, the external validity of the typology is a subject to external verification.

10.5 Future research recommendations

The research project calls for a renewed research on the phenomenon of complementarity between product and process innovation, due to its prominence among process industry sectors. The high reference rate of the 'classic models', particularly the one developed by Abernathy and Utterback (1978) in the literature (Lager 2002; Lim et al., 2006), still provides evidence that the consideration of complementarity between product and process innovation lacks in receiving the required attention beyond the industry level (Lim et al., 2006; Reichstein and Salter, 2006).

The proposed Revised Typology: Complementarity-Capability Matrix constitutes the first step in the direction of strengthening the theoretical foundations for research on complementarities between product and process innovation at the New Product and Process Development Project level, and provides avenues for further research. Therefore, further case studies to measure the validity and applicability of this construct would need to be examined by future research. Each of the seven complementarities requires further exploration, while three complementarity types stand out as particularly interesting for the follow-up investigations.

1) Product Amensalism, because of its ability to harm company's innovation capabilities that may be unwittingly damaged. This complementarity was prosed to exist in the Typology: Complementarity-Capability Matrix, however none of the respondents from food and drink sector identified this complementarity to occur within their innovation project portfolios.

2) Reciprocal complementarity has favourable influence on company's performance, such as ability to control product mix more tightly and acquire flexible process equipment (Hayes and Wheelwright, 1979a; Kotabe and Murray, 1990), smoother launch of new products, more rapid penetration of new markets and ease of production ramp up process (Pisano and Wheelwright, 1995; Pisano 1997).

3) Incremental Reciprocal complementarity, is an unique contribution of exploratory Phase 1. Therefore, further case studies are required to examine the relevance of contingencies (resources and capabilities) required to achieve these complementarity types.

Secondly, the propositions assumed within the Revised Typology: Complementarity-Capability Matrix could be the source of a major empirical research. Future investigations could not only test their applicability to different sectors of process industries, but also suggest contingencies that are particularly relevant for each of the sectors individually and hence, follow the proposed theoretical base; the contingency approach. For example, by considering different New Product and Process Development Projects, researchers could attempt to answer the following questions; What type of complementarity was the company aiming for originally? Where did they end up? What factors influenced their decisions and behaviour? Why did they play a dominant role in firms decision making? Given the lack of academic focus on process industries, future research could provide more insights into innovation practices of both high and medium-low technology sectors.

Future studies can investigate the applicability of this Matrix in different national contexts within the process industry sectors. Interesting approach to investigating complementarity between product and process innovation will be by combining it with the impact of different moderating factors on complementarity. Thus, extending the Matrix to include further contingency factors (e.g. size, age, organisational structure, business model, managerial model) and their level of influence in different contexts.

11. References

Abernathy, W. J., & Townsend, P. L. (1975). Technology, productivity and process change. *Technological Forecasting and Social Change*, *7*(4), 379-396.

Abernathy, W.J., & Utterback, J. M. (1978). Patterns of Industrial Innovation. *Technology Review*, *June-July,* 41-47.

Abernathy, W. J., & Wayne, K. (1974). Limits of the learning curve. *Harvard Business Review*, *52*(5), 109-119.

Adegbesan, J. A. (2009). On the origins of competitive advantage: Strategic factor markets and heterogeneous resource complementarity. *Academy of Management Review*, *34*(3), 463-475.

Addy, R. (2014). *Raw material costs hit Scottish ingredients firm*. Retrieved form Food Manufacture website: http://www.foodmanufacture.co.uk/Business-News/Raw-material-costs-hit-Scottish-ingredients-firm

Addy, R. (2014b). Top healthy food trends: Healthy food at the forefront. Retrieved from Food Manufacture website: http://www.foodmanufacture.co.uk/NPD/Top-healthy-food-trends-low-sodium-at-forefront

Adler, P., Goldoftas, B., & Levine, D. (1999). Flexibility versus efficiency? A case study of model changeovers in the Toyota Production System. *Organization Science 10*, 43–68.

AIM European Brands Association & Food and Drink Europe. (2016). The economic impact of modern retail on choice and innovation in the EU food sector. Retrieved from: http://www.aim.be/uploads/brand_events_documents/AIM-FoodDrinkEurope.pdf

Amabile, T. M., Patterson, C., Mueller, J., Wojcik, T., Odomirok, P. W., Marsh, M., & Kramer, S. J. (2001). Academic-practitioner collaboration in management research: A case of cross-profession collaboration. *Academy of Management Journal*, *44*(2), 418-431.

Amaratunga, D., & Baldry, D. (2001). Case study methodology as a means of theory building: performance measurement in facilities management organisations. *Work study*, *50*(3), 95-105.

Anderson, P., & Tushman, M.L. (1991). Managing through cycles of technological change. *Research Technology Management. May/June,* 26-34.

Anselmsson, J., & Johansson, U. (2009). Retailer brands and the impact on innovativeness in the grocery market. *Journal of Marketing Management*, *25*(1-2), 75-95.

Arora, A., & Gambardella, A. (1994). Evaluating technological information and utilizing it: Scientific knowledge, technological capability, and external linkages in biotechnology. *Journal of Economic Behavior & Organization*, *24*(1), 91-114.

Artherton, M. (2016). *Dessert firm creates 50 jobs after 1.5M investment*. Retrieved from: http://www.foodmanufacture.co.uk/Business-News/Dessert-manufacturer-gains-1.5M-investment

Artherton, M. (2016). *Surrey brewery begins 400k expansion*. Retrieved: http://www.foodmanufacture.co.uk/Business-News/Brewery-embarks-on-400k-investment

Ashayeri, J., Teelen, A., & Selen, W. (1996) A Production and Maintenance Planning Model for the Process Industry. *International Journal of Production Research, 34(*12), 3311-3326.

Avermaete, T., Viaene, J., Morgan, E. J., Pitts, E., Crawford, N., & Mahon, D. (2004). Determinants of product and process innovation in small food manufacturing firms. *Trends in food science & technology*, *15*(10), 474-483.

Aylen, J. (2010). Open versus closed innovation: development of the wide strip mill for steel in the USA during the 1920's. *R&D Management*, 40, 67-80.

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

Baker, Ch. G. J. (2013). *Handbook of Food Factory Design*. New York: Springer.

Baker, S. E., Edwards, R., & Doidge, M. (2012). *How many qualitative interviews is enough?: Expert voices and early career reflections on sampling and cases in qualitative research*. Southampton: ESRC National Centre for Research Methods, University of Southampton.

Ballot, G., Fakhfakh, F., Galia, F., & Salter, A. (2015). The fateful triangle: Complementarities in performance between product, process and organizational innovation in France and the UK. *Research Policy, 44,* 217-232.

Bamford, W. (2014). Sugar puffs renamed honey monster puffs as halo cuts sugar from recipe and name. Retrieved from The Grocer website: http://www.thegrocer.co.uk/buying-and-supplying/marketing/sugar-puffs-rebrand-cuts-sugar-even-from-its-name/372590.article

Baregheh, A., Rowley, J., Sambrook, S., & Davies, D. (2012). Food sector SMEs and innovation types. *British Food Journal*, *114*(11), 1640-1653.

Barney, J. B. (2001). Resource-based theories of competitive advantage: A ten-year retrospective on the resource-based view. *Journal of Management, 27,* 643-650.

Barney, J. B., & Clark, D. N. (2007). *Resource-based theory: creating and sustaining competitive advantage.* Oxford: Oxford University Press.

Barras, R. (1986). Towards a theory of innovation in services. *Research Policy, 15,* 161-173.

Barras, R. (1990). Interactive innovation in financial and business services: The vanguard of the service revolution. *Research Policy, 19,* 215-237.

Barrett, A. (2003, January 27). DuPont Tries to Unclog a Pipeline. *Business Week,* 103–104.

Bartos, D. J. (2007). Is mining a high-tech industry? Investigations into innovation and productivity advance. *Resources Policy, 32,* 149-158.

Battisti, G., & Stoneman, P. (2010). How Innovative are UK Firms? Evidence from the Fourth UK Community Innovation Survey on Synergies between Technological and Organizational Innovations. *British Journal of Management, 21,*187-206.

Bauer, M., & Leker, J. (2013). Exploration and exploitation in product and process innovation in the chemical industry. *R&D Management, 43,* 196-212.

Beckeman, M., Bourlakis, M., & Olsson, A. (2013). The role of manufacturers in food innovations in Sweden. *British Food Journal*, *115*(7), 953-974.

Bellgran, M., & Säfsten, K. (2010). *Production Development: Design and Operation of Production Systems*. London: Springer.

Benner, M. J., & Tushman, M. (2003). Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of Management Review, 28,* 238-256.

Bengtsson, M., & Kock, S. (2000). Coopetition' in business networks – to cooperate and compete simultaneously. *Industrial Marketing Management*, *29*, 411-426.

Berchicci, L., Tucci, Ch. L. & Zazzara, C. (2013). The influence of industry downturns on the propensity of product versus process innovation. *Industrial and Corporate Change, 23,* 429-465.

Bergfors, M., & Lager, T. (2011). Innovation of Process Technology: Exploring Determinants for Organizational Design. *International Journal of Innovation Management, 15,* 1113-1140.

Bergfors, M., & Larsson, A. (2009). Product and process innovation in process industry: a new perspective on development. *Journal of Strategy and Management, 2,* 187-206.

Bessant, J., & Tidd, J. (2007). *Innovation and entrepreneurship*. John Wiley & Sons.

Beverland, M., Farrelly, F., & Quester, P. (2006). Brand-personal values fit and brand meanings: Exploring the role individual values play in ongoing brand loyalty in extreme sports subcultures. *NA-Advances in Consumer Research, 33*.

Bigliardi, B., & Dormio, I. A. (2009). An empirical investigation of innovation determinants in food machinery enterprises. *European Journal of Innovation Management*, *12*(2), 223-242.

Bigliardi, B., & Galati, F. (2013). Innovation trends in the food industry: The case of functional foods. *Trends in Food Science & Technology, 31,* 118-129.

Bierly, P., & Chakrabarti, A. (1996). Generic knowledge strategies in the US pharmaceutical industry. *Strategic Management Journal 17,* 123–135.

Blalock, H. M., Jr. (1969). *Theory construction: From verbal to mathematical formulations.* Englewood Cliffs, NJ: Prentice Hall.

Bonaccorsi, A., & Lipparini, A. (1994). Strategic partnerships in new product development: an Italian case study. *Journal of product innovation management*, *11*(2), 134-145.

Boyer, K. K., & McDermott, C. (1999). Strategic consensus in operations strategy. *Journal of Operations Management*, *17*(3), 289-305.

Brewin, D. G., Monchuk, D. C., & Partridge, M. D. (2009). Examining the adoption of product and process innovations in the Canadian food processing industry. *Canadian Journal of Agricultural Economics*, *57*(1), 75-97.

Brinkmann, P., Håkansson, A., Būtienė, I., Kjærsgard, H., Mortensen, B.K., Martens, J., Müller-Hansen, B., & Petrenko, A. (2014). The use of networks as a strategic approach of micro-enterprises in the agri-food sector. *The International Journal of Entrepreneurship and Innovation*, *15*(3), 169-178.

British Automation and Robot Association. (2014). *Automating Manufacturing Programme is extended*. Retrieved from: http://www.bara.org.uk/News/pdf/BARA-News-Issue-22.pdf

British Soft Drinks Association. (2014). *Creating new choices: The 2014 UK Soft Drinks Report.* Retrieved from: http://www.britishsoftdrinks.com/write/mediauploads/publications/revised_bsda_annual_report_2014.pdf

Britz, T. J., & Robinson, R. K. (2008). *Advanced dairy science and technology*. Oxford: Blackwell.

Brown, S. L., & Eisenhardt, K. M. (1995). Product development: Past research, present findings, and future directions. *Academy of management review*, *20*(2), 343-378.

Browning, T. R., & Ramasesh, R. V. (2007). A Survey of Activity Network-Based Process Models for Managing Product Development Projects. *Production and Operations Management*, *16*(2), 217-240.

Brynjolfsson, E., & Hitt, L. M. (2000). Beyond computation: Information technology, organizational transformation and business performance. *The Journal of Economic Perspectives*, *14*(4), 23-48.

Bruce, A. (2011). *Leeds Foods hit by commodity prices*. Retrieved from: http://www.foodmanufacture.co.uk/Business-News/Lees-Foods-hit-by-commodity-prices

Bruch, J., & Bellgran, M. (2014). Integrated portfolio planning of products and production systems. *Journal of Manufacturing and Technology Management, 25,* 155-174.

Bunduchi, R., & Smart, A. U. (2010). Process innovation costs in supply networks: a synthesis. *International Journal of Management Reviews, 12,* 365-383.

Burgelman, R. (1983). A process model of internal corporate venturing in a major diversified firm. *Administrative Science Quarterly, 28*, 223-244.

Burns, T., & Stalker, T. M. (1961). *The Management of Innovation.* London: Tavistock.

Burrell, G. and Morgan, G. (1994). *Sociological Paradigms and Organisational Analysis*. Aldershot: Ashgate Publishing Limited

Burt, S., & Davies, K. (2010). From the retail brand to the retail-er as a brand: themes and issues in retail branding research. *International Journal of Retail & Distribution Management, 38(*11), 865-878.

Burt, S., & Sparks, L. (2003). Power and competition in the UK retail grocery market. *British Journal of Management*, 14 (3), 237-254.

Cabagnols, A., Le Bas, C. (2002). Differences in the determinants of product and process innovations: the French case. In A. Kleinknecht and P. Mohnen (Eds.), *Innovation and Firm Performance* (pp.112-149). New York: Palgrave.

Caizza, R. & Volpe, T. (2013). How Canadian small and medium enterprises (SMEs) can compete in the global agro-food industry. *Journal of Food Products Marketing, 19(*5), 406-412.

Caloghirou, Y., Kastelli, I., & Tsakanikas, A. (2004). Internal capabilities and external knowledge sources: complements or substitutes for innovative performance? *Technovation. 24*(1), 29-39.

Camisón, C., & Forés, B. (2010). Knowledge absorptive capacity: New insights for its conceptualization and measurement. *Journal of Business Research*, *63*(7), 707-715.

Capitanio, F., Coppola, A., & Pascucci, S. (2010). Product and process innovation in the Italian food industry. *Agribusiness*, *26*(4), 503-518.

Capon, N., Farley, J. U., Lehmann, D. R., & Hulbert, J. M. (1992). Profiles of product innovators among large U.S. manufacturers. *Management Science, 38,* 157-169.

Cassiman, B., & Veugelers, R. (2006). In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Science*, *52*(1), 68-82.

Charmaz, K. (2014). *Constructing grounded theory*. London: Sage.

Chaudhuri, A. (2013). Simultaneous improvement in development time, cost and quality: a practical framework for generic pharmaceuticals industry. *R&D Management, 43,* 227-241.

Chen, L. H., & Hung, C. C. (2010). An integrated fuzzy approach for the selection of outsourcing manufacturing partners in pharmaceutical R&D. *International Journal of Production Research, 48,* 7483-7506.

Chesbrough, H.W. (2003). The era of open innovation. *MIT Sloan Management Review*, *44* (3), 35-41.

CIAA. (2008). *Review of Key Competitiveness Indicators for the European Food Industry*. Brussels: CIAA

Chiaroni, D., Chiesa, V., & Frattini, F. (2011). The Open Innovation Journey: How firms dynamically implement the emerging innovation management paradigm. *Technovation*, *31*(1), 34-43.

Child, J. (2005). *Organizations: Contemporary Principles and Practices.* Basil Blackwell, London.

Christensen, C. M., & Bower, J. L. (1996). Customer power, strategic investment, and the failure of leading firms. *Strategic management journal*, *17*(3), 197-218.

Christopher, M., & Jüttner, U. (2000). Developing strategic partnerships in the supply chain: a practitioner perspective. *European Journal of Purchasing & Supply Chain Management, 6,* 117-127.

Clark, K.B., & Wheelwright, S.C. (1993). *Managing New Product and Process Development: Text and Cases.* NY: Free Press.

Clausen, T. H. (2013). External knowledge sourcing from innovation cooperation and the role of absorptive capacity: empirical evidence from Norway and Sweden. *Technology Analysis & Strategic Management*, *25*(1), 57-70.

Clifford, E. (2016). *Food Packaging Trends- UK*. Retrieved from Mintel Academic website: http://academic.mintel.com/display/747404/

De Clercq, D., Thongpapanl, N. T., & Dimov, D. (2013). Shedding new light on the relationship between contextual ambidexterity and firm performance: an investigation of internal contingencies. *Technovation*, *33*(4), 119-132.

Cobbenhagen, J., den Hertog, F., & Philips, G. (1990). Management of innovation in the processing industry: a theoretical framework. In C. Freeman & L. Soete (Eds.), *New Explorations in the Economics of Technological Change* (pp. 55–72). London: Printer Publishers.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative science quarterly*, 128-152.

Collins, R., & Bechler, K. (1999). Outsourcing in the Chemical and Automotive Industries: Choice or Competitive Imperative? *Journal of Supply Chain Management. 35,* 4-11.

Collins, P. D., & Hull, F. M. (2002). Early simultaneous influence of manufacturing across stages of the product development process: impact on time and cost. *International Journal of Innovation Management*, *6*(1), 1-24.

Competition and Markets Authority. (2008). *Groceries Market Investigation*. Retrieved from GOV.UK website: https://www.gov.uk/cma-cases/groceries-market-investigation-cc

Cooper, R. G. (1979). The dimensions of industrial new product success and failure. *The Journal of Marketing*, 93-103.

Cooper, R.G., Edgett, S. J., & Kleinschmidt, E. J. (1997). Portfolio management in new product development: Lessons from the leaders- I. *Research Technology Management, Sept-Oct, 16-28*.

Cooper, R. (1999). The invisible success factors in product innovation. *Journal of Product Innovation Management, 16,* 115-33.

Cooper, R.G., Edgett, S.J. & Kleinschmidt, E.J. (2001). *Portfolio Management for New Products*. 2nd ed. Perseus, Cambridge, MA.

Cooper, R.G. (2008)**.** Perspective: The Stage-Gate® Idea-to-Launch Process-Update, What's New, and NexGen Systems. *Journal of Product Innovation Management. 25,* 213-232.

Cooper, R. G., & Kleinschmidt, E. J. (1994). Determinants of timeliness in product development. *Journal of Product Innovation Management, 11*: 381-396.

Corbin, T. (2016). *Northern Ireland packaging firm invests £2M in export drive*. Retrieved from: http://www.packagingnews.co.uk/news/business/ni-packaging-firm-invests-over-2m-for-export-drive-05-10-2016

Corley, K. G., & Gioia, D. A. (2011). Building theory about theory building: what constitutes a theoretical contribution?. *Academy of management review*, *36*(1), 12-32.

Costa, A.I.A. & Jongen, W.M.F. (2006). New insights into consumer-led food product development. *Trends in Food Science and Technology, 17(*8), 457.

Cotterill, R.W. & Putsis, W.P. (2000). Market share and price setting behavior for private labels and national brands. *Review of Industrial Organization, 17(*1), 17-39.

Creswell, J. W., & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into practice*, *39*(3), 124-130.

Crawford, L., Hobbs, J. B., & Turner, J. R. (2006). Aligning capability with strategy: Categorizing projects to do the right projects and to do them right. *Project Management Journal*, *37*(2).

Dahlander, L., & Gann, D. M. (2010). How open is innovation?. *Research policy*, *39*(6), 699-709.

Damanpour, F., & Gopalakrishnan, S. (2001). The Dynamics of the adoption of Product and Process Innovation in Organizations. *Journal of Management Studies, 38*(1), 45-65.

Damanpour, F. (2010). An Integration of Research Findings of Effects of Firm Size and Market Competition on Product and Process Innovations. *British Journal of Management, 21,* 996-1010.

Damanpour, F. (2014). Footnotes to research on management innovation. *Organization Studies*, *35*(9), 1265-1285.

Davies, A. 2015. *Innovation and Project Management.* In. Dodgson, M., Gann, D.M. and Phillips, N. 2015. The Oxford Handbook of Innovation Management. NY: Oxford University Press

Day, G.S. & Moorman, C. (2010). *Strategy from the Outside*. NY: McGraw-Hill.

Delivans, Ch., & Rendle, J. (2015). *The path back to value in prepared meals*. Retrieved from: http://www.foodmanufacture.co.uk/Business-News/Prepared-meals-the-path-back-to-value

Dennis, D., & Meredith, J. (2000). An empirical analysis of process industry transformation systems. *Management Science, 46,* 1085-1099.

Department for Environment, Food and Rural Affairs. (2016). *Food Statistics Pocketbook 2015.* Retrieved from Department for Environment, Food and Rural Affairs, GOV.UK website: https://www.gov.uk/government/collections/food-statistics-pocketbook

DeSarbo, W., Di Benedetto, A., Song, M., & Sinha, I. J. (2005). Extending the miles and snow strategic framework: Strategic types, capabilities, environmental uncertainty, and firm performance. *Strategic Management Journal*, *26*(1), 47-74.

Desouza, K.C., Awazu, Y., & Jasimuddin, S. (2005). Utilizing external sources of knowledge. *KM Review, 8*(1), 16-19.

Diageo. (2015). *Financial Reports*. Retrieved from Diageo website: http://www.diageo.com/en-us/investor/Pages/financialreports.aspx

Dobson, P., & Charkaborty, R. (2015). Assessing Brand and Private Label Competition. *European Competition Law Review, 2,* 76-81.

Donaldson, L. (2001). *The Contingency Theory of Organizations.* London: Sage Publications.

Doty, D. H., & Glick, W. H. (1994). Typologies as a unique form of theory building: Toward improved understanding and modeling. *Academy of management review*, *19*(2), 230-251.

Dubois, A., & Gadde, L. E. (2002). Systematic combining: an abductive approach to case research. *Journal of Business Research*, *55*(7), 553-560.

Duncan, R.B. (1972). Characteristics of organizational environments and perceived environmental uncertainty. *Administrative Science Quarterly, 17,* 313-327.

Durand, T. (1992). Dual technological trees: Assessing the intensity and strategic significance of technological change. *Research policy, 21,* 361-380.

Earle, M. D. (1997). Innovation in the food industry. *Trends in Food Science & Technology*, *8*(5), 166-175.

Edquist, C., Hommen, L., & Mckelvey, M. (2001). *Innovation and Employment: Process versus Product Innovation.* Cheltenham, UK: Edward Elgar.

Edmondson, A. C., & McManus, S. E. (2007). Methodological fit in management field research. *Academy of management review*, *32*(4), 1246-1264.

Eisenhardt, K. M. (1989). Agency theory: An assessment and review. *Academy of management review*, *14*(1), 57-74.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of management journal*, *50*(1), 25-32.

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: what are they? *Strategic management journal*, *21*(10-11), 1105-1121.

El Shafeey, T., & Trott, P. (2014). Resource-based competition: three schools of thought and thirteen criticisms. *European Business Review*, 26, 122-148.

Encyclopedia Britannica. (2015). *Definition Amensalism*. Retrieved from: http://www.britannica.com/science/amensalism

Engineering and Machinery Alliance. (2010). *Automation Study 2010*. Retrieved from: http://www.eama.info/downloads/Automation%20Study%20%96%20highlights%20from%20the%20benchmarking%20study.pdf

Engwall, M. (2003). No project is an island: linking projects to history and context. *Research Policy*, *32*(5), 789-808.

Ennen, E., & Richter, A. (2010). The Whole Is More than the Sum of Its Parts- Or Is It? A Review of the Empirical Literature on Complementarities in Organizations. *Journal of Management*, *36,* 207-233.

Erickson, P. (2008). Partnering for innovation. *Food Technology, 62(*1), 32-37

Evangelista, R., & Vezzani, A. (2010). The economic impact of technological and organizational innovations. A firm-level analysis. *Research Policy*, *39,* 1253-1263.

Esbjerg, L., Burt, S., Pearse, H., & Glanz-Chanos, V. (2016). Retailers and technology-driven innovation in the food sector: caretakers of consumer interests or barriers to innovation? *British Food Journal*, *118*(6), 1370-1383.

Ettlie, J.E. (1988). *Taking charge of manufacturing: how companies are combining technological and organizational innovations to compete successfully.* San Francisco: Jossey-Bass, Inc. Publishers.

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

Ettlie, J., & Reza, E. (1992). Organizational Integration and process innovation. *Academy of Management Journal. 35,* 795-827.

Euromonitor International. (2015). *Packaged Food in the United Kingdom.* Retrieved from Euromonitor International website: http://www.euromonitor.com/packaged-food-in-the-united-kingdom/report

Euromonitor International. (2016). *Retailing in the United Kingdom*. Retrieved from Euromonitor International website: http://www.euromonitor.com/retailing-in-the-united-kingdom/report

European Commission. (2014). *The Economic Impact of Modern Retail on Choice and Innovation in the EU Food Sector*. Retrieved from: http://ec.europa.eu/competition/publications/KD0214955ENN.pdf

European Commission. (2016*). Packaging and Packaging waste: European Parliament and Council Directive 94/62/EC. Definition of Packaging.* Retrieved from European Parliament website: http://ec.europa.eu/environment/waste/packaging/index_en.htm

Farrell, C. (2015). *Tesco to let customers to shop with Google Glass using new app.* Retrieved from: http://m.thegrocer.co.uk/stores/store-design/tesco-to-let-customers-shop-with-google-glass-using-new-app/511985.article

Fearne, A., & Hughes, D. (2013). Success factors in the fresh produce supply chain. *British food journal*. *102,* 760-772.

Featherston, C. R., Ho, J. Y., Brévignon-Dodin, L., & O'Sullivan, E. (2016). Mediating and catalysing innovation: A framework for anticipating the standardisation needs of emerging technologies. *Technovation*, *48*, 25-40.

Feldman, M.P., & Ronzio, C.R. (2001). Closing the innovative loop: moving from the laboratory to the shop floor in biotechnology manufacturing. *Entrepreneurship & Regional development*, 13, 1-16.

Fernie, J., Sparks, L., & McKinnon, A. C. (2010). Retail logistics in the UK: past, present and future. *International Journal of Retail & Distribution Management*, *38*(11/12), 894-914.

Fiss, P. C. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. *Academy of Management Journal*, *54*(2), 393-420.

Fitjar, R. D., & Rodríguez-Pose, A. (2011). When local interaction does not suffice: sources of firm innovation in urban Norway. *Environment and Planning*, *43*(6), 1248-1267.

Fitjar, R. D., & Rodríguez-Pose, A. (2013). Firm collaboration and modes of innovation in Norway. *Research Policy*, *42*(1), 128-138.

Fillipou, D., & King, M.G. (2011). R&D prospects in the mining and metals industry. *Resources Policy*, *36,* 276-284.

Flick, U. (2009). *An introduction to qualitative research*. London: Sage.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research.*Qualitative inquiry*, *12*(2), 219-245.

Food and Drink Federation (FDF). (2016). *Representing the UK's largest manufacturing sector.* Retrieved from: http://www.fdf.org.uk/statsataglance.aspx

Food and Drink Federation (FDF). (2016). *Delivering sustainable growth through innovation.* Retrieved from Food and Drink Federation website: http://www.fdf.org.uk/growth-through-innovation.aspx

Food Pocketbook. (2015). *Department for Environment, Food and Rural Affairs, 2016.* Retrieved from GOV.UK website: https://www.gov.uk/government/collections/food-statistics-pocketbook

Fortuin, F. T., & Omta, S. W. F. (2009). Innovation drivers and barriers in food processing. *British Food Journal*, *111*(8), 839-851.

Fortune, J., White, D., Jugdev, K., & Walker, D. (2011). Looking again at current practice in project management. *International Journal of Managing Projects in Business*, *4*(4), 553-572.

Fosfuri, A., & Tribó, J. A. (2008). Exploring the antecedents of potential absorptive capacity and its impact on innovation performance. *Omega*, 36, 173-187.

Francis, D., & Bessant, J. (2005). Targeting innovation and implications for capability development. *Technovation*, *25*(3), 171-183.

Fredericks, E. (2005). Infusing flexibility into business-to-business firms: A contingency theory and resource-based view perspective and practical implications. *Industrial Marketing Management*, *34,* 555-565.

Frishammar, J., & Hörte, S. (2005). Managing external information in manufacturing firms: The impact on innovation performance. *Journal of Product Innovation Management*, *22,* 251-266.

Frishammar, J., Kurkkio, M., Abrahamsson, L., & Lichtenthaler, U. (2012). Antecedents and consequences of firm's process innovation capability: a literature review and conceptual framework. *Engineering Management IEEE Transactions*, *99,* 1-11.

Fritsch, M., & Meschede, M. (2001). Product Innovation, Process Innovation, and Size. *Review of Industrial Organization*, *19,* 335-350.

Fuller, G.W. (2011). *New Food Product Development: From Concept to Marketplace.* 3rd ed. London: CRC Press.

Gander, P. (2016). *From automation to optimisation.* Retrieved from Food Manufacture website: http://www.foodmanufacture.co.uk/Manufacturing/Automation-helps-integrate-control-with-information

Garud, R., & Nayyar, P.R. (1994). Transformative capacity: Continual structuring by intertemporal technology transfer. *Strategic Management Journal*, 35, 365-385.

Gatignon, H., Tushman, M. L., Smith, W., & Anderson, P. (2002). A structural approach to assessing innovation: construct development of innovation locus, type, and characteristics. *Manage Science. 48*(9), 1103–22.

Gautié, J., & Schmitt, J. (2009). *Low-wage work in wealthy world.* New York: Russell Sage Foundation.

Gebauer, H., Worch, H., & Truffer, B. (2012). Absorptive capacity, learning processes and combinative capabilities as determinants of strategic innovation. *European Management Journal*, *30*(1), 57-73.

Gellynck, X., Vermeire, B., & Viaene, J. (2007). Innovation in food firms: contribution of regional networks within the international business context. *Entrepreneurship & Regional Development*, *19*(3), 209-226.

Ghemawat, P., Costa, R. J. (1993). The organizational tension between static and dynamic efficiency. *Strategic Management Journal 14*, 59–73.

Gibbert, M., Ruigrok, W., & Wicki, B. (2008). What passes as a rigorous case study? *Strategic management journal*, *29*(13), 1465-1474.

Gibson, C., & Birkinshaw, J. (2004). The antecedents, consequences, and mediating role of organizational ambidexterity. *Academy of Management Journal, 47*, 209–226.

Gioia, D. A., & Pitre, E. (1990). Multiparadigm perspectives on theory building. *Academy of management review*, *15*(4), 584-602.

Glaser, B. G., & Strauss, A. L. (1967). *Discovery of grounded theory.* New York: Mill Valley.

Gladding, N. (2016). *Five year forecast: The grocery market by 2021.* Retrieved from IGD website: http://www.igd.com/Research/Retail/Five-year-forecast-the-grocery-market-by-2021/

Glotz, J. (2016). *A third of UK shoppers willing to buy groceries direct from suppliers.* Retrieved from The Grocer website: http://www.thegrocer.co.uk/channels/online/a-third-of-uk-shoppers-willing-to-buy-groceries-direct-from-suppliers/531948.article

Gomes, J. F. (2003). Order and disorder in product innovation models. *Creativity and innovation management*, *12*(3), 174-187.

Gooroochurn, N., & Hanley, A. (2007). A tale of two literatures: transaction costs and property rights in innovation outsourcing. *Research Policy*, *36*(10), 1483-1495.

Grant, R.M. (1991). The Resource Based Theory of Competitive Advantage: Implications for Strategy Formulation. In M.H. Zack, (Ed.), *Knowledge and Strategy* (pp. 114-135). Oxford: Routledge Taylor & Francis.

Groceries Code Adjudicator. (2016). *What we do.* Retrieved from GOV.UK website: https://www.gov.uk/government/organisations/groceries-code-adjudicator/about

Groceries Code Adjudicator. (2016b). Annual Sector Survey Results 2016. Retrieved from GOV.UK website: https://www.gov.uk/government/publications/annual-sector-survey-results-2016

Grunert, K. G. (1997). What's in a steak? A cross-cultural study on the quality perception of beef. *Food quality and preference*, *8*(3), 157-174.

Grunert, K. G., Jensen, B. B., Sonne, A. M., Brunsø, K., Byrne, D. V., Clausen, C.,& Lettl, C. (2008). User-oriented innovation in the food sector: relevant streams of research and an agenda for future work. *Trends in Food Science & Technology*, *19*(11), 590-602.

Gupta, A. K., Tesluk, P. E., & Taylor, M. S. (2007). Innovation at and across multiple levels of analysis. *Organization Science*, *18*(6), 885-897.

Gupta, A.K., & Souder, W. E. (1998). Key drivers of reduced cycle time. *Research Technology Management, 41,* 38-43.

Handfield, R. B., & Melnyk, S. A. (1998). The scientific theory-building process: a primer using the case of TQM. *Journal of operations management*, *16*(4), 321-339.

Hayes, D. C. (1977). The contingency theory of managerial accounting. *Accounting review, 52,* 22-39.

Hayes, R.H., & Wheelwright, S.G. (1979a). The dynamics of process-product lifecycles. *Harvard Business Review, 57,* 127-136.

Hayes, R.H., & Wheelwright, S.G. (1979b). Link Manufacturing Process and Product Life Cycles. *Harvard Business Review*, *January-February,* 133-140.

Hayes, R. H., & Wheelwright, S.C. (1984). *Restoring our Competitive Edge: Competing Through Manufacturing.* New York: John Wiley & Sons.

He, Z. L., & Wong, P. K. (2004). Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis. *Organization science*, *15*(4), 481-494.

Helfat, C.E., & Peteraf, M.A. (2003). The dynamic resource-based view: capability lifecycles. *Strategic Management Journal, 24,* 997-1010.

Henderson, R.M., & Clark, K. B. (1990). Architectural innovation: the reconfiguration of existing product technology and the failure of established firms. *Administrative Science Quarterly, 35,* 9-31.

Hillebrand, B., Kok, R. A., & Biemans, W. G. (2001). Theory-testing using case studies: a comment on Johnston, Leach, and Liu. *Industrial Marketing Management*, *30*(8), 651-657.

Hingley, M. K. (2005). Power imbalance in UK agri-food supply channels: Learning to live with the supermarkets?. *Journal of Marketing Management*, *21*(1-2), 63-88.

Hingley, M., Lindgreen, A., & Casswell, B. (2006). Supplier-retailer relationships in the UK fresh produce supply chain. *Journal of International Food & Agribusiness Marketing*, *18*(1-2), 49-86.

Hingley, M. & Hollingsworth, A. (2003). Competitiveness and power relationships: where now for the UK food supply chain? Proceedings of the 19th Annual IMP Conference, Lugano, Switzerland.

HM Government. (2015). *Strengthening UK manufacturing supply chains.* Retrieved from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/407071/bis-15-6-strengthening-uk-manufacturing-supply-chains-action-plan.pdf

Hobday, M. (1998). Product complexity, innovation and industrial organisation. *Research Policy*, 26, 689-710.

Hollenstein, H. (2003). Innovation modes in the Swiss service sector: a cluster analysis based on firm-level data. *Research Policy, 32,* 845-863.

Howells, J., Gagliardi, D., & Malik, K. (2008). The growth and management of R&D outsourcing: evidence from UK pharmaceuticals. *R&D Management, 38,* 205-219.

Huang, F., & Rice, J. (2009). The Role of Absorptive Capacity in Facilitating “Open Innovation” Outcomes: A Study of Australian SMEs in the Manufacturing Sector. *International Journal of Innovation Management, 13,* 201-220.

Huang, F., & Rice, J. (2012). Openness in Product and Process Innovation. *International Journal of Innovation Management, 16,* 1-24.

Hullova., D., Trott, P. & Simms, C.D. (2016). Uncovering the reciprocal complementarity between product and process innovation. *Research Policy*, *45,* 929-940.

Huston, L., & Sakkab, N. (2006). Connect and develop: inside Procter and Gamble's new model for innovation. *Harvard Business Review, 84*, 58–66.

Hutcheson, P., Pearson, A.W., & Ball, D.F. (1995). 'Innovation in process plant: a case study of ethylene'.*Journal of Product Innovation Management*. *12*(5), 415-430.

Institute of European and Comparative Law, University of Oxford. (2015). *Trends in Retail Competition: Private Label, Brands and Competition Policy.* Retrieved from University of Oxford website: https://www.law.ox.ac.uk/sites/files/oxlaw/symposium_report_2015.pdf

International Federation of Robotics. (2016). *World Robotics 2015 Industrial Robots*. Retrieved from International Federation of Robotics website: http://www.ifr.org/industrial-robots/statistics/

IGD Retail Analysis. (2016). *UK Grocery Retailing.* Retrieved from IGD website: http://www.igd.com/Research/Retail/UK-grocery-retailing/

Jansen, J.J.P., Van den Bosch, F.A.J., & Volberda, H.W. (2005). Exploratory innovation, exploitative innovation, and performance: Effects of organizational antecedents and environmental moderators. *Management Science, 52,* 1661-1674.

Järvensivu, T., & Möller, K. (2009). Metatheory of network management: A contingency perspective. *Industrial Marketing Management, 38,* 654-661.

Jensen, M. B., Johnson, B., Lorenz, E., & Lundvall, B. Å. (2007). Forms of knowledge and modes of innovation. *Research policy*, *36*(5), 680-693.

Kähkönen, A. K. (2014). The influence of power position on the depth of collaboration. *Supply Chain Management: An International Journal*, *19*(1), 17-30.

Kähkönen, A. K., & Virolainen, V. M. (2011). Sources of structural power in the context of value nets. *Journal of Purchasing and Supply Management*,*17*(2), 109-120.

Kantar Worldpanel. (2016). *Great Britatin: Grocery Market Share*. Retrieved from: http://www.kantarworldpanel.com/en/grocery-market-share/great-britain

Kauffman, S., Lobo, J., & Macready, W.G. (2000). Optimal search on a technology landscape. *Journal of Economic Behavior & Organization, 43,* 141-166.

Keupp, M. M. Palmié, M., & Gassmann, O. (2012). A strategic management of innovation: a systematic literature review and paths for future research. *International Journal of Management Reviews. 14,* 367-390.

Kibbelling, M., van der Bij, H., & van Weele, A. (2013). Market Orientation and Innovativeness in Supply Chains: Supplier's Impact on Customer Satisfaction. *Journal of Product Innovation Management. 30*(3), 500-515.

Kim, J. S., Ritzman, L. P., Benton, W. C., & Snyder, D. L. (1992). Linking Product Planning and Process Design Decisions. *Decision Sciences, 23,* 44-60.

Killen, C.P. and Hunt, R.A. (2010). Dynamic capability through project portfolio management in service and manufacturing industries. *International Journal of Managing Projects in Business*, 3: 157-69.

Killen, C. P., & Hunt, R. A. (2013). Robust project portfolio management: capability evolution and maturity. *International Journal of Managing Projects in Business*, *6*(1), 131-151.

Klein, B., and Meckling, W. (1958). Application of Operations Research to Development Decisions. *Operations Research*. 6, 352-363.

Klepper, S. (1997). Industry life cycles. *Industrial and corporate change*, *6*(1), 145-182.

Klingebiel, R., & Rammer, C. (2014). Resource allocation strategy for innovation portfolio management. *Strategic Management Journal*, *35*(2), 246-268.

Knott, M. (2016). *Food chain transparency is the goal*. Retrieved from: http://www.foodmanufacture.co.uk/Supply-Chain/Food-supply-chain-seeks-transparency

Knox, B., Parr, H. & Bunting, B. (2001). Model of 'best practice' for the food industry. Proceedings of the British Nutrition Society, 60, 169.

Knudsen, M. P. (2007). The relative importance of interfirm relationships and knowledge transfer for new product development success. *Journal of Product Innovation Management*, *24*(2), 117-138.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capacities and the replication of tech- nology. *Organization Science, 3,* 383-397.

Kotabe, M., Murray, J.Y. (1990). Linking product and process innovations and modes of international sourcing in global competition: a case of foreign multinational firms. *Journal of International Business Studies, 21,* 383-408.

Kotabe, M. (1990). Corporate product policy and innovation behaviour of European and Japanese multinationals: an empirical investigation. *Journal of Marketing, 54,* 19-33.

Kottila, M. R., & Rönni, P. (2008). Collaboration and trust in two organic food chains. *British Food Journal*, *110*(4/5), 376-394.

Kraft, K. (1990). Are product- and process-innovations independent of each other? *Applied Economics, 22,* 1029-1038.

Kumar, N. (1996). The power of trust in manufacturer/ retailer relationships. *Harvard Business Review, November – December,* 92-106.

Kurkkio, M. Frishammar, J., & Lichtenthaler, U. (2011). Where process development begins: a multiple case study of front end activities in process firms. *Technovation. 31,* 490-504.

Kühne, B. (2011). *Understanding innovation capacity in food chains: the European traditional food sector* (Doctoral dissertation, Ghent University).

Kühne, B., Gellynck, X., & Weaver, R. D. (2013). The influence of relationship quality on the innovation capacity in traditional food chains. *Supply Chain Management: An International Journal*, *18*(1), 52-65.

Kühne, B., Vanhonacker, F., Gellynck, X., & Verbeke, W. (2010). Innovation in traditional food products in Europe: Do sector innovation activities match consumers' acceptance? *Food Quality and Preference*, *21*(6), 629-638.

Laaksonen, H. & Reynolds, J. (1994). Own Brands in Food Retailing Across Europe. *Journal of Brand Management*, 2, 37–46.

Lager, T. (2002). Product and Process Development Intensity in Process Industry: A conceptual and empirical analysis of the allocation of company resources for the development of process technology. *International Journal of Innovation Management, 6,* 105-130.

Lager, T. (2011). *Managing Process Innovation: From Idea Generation to Implementation.* London: Imperial College Press.

Lager, T., & 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,* 128-150.

Lager, T., & Frishammar, J. (2010). Equipment supplier/user collaboration in the process industries. *Journal of Manufacturing Technology Management, 21,* 698-720.

Lager, T., & Frishammar, J. (2012). Collaborative development of new process technology/ equipment in the process industries: in search of enhanced innovation performance. *Journal of Business Chemistry, 9,* 67-84.

Lager, T., & Storm, P. (2013). Application development in process firms: adding value to customer products and production systems. *R&D Management, 43,* 288-302.

Lager, T., Blanco, S., & Frishammar, J. (2013). Managing R&D and innovation in the process industries. *R&D Management, 43,* 189- 195.

Lane, P. J., Koka, B.R., & Pathak, S. (2006). The reification of absorptive capacity: a critical review and rejuvenation of the construct. *Academy of Management Review, 31,* 833-863.

Langhauser, K. (2008). *Are you playing the lean game evaluating the food industry's lean comeback*. Retrieved from: http://www.foodmanufacturing.com/article/2008/10/are-you-playing-lean-game

Lagnevik, M., Sjöholm, I., Lareke, A. & Östberg, J. (2003). *The Dynamics of Innovation Clusters: A Study of the Food Industry*. Cheltenham: Edward Elgar.

Lake, R. (2015). *Packaging Automation Demonstrates Truly Revolutionary High Speed Tray Sealer at Fruit Focus.* Retrieved from: http://foodanddrinknetwork-uk.co.uk/2015/07/14/packaging-automation-demonstrates-truly-revolutionary-high-speed-tray-sealer-at-fruit-focus/

Lake, R. (2016). *Stockport thermoformer Macpac completes 2M expansion*. Retrieved from : http://foodanddrinknetwork-uk.co.uk/2016/09/07/stockport-thermoformer-macpac-completes-2m-expansion/

Lamming, R. C. (1993). *Beyond Partnership: Strategies for Innovation and Lean Supply.* Prentice-Hall, Hemel Hempstead, UK.

Laursen, K., & Salter, A. (2006). Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal, 27,* 131-150.

Layder, D. (1998). *Sociological practice: Linking theory and social research*. London: Sage Publications Ltd.

Lawrence, F. (2013). *Horsemeat scandal: where did the 29% horse in your Tesco burger come from.* Retrieved from: https://www.theguardian.com/uk-news/2013/oct/22/horsemeat-scandal-guardian-investigation-public-secrecy

Lawrence, P.R., & Lorsch, J.W. (1967). *Organizations and Environment: Managing Differentiation and Integration.* Boston, MA; Harvard Business School Press

Leczo, T. (2009). HIsmelt® technology: the future of ironmaking. *Iron & Steel Technology, 6,* 33-49.

Lee, T. L., Mitchell, T. R., Wise, L., & Fireman, S. (1996). An unfolding model of voluntary employee turnover. *Academy of Management Journal, 39*(1), 5-36.

Lefebvre, V. M., De Steur, H., & Gellynck, X. (2015). External sources for innovation in food SMEs. *British Food Journal*, *117*(1), 412-430.

Leitch, C. M., Hill, F. M., & Harrison, R. T. (2009). *The philosophy and practice of interpretivist research in entrepreneurship: Quality, validation, and trust.* Organizational Research Methods.

Leonard-Barton, D. (1992). Core capabilities and core rigidities: A paradox in managing new product development. *Strategic management journal*, *13,* 111-125.

Leseure, M. J., Bauer, J., Birdi, K, Neely, A. & Denyer, D. (2004). Adoption of promising practices: a systematic review of the evidence. *International Journal of Management Reviews, 5/6*, 169-190.

Levinthal, D. A., & March, J. G. (1993). The myopia of learning. *Strategic management journal*, *14*(S2), 95-112.

Levinthal, D.A., & Warglien, M. (1999). Landscape Design: Designing for Local Action in Complex Worlds. *Organization Science, 10,* 342-357.

Leyland, A. (2016). Tesco's new farm based ranges introduce a new dynamic into its range review. Retrieved from The Grocer website: http://www.thegrocer.co.uk/opinion/columns/leader/tescos-new-farm-based-ranges-introduce-a-new-dynamic/533796.article?rtnurl=http://www.thegrocer.co.uk/searchresults?cmd=gotopage#

Lichtenthaler, U. (2009). Absorptive capacity, environmental turbulence, and the complementarity of organizational learning processes. *Academy of management journal*, *52*(4), 822-846.

Lienhardt (2004), The Food Industry in Europe, Statistics in Focus – Industry, Trade and Services, 39/2004, Eurostat, European Communities, Luxembourg.

Linpac. (2016). *Packaging duo unveil stylish new patisserie pack*. Retrieved from: https://www.linpacpackaging.com/en/news/201601/packaging-duo-unveil-stylish-new-patisserie-packs

Loch, C., & Kavadias, S. (2008). *Handbook of new product development management*. London: Routledge.

Lim, L.P.L., Garnsey, E. & Gregory, M. (2006). Product and process innovation in biopharmaceuticals: a new perspective on development. *R&D Management, 36*(1), 27-36.

Lindblom, A., Olkkonen, R., Ollila, P., & Hyvönen, S. (2009). Suppliers' roles in category management: A study of supplier–retailer relationships in Finland and Sweden. *Industrial Marketing Management*, *38*(8), 1006-1013.

Lubatkin, M.H., Simsek, Z., Ling, Y., & Veiga, J.F. (2006). Ambidexterity and performance in small to medium-sized firms: the pivotal role of TMT behavioral integration. *Journal of Management 32*, 1–17.

Lundin, R. A. and Söderholm, A. (1998). *Managing the black boxes of the project environment*. In Pinto, J. The handbook of project management, San Francisco: Jossey-Bass,

Mahalik, N. P., & Nambiar, A. N. (2010). Trends in food packaging and manufacturing systems and technology. *Trends in Food Science & Technology*, *21*(3), 117-128.

Mahoney, J.P. (1995). The management of resources and the resource of management. *Journal of Business Research. 33,* 91-101.

Management Technology Policy. (2016). *Open Innovation Forum Food and FMCG pitching event.* Retrieved from University of Cambridge website: http://www.ifm.eng.cam.ac.uk/events/oipitching16/

March, James G. (1991). Exploration and exploitation in organizational learning. *Organization Science, 2,* 71-87.

Marsh, S. J., & Stock, G. N. (2003). Building dynamic capabilities in new product development through intertemporal integration. *Journal of Product Innovation Management*, *20*(2), 136-148.

Martin, B. (2012). The evolution of science policy and innovation studies. *Research Policy. 41,* 1219-1239.

Martinez, M. G., & Briz, J. (2000). Innovation in the Spanish food & drink industry. *The International Food and Agribusiness Management Review*, *3*(2), 155-176.

Martinez, M. G., & Burns, J. (1999). Sources of technological development in the Spanish food and drink industry. A" supplier-dominated" industry? *Agribusiness*, *15*(4), 431.

Martínez-Ros, E., Labeaga, J.M. (2009). Product and process innovation: Persistence and complementarities. *European Management Review, 6,* 64-75.

Matusik, S. F., & Heeley, M. B. (2005). Absorptive capacity in the software industry: Identifying dimensions that affect knowledge and knowledge creation activities. *Journal of Management*, *31*(4), 549-572.

Matsuyama, K. (1995). Complementarities and cumulative processes in models of monopolistic competition. *Journal of Economic Literature*, *33*(2), 701-729.

Maylor, H., & Söderlund, J. (2015). Project management research: Addressing integrative challenges. In. Pasian, M. B. (2015). *Designs, Methods and Practices for Research of Project Management*, London: Gower Publishing, Ltd.

Meredith, J. (1998). Building operations management theory through case and field research. *Journal of operations management*, *16*(4), 441-454.

Meyer, A. D., Tsui, A. S., & Hinings, C. R. (1993). Configurational approaches to organizational analysis. *Academy of Management journal*, *36*(6), 1175-1195.

McNulty, T., & Ferlie, E. (2004). Process transformation: Limitations to radical organizational change within public service organisations. *Organization studies*, *25*(8), 1389-1412.

Menrad, K. (2004). Innovations in the food industry in Germany. Research Policy, *33*(6-7), 845-78.

Milgrom, P. R., & Roberts, B. M. (1995). Complementarities in fit: strategy, structure and organizational change in manufacturing. *Journal of Accounting and Economics, 18,* 179-208.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. London: Sage Publishing Ltd.

Miles, R. E., & Snow, Ch. C. (1978). *Organizational strategy, structure, and process.* Tokyo: McGraw-Hill Kogakusha.

Mintel Academic. (2015). *Supermarkets UK*. Retrieved from Mintel Academic website: http://academic.mintel.com/display/755745/?highlight#hit1

Mintel Academic. (2016). *Consumer Snacking-UK- 2016.* Retrieved from Mintel website: http://store.mintel.com/consumer-snacking-uk-march-2016?cookie_test=true

Mintel Academic. (2016b). *Online Grocery Retailing-UK*. Retrieved from: Mintel Academic website: http://academic.mintel.com/display/767176/?highlight#hit1

Monczka, R. M., Handfield, R. B. Scannell, T. V. Ragatz, G. L. & Frayer, D. J. (2000). *New Product Development: Strategies for Supplier Integration*. Milwaukee: ASQ Quality Press.

Nadler, D. A., & Tushman, M.L. (1997). *Implementing new designs: managing organizational change. Managing strategic innovation and change.* Oxford: Oxford University Press.

Nag, R., Corley, K. G., & Gioia, D. A. (2007). The intersection of organizational identity, knowledge, and practice: Attempting strategic change via knowledge grafting. *Academy of Management Journal*, *50*(4), 821-847.

Nelson, R. R., & Winter, S. G. (1982). The Schumpeterian tradeoff revisited.*The American Economic Review*, *72*(1), 114-132.

Nicholls-Nixon, C. L., & Woo, C. Y. (2003). Technology sourcing and output of established firms in a regime of encompassing technological change.*Strategic Management Journal*, *24*(7), 651-666.

Nieto, M. J., Santamaría, L. (2007). The importance of diverse collaborative networks for novelty of product innovation. *Technovation, 27,* 367-377.

Novotny, M., Laestadius, S. (2014). Beyond papermaking: technology and market shifts for wood-based biomass industries – management implications for large-scale industries. *Technology Analysis & Strategic Management, 26,* 875-891.

O'Connor, G. C., & McDermott, C. M. (2004). The human side of radical innovation. *Journal of Engineering and Technology Management*, *21*(1), 11-30.

OECD: Better Policies for Better Life. (2015). *OECD Innovation Strategy: Defining Innovation.* Retrieved from: http://www.oecd.org/site/innovationstrategy/definininginnovation.htm

Oke, A., Burke, G., & Myers, A. (2007). Innovation types and performance in growing UK SMEs. *International Journal of Operations & Production Management*, *27*(7), 735-753.

Olsson, A., & Larsson, A. C. (2009). Value creation in PSS design through product and packaging innovation processes. In *Introduction to Product/Service-System Design* (pp. 93-109). Springer London.

O'Reilly, C.A., & Tushman, M. L. (2004). The ambidextrous organization. *Harvard Business Review 82*, 74–82.

Ortt, J. P., & van der Duin, P. A. (2008). The evolution of innovation management towards contextual innovation. *European Journal of Innovation Management, 11,* 522-538.

Oswick, C., Fleming, P., & Hanlon, G. (2011). From borrowing to blending: Rethinking the processes of organizational theory building. *Academy of Management Review*, *36*(2), 318-337.

Ozman, M. (2011). Modularity, industry life cycle and open innovation. *Journal of technology management & innovation*, *6*(1), 26-34.

Parker, D & Hartley, K. (1997) The Economics of Partnership Sourcing Versus Adversarial Competition: A Critique. *The European Journal of Purchasing & Supply Management 3*(2), 115-125.

Passport. (2016). *Statistics.* Retrieved from: http://www.portal.euromonitor.com/portal/statistics/tab

Patton, M. Q. (2002). Two decades of developments in qualitative inquiry a personal, experiential perspective. *Qualitative social work*, *1*(3), 261-283.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy, 13,* 343-373.

Pavitt, K. (1990). What we know about the strategic management of technology. *California management review, 32,* 17-26.

Pendrous, R. (2015). *Here is what the industry is in.* Retrieved from Food Manufacture website: http://www.foodmanufacture.co.uk/Manufacturing/Food-manufacturing-state-of-the-industry

Peng, T.A. & Bourne, M. (2009). The coexistence of competition and cooperation between networks: implications from two Taiwanese healthcare networks. *British Academy of Management*, *20*, 377-400.

Pennings, J. M. (1992). Structural Contingency Theory: A Reappraisal. *Research in Organizational Behavior, 14,* 267–309.

Pereira, H. (2007). *Cork: Biology, production and uses*. Oxford: Elsevier.

Perks, R. (2012). *The Retailing of Food and Drink*. Retrieved from Mintel Academic website: http://academic.mintel.com/display/590025/

Perks, R. (2015). *Supermarkets UK*. Retrieved from Mintel Academic website: http://academic.mintel.com/display/716172/

Piening, E. P., & Salge, T. O. (2015). Understanding the antecedents, contingencies, and performance implications of process innovation: A dynamic capabilities perspective. *Journal of Product Innovation Management*, *32*(1), 80-97.

Pinto, J. K., & Prescott, J. E. (1990). Planning and tactical factors in the project implementation process. *Journal of Management studies*, *27*(3), 305-327.

Pisano, G., & Shih, W. (2012). *Producing Prosperity: Why America Needs a Manufacturing Renaissance.* Boston: Harvard Business Review Press.

Pisano, G. P., & Wheelwright, S.C. (1995). The new logic of high-tech R&D. *Long Range Planning, 28,* 128-128.

Pisano, G. P. (1997). *The Development Factory: Unlocking the Potential of Process Innovation.* Boston: Harvard Business School Press.

Pollack, J. (2007). The changing paradigms of project management. *International journal of project management*, *25*(3), 266-274.

Porter, M. E. (1980). *Competitive strategy*. New York: Free Press.

Porter, M., & Siggelkow, N. (2008). Contextuality within activity systems and sustainability of competitive advantage. *The Academy of Management Perspectives*, *22*(2), 34-56.

Powell, W.W., Keneth, K.W., & Smith-Doerr, L. (1996). Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology. *Administrative Science Quarterly, 41*(1), 116-145.

Prange, C., & Schlegelmilch, B. B. (2010). Heading for the next innovation archetype? *Journal of Business strategy*, *31*(1), 46-55.

Primo, M. A., & Amundson, S. D. (2002). An exploratory study of the effects of supplier relationships on new product development outcomes. *Journal of Operations Management, 20*(1), 33-52.

Project Management Institute (2015). *Professional Qualifications.* Retrieved from: https://pmi.org.uk/prof-development/professional-qualifications

Ramsay, J. (2014). Serendipity and the realpolitik of negotiations in supply chains. *Supply Chain Management: An International Journal, 9(*3), 219 – 229.

R&D Management. (2013). Managing R&D, Technology and Innovation in the Process industries. 3 (Special Issue), 189-302.

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

Reid, S. E., & De Brentani, U. (2004). The fuzzy front end of new product development for discontinuous innovations: A theoretical model. *Journal of product innovation management*, *21*(3), 170-184.

Research Policy. (2009). Innovation in Low- and Medium-Technology Industries. April (Special Issue), 189-302.

Retail Gazette. (2013). *Tesco reveals new Watford extra store.* Retrieved from Retail Gazette website: http://www.retailgazette.co.uk/blog/2013/08/12224-tesco-reveals-new-watford-extra-store

Riedel, J. C., & Pawar, K. S. (1991). The strategic choice of simultaneous versus sequential engineering for the introduction of new products. *International Journal of Technology Management*, *6*(3-4), 321-334.

Riis, J.O., Johansen, J., Waehrens, B.V., & Englyst, L. (2007). Strategic roles of manufacturing. *Journal of Manufacturing Technology Management, 18,* 933-948.

Rich, S.J. (2009). Food Packaging History and Innovations. *Journal of Agriculture Food and Chemistry, 57*(18), 8089-8092.

Ritala P., & Hurmelina-Laukkanen P., (2013). Incremental and radical innovation in coopetition - The role of absorptive capacity and appropriability. *Journal of Product Innovation Management, 30,* 154-169.

Rivkin, J. W. (2000). Imitation of complex strategies. *Management science*, *46*(6), 824-844.

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

Romijn, H., & Albaladejo, M. (2002). Determinants of innovation capability in small electronics and software firms in southeast England. *Research policy*, *31*(7), 1053-1067.

Rönnberg Sjödin, D., Eriksson, P. E., & Frishammar, J. (2011). Open innovation in process industries: a lifecycle perspective on development of process equipment. *International Journal of Technology Management*, *56*(2/3/4), 225-240.

Ross, J., & Staw, B. M. (1993). Organizational escalation and exit: Lessons from the Shoreham Nnuclear Power Plant. *Academy of Management Journal, 36*(4), 701-731.

Rösiö, C., & Säfsten, K. (2013). Reconfigurable production system design–theoretical and practical challenges. *Journal of Manufacturing Technology Management*, *24*(7), 998-1018.

Rosenberg, N. (1982). *Inside the black box: technology and economics*. Cambridge University Press.

Rosell, D. T., & Lakemond, N. (2012). Collaborative innovation with suppliers: a conceptual model for characterising supplier contributions to NPD.*International Journal of Technology Intelligence and Planning*, *8*(2), 197-214.

Roussel, P. A., Saad, K. M., & Erickson, T. J. (1991). The R&D Portfolio. *3rd Generation R&D*, 93-122.

Rouvinen, P. (2002). Characteristics of Product and Process innovators: some evidence from Finnish Innovation survey. *Applied Economics Letter, 9,* 575-580.

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

Sarkar, S., & Costa, A. I. (2008). Dynamics of open innovation in the food industry. *Trends in Food Science & Technology*, *19*(11), 574-580.

Saguy, I. S. (2011). Paradigm shifts in academia and the food industry required to meet innovation challenges. *Trends in food science & technology*, *22*(9), 467-475.

Sanderson, J. (2004). Opportunity and constraint in business-to-business relationships: insights form strategic choice and zones of manoeuvre. *Supply Chain Management: An International Journal, 9(*5), 392-401.

Saunders, M., Lewis, P., Thornhill, A. (2009). *Research Methods for Business Students.* London: Peason Education

Schumpeter, J.A. (1934). *Theory of Economic Development*. Harvard University Press, Cambridge, MA.

Schwab, A. and Miner, A. S. (2008). Learning in Hybrid-Project Systems: The Effects of Project Performance on Repeated Collaboration. *Academy of Management Journal*, 51(6), 1117-1149.

Semadeni, M., & Cannella, A. A. (2011). Examining the performance effects of post spin-off links to parent firms: should the apron strings be cut? *Strategic Management Journal, 32,* 1083-1098.

Shenhar, A. J., & Dvir, D. (2007). Project management research-the challenge and opportunity. *Project management journal*, *38*(2), 93.

Siggelkow, N. (2007). Persuasion with case studies. *Academy of management journal*, *50*(1), 20.

Simms, C. D., & Trott, P. (2010). Packaging development: A conceptual framework for identifying new product opportunities. *Marketing Theory*, *10*(4), 397-415.

Simms, C. D., Trott, P. (2014). Barriers to the upgrade cycle in a commodity process industry: evidence from UK packaging industry. *R&D Management, 44,* 152-170.

Smethurst, E. (2016). Food manufacturers advised to plan for Industry 4.0. Retrieved from Food Manufacture website: http://www.foodmanufacture.co.uk/Manufacturing/Food-manufacturers-should-prepare-for-Industry-4.0

Smyth, H. J., & Morris, P. W. (2007). An epistemological evaluation of research into projects and their management: Methodological issues. *International Journal of Project Management*, *25*(4), 423-436.

Sjödin, D. R., Frishammar, J., & Eriksson, P. E. (2016). Managing uncertainty and equivocality in joint process development projects. *Journal of Engineering and Technology Management*, *39*, 13-25.

Slayton, R., & Spinardi, G. (2016). Radical innovation in scaling up: Boeing's Dreamliner and the challenge of socio-technical transitions. *Technovation*, *47*, 47-58.

Söderlund, J. (2004). Building theories of project management: past research, questions for the future. *International journal of project management*, *22*(3), 183-191.

Soinien, K. (2015). *Attitudes towards innovation in the food sector.* Retrieved from Mintel Academic website: http://academic.mintel.com/display/716155/

Song, M., Montoya-Weiss, MM., Schmidt, JB. (1997). Antecedents and Consequences of CrossFunctional Cooperation: A Comparison of R&D, Manufacturing, and Marketing Perspectives. *Journal of Product Innovation Management 14* (1), 35-47.

Soosay, C. A., Hyland, P. W., & Ferrer, M. (2008). Supply chain collaboration: capabilities for continuous innovation. *Supply Chain Management: An International Journal, 13,* 160-169.

Spary, S. (2014). *Own Label Category Report.* Retrieved from The Grocer website: http://m.thegrocer.co.uk/reports/category-reports/own-label-category-report-2014/356584.article

Spekman, R.E., Kamauff, J.W. Jr & Myhr, N. (1998). An empirical investigation into supply chain management: a perspective on partnerships. *Supply Chain Management, 3*(2), 53-67.

Spithoven, A., Frantzen, D., & Clarysse, B. (2010). Heterogeneous Firm-Level Effects of Knowledge Exchanges on Product Innovation: Differences between Dynamic and Lagging Product Innovators. *Journal of Product Innovation Management*, *27*(3), 362-381.

Stadler, C. (2011). Process Innovation and Integration in Process-Oriented Settings: The Case of the Oil Industry. *Journal of Product Innovation Management*, *28*(s1), 44-62.

Stake, R. E. (1995). *The art of case study research*. London: Sage.

Stahl, B. C. (2007). Positivism or non-positivism—tertium non datur: A critique of ontological syncretisim in IS research. In R. Kishore, R. Ramesh, & R. Sharman (Eds.), *Ontologies: A handbook of principles, concepts and applications in information systems* (pp. 115-142). New York: Springer.

Steiner, R. L. (2004). The Nature and Benefits of National Brand/Private Label Competition. *Review of Industrial Organisation, 24(*2), 105–127.

Stones, M. (2016). Brexit: top three challenges for food manufacturers. *The Food Manufacture*. Retrieved from: http://www.foodmanufacture.co.uk/Regulation/Brexit-top-three-challenges-for-food-manufacturers

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory.* London: Sage Publications, Inc.

Storm, P., Lager, T., & Samuelsson, P. (2013). Managing the manufacturing- R&D interface in the process industries. *R&D Management, 43,* 252-270.

Swift, T. (2016). The perilous leap between exploration and exploitation. *Strategic Management Journal*. 37, 1688-1698.

Takeuchi, H., & Nonaka, I. (1986). The new new product development game. *Harvard business review*, *64*(1), 137-146.

Taylor, S. G., Seward, S. M., & Bolander, S. F. (1981). Why the process industries are different. *Production and Inventory Management Journal, 22,* 9-24.

Tang, J. (2006). Competition and innovation behaviour. *Research Policy, 35,* 68-82.

Tatum, M. (2016). *Workers must not pay price for Brexit, warn trade unions.* Retrieved from The Grocer: http://www.thegrocer.co.uk/home/topics/brexit/workers-must-not-pay-the-price-for-brexit-warn-trade-unions/538129.article

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research policy*, *15*(6), 285-305.

Teece, D.J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18,* 509-533.

Teichert, T., & Bouncken, R. B. (2011). Rigidities considered: supplier strategies for integrated innovation. *International Journal of Innovation Management, 15*(1), 95-115.

Tell, J., Hoveskog, M., Ulvenblad, P., Ulvenblad, P. O., Barth, H., & Ståhl, J. (2016). Business model innovation in the agri-food sector: a literature review. *British Food Journal, 118*(6), 1462-1476.

Teller, J., Unger, B. N., Kock, A., & Gemünden, H. G. (2012). Formalization of project portfolio management: The moderating role of project portfolio complexity. *International Journal of Project Management*, *30*(5), 596-607.

Tether, B. S., & Tajar, A. (2008). Beyond industry–university links: Sourcing knowledge for innovation from consultants, private research organisations and the public science-base. *Research Policy*, *37*(6), 1079-1095.

The Food and Drink Innovation Network. (2016). *Crosse Blackwell adds new flavours to best of British range.* Retrieved from: http://www.fdin.org.uk/2016/10/crosse-blackwell-adds-new-flavours-to-best-of-british-range/

The Manufacturer. (2016). Annual Manufacturing Report 2016. Retrieved from The Manufacturer website: http://www.themanufacturer.com/reports-whitepapers/annual-manufacturing-report-2016/

Thomas, J. (1993). *Doing critical ethnography* (Vol. 26). London: Sage.

Thomke S., & Von Hippel E. (2002). Customers as innovators: A new way to create value. *Harvard Business Review, 80(*2), 5−11.

Trochim, W. M. (1989). Outcome pattern matching and program theory. *Evaluation and program planning*, *12*(4), 355-366.

Turkulainen, V., & Ketokivi, M. (2012). Cross-functional integration and performance: what are the real benefits? *International Journal of Operations & Production Management*, *32*(4), 447-467.

Thompson, J. D. (1967). *Organizations in Action: Social Science Bases of Administrative Theory.* New York: McGraw-Hill.

Todorova, G., & Durisin, B. (2007). Absorptive capacity: Valuing a reconceptualization. *Academy of Management Review, 32,* 774-786.

Tottie, M., & Lager, T. (1995). QFD- linking the customer to the product development process as a part of the TQM concept. *R&D Management, 25,* 257-267.

Traill, W. B., & Meulenberg, M. (2002). Innovation in the Food Industry. *Agribusiness, 18* (1), 1-21.

Trott, P. (2010). *Innovation Management and New Product Development.* (5th ed.), Harlow: Pearson Education Limited.

Tushman, M. L., & Anderson, P. (1986). Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly, 31,* 439-465.

Tushman, M L. & O'Reilly, C. A. (1997). *Winning through Innovation: A Practical Guide to Leading Organization Change and Renewal*. Boston: Harvard Business School Press.

Tushman, M. L., & Rosenkopf, L. (1992). Organizational determinants of technological-change-toward a sociology of technological evolution. *Research in organizational behavior*, *14*, 311-347.

Tushman, M. L., & Smith, W. (2002). Organizational technology. *Companion to organizations*, *386*, 414.

Ulrich, K.T., & Eppinger, S.D. (2000). *Product Design and Development*. 2nd ed. USA: McGraw-Hill Higher Education.

Utterback, J.M. (1994). *Mastering the Dynamics of Innovation.* USA: Harvard Business School Press.

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

Utterback, J. M., & Suárez, F. F. (1993). Innovation, competition, and industry structure. *Research policy*, *22*(1), 1-21.

Vandevelde, A., & Van Dierdonck, R. (2003). Managing the design-manufacturing interface. *International Journal of Operations & Production Management*, *23*(11), 1326-1348.

Van der Duin, P. A., Ortt, R. & Wieger, T.M. (2013). Contextual Innovation Management Using a Stage-Gate Platform: The Case of Phillips Shaving and Beauty. *Product Development & Management Association, 31,* 1-12.

Van Echtelt, F. E., Wynstra, F., Van Weele, A. J., & Duysters, G. (2008). Managing supplier involvement in new product development: a multiple-case study. *Journal of Product Innovation Management*, *25*(2), 180-201.

Van de Ven, A.H., Ganco, M., & Hinings, C.R. (2013). Returning to the Frontier of Contingency Theory of Organizational and Institutional Designs. *The Academy of Management Annals, 7*(1), 393-440.

Van der Valk, W., & Wynstra, F. (2005). Supplier involvement in new product development in the food industry. *Industrial Marketing Management*, *34*(7), 681-694.

Van Donk, D.P., Akkerman, R. & Van der Vaart, T. (2008). Opportunities and realities of supply chain integration: the case of food manufacturers. *British Food Journal, 110(*2), 218-235.

Van Donk, D.P., & Van der Vaart, T. (2001), Is integration (really) needed in supply chains?, In K. Blackmon et al., (Eds). *What Really Matters in Operations Management*, Proceedings of the European Operations Management Association, 8th International Annual Conference, Bath, 3-5 June, 425-436.

Van Looy, B., Martens, T., & Debackere, K. (2005). Organizing for continuous innova- tion: on the sustainability of ambidextrous organizations. *Creativity and Innovation Management 14*, 208–221.

Vidales Giovannetti, M.D. (1995) El mundo del envase. Manual para el diseno y production de envases y embalajes, p. 90. Mexico City: Gustavo Gili, cited in O. Ampuero and N. Vila (2006) ‘Consumer Perceptions of Product Packaging’, *Journal of Consumer Marketing 23*(2): 100–12.

Vivero, R. L. (2002). The impact of process innovations on firm's productivity growth: the case of Spain. *Applied Economics*, *34*(8), 1007-1016.

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International journal of operations & production management*, *22,* 195-219.

Vyas, V. (2015). *Low-cost, Low-tech Innovation: New Product Development in the Food Industry.* Oxon: Routledge.

Weinekötter, R. (2009). Compact and efficient continuous mixing processes for production of food and pharmaceutical powders. *Trends in Food Science & Technology*, *20*, 48-50.

Weiss, P. (2003). Adoption of Product and Process Innovation in Differentiated Markets: The Impact of Competition. *Review of Industrial Organization, 23,* 301-314.

Weinbren, E. (2016). *Could Amazon Fresh deliver a knockout to Ocado?* Retrieved from The Grocer website: http://www.thegrocer.co.uk/channels/online/could-amazon-fresh-deliver-a-knockout-blow-to-ocado/538199.article

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

West, J., & Gallagher, S. (2006). Challenges of open innovation: the paradox of firm investment in open-source software. *R&d Management*, *36*(3), 319-331.

White, K. (2016). *Tesco Rolls out Fair For Farmers Guarantee logo on all its fresh milk products.* Retrieved from Grocer website: http://www.thegrocer.co.uk/buying-and-supplying/tesco-rolls-out-fair-for-farmers-guarantee-logo-on-fresh-milk/538297.article

White, K. (2016b). *Tesco looking to cut waste with new chicken breast two-portion packs.* Retrieved from The Grocer website: http://www.thegrocer.co.uk/home/topics/waste-not-want-not/tesco-introduces-two-portion-packs-for-chicken-breasts/538197.article

Wilkinson, P. & Holmes, J. (2016). Launching Tesco on If This Than That (IFTTT). Retrieved from Tesco Labs: https://www.tescolabs.com/launching-tesco-on-if-this-then-that-ifttt-com/

Wischnevsky, J. D., Damanpour, F., & Mendez, F. A. (2011). Influence of environmental factors and prior changes on the organizational adoption of changes in products and in technological and administrative processes. *British Journal of Management*, *22*(1), 132-149.

Womack, J. P., & Jones, D. T. (1996). *Lean thinking: Banish waste and create wealth in your corporation.* Free Press.

Yeoh, P. L. (2009). Realized and potential absorptive capacity: Understanding their antecedents and performance in the sourcing context. *Journal of marketing theory and practice*, *17*(1), 21-36.

Yin, R.K. (2009). *Case Study Research: Design and Methods*. 4th ed., Thosand Oaks: Sage Publications.

Zahra, S.A., George, G. (2002). Absorptive capacity: a review, reconceptualization, and extension. *Academy of Management Review, 27,* 185-203.

Zirpoli, F., & Becker, M. C. (2011). The limits of design and engineering outsourcing: performance integration and the unfulfilled promises of modularity. *R&d Management*, *41*(1), 21-43.

Zollo, M., & Winter, S. G. (2002). Deliberate learning and the evolution of dynamic capabilities. *Organization science*, *13*(3), 339-351.

Zucker, L.G., Darby, M.R. (1996). Star scientists and institutional transformation: patterns of invention and innovation in the formation of biotechnology industry. *Proceedings of National Academy of Sciences of the United States of America, 93*: 12709-12716.

12. Appendices

Appendix 1. Questions for Phase 1 Semi-structured interviews with processing and packaging companies

Interview Questions
Aim: Investigating different relationships occurring between product and process (manufacturing) innovation during new product development.
Name:
Position:
Contact details:
Company:
Company size:

Types of relationships between product and process innovation

1. How many incremental/moderate/radical product innovations have you launched in the past 5 years?
2. Can you give me an example of those that fall into incremental/moderate/radical product innovations?
3. How many incremental/moderate/radical process innovations have you launched in the past 5 years?
4. Can you give me an example of those that fall into incremental/moderate/radical process innovations?
5. What is the relationship between product and process innovation in these NPD projects?
6. Is it possible for both product and process innovation to occur in NPD project?
7. Is it the case that one dominates the other?
8. Does your current manufacturing process constrain developments in the product? / Does your product constrain developments in the manufacturing process of delivering this product?
9. What are the reasons for different innovation strategies among your projects?
10. What advantages and opportunities does this bring? Can you give me examples of these?
11. Have you developed/implemented any structures in order to coordinate product and process development? (e.g. design for manufacturability, concurrent engineering)
12. What are the barriers/challenges to this? Can you give me examples of these?

Additional part

I would like to discuss six examples of types of relationships between product and process innovation that may occur in the NPD projects;

a) Product and process innovation are synchronous
b) Product innovation is dominant
c) Process innovation is dominant

d) Established product technology hinders developments in the process
e) Established process technology hinders developments in the product
f) Product and process innovation occur separately
g) Can you think of any other relationship(s)?

13. Can you give me examples of a case(s) of NPD projects when these innovation strategies were applied at your company in the past 5 years?

Appendix 2. Outline of Case study protocol

1. Research Aim and Questions to be addressed

The primary aim of this phase is to test and further refine the Typology: Complementarity-Capability Matrix on the basis of 'illustrative' case studies identified by expert respondents during Phase 1 of the data collection. Moreover, identify any additional contingencies that influenced development of different types of complementarities between product and process innovation.

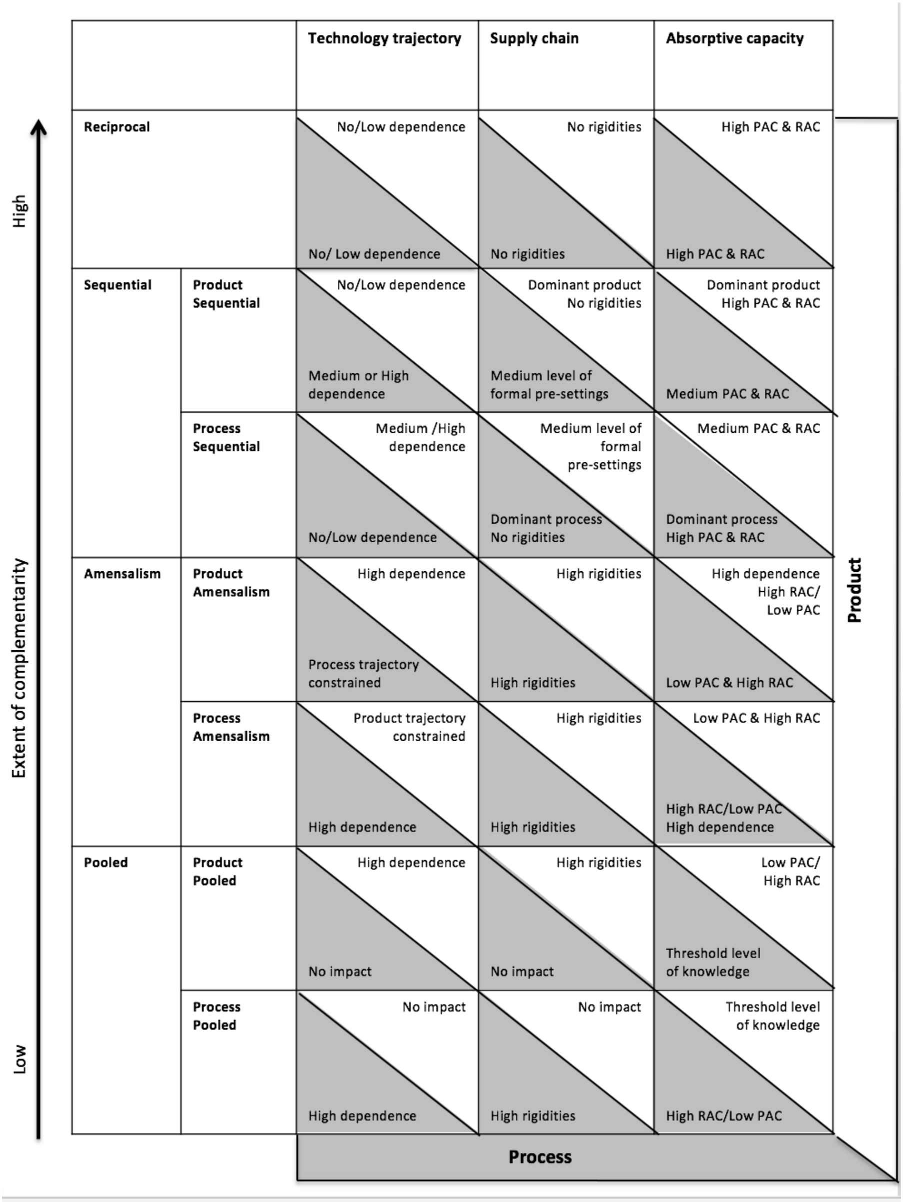
1.1 Research Aim

To test and further refine the Typology: Complementarity-Capability Matrix on the basis of 'illustrative' case studies identified by expert respondents during Phase 1 of the data collection.

1.2 Research Question

What are the different contingencies in terms of resources and capabilities that influence the adoption of the complementarity strategies?

1.3 Typology: Complementarity-Capability Matrix



2. Data collection procedures

2.1 Sites to be visited

Headquarters, UK SBU Headquarters or main production plants

Specific details for case organisation:

2.2 Contacts

Manufacturing Managers, NPD Managers, General Managers, Production equipment suppliers, Packaging suppliers, Product Innovation Managers, Engineers

Specific details for case organisation:

2.3 Note any new contacts made or provided

Details:

2.4 Data collection plan

Key activities for interview:

- To gain insights into the New Product and Process Development project from its beginning to the final stages
- To gain insight into what role was played by existing product and process technology trajectories
- To identify the type of collaboration between the processing company and equipment supplier as well as the type of relationship between the processing company and the retailer
- To identify the external parties that contributed to the project and company's level of experience in external collaboration
- To gain understanding of the level of internal knowledge of the processing company
- To identify any additional factors that influenced development of complementarity in the project

Preparation required:

- Read through case study protocol prior to the interview
- Read up on the company: website and recent trade articles
- Read the notes from Phase 1 of the data collection

3. Case Study Interview Questions

1. With reference to the xxx project describe what happened from the beginning to the end? (Note: The discussion should include at what pattern were product and production process considered)

2. What role did the existing product and process technologies play during the project?

3. What type of collaboration existed between the production/packaging/processing equipment suppliers and the processing company?

4. What type of collaboration existed between the customer (retailer) and the processing company?

5. What other external sources of knowledge (collaboration parties) were utilised during the project?

6. What level of experience does the processing company have in collaboration with external parties?

7. To what extent was the existing internal knowledge of the processing company utilised in the project?

8. Did any additional factors (not mentioned until now) influence the project?

Appendix 3. Interview NPD Manager at Food Co. (Sample from a transcript with coding scheme)

Q1) How many incremental/moderate/radical product innovations have you launched in the past 5 years?

NPD Manager: "We are a follower rather than the leader. I would say that 50% of what we do is incremental product innovation, 40% is moderate product innovation and only about 10% are radical projects. These are new to the company and the knowledge on how to develop such radical products is new to us. We tend to sit in our comfort zone. Radical innovations are 'out of their comfort zone'."

Q2) Can you give me an example of those that fall into incremental/moderate/radical product innovations?

NPD Manager: "The ideas for a radical product change in majority of the cases come from retailers, who have received complaints about certain product from consumers. Retailers give us certain specifications that we have to obey. One such example was project of the Chunky Steak Ready Meal. The idea came from one of the major retailers, our biggest customer. This customer has a complete control of meat fill and amount of meat that goes into cans. The complaints to the retailer were unacceptable: it had to be fixed! The idea was to match Brazilian product that was highly successful in Brazil, however in UK the retailer was receiving a lot of complaints from customers and retailer was pushing us for improvement. They wanted to achieve the same taste as in the Brazilian product. 30% of our production is under Food Co. label and 70% are customer label. [memo; interesting that despite that the ambient food manufacturer is positioned at the lower end price and perceived as a low cost, canned product it supplies own label products for premium retailer]. Our company has doubled in size over the past 5 years and this enabled us to manoeuvre much faster. We are able to do this thanks to being owned by a huge multinational conglomerate that already owns many food businesses all around the world. But, we are still facing issues of getting listed and I admit there is a need for more innovation. One of the innovations that was initiated by us was in the use of micropots packaging, these were supplied by RBC pots manufacturers. The pots were used for composite meals, soups and sauces. These pots came to the UK market about 10 years ago the same pots were already used 30 years ago by Heinz and Campbell's soup in USA. We were one of the first companies to bring this type of packaging to the UK market. The reasoning behind the change of packaging was to change the perception of their products as canned low cost products to a better quality/higher end products. We also tried pouches as a packaging format, however they have proven to be very slow and costly (slow line speed, 15 units per minute) in comparison to cans (200 units per minute)."

Extracts from interview	First order category	Second order theme	Overarching theme
"We are a follower rather than the leader. I would say that 50% of what we do is incremental product innovation, 40% is moderate product innovation and only about 10% are radical projects. These are new to the company and the knowledge on how to develop such radical products is new to us. We tend to sit in our comfort zone. Radical innovations are "out of their comfort zone."	Focus on incremental product innovation	Aversion towards making radical change	Factors (contingencies) negatively influencing innovation
"The ideas for a radical product change in majority of the cases come from retailers, who have received complaints about certain product from consumers."	Customer as initiator of innovation	Impact of supply chain members on innovation	Factors (contingencies) positively influencing innovation
"Retailers give us certain specifications that we have to obey. One such example was project of the Chunky Steak Ready Meal. The idea came from one of the major retailers, our biggest customer. This customer has a complete control of meat fill and amount of meat that goes into cans. The complaints to the retailer were unacceptable: it had to be fixed! The idea was to match Brazilian product that was highly successful in Brazil, however in UK the retailer was receiving a lot of complaints from customers and retailer was pushing us for improvement. They wanted to achieve the same taste as in the Brazilian product."	Prescribed product specifications by the main customer	The power of the dominant supply chain member imposed over innovation practices of the supplier	Factors (contingencies) facilitating innovation
"30% of our production is under Princes Foods label and 70% are customer label."	Production of predominantly own label products for the key customer (retailer)	Impact of the dominant supply chain member (customer) on the brand	Shift from branded products to own label products sold in the main retailer chains
"Our company has doubled in size over the past 5 years and this enabled us to maneuver much faster. We are able to do this thanks to being owned by a huge multinational conglomerate that already owns many food businesses all around the world."	Expansion of business due to being owned by large conglomerate (cash-rich owner)	Impact of the supply chain member (owner) on expansion of the manufacturer	Factor influencing expansion and innovation

"One of the innovations that was initiated by us was in the use of micropots packaging, these were supplied by RBC pots manufacturers. The pots were used for composite meals, soups and sauces. These pots came to the UK market about 10 years ago the same pots were already used 30 years ago by Heinz and Campbell's soup in USA. We were one of the first companies to bring this type of packaging to the UK market."	Trend-setter in packaging innovation	Identifying novel (to the UK market) packaging options	Packaging innovation as a form of product innovation/ High Potential Absorptive capacity
"The reasoning behind the change of packaging was to change the perception of their products as canned low cost products to a better quality/higher end products."	Packaging as a convenient form of product innovation to change consumer perception	Packaging innovation	Changing consumer perception of the product
"We also tried pouches as a packaging format, however they have proven to be very slow and costly (slow line speed, 15 units per minute) in comparison to cans (200 units per minute)."	New packaging formats rejected due to slower production speed	The efficiency of production is more important than product innovation	Operation under tight product margins

Appendix 4. Certificate of Attendance


KU LEUVEN

CERTIFICATE OF ATTENDANCE

This is to certify that

DUSANA HULLOVA

Has participated in the 24TH EUROPEAN DOCTORAL SUMMER SCHOOL ON TECHNOLOGY MANAGEMENT, held in LEUVEN, SEPTEMBER 15-19, 2014

ECTS Assigned: 4

Programme Coordinator
Prof. Bart Van Looy
Katholieke Universiteit Leuven

PLACE DE BROUCKÈRE-PLEIN 31, 1000 BRUSSELS BELGIUM, Tel: +32 2 226 66 61 Fax: (+32) 2 512 19 29
Website http://www.eiasm.org

E I A S M

Appendix 5. Research Policy Publication

Research Policy 45 (2016) 929–940

Contents lists available at ScienceDirect

Research Policy

ELSEVIER

journal homepage: www.elsevier.com/locate/respol

Uncovering the reciprocal complementarity between product and process innovation

Dusana Hullova*, Paul Trott, Christopher Don Simms

University of Portsmouth, Portsmouth Business School, Richmond Building, Portland Street, Portsmouth PO1 3DE, UK

ARTICLE INFO

Article history:
Received 2 February 2015
Received in revised form 12 January 2016
Accepted 18 January 2016
Available online 17 February 2016

Keywords:
Complementarity
Product innovation
Process innovation
Contingency approach
Resource based view
Process industries

ABSTRACT

The purpose of this paper is to provide a starting point in examining the relationship between pro uct and process innovation beyond the industry and company level. This is the first study to integra perspectives from contingency theory and the resource-based view of the firm to show how diffe ences in resources and capabilities combined with the specific needs of the New Product and Proce Development Projects, will influence the type of complementarity between product and process inn vation. We develop a classification that defines seven unique complementarities between product ar process innovation and illustrate them in a Product-Process Complementarity Map. This helps Produ and Process Development Managers to visualize the variety of options companies have in their Ne Product and Process Development Projects. We advance our argument by identifying three contingen factors: technology trajectories, power of supply chain, potential and realized absorptive capacity. The three discrete, but interrelated resources and capabilities are widely referenced in the context of proce industries that are likely to lead to different complementarity types. Finally, these two contributions a brought together in The Complementarity-Capability Matrix, where we propose seven complementari strategies and resources and capabilities necessary to achieve them. The matrix was designed to co tribute to our understanding of complementarities beyond the industry and company level and ser as a useful tool in decision making for managers that are facing New Product and Process Developme Projects.

© 2016 Elsevier B.V. All rights reserve

1. Introduction

Product and process development are commonly interrelated. The introduction of a cost-reducing process is often accompanied by changes in product design and materials, while new products frequently require the development of new equipment (Lager, 2002; Reichstein and Salter, 2006; Tang, 2006). Companies that are able to develop a tighter relationship between product and process innovation will enhance the cost efficiency of production, effect the smoother launch of new products, and create new opportunities for product and process development (Pisano and Wheelwright, 1995; Pisano, 1997). Despite all of these benefits, over the past decades, the understanding of complementarity between these two types of innovative activities has been a rare theme in the innovation literature (e.g. Damanpour and Gopalakrishnan, 2001; Damanpour, 2010; Kotabe and Murray, 1990).

Models of the dynamics of product and process innovatio were mainly developed at the industry level (Abernathy a Utterback, 1978; Barras, 1986). Given the limited number of mod developed at the company level (Damanpour and Gopalakrishna 2001) the majority of studies have focused on studying these t phenomenon separately. Researchers have claimed, that produ and process innovation are two different ways of contributi to the competitiveness of the company, which are influenced environmental and organizational factors, such as intensity of co petition (Kotabe, 1990; Weiss, 2003), company size (Cabagnols a Le Bas, 2002; Fritsch and Meschede, 2001) and the industrial c text (Berchicci et al., 2013).

The stream of research investigating complementarities has f lowed two different perspectives. One group of researchers direc tested the economic value of combining different activities a practices on organizational performance, termed and defined Ballot et al. (2015) as *complementarities-in-performance* (Pisano a Wheelwright, 1995; Pisano, 1997). The other group of research took the approach of *complementarities-in-use*, they linked betw two sets of activities and argued that one practice often requi the other practice. These authors identified "mutual and benefi

* Corresponding author.
E-mail addresses: dusana.hullova@port.ac.uk (D. Hullova), paul.trott@port.ac.uk (P. Trott), chris.simms@port.ac.uk (C.D. Simms).

http://dx.doi.org/10.1016/j.respol.2016.01.012
0048-7333/© 2016 Elsevier B.V. All rights reserved.

Appendix 6. Conference Paper Abstract presented at 22nd International Product Innovation Conference in Copenhagen 2015

COMPLEMENTARITY BETWEEN PRODUCT AND PROCESS INNOVATION: THE CONTINGENCY APPROACH

DUSANA HULLOVA (UNIVERSITY OF PORTSMOUTH, UNITED KINGDOM) - DUSANA.HULLOVA@MYPORT.AC.UK
PAUL TROTT (UNIVERSITY OF PORTSMOUTH)
CHRISTOPHER DON SIMMS (UNIVERSITY OF PORTSMOUTH)

Our paper addresses a topic that has attracted attention from innovation theorists over the last four decades - the complementarities-in-use that sought to identify linkages between product and process innovation in new product development. Three sub-categories emerged following this stream of research: (1) product and process innovations are interrelated often implying expressions such as "brothers" or "fuzzy set" as reflected in the statement, "the process is the product," (2) product innovation is positively related to process innovation following the logic of product-process pattern in the Industry Life Cycle model, (3) process innovation has a significant impact on the development of innovative products suggested in the Reverse Product Cycle model. Each of these streams has followed a single best pattern of complementarity companies should achieve, either based on the integrative view, commonly described as the "Holy Grail" or the dominant models developed at the industry level. This has resulted in a lack of conceptual work that would take into account the organizational complexity and the considerable variety in the ways companies develop complementarities between product and process innovation. The research to date has not progressed sufficiently to constitute a theory that would offer specific scenarios defining different types of complementarities or conditions for their emergence. Our intent in this article is to provide a starting point in this research area. Given the theory-building purposes of this research, we position our paper within the context of process industries. Previous research has emphasized that within these industries the development of a new product is related to the need to find an improved process. Despite this, little attention has been given to studying this phenomenon. A few studies have taken place in high-technology industries (e.g. pharmaceutical, biopharmaceutical industry) in which both product and process technology are rapidly evolving and therefore must be well synchronized. There is, however, a lack of academic attention to low-medium-technology sectors of process industries (e.g. metal, mineral and paper) in which the relationship is likely to be moderated by their long interconnected production chains or large fixed items of capital equipment.

We make three contributions to the literature in this article :

First, we adopt contingency approach and argue that companies do not follow the best practices that were given by the dominant model of the time, but carefully select their innovation practices on the basis of the specific context in which they operate. We build on Thompson's (1967: 54) classification of relationships that occur between branches of an organization, as it appears to be particularly relevant to develop a theoretical underpinning that describes the different complementarities between product and process innovation. The result is six unique complementarities: Reciprocal, Product and Process Sequential, Product and Process Amensalism and Pooled. By drawing a distinction between the possible complementarities, we emphasize two types of innovation that may differ in the extent to which they contribute to the overall innovation.

Second, we illustrate this classification in the form of conceptual framework "The Product-process positioning map," where we visually represent the different interdependencies. The simple Product-process positioning map was designed to serve as an aid for managers, who

101

Appendix 7. Conference paper Abstract presented at R&D Management Conference in Cambridge 2016

Antecedents and benefits of achieving reciprocal complementarity: a case study of the Guinness Draught in-can system project

Dusana Hullova[1], Christopher Don Simms[2] and Paul Trott[3]

[1]University of Portsmouth, Portsmouth Business School, Portland Street, Portsmouth PO1 3DE, United Kingdom. dusana.hullova@port.ac.uk

[2]University of Portsmouth, Portsmouth Business School, Portland Street, Portsmouth PO1 3DE, United Kingdom. chris.simms@port.ac.uk

[3]University of Portsmouth, Portsmouth Business School, Portland Street, Portsmouth PO1 3DE, United Kingdom. paul.trott@port.ac.uk

The development of a synchronous relationship between product and process innovation within new product development projects (NPD) can present organisations with a number of benefits including cost efficiency of production, smoother launch of new products, and new opportunities for product and process development. Yet, to date the literature provides fragmented knowledge about when and how to achieve such reciprocal complementarity as well as on the range of opportunities that open up to the company once it achieves this. In this paper we develop a new conceptual framework, drawing upon several streams of literature that proposes three components contributing to an organisations ability to achieve reciprocal complementarity within radical new product development projects: potential, co-ordinational and realized reciprocal complementarity. We apply our framework to the historic case study of the Guinness Draught in-can system project with its pre-ceding and following projects focused on froth formation. Our findings demonstrate that all three components of reciprocal complementarity are necessary for synchronous integration to occur. In particular, we uncover the significance of external collaboration and absorptive capacity, the need for equal managerial attention to product and process innovation, and the important role played by cross-functional teams and crucial role of the Integrators. Analysis of our findings leads us to develop a number of propositions that drive the way forward for future research. By combining evidence from the literature and results from the case study we suggest several managerial implications.

Appendix 8. Research Ethics Form
Appendix 9. UPR 16 Form

Ethics Approval Form - Students

This form should be completed by the student and passed to the supervisor prior to a review of the possible ethical implications of the proposed dissertation or project.

No primary data collection can be undertaken before the supervisor has approved the plan.

If, following review of this form, amendments to the proposals are agreed to be necessary, the student should provide the supervisor with an amended version for endorsement.

The final signed and dated version of this form must be handed in with the dissertation. The form MUST be signed and dated by both the student AND the supervisor. If the dissertation is submitted without a fully completed, signed and dated ethics form it will be deemed to be a fail. Second attempt assessment may be permitted by the Board of Examiners.

1. What are the objectives of the dissertation / research project?

The objectives of this research are to answer two research questions:

1) How do food and drink companies manage the complementarity between product and manufacturing process innovation in their NPD projects?

2) How do internal technological and organisational factors influence the type of complementarity that develops between product and manufacturing process innovation in the NPD projects?

These will be researched using semi-structured interviews and multiple case studies investigating three specific areas:

a) To identify different types of complementarities between product and manufacturing process innovation in new product development projects in food and drink companies in the United Kingdom.

b) To demonstrate these complementarities on case studies of new product development projects in food and drink companied in the United Kingdom.

c) To identify factors that led companies to achieve a certain type of complementarity in their NPD projects.

The research is planned to take place in two stages. Phase 1, will include semi-structured interviews with 20 managers involved in different phases of NPD (e.g. NPD managers, innovation managers, R&D managers, production managers) as well as practitioners knowledgeable in the researched area from the UK food and drink industry. The aim of this phase will be to collect general attitudes towards product and manufacturing process innovation within the food and drink industry as well as development of complementarities between these. During these interviews will be utilized the conceptual framework, The Product-process map, developed based on the literature review to help respondents identify complementarities they utilize in portfolio of their NPD projects. And possibly identify other complementarities that were not yet mentioned in the academic literature, but are applied in practice. This will be followed by a range of questions on factors that influenced the type of complementarity that was adopted in different NPD projects. Researcher aims to get unique insights to complement the existing contingencies already well-established in the low-technology process industries.

In the second phase, using theoretical sampling methodology will be identified case studies that demonstrate the above mentioned complementarities. Researcher will identify 4-7 case studies of NPD projects that demonstrate extreme examples of complementarities portrayed in the map, and possibly identify further unique complementarities utilized within food and drink industry. Researcher will aim to get in-depth understanding of complementarity choices as well as organisational and technological factors that influenced these.

2. Does the research involve *NHS patients, resources or staff*? YES / **NO** (please circle).

   If YES, it is likely that full ethical review must be obtained from the NHS process before the research can start.

3. *Does the research involve MoD staff?* YES / **NO** (please circle).

   If YES, then ethical review may need to be undertaken by MoD REC. Please discuss your proposal with your Supervisor and/or Course Leader and, if necessary, include a copy of your MoD REC application for quality review.

4. Do you intend to collect *primary data* from human subjects or data that are identifiable with individuals? (This includes, for example, questionnaires and interviews.) **YES** / NO (please circle)

   If you do not intend to collect such primary data then please go to question 15.

   If you do intend to collect such primary data then please respond to ALL the questions 5 through 14. If you feel a question does not apply then please respond with n/a (for not applicable).

5. How will the primary data contribute to the objectives of the dissertation / research project?

   Primary data will be collected using semi-structured interviews with 20 managers involved in different phases of NPD (e.g. NPD managers, innovation managers, R&D managers, production managers) as well as practitioners knowledgeable in the researched area from UK food and drink industry, during the first phase of the study. The aim is to answer objective a) and partly objective b). In the second phase, researcher will adopt theoretical sampling and choose case studies that demonstrate a range of complementarities identified in the Product-process map and investigate 4-7 case studies in-depth throughout the NPD project. Interviews will be conducted with at least 3 managers involved in different areas of the project to collect a broad range of insights and factors that influence complementarity. This will answer objectives b) and c).

6. What is/are the *survey population(s)*?

7. To answer objectives a) and partly objective b) the third research objective will be conducted 20 face-to-face semi-structured interviews with managers from food and drink industry; i.e. production managers, packaging managers, NPD managers, R&D managers, food industry consultations consultants. The informants will have experience in working on different types of NPD projects and provide a broad range of perspectives on product and process innovation in the UK food and drink industry.

   To answer objectives b) and c) theoretical case study sampling of NPD projects both from food and beverage industries will be used to fill the theoretical categories identified in the Product-process map. Four to seven case studies will be conducted based on secondary and primary data collection, according to seven complementarity types we have identified in our classification of complementarities. This data collection will include interviews with NPD managers, operations managers and R&D managers and any other important parties that were key during the project. There will be approximately 3 interviews per each case to collect a broad range of perspectives towards product and process innovation and factors influencing the complementarity decisions.

8. How big is the *sample* for each of the survey populations and how was this sample arrived at?

   In the first phase, will be conducted 20 face-to-face semi-structured interviews with a range of managers involved in NPD project and practitioners from food and drink industry. We believe that this number will be sufficient to achieve a broad range of perceptions and attitudes towards product and process innovation in the food and drink industry in the UK and factors that influence companies in their complementarity decision making process. This sample was arrived at after discussion with supervisory team.

   For the second phase, case study part will be conducted approximately 21 interviews, 3 interviews per case study (maximum 7 case studies) have been identified as a minimum number in order to be able to construct a case study and apply triangulation to make sure the case is described accurately and managers from different departments, i.e. R&D, production, NPD, marketing and packaging are involved to get a range of different insights. The number of cases has been chosen based on the classification of complementarities between product and process innovation based on the literature review and we aim to identify "transparently observable" cases that demonstrate different complementarity types.

9. How will respondents be *selected and recruited*?

   Both published research and my own experience indicates that "cold calling" companies in the food and drink industry to request participation in the research study is highly unlikely to be a successful recruitment technique. It is therefore aimed to initiate the first contact with the company through gatekeepers from the Product Innovation Research at the Portsmouth Business School and their existing contacts as well as personal contacts, using convenience sampling. Ideally these contacts would have had significant experience in working on NPD projects within food and drink industries across range of product sectors. Additional individuals for the case studies will be recruited via gatekeepers within the organisation.

10. What steps are proposed to ensure that the requirements of *informed consent* will be met for those taking part in the research? If an Information Sheet for participants is to be used, please attach it to this form. If not, please explain how you will be able to demonstrate that informed consent has been gained from participants.

    Informed consent will be sought at both organisational and individual participant level. Information sheets and consent forms have been developed (see attached). Organisational consent will be sought from companies before the initial interviews with managers. Each participant will be given an information sheet and researcher will explain the aims of the study and all the points covered in the information sheet. If the participant agrees to participate in the research he or she will be asked to sign the consent form.

11. How will *data* be *collected* from each of the sample groups?

    During both phases of the study, primary data will be collected by taking notes during the semi-structured interviews. In addition, copies of relevant material related with NPD projects might be taken.

12. How will *data* be *stored* and what will happen to the data at the end of the research?

    All transcribed material will be stored securely on the university N drive (notes will be disposed of immediately after transcription by secure disposal) and copied documents will be stored in locked filing cabinets. All data will be stored until publications (PhD thesis and academic publications including journal article, book chapters and conference presentations) are finalised and this will form part of the organisational and individual consent obtained from participants. Data will be safely disposed of five years after being awarded degree.

13. What measures will be taken to prevent unauthorised persons gaining access to the data, and especially to data that may be attributed to identifiable individuals?

    All companies and individual participants will be given a specific code, which will be used in place of names to specify transcripts. Copies of consent forms giving both codes and identifying data will be stored in separate files on the N drive from all other data to facilitate the security of companies and individuals. The raw data will be made available only to research and PhD supervisors (Prof. Paul Trott; Dr. Christopher Simms) together with PhD examiners on request.

14. What steps are proposed to safeguard the *anonymity* of the respondents?

    During transcription all data will be anonymised to remove reference to individual and company names, products, and locations of food and drink business facilities. All companies and individual participants will be given a specific code, which will be used in place of names, to identify transcripts. Copies of consent forms giving both codes and identifying data will be stored in separate files on the N drive from all other data to facilitate the security of companies and individuals. Care will be taken to preserve the anonymity of individual respondents when reporting back to company gatekeepers by presenting only anonymised data (removing names and job titles).

15. Are there any *risks* (physical or other, including reputational) *to respondents* that may result from taking part in this research? **<u>YES</u>** / NO (please circle).

    If YES, please specify and state what measures are proposed to deal with these risks.

    Individuals: risks may be perceived in terms of disclosing confidential information about the company they work for and equally about the relationships already developed with researchers at the Product Innovation Research Group. Researcher will try to avoid this by giving participants opportunity for voluntary participation in the study after reading the information sheet, in case they would not feel comfortable in answering questions related to product and manufacturing process innovation. In case they decide to participate, researcher will inform them about aims of the study ensuring the informed consent both at organisational and individual level is reached. The potential risks will be also managed by ensuring the anonymity of participants, both in academic publications and in any reports to the company concerned.

    Companies: Researcher will make sure that companies have read and signed the consent form before any primary data collection is done with their employees. The risks of disclosing commercially sensitive information will be managed by anonymisation and appropriate secure storage of all data.

16. Are there any *risks* (physical or other, including reputational) *to the researcher or to the University* that may result from conducting this research? YES / **NO** (please circle).

    If YES, please specify and state what measures are proposed to manage these risks.[1]

17. Will any *data* be *obtained from a company or* other *organisation*. **YES** / NO (please circle) For example, information provided by an employer or its employees.

    If NO, then please go to question 19.

18. What steps are proposed to ensure that the requirements of *informed consent* will be met for that organisation? How will *confidentiality* be assured for the organisation?

    Full informed consent for organisation participation in the research will be sought by getting written consent from senior management of the organisation for the researcher to be conducted. As part of the consent process it will be clarified with the gatekeeper if they have the authority to sign the informed consent form of it additional approval is required.

19. Does the organisation have its own ethics procedure relating to the research you intend to carry out? YES / NO (please circle). **Not known at this time.**

    If YES, the University will require written evidence from the organisation that they have approved the research.

20. Will the proposed research involve any of the following (please put a √ next to 'yes' or 'no'; consult your supervisor if you are unsure):

	YES		NO	
• Vulnerable groups (e.g. children) ?	YES		NO	√
• Particularly sensitive topics ?	YES		NO	√
• Access to respondents via 'gatekeepers' ?	YES	√	NO	
• Use of deception ?	YES		NO	√
• Access to confidential personal data ?	YES		NO	√
• Psychological stress, anxiety etc ?	YES		NO	√
• Intrusive interventions ?	YES		NO	√

If answers to any of the above are "YES", how will the associated risks be minimised?

21. Are there any other ethical issues that may arise from the proposed research? **NO**

[1] Risk evaluation should take account of the broad liberty of expression provided by the principle of academic freedom. The university's conduct with respect to academic freedom is set out in section 9.2 of the Articles of Government and its commitment to academic freedom is in section 1.2 of the Strategic Plan 2004-2008.

Please print the name of: I/We grant Ethical Approval

student DUSANA HULLOVA supervisor CHRISTOPHER SIMMS

Signed:

(student) [signature] (supervisor) [signature]

Date 10/11/2015 Date 10/11/2015

AMENDMENTS

If you need to make changes please ensure you have permission before the primary data collection. If there are major changes, fill in a new form if that will make it easier for everyone. If there are minor changes then fill in the amendments (next page) and get them signed before the primary data collection begins.

CHANGES TO ETHICS PERMISSION

VERSION: ____

Please describe the nature of the change and impact on ethics:

Please print the name of: I/We grant Ethical Approval

student ________________________________ supervisor ________________________________

Signed:

(student) ________________________________ (supervisor) ________________________________

Date ________________________________ Date ________________________________

(please cut and paste the next section, together with the heading at the top of this page, as many times as required)

VERSION: ____

Please describe the nature of the change and impact on ethics:

Please print the name of: I/We grant Ethical Approval

student ________________________________ supervisor ________________________________

Signed:

(student) ________________________________ (supervisor) ________________________________

Date ________________________________ Date ________________________________

FORM UPR16

Research Ethics Review Checklist

University of Portsmouth

Please include this completed form as an appendix to your thesis (see the Postgraduate Research Student Handbook for more information

Postgraduate Research Student (PGRS) Information			**Student ID:**	633602	
PGRS Name:	Dusana Hullova				
Department:	SEI	**First Supervisor:**	Christopher Simms		
Start Date: (or progression date for Prof Doc students)		October, 2013			
Study Mode and Route:	Part-time ☒ Full-time ☐	MPhil ☐ PhD ☒	MD ☐ Professional Doctorate ☐		

Title of Thesis:	Uncovering the complementarity between product and process innovation in New Product and Process Development Projects: An investigation in the UK food and drink sector
Thesis Word Count: (excluding ancillary data)	78,310

If you are unsure about any of the following, please contact the local representative on your Faculty Ethics Committee for advice. Please note that it is your responsibility to follow the University's Ethics Policy and any relevant University, academic or professional guidelines in the conduct of your study

Although the Ethics Committee may have given your study a favourable opinion, the final responsibility for the ethical conduct of this work lies with the researcher(s).

UKRIO Finished Research Checklist:
(If you would like to know more about the checklist, please see your Faculty or Departmental Ethics Committee rep or see the online version of the full checklist at: http://www.ukrio.org/what-we-do/code-of-practice-for-research/)

a) Have all of your research and findings been reported accurately, honestly and within a reasonable time frame?	YES NO	☒ ☐
b) Have all contributions to knowledge been acknowledged?	YES NO	☒ ☐
c) Have you complied with all agreements relating to intellectual property, publication and authorship?	YES NO	☒ ☐
d) Has your research data been retained in a secure and accessible form and will it remain so for the required duration?	YES NO	☒ ☐
e) Does your research comply with all legal, ethical, and contractual requirements?	YES NO	☒ ☐

Candidate Statement:

I have considered the ethical dimensions of the above named research project, and have successfully obtained the necessary ethical approval(s)

Ethical review number(s) from Faculty Ethics Committee (or from NRES/SCREC):	E340

If you have *not* submitted your work for ethical review, and/or you have answered 'No' to one or more of questions a) to e), please explain below why this is so:

Signed *(PGRS)*:		**Date:** 29/5/2017