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Exploration & Exploitation: Reconciling Product Innovation and Supply Chain Performance in Consumer Packaged Goods Manufacturing

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EXPLORATION & EXPLOITATION: RECONCILING PRODUCT INNOVATION AND SUPPLY CHAIN PERFORMANCE IN CONSUMER PACKAGED GOODS MANUFACTURING

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by

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by

Leonardo Laranjeira Gomes

Submitted to the MIT-Zaragoza International Logistics Program in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the Zaragoza Logistics Center, a research institute affiliated with the Massachusetts Institute of Technology and the University of Zaragoza.

Abstract

Product innovation often introduces complexity within supply chains, hurting operational efficiency –yet companies must be innovative to survive. That is the central issue of this thesis. We analyze the innovation *vs.* efficiency trade-off from the supply chain perspective using multiple research methods and the lenses of the exploration & exploitation literature, aiming at developing a framework for dealing with product portfolio exploration & exploitation issues in consumer packaged goods (CPG) manufacturing operations.

We conducted a thorough, systematic review of the relevant literature related exploration & exploitation and identified that operations management, being the discipline that deals with getting things done, may be the next frontier of this multidisciplinary research stream. We then empirically analyzed the impact of new product introductions on supply chain performance, using qualitative and quantitative methods: we identified the nuances of how this impact flows and also tested and measured the impact using cross-sectional-longitudinal operational data. We finally conducted an action research project in order to analyze how to build exploration-and-exploitation-enabling supply chain strategies.

We found evidence that new product introductions imply an impact on supply chain performance; yet it mostly goes through the increased variability of production assortment and is associated with category-based long-term impacts. We claim that, for small businesses and single business units aiming to be both innovative and efficient, supply chain strategies should

incorporate certain conflicting goals; however, certain actions can be taken to mitigate the negative impact of concurrent goals interfering into one another.

This study contributes to the exploration & exploitation literature by: (1) analyzing and summarizing the evolution of the literature stream, being among the first to do it from the operations management perspective; (2) evaluating how new product introductions impact supply chain performance in a CPG manufacturing firm, providing a set of testable hypotheses; (3) testing and measuring the short-term and long-term impact of new product introductions on the supply chain performance in CPG manufacturing operations using robust panel data econometrics; (4) testing the moderation effects of product-level degree of innovativeness on the relationship between new product introductions and supply chain performance; (5) adding a different level of analysis –i.e. product category– to dealing with new product introductions; (6) employing the Conceptual System Assessment and Reformulation (CSAR) as a research method for the first time; and (7) unveiling a set of supply chain trade-offs that can be faced by CPG manufacturing companies willing to be both innovative and efficient, also challenging the notion that a good supply chain strategy must be free of conflicting goals.

This research is also carries managerial implications, as it: (1) provides a summary of the relevant literature on exploration & exploitation, which can be a helpful source for practitioners willing to overcome this dilemma; (2) improves the understanding about the how new product introductions impact supply chain performance; (3) quantifies the impact of new product introductions on supply chain performance, which can be a helpful decision-making tool when balancing exploration & exploitation; (4) improves managerial intuition for the conditional supply chain implications of product-level degree of innovativeness when introducing new products; and (5) provides guidance for building supply chain strategies to balance exploration & exploitation in CPG manufacturing firms.

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Dedication

To my son, Benjamin –may you grow wise, healthy, and happy.

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[1]The true name of the company has been disguised for confidentiality reasons.

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List of acronyms

AR	Action Research
CD	Cross-sectional Dependence
CPG	Consumer Packaged Goods
CSAR	Conceptual System Assessment and Reformulation
DK	Driscoll-Kraay standard errors
E&E	Exploration and Exploitation
FE&RE	Fixed Effects & Random Effects
FSM	Functional Strategy Map
GLS	Generalized Least Squares
HAC	Heteroskedasticity- and Autocorrelation-Consistent
NPI	New Product Introductions
OA	Organizational Ambidexterity
OLS	Ordinary Least Squares
OVB	Omitted Variable Bias
ROA	Return On Assets
ROE	Return On Equity
ROIC	Return On Invested Capital
SC	Supply Chain
SCS	Supply Chain Strategy
SEM	Structural Equation Modeling
SKU	Stock Keeping Unit

Chapter 1

Introduction

1.1. Can companies be both innovative and efficient?

Product innovation often introduces complexity to supply chains that hurts operational efficiency –yet companies must be innovative to survive. How can these conflicting outcomes be reconciled? That is the central question of this thesis.

As this poses a real-world question, we have worked with a company in the meat products business to analyze this apparent conflict. The company's double-digit growth rate owes much of its success to developing product innovations in response to demands from well-known retailer clients in Europe. The firm wants to continue this success, but not at the cost of impeding the performance of its supply chain.

The meat products supplied by the manufacturer have a relatively short shelf life and are shipped to tight delivery windows in high volumes to retail chains. Moreover, retailers expect excellent service levels, so the company cannot afford to compromise supply chain efficiency.

One of the challenges is understanding the degree to which innovations will disrupt everyday operations. Altering a product recipe, for example, can require a change on the factory floor that stresses production processes. Experimenting with new market segments is another potential source of disruption.

Other variables include the type of product involved and the way an innovation is introduced. The company supports six product categories, and some are more vulnerable to the adverse effects of innovation than others. Implementing a new idea may overly add stock-

keeping units (SKUs) to the supply chain or trigger disruptive changes, and the net effect on the business can be minimal or harmful.

Deciding which scenario is likely to occur and how to manage the likely outcome is always important, but especially when an innovation is the direct result of customer feedback. In such cases, there may be advance orders for the new product which create a financial imperative to proceed as quickly as possible. Thus, the company needs to develop better methods for analyzing these variables, evaluating the risk profiles of innovations, and planning to ensure that product changes progress as smoothly as possible.

A first step to achieving these goals is to align departmental agendas. Differences between the way departments perceive and execute innovation can undermine efforts to develop a cohesive strategy for new projects. For example, the marketing department might support more product variants and hence SKUs to meet the demand from ever-smaller customer segments. The supply chain function, on the other hand, prefers to keep the number of SKUs –and hence the level of complexity– to a minimum. A survey of the company's personnel identified clear differences between departments on the way innovations are perceived. For instance, production personnel might view the creation of a new SKU as having a detrimental impact on product flows, while other functional units are largely oblivious of such a possibility.

Tackling the problem from the academic side, we conducted interviews, workshops, and data analyses to create a framework to help management dealing with innovations. Using well-known metrics such as inventory turnover, fill rate, and rate of product returns, our study enlightens future academic research and can also be informative to practitioners dealing with innovation *vs.* efficiency dilemmas. We also identified certain actions that managers need to take to minimize the disruptions caused by innovation, preparing the ground for smoothening the process and mitigating shocks to the system. The value of the knowledge gained on this research extends beyond this specific project, at a time when companies across industries are grappling with the challenges of managing rapid technological change and market volatility.

1.2. The objective of this thesis

This thesis aims at developing a framework for dealing with product portfolio exploration & exploitation in consumer packaged goods (CPG) manufacturing operations, which is inspired by issues faced by MeatCo[1], a medium-sized manufacturer of meat products. The research includes analyzing MeatCo's operations, concentrating on issues related to new product introductions, as well as the overall supply chain strategy of the company.

This study contributes to the exploration & exploitation literature by: (1) analyzing and summarizing the evolution of the literature stream, being among the first to do it from the operations management perspective; (2) evaluating how new product introductions impact supply chain performance in a CPG manufacturing firm, providing a set of testable hypotheses; (3) testing and measuring the short-term and long-term impact of new product introductions on the supply chain performance in CPG manufacturing operations using robust panel data econometrics; (4) testing the moderation effects of product-level degree of innovativeness on the relationship between new product introductions and supply chain performance; (5) adding a different level of analysis –i.e. product category– to dealing with new product introductions; (6) employing the Conceptual System Assessment and Reformulation (CSAR) as a research method for the first time; and (7) unveiling a set of supply chain trade-offs that can be faced by CPG manufacturing companies willing to be both innovative and efficient, also challenging the notion that a good supply chain strategy must be free of conflicting goals.

The main research question is: "how can we reconcile product portfolio exploration & exploitation and supply chain performance in consumer packaged goods manufacturing?". Secondary questions are:

1. How has exploration & exploitation research evolved so far? What are its implications to new product introductions from an operations management perspective?

2. How does the introduction of new products impact the operations of a CPG manufacturing firm?

3. To what extend does the introduction of new product impact CPG manufacturing

[1]The true name of the company has been disguised for confidentiality reasons.

operations? Does this impact vary according to short-term or long-term perspectives?

4. What are the factors that must be considered when crafting exploration-and-exploitation-enabling supply chain strategies to support new product introductions into consumer packaged goods manufacturing operations?

1.3. Methodological approach

This thesis followed on a multi-method, theory-building-and-testing research approach, as summarized in figure 1.1 and detailed as follows.

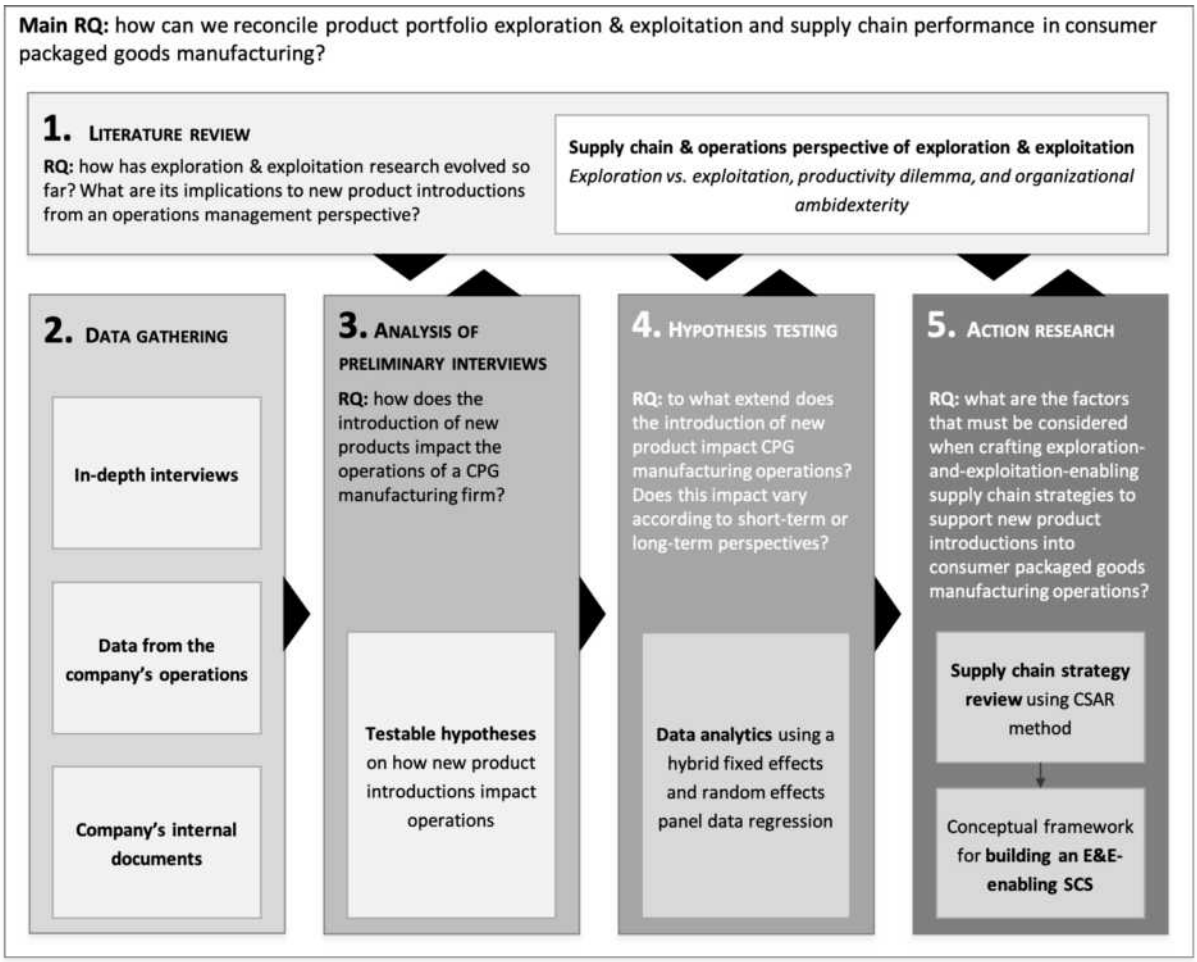

Figure 1.1: *Summary of the overall research approach followed in this thesis*

1.3.1. Literature review

We began by reviewing some previous scholarly works on topics related to dealing with exploration & exploitation issues. We paid especial attention to developing a systematic literature review in exploration & exploitation from the optics of operations management (chapter2). We analyzed 82 relevant research articles, all published in top-ranked journals, and found that operations management can add to this literature stream by tackling implementation-oriented, exploration-and-exploitation-enabling questions that remain unanswered.

1.3.2. Data gathering

The data used in this research has been provided by MeatCo and consisted of historical data from the company's operations: sales, lost sales, production batches, product returns, inventory position, and new product introductions. The company also provided extensive qualitative data through interviews, workshops, and internal documents.

As part of the research, we spent three months at MeatCo's facilities on a daily basis. We conducted interviews, collected operational data, and observed field operations. The interviews were confidential, recorded, and transcribed. Within the functional areas related to the firm's supply chain, we interviewed people from the lowest hierarchical level directly involved in the process of crafting the business strategy and also from two hierarchical levels below.

We used STATA 14 software to organize and clean multiple gigabytes of operational data provided by the company. Some of the databases, such as daily inventory positions by SKU and warehouse, included millions of data entries (six millions in the case of inventory positions). We then built our final, consolidated database, in order to be able to conduct econometric analysis in later stages.

Qualitative data was organized within the NVivo 12 software package. All of the results from the interviews, including recordings and transcriptions, were stored at that platform, as well as other documents provided by the company, such as memos, brochures, and pictures. Organizing qualitative data this way allowed us to better conduct our case study part of this research.

1.3.3. Analysis of preliminary interviews

Upon concluding the initial literature review and data collection, the research advanced to the qualitative analysis of the operational impact of new product introductions, at the business unit level of analysis. We coded the qualitative data using NVivo 12 software package, in order to make sense of the available information.

The analysis of the interviews helped on tackling the following research question: how does the introduction of new products impact the operations of a CPG manufacturing firm? From the patterns found on the case, we developed a set of hypotheses to be tested in further stages in the research using data analytics.

1.3.4. Hypothesis testing

The hypotheses generated from the analysis of the interviews were statistically tested and measured by analyzing the operational data provided by the company using robust panel data regression techniques, aided by STATA 14 statistical package. Here, we moved our analysis to one level below the business unit, to the product category –i.e. groups of similar products. We employed hybrid fixed effects & random effects panel data analysis using contemporaneous-autocorrelation-robust Driscoll & Kraay standard errors. This analysis helped us investigating the following research question: to what extend does the introduction of new product impact CPG manufacturing operations? Does this impact vary according to short-term or long-term perspectives?

We paid close attention to threats to validity and, at a certain point we faced the dilemma arising from a moderator variable being susceptible to measurement error. Thus, we decided to conduct this part of the research in two stages: in the first we excluded the moderator variable and tested a subset of the hypotheses developed in the analysis of the interviews –this has allowed us to develop a model with no apparent threats to internal validity; in the second stage, we included the moderator variable, for being of genuine interest for the research question, although threatening to internal validity to a certain extent. We then compared the results obtained in both stages and analyzed the results in light of the extant literature.

1.3.5. Action research

This part served as a capstone to the entire research, on which we summarized the findings from the previous steps and devised an action-research-based conceptual framework for developing exploration-and-exploitation-enabling supply chain strategies, at the business unit level of analysis. Continuing our work with MeatCo, we assessed and reviewed the company's supply chain strategy aiming at better reconciling product portfolio exploration & exploitation with supply chain performance.

We started by capturing and mapping the current state of MeatCo's supply chain strategy based on interviews with the company's personnel as well on the analysis of the company's documentation. We then evaluated the company's supply chain strategy and uncovered the major trade-offs within the company's operations –highlighting those related to the exploration & exploitation conflict. The results, along with the findings from previous steps in this research, were used to crafting an improved, supply chain strategy, which enlightened generalization and our recommendations for building exploration-and-exploitation-enabling supply chain strategies.

1.4. Outline of the thesis

This thesis is divided as follows: in chapter 2 we systematically review the relevant literature related to the exploration & exploitation, from the operations management perspective; in chapter 3 we conduct a qualitative analysis on the impact of new product introductions on the supply chain of a manufacturing company; in chapter 4 we test and measure the hypotheses from the case study using a robust panel data econometric methods based on operational data from a manufacturing company; in chapter 5 we extend the results from the previous chapter to account for the moderation effects from the product-level degree of innovativeness; in chapter 6 we uncover some specific trade-offs and provide guidelines to crafting a exploration-and-exploitation-enabling supply chain strategies; and in chapter 7 we conclude by summarizing our findings and discussing the overall results, tracing back to the exploration & exploitation literature. On each chapters we provide intermediate conclusions, address limitations, and provide directions for future research.

Chapter 2

The exploration & exploitation literature and its relation to new product introductions and operations management

2.1. Introduction

Exploration & exploitation (E&E) denotes the relationship between conflicting processes (March 1991), respectively related to experimentation and efficiency (Holmqvist 2004; He and Wong 2004). Exploration implies creativity, innovation, search, disruption, variation-increasing, and entrepreneurship; on the other hand, exploitation is associated with efficiency, productivity, variation-decreasing, implementation, and execution (March 1991; Benner and Tushman 2003; O'Reilly III and Tushman 2013).

The conflicting relationship between E&E –or productivity dilemma, as noted by some authors (Abernathy 1978; Adler et al. 2009; Benner and Tushman 2003)– has been studied within various literature streams, such as organizational learning, strategy & general management, innovation management, operations management and organization design (Raisch and Birkinshaw 2008; Birkinshaw and Gupta 2013). That conflicting relationship has been such a highly debated topic over the past decade that the Academy of Management Review has given its 2013 Decade Award to an article on E&E (Benner and Tushman 2003). However, the topic is not new, as more than three decades ago Abernathy 1978 suggested that a firm's potential to remain competitive in the long range is related to its ability to be both innovative and efficient, which is closely comparable to presenting concurrent high levels of exploration and exploitation.

In an article that elicited a great extent of the scholarship on E&E, March 1991 suggested that there is a trade-off between exploration and exploitation, as they compete to for scarce resources –i.e. exploration and exploitation are two ends of a continuum on which companies tend to allocate resources on (Gupta, Smith, and Shalley 2006). While that idea is shared by some scholars (Levinthal and March 1993; He and Wong 2004; Rothaermel and Alexandre 2009), other authors consider that achieving concurrent high levels of both exploration and exploitation –sometimes referred as ambidexterity (O'Reilly III and Tushman 2007; Kristal, Huang, and Roth 2010; Jansen, Bosch, and Volberda 2006)– is actually possible (Birkinshaw and Gibson 2004; Adler, Goldoftas, and Levine 1999; Andriopoulos and Lewis 2009) and that is significantly associated with greater performance outcomes (Gibson and Birkinshaw 2004; Lubatkin et al. 2006).

Three major solution streams to the productivity dilemma have emerged from the literature (O'Reilly III and Tushman 2013), namely structural ambidexterity (Tushman and O'Reilly III 1996; Benner and Tushman 2003; O'Reilly III and Tushman 2007; Jansen et al. 2009; Fang, Lee, and Schilling 2010; Blindenbach-Driessen and Ende 2014), contextual ambidexterity (Birkinshaw and Gibson 2004; Gibson and Birkinshaw 2004), and vacillation (Boumgarden, Nickerson, and Zenger 2012; Mudambi and Swift 2014; Kang, Kang, and Kim 2017). Moreover, studies related to E&E vary on their respective levels of analysis, for example the individual (Lee and Meyer-Doyle 2017; Knight and Paroutis 2017), the project (Leonard-Barton 1992; Sethi and Sethi 2009), the firm (Uotila et al. 2009; Stettner and Lavie 2014), and cross-boundary relationships (Lin, Yang, and Demirkan 2007; Wong, Wong, and Boon-Itt 2013).

At the conceptual level, some authors argue that E&E research its approaching its maturity (Benner and Tushman 2015); yet, there is growing consensus in the academia that ambidexterity is hard to achieve (Birkinshaw and Gibson 2004; Flynn and Flynn 2004; He and Wong 2004; Lubatkin et al. 2006; Adler et al. 2009; Voss and Voss 2013; Birkinshaw and Gupta 2013; Zhang et al. 2017) and some authors underscore the lack of detailed investigation on how to achieve it (Adler, Goldoftas, and Levine 1999; Gibson and Birkinshaw 2004; Raisch and Birkinshaw 2008; Simsek et al. 2009; Birkinshaw and Gupta 2013; Benner and Tushman 2015).

This study aims at systematically analyzing the evolution of the academic research on E&E,

evaluating its trends regarding contextual emphasis, central issue, level of analysis, research methods, performance metrics, view of the E&E construct, and findings. Moreover, we are particularly interested in relating the topic to new product introductions and operations, thus addressing the following research questions: how has exploration & exploitation research evolved so far? What are its implications to new product introductions from an operations management perspective?

The next sections are organized as follows: section 2.2.1 briefly explains our definition of supply chain & operations management and performance, section 2.3 explains our research approach, section 2.4 provides a brief overview of the E&E concept, section 2.5 provides a descriptive analysis of the data gathered, section 2.6 provides an analysis of the literature evolution and its relation to operations management, section 2.7 connects new product introductions and operations management to E&E, and section 2.8 discusses the implications to operations management literature and provides directions for future research.

2.2. Supply chain & operations management definitions and performance metrics

2.2.1. Supply chain & operations management

A broad definition of supply chain management was stated by Mentzer et al. 2001 as *"the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving long-term performance of the individual companies and the supply chain as a whole"*. This definition encompasses the inter-functional coordination in a given business, including marketing, sales, research & development, forecasting, production, procurement, logistics, information technology, finance, and customer service.

In a similar fashion, Slack and Lewis 2008 defined operations management as the *"activity of managing the resources and processes that produce and deliver goods and services"*. This concept embraces all the processes and functions involving the transformation of resource inputs into outputs of products and services, including demand management, procurement, inventory

management, production, quality control, maintenance, and logistics.

Comparing these two definitions, it seems that the main difference between supply chain management and operations management concepts seems to be that the former considers a wider scope of action and includes all the firms in a given supply chain, while the latter is focused primarily, but not exclusively, in a particular enterprise.

Despite this subtle difference, for the purpose of this whole thesis, both ideas can be considered relatively equivalent and will be used interchangeably. We will also refer to operations in different, embedded, levels of analysis: in chapters 3 and 6 we analyze operations from the business unit level, while in chapters 4 and 5 we view it from one level below, from a product category –i.e. groups of similar products– perspective.

2.2.2. Supply chain performance

Gunasekaran, Patel, and McGaughey 2004 developed a framework for supply chain performance measurement, following major supply chain processes: planning, sourcing, making, and delivering. As such, it can be approached on different perspectives, including suppliers, production, delivery performance, cost, and customer satisfaction. Some key metrics include: quality of delivered goods, on-time delivery of goods, order lead time, accuracy of forecasting, supplier delivery performance, supplier lead time, product quality conformance, production assortment, and inventory turnover.

On another supply chain performance measurement review, Griffis, Cooper, and Goldsby 2004 recognize that strong consensus exist on some of the most recommended logistics performance measures, such as: average line item fill rate, average backorder fill time, complete order fill time, days order late, inventory turnover ratio, logistics cost per unit, lost sales due to stockouts, on-time delivery percentage, order cycle time variability, percent error pick rate, and weeks of supply.

In both cases, the authors agree that the selection of performance measures must reflect the particular needs of the company and must be based on the firm's strategy (Griffis, Cooper, and Goldsby 2004) and the unique operations of their business (Gunasekaran, Patel, and

McGaughey 2004).

2.3. Research method and sampling

Our research approach consisted of a systematic literature review, following the guidelines proposed by Denyer and Tranfield 2009. The selection of journals was based on the Journal Quality List by Harzing 2017, a compilation of fourteen journal rankings that has been used as a reference for assessing a journal's quality by other authors (Bartunek and Rynes 2014; Hambrick and Chen 2008; Pedrosa 2012). Among the publications listed by Harzing 2017, we analyzed journals within the fields that are related to the object of study, namely general management & strategy, organization studies, operations management, innovation, entrepreneurship, and managerial-oriented journals. The scoring criteria considered the number of journal rankings, among those listed by Harzing 2017, that have given the maximum score to a journal –for example, if two out of the 14 journal rankings compiled give the maximum score to a particular journal, then that journal receives a score of two. We then selected the highest-scoring journals on each field, imposing a maximum of four journals per field and a four-point minimum requirement. Although Harzing 2017 includes managerial-oriented journals within the general management & strategy field, we decided to create a separate category for these publications, for their different nature, and also to relax the minimum-score constraint in that case, as they are usually treated differently by most journal rankings. Apart from that, we have deliberately included two additional journals in our operations management selection, for their recent growth and respective importance to the focus of this study. table 2.1 indicates the journals selected for our search.

Upon the definition of its loci, we performed a parametrical, abstract-only, search using the EBSCO Business Source Complete database, which was available to us through our university's library. The search parameters[1] contained keywords related to the E&E, such as productivity dilemma, efficiency and flexibility, and exploration and exploitation. As the procedure returned 443 articles, we carefully read all the papers' abstracts in order to select those that were suitable to addressing our research questions, yielding a 69-paper preliminary

[1]Search command: ((ambidexterity OR ambidextrous) OR (productivity AND dilemma) OR ((efficient OR efficiency) AND (flexible OR flexibility)) OR ((exploration OR explore OR exploratory) AND (exploitation OR exploit OR exploitative))

Field	Journal	Score
Gen. Manag. & Strat.	Academy of Management Review	14
Gen. Manag. & Strat.	Administrative Science Quarterly	14
Gen. Manag. & Strat.	Strategic Management Journal	13
Gen. Manag. & Strat.	Academy of Management Journal	12
Organ. Studies	Organization Science	12
Organ. Studies	Organization Studies	6
Operations Manag.	Management Science	14
Operations Manag.	Operations Research	11
Operations Manag.	Journal of Operations Management	8
Operations Manag.	Production & Operations Management	5
Operations Manag.	International Journal of Production Economics	3
Operations Manag.	Journal of Business Logistics	1
Innovation	Journal of Business Venturing	8
Entrepreneurship	Journal of Product Innovation Management	4
Managerial	MIT Sloan Management Review	3
Managerial	Harvard Business Review	3
Managerial	California Management Review	2

Table 2.1: *Journals initially selected, based on Harzing 2017*

list. Following, we expanded our list of papers by adding articles that were largely cited within the papers initially selected –note that the additional articles were not necessarily published in a journal from within our original selection. The resulting final sample contained the 82 articles that were included in our investigation, as demonstrated in table 2.2. The final reading list contained articles from 1991 to 2017, with higher occurrence after 2002, as demonstrated in figure 2.1. The most cited authors from our sample are listed in table 2.3.

After analyzing the material, we coded each article regarding their respective study type, contextual emphasis, central issue, level of analysis, research method, and salient findings. We also scrutinized each paper regarding performance metrics used and their views of the E&E construct. The coding was performed by two independent researchers, which was followed by the comparison of initial findings (95% of initial agreement) and iterative discussions, until the eventual differences were resolved (Denyer and Tranfield 2009; Zimmermann, D.F. Ferreira, and Carrizo Moreira 2016). We then compiled the summarized paper database (table A.1, in the appendix) and analyzed the emerging patterns and trends.

[2]Database: EBSCO Business Source Complete, accessed on December 4, 2017

Field	Journal	Hit count[2]	Articles select. from parametrical search	Artic. select. from ref.	Total select.
Gen. Manag. & Strat.	Strat. Manage. J.	46	13	3	16
Gen. Manag. & Strat.	Acad. Manage. J.	19	4	-	4
Gen. Manag. & Strat.	Adm. Science Quarterly	7	1	-	1
Gen. Manag. & Strat.	**Acad. Manage. Perspect.**	-	-	3	3
Gen. Manag. & Strat.	Academy of Mgt. Rev.	7	3	-	3
Gen. Manag. & Strat.	**J. Manage.**	-	-	3	3
Gen. Manag. & Strat.	**J. Manage. Stud.**	-	-	1	1
Gen. Manag. & Strat.	**Strateg. Organ.**	-	-	1	1
Organ. Studies	Organ. Sci.	55	18	1	19
Organ. Studies	Organ. Stud.	13	3	-	3
Operations Manag.	J. Oper. Manag.	34	5	1	6
Operations Manag.	Manag. Sci.	35	4	-	4
Operations Manag.	Prod. & Oper. Manag.	25	-	-	-
Operations Manag.	J. Bus. Logist.	13	-	-	-
Operations Manag.	Int. J. Prod. Econ.	82	4	-	4
Innovation	J. Prod. Innovat. Manag.	5	1	-	1
Entrepreneurship	J. Bus. Venturing	44	7	-	7
Managerial	Calif. Manag. Rev.	5	2	-	2
Managerial	MIT Sloan Manag. Rev.	6	2	-	2
Managerial	Harvard Bus. Rev.	13	1	-	1
Total		443	69	13	82

Note: Journals not included in the initial list appear in **bold**.

Table 2.2: *Sources of articles selected*

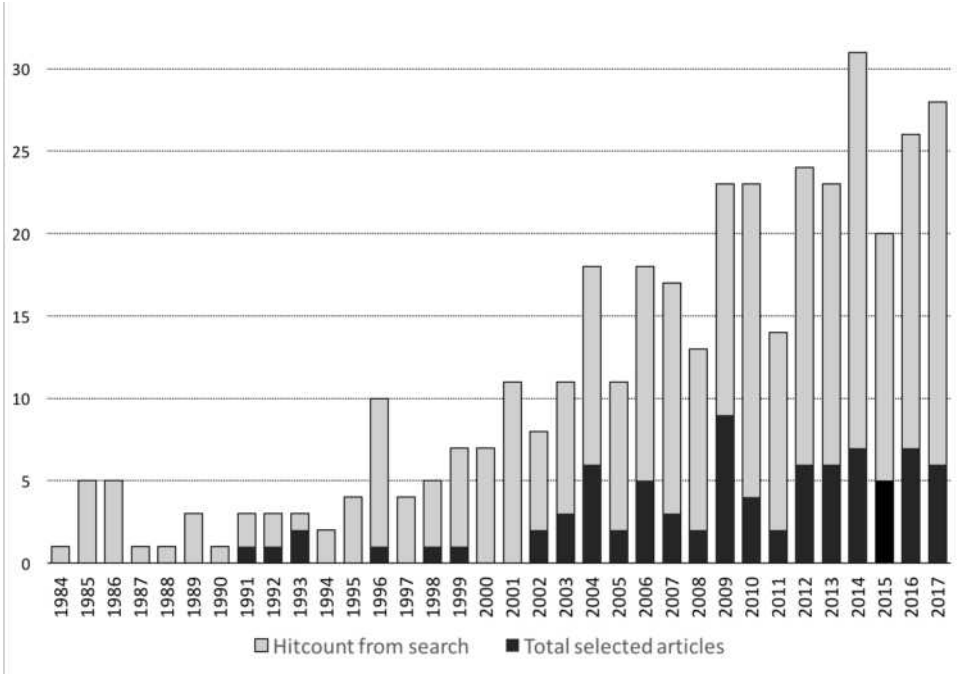

Figure 2.1: *Hitcount and sample per year of publication*

Author	Number of selected papers	Number of citations (selected papers)
March JG	2	27048
Tushman ML	11	15924
Leonard-Barton D	1	8303
Levinthal DA	3	8294
Birkinshaw J	7	5349
Benner MJ	4	5064
O'Reilly CA	4	4341
Anderson P	1	3871
Simsek Z	3	3707
Gibson CB	2	3341
Raisch S	4	2995
Jansen JJP	3	2911
He Z-L	1	2806
Wong P-K	1	2806
Cao Q	2	2765
Gupta AK	1	2454
Shalley CE	1	2454
Smith KG	1	2454
Rothaermel FT	2	2316
Danneels E	1	2297

Note: citations from Google Scholar on December 9, 2017.

Table 2.3: *Most cited authors from the paper within our sample*

2.4. The conflicting forces of exploration and exploitation

Efficiency, related to exploitation, is a significant component of the competitive business arena and several authors (Taylor 1911; Ford 1922; Deming 1986; Ohno 1988; Hammer and Champy 1993) have worked on improving business productivity for over a century (Adler et al. 2009). On the other hand, innovation, related to exploration, is also a major component of competitive-advantage-strenghtening efforts (Danneels 2002; Siggelkow and Levinthal 2003; Smith and Tushman 2005; Zhou and Wu 2010; Mudambi and Swift 2014; Swift 2016; Zhang et al. 2017) and enterprises that exclusively focus on efficiency, to the exclusion of innovation, might find themselves trapped in suboptimal stable equilibria (March 1991). A side effect of efficiency is that its enabling capabilities can also render a rigid organization, one that thwarts the innovation process and can ultimately cause the collapse of once-successful firms that fail to adapt to a dynamic environment (March 1991). The relationship of these conflicting forces is named exploration & exploitation –or productivity dilemma.

The productivity dilemma emerges from the routinization of previously solved problems, which enables the exploitation of accumulated knowledge by using efficient processes that are stable and predictable; yet, guidance by old knowledge is not exactly the best formula for exploring new knowledge (Adler et al. 2009). Therefore, because the routines, processes and skills needed for exploration and exploitation are essentially different, the capability to excel (i.e. high performance levels) in two conflicting objectives, such as innovation and efficiency, is named ambidexterity (Tushman and O'Reilly III 1996; Gibson and Birkinshaw 2004; O'Reilly III and Tushman 2007; Birkinshaw and Gupta 2013).

2.4.1. Three major solution streams to the productivity dilemma

Three major solution streams to the exploration & exploitation conflict are highlighted by researchers: structural ambidexterity, vacillation, and contextual ambidexterity. The first contemporaneously deals with ambidexterity at the system level, the second adds a temporal component to the system-wide solution, and the last deals with E&E at the individual or business unit level.

Bearing the notion that E&E compete for scarce resources (March 1991), as two ends of

a continuum in a single domain, structural ambidexterity proponents argue that ambidexterity is easier to achieve at the system level (Gupta, Smith, and Shalley 2006) by breaking an organization down into smaller semi-autonomous subunits, each one with their own organizational culture and focus on either exploration or exploitation (Tushman and O'Reilly III 1996; Raisch and Birkinshaw 2008; Fang, Lee, and Schilling 2010). These structurally-differentiated business units are then strategically integrated by senior managers (Tushman and O'Reilly III 1996; Raisch and Birkinshaw 2008; Jansen et al. 2009) and/or few cross-group links (Fang, Lee, and Schilling 2010). The top management team allows strategic synergy and cross-fertilization among units, while preventing cross-contamination through structural separation (O'Reilly III and Tushman 2007), thus preventing from E&E resource competition at the unit level.

Another possible way to achieving high levels of exploration and exploitation is organizational vacillation, sometimes denoted as punctuated equilibrium (Choi, Kumar, and Zambuto 2016) or sequential ambidexterity (O'Reilly III and Tushman 2013). On this solution stream, the organization temporally alternates its focus between exploration and exploitation, avoiding some of the tensions that arise from the simultaneous pursuing E&E (Boumgarden, Nickerson, and Zenger 2012) and delivering brief episodes of dual capability (Raisch and Tushman 2016).

Those who support the idea that ambidexterity is an organization's capacity to explore and exploit within a single business units suggest that it is best achieved not though structural or temporal separation, but by *"building a business unit context that encourages individuals to make their own judgments as to how best divide their time between the conflicting demands"*, which is denoted as contextual ambidexterity (Gibson and Birkinshaw 2004). That is the case represented by the Toyota Production System (Adler, Goldoftas, and Levine 1999; Osono, Shimizu, and Takeuchi 2008; Adler et al. 2009), on which the plant transcends the productivity dilemma by seeking a higher-order resolution to conflicting forces, shifting the performance frontier outward (Cole 1992; Flynn and Flynn 2004).

Nonetheless, one should look at those three approaches as part of a complementary process, rather than substitutes (Birkinshaw and Gibson 2004). As noted by Benner and Tushman 2015, structural separation, contextual ambidexterity, and vacillation characterize firm-product evolution, as the nature of the structural form and the locus of the E&E integration are contin-

gent on the product's conditions and time. For example, structural ambidexterity might be more adequate early in a product's evolution and turbulent-environment conditions, while contextual ambidexterity might be more suitable upon the exploratory efforts achieving strategic and customer legitimacy, being less vulnerable to being "crowded out" by exploitation (Benner and Tushman 2015). On the other hand, Boumgarden, Nickerson, and Zenger 2012 argues that vacillation yields to higher long-run benefits than ambidexterity (structural or contextual); yet the latter is better used within epochs of vacillation, being employed after long periods of focus on exploration (exploitation), before shifting focus to exploitation (exploration), delivering brief episodes of dual capability.

2.5. Descriptive results: the evolution of scholarship on exploration and exploitation

This section aims at providing a descriptive analysis of the papers in our sample. In the following sections, we analyze selected relevant characteristics of our sample, namely predominant study types, contextual emphases, central issues, levels of analysis, research methods, performance metrics, relationship between E&E components, and groups of salient findings.

2.5.1. Predominant study types

Within the sample analyzed, we can observe that empirical studies are the predominant study type, as shown in figure 2.2. The greater number of that type of study, relative to the sample size, is more relevant as that research topic evolves through time, noting that most of the initial work related to E&E in the sample were theoretically-driven studies (March 1991; Ghemawat and Costa 1993; Levinthal and March 1993; Tushman and O'Reilly III 1996), which elicited the subsequent scholarly work, as we can see from their respective authors' citations in table 2.3.

2.5.2. Contextual emphases

The exploration *vs.* exploitation debate has been initiated from the organizational learning and strategy & management contexts, as we can see in table 2.4. As the conversation evolved, it started being analyzed from other perspectives, such as operations management, innovation, organizational design, leadership, organizational alliances. It is worth noting that, since 2005,

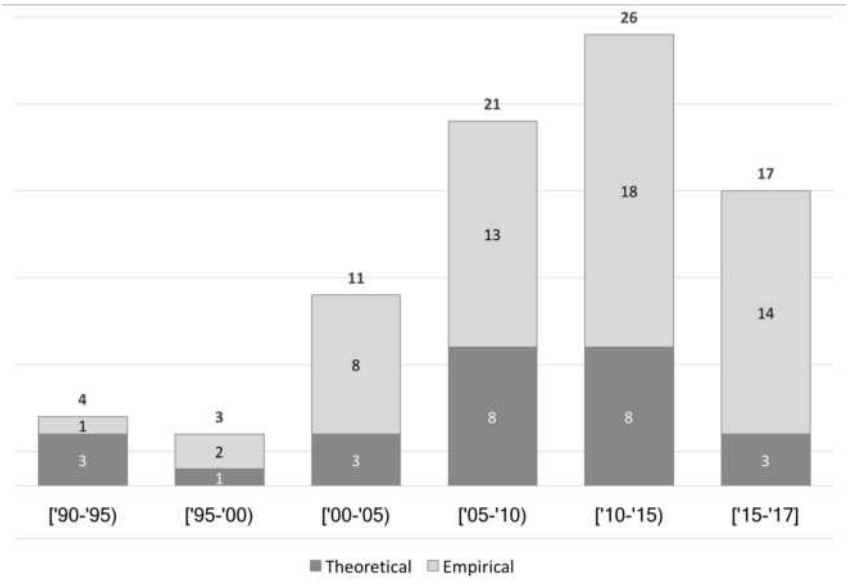

Figure 2.2: *Predominant study types of E&E papers within the sample*

Contextual Emphasis	['90-'95)	['95-'00)	['00-'05)	['05-'10)	['10-'15)	['15-'17]	Total
Strategy & general mgmt.	1 (25%)	1 (33%)	4 (36%)	6 (29%)	6 (23%)	4 (24%)	22 (27%)
Operations mgmt.	-	1 (33%)	-	2 (10%)	7 (27%)	1 (6%)	11 (13%)
Org. learning	3 (75%)	-	2 (18%)	1 (5%)	3 (12%)	2 (12%)	11 (13%)
Innovation mgmt.	-	1 (33%)	2 (18%)	3 (14%)	2 (8%)	2 (12%)	10 (12%)
Org. design	-	-	2 (18%)	1 (5%)	6 (23%)	-	9 (11%)
Leadership	-	-	-	4 (19%)	1 (4%)	2 (12%)	7 (9%)
Org. alliances	-	-	1 (9%)	3 (14%)	-	1 (6%)	5 (6%)
Other	-	-	-	1 (5%)	1 (4%)	5 (29%)	7 (9%)
Total (100%)	4	3	11	21	26	17	82

Table 2.4: *Contextual emphases of E&E papers within the sample, by period –frequency and relative figures*

research on E&E has been further diversified to emphasize other contexts, including corporate venturing, human resources, corporate governance, and corporate social responsibility – although strategy & management remains as the predominant context.

2.5.3. Central issues

The ongoing debate related to E&E has been initiated around the organizational learning dynamics issue (March 1991; Levinthal and March 1993); yet, the conversation now spans a broad range of central issues, including E&E & ambidexterity itself, ambidexterity-building, performance consequences of E&E, the role of the top management on E&E, ambidexterity

Central issue	['90-'95)	['95-'00)	['00-'05)	['05-'10)	['10-'15)	['15-'17]	Total
E&E & ambidext.	-	-	1 (9%)	6 (29%)	3 (12%)	3 (18%)	13 (16%)
Ambidext. building	-	-	2 (18%)	-	2 (8%)	3 (18%)	7 (9%)
Performance conseq.	-	-	2 (18%)	4 (19%)	1 (4%)	-	7 (9%)
Top mgmt.	-	-	-	4 (19%)	1 (4%)	2 (12%)	7 (9%)
Ambidext. Strategies	-	-	1 (9%)	-	4 (15%)	2 (12%)	7 (9%)
Operations strategies	-	1 (33%)	-	1 (5%)	4 (15%)	-	6 (7%)
Learning dynamics	2 (50%)	-	1 (9%)	1 (5%)	-	-	4 (5%)
Cross-domain ambidext.	-	-	1 (9%)	1 (5%)	1 (4%)	1 (6%)	4 (5%)
Literature structure	-	-	-	1 (5%)	1 (4%)	-	2 (2%)
Special topics	2 (50%)	2 (67%)	3 (27%)	3 (14%)	9 (35%)	6 (35%)	25 (30%)
Total (100%)	4	3	11	21	26	17	82

Table 2.5: *Central issue categories on E&E papers from within the sample, by period –frequency and relative figures*

strategies, operations strategies, cross-domain ambidexterity, and the literature structure of E&E & ambidexterity, as demonstrated in table 2.5. As what can be considered a diversified, multi-disciplinary debate, it also encompasses several special topics, such as process management, product variety, capital structure, performance incentives, and several others. These special topics are quantitatively less relevant, yet, as a group, is the most representative within our sample.

2.5.4. Levels of analysis

Studies on E&E can be analyzed within diverse levels, such as the overall firm, the business unit, the plant/project/process, and the individual, as well as beyond the firm's boundaries (i.e. cross-boundary) and within a multi-level approach. There are also some studies that employ a more general approach, not specifying any level of analysis. table 2.6 demonstrates that the majority of the articles within the sample employs the firm level of analysis, followed by business unit and multilevel studies. More recent studies also look beyond the firms' boundaries.

2.5.5. Research methods

Most of the research on E&E is quantitative and predominantly cross-sectional. As demonstrated in table 2.7, E&E scholars have employed diverse research methods to analyze the theme, such as conceptual studies, simulation, mathematical models, case studies, and litera-

Level of analysis	['90-'95)	['95-'00)	['00-'05)	['05-'10)	['10-'15)	['15-'17]	Total
Firm	2 (50%)	-	5 (45%)	16 (76%)	13 (50%)	10 (59%)	46 (56%)
Business unit	-	-	4 (36%)	2 (10%)	5 (19%)	-	11 (13%)
Multilevel	-	1 (33%)	2 (18%)	-	3 (12%)	2 (12%)	8 (10%)
Plant/ project/ process	1 (25%)	2 (67%)	-	1 (5%)	1 (4%)	-	5 (6%)
Individual	-	-	-	-	-	3 (18%)	3 (4%)
Cross-boundary	-	-	-	1 (5%)	1 (4%)	1 (6%)	3 (4%)
General	1 (25%)	-	-	1 (5%)	3 (12%)	1 (6%)	6 (7%)
Total (100%)	4	3	11	21	26	17	82

Table 2.6: *Levels of analysis of E&E papers from within the sample, by period –frequency and relative figures*

Research method	['90-'95)	['95-'00)	['00-'05)	['05-'10)	['10-'15)	['15-'17]	Total
Quant., cross-sect.	-	-	3 (27%)	10 (48%)	14 (54%)	6 (35%)	33 (40%)
Quant., longit.	-	1 (33%)	2 (18%)	2 (10%)	3 (12%)	6 (35%)	14 (17%)
Conceptual	1 (25%)	1 (33%)	2 (18%)	6 (29%)	2 (8%)	2 (12%)	14 (17%)
Simulation	1 (25%)	-	1 (9%)	1 (5%)	2 (8%)	-	5 (6%)
Quali., cross-sect.	-	-	2 (18%)	1 (5%)	1 (4%)	-	4 (5%)
Math.	1 (25%)	-	-	-	1 (4%)	1 (6%)	3 (4%)
Quali., longit.	-	-	1 (9%)	-	-	2 (12%)	3 (4%)
Quali., multiple cases	1 (25%)	-	-	-	1 (4%)	-	2 (2%)
Lit. rev.	-	-	-	1 (5%)	1 (4%)	-	2 (2%)
Quant., bibliometric	-	-	-	-	1 (4%)	-	1 (1%)
Quali., single case	-	1 (33%)	-	-	-	-	1 (1%)
Total (100%)	4	3	11	21	26	17	82

Table 2.7: *Research methods on E&E papers from within the sample, by period –frequency and relative figures*

ture reviews.

2.5.6. Performance metrics

Among the papers that refer to the consequences of E&E (table 2.8), the predominant performance metrics, considered by 29 papers, are related to growth –such as sales– and/or finance –such as return on equity (ROE), return on invested capital (ROIC), return on assets (ROA), and profit. That is the predominant view in studies from most contextual emphases, including strategy & general management, which represent the largest group in this study and focus almost exclusively in growth and finance, when relating to E&E performance metrics.

We found four papers that relate to innovation performance metrics –such as new product

success rate and patent creation–, in the operations, innovation, and organizational learning contexts. Regarding operational metrics –such as those related to suppliers, production, delivery performance, cost efficiency, and customer satisfaction–, we found eight papers, mostly considering the operations management contextual emphasis. We also identified six papers considering other metrics –such as corporate social responsibility, firm survival rate, and learning performance.

Contextual emphasis	Performance metrics				
	Growth	Finance	Innovation	Operations	Other
Strategy & general mgmt.	Voss and Voss 2013; Cao, Gedajlovic, and Zhang 2009; O'Reilly III and Tushman 2011; Raisch and Birkinshaw 2008; Junni et al. 2013	Ebben and Johnson 2005; Gibson and Birkinshaw 2004; Kang, Kang, and Kim 2017; Uotila et al. 2009; Cao, Gedajlovic, and Zhang 2009; Benner and Tushman 2003; O'Reilly III and Tushman 2011; Raisch and Birkinshaw 2008; Junni et al. 2013		Cao, Gedajlovic, and Zhang 2009	
Operations mgmt.	Patel, Terjesen, and Li 2012; Fernhaber and Patel 2012; Kristal, Huang, and Roth 2010; Salvador, Chandrasekaran, and Sohail 2014	Rothaermel and Alexandre 2009; Fernhaber and Patel 2012; Kristal, Huang, and Roth 2010; Salvador, Chandrasekaran, and Sohail 2014	Rothaermel and Alexandre 2009	Um et al. 2017; Kristal, Huang, and Roth 2010; Adler, Goldoftas, and Levine 1999; Kortmann et al. 2014; Wong, Wong, and Boon-Itt 2013; Salvador, Chandrasekaran, and Sohail 2014	
Innovation mgmt.	He and Wong 2004; Mudambi and Swift 2014; Zhang et al. 2017	Jansen, Bosch, and Volberda 2006; Mudambi and Swift 2014; Zhang et al. 2017	Zhang et al. 2017; Sethi and Sethi 2009	Zhang et al. 2017	Swift 2016
Org. design		Blindenbach-Driessen and Ende 2014; Boumgarden, Nickerson, and Zenger 2012; Jansen, Simsek, and Cao 2012; Stettner and Lavie 2014			Fang, Lee, and Schilling 2010
Org. learning	Lin et al. 2013	Lin et al. 2013; Ghemawat and Costa 1993	Wei, Yi, and Guo 2014		Miller et al. 2006
Org. alliances	Lin, Yang, and Demirkan 2007	Lin, Yang, and Demirkan 2007			Tokman et al. 2007
Leadership	Lubatkin et al. 2006; Smith and Tushman 2005	Lubatkin et al. 2006; Smith and Tushman 2005			
Corp. venturing		Hill and Birkinshaw 2008			Hill and Birkinshaw 2008
Corp. social responsib.					Hahn et al. 2016

Table 2.8: *Performance metrics used on E&E papers analyzed*

2.5.7. The relationship between the E&E components

The papers in our sample consider three different views regarding the relationship between the exploration and the exploitation constructs: (1) the orthogonal relationship, on which both components are independents and their levels of intensity can be added up or multiplied;

E&E View	['90-'95)	['95-'00)	['00-'05)	['05-'10)	['10-'15)	['15-'17]	Total
Orthogonal	-	2 (67%)	5 (45%)	9 (43%)	12 (46%)	5 (29%)	33 (40%)
Continuous	4 (100%)	1 (33%)	2 (18%)	5 (24%)	7 (27%)	4 (24%)	23 (28%)
Layered	-	-	-	5 (24%)	3 (12%)	1 (6%)	9 (11%)
None	-	-	4 (36%)	2 (10%)	4 (15%)	7 (41%)	17 (21%)
Total (100%)	4	3	11	21	26	17	82

Table 2.9: *E&E views through time*

(2) they are part of a continuum, each component being part of one extreme, and their relationship is part of a zero-sum game, thus their relationship is operationalized by their level difference; and (3) the layered view, on which their relationship actually depends on the level of analysis, usually being orthogonal at the macro, aggregated level –e.g. the firm as a whole and across-boundaries– and continuous at the micro, disaggregated level –e.g. a business unit or a manufacturing plant.

As shown in table 2.9, the whole E&E discussion was kicked-off from the continuous view –which maintained its relevance through time– followed by the orthogonal view, which has been the most widely debated view during the period. More recently, we noticed the occurrence of the more balanced, layered view, which combines the good aspects of both the orthogonal and the continuous views, by associating them with different levels of analyses.

When we combine the E&E views with levels of analysis in our sample, in table 2.10, we see that, although the orthogonal view is still predominant, the multilevel studies mostly endorse a more balanced perspective of being orthogonal at the macro level and continuous at the micro level.

Digging deeper into studied addressing the plant/ project/ process levels of analysis, we see that those supporting the orthogonal view (i.e. Adler, Goldoftas, and Levine 1999; Sethi and Sethi 2009) are related to contextual ambidexterity, addressing leadership/management aspects, even when evaluating factory floor operations –actually, the only operations-related, at the micro level sustaining an orthogonal view is Adler, Goldoftas, and Levine 1999, which claims that Toyota transcends the productivity dilemma by resorting to higher-order resolutions of conflicting forces.

Level of analysis	Orthogonal	Continuous	Layered
General	O'Reilly III and Tushman 2013	-	-
Cross-boundary	-	-	-
Multilevel	Tushman and O'Reilly III 1996; Zhang et al. 2017	-	Gupta, Smith, and Shalley 2006; Adler et al. 2009; Ebben and Johnson 2005; Kammerlander et al. 2015; Lin, Yang, and Demirkan 2007; Cao, Gedajlovic, and Zhang 2009; Blindenbach-Driessen and Ende 2014; Voss and Voss 2013
Firm	Benner and Tushman 2003; Raisch and Birkinshaw 2008; O'Reilly III and Tushman 2007; Benner and Tushman 2015; Smith and Tushman 2005; Raisch et al. 2009; Andriopoulos and Lewis 2009; Birkinshaw and Gupta 2013; Lubatkin et al. 2006; Jansen et al. 2009; O'Reilly III and Tushman 2011; Fang, Lee, and Schilling 2010; Jansen, Simsek, and Cao 2012; Stettner and Lavie 2014; Holmqvist 2004; Hahn et al. 2016	March 1991; He and Wong 2004; Uotila et al. 2009; Kortmann et al. 2014; Zhou and Wu 2010; Levinthal and March 1993; Lavie and Rosenkopf 2006; Fernhaber and Patel 2012; Piao and Zajac 2016; Wei, Yi, and Guo 2014; Choi, Kumar, and Zambuto 2016; Um et al. 2017; Kang, Kang, and Kim 2017; Tokman et al. 2007; Azadegan and Wagner 2011; Mudambi and Swift 2014; Rothaermel and Alexandre 2009; Miller et al. 2006	-
Business unit	Gibson and Birkinshaw 2004; Kristal, Huang, and Roth 2010; Birkinshaw and Gibson 2004; Salvador, Chandrasekaran, and Sohail 2014; O'Reilly III and Tushman 2004; Patel, Terjesen, and Li 2012; Jansen, Bosch, and Volberda 2006; Lin et al. 2013; Lin and McDonough III 2014	Benner and Tushman 2002	-
Plant/ project/ process	Adler, Goldoftas, and Levine 1999; Sethi and Sethi 2009	Leonard-Barton 1992; Csaszar 2013; Jayanthi and Sinha 1998	-
Individual	Lee and Meyer-Doyle 2017; Knight and Paroutis 2017	-	-

Table 2.10: *E&E views by level of analysis*

2.5.8. Salient findings

Salient findings from within the sample cover the dynamics of the interplay between exploration and exploitation, the conceptualization of balancing E&E and ambidexterity, ambidexterity-building tools, and the performance consequences of pursuing high levels of E&E, as well as E&E contingencies and boundaries. Ambidexterity-building tools is the most frequent group of findings observed on the sample, followed by E&E conceptualization and analyses of performance consequences (table 2.11). It is worth noting that studies concerning E&E contingencies and boundaries were only introduced after the year 2005.

2.6. Analysis of the E&E literature and its relation to operations management

Most of the first decade of scholarly work on E&E, between 1990 and 1999, was characterized by theoretical and empirical analyses of the general trade-off between exploration and exploitation in the context of organizational learning (March 1991; Ghemawat and Costa

Findings	['90-'95)	['95-'00)	['00-'05)	['05-'10)	['10-'15)	['15-'17]	Total
Ambidext.-building tools	1 (25%)	2 (67%)	5 (45%)	8 (38%)	10 (38%)	8 (47%)	34 (41%)
Conceptualization	2 (50%)	1 (33%)	1 (9%)	6 (29%)	4 (15%)	4 (24%)	18 (22%)
Consequences	-	-	2 (18%)	4 (19%)	6 (23%)	3 (18%)	15 (18%)
Boundaries	-	-	-	3 (14%)	5 (19%)	1 (6%)	9 (11%)
E&E dynamics	1 (25%)	-	3 (27%)	-	1 (4%)	1 (6%)	6 (7%)
Total	4	3	11	21	26	17	82

Table 2.11: *Salient findings categories on E&E papers from within the sample, by period –frequency and relative figures*

1993; Levinthal and March 1993), as well as the hypothesis of some ambidexterity-building tools, in the context of strategy & general management (Leonard-Barton 1992; Tushman and O'Reilly III 1996). Those early studies claimed that there is a trade-off between exploration and exploitation (March 1991), such that organizations find difficult to improve their learning capabilities (Levinthal and March 1993) and tend to allocate resources towards the extremes along the E&E continuum (Ghemawat and Costa 1993). The tools for reconciling that trade-off were presented in the context of strategy & general management and emphasized the role of project managers in challenging the organization's core capabilities (Leonard-Barton 1992) and the introduction of the structural ambidexterity concept by Tushman and O'Reilly III 1996. Later on that decade, E&E raised the attention of innovation management (Jayanthi and Sinha 1998) as well as operations management scholars (Adler, Goldoftas, and Levine 1999), both at the plant level of analysis. Adler, Goldoftas, and Levine 1999 conducted an in-depth analysis at a Toyota joint-venture (NUMMI) on how the organization manages the paradox of efficiency and flexibility and found that E&E can be reconciled by employing metaroutines and job enrichment (similar to contextual ambidexterity), temporal separation (associated with vacillation), and organizational partitioning (resembling structural ambidexterity).

Despite the initial spark that attracted their attention to E&E, the theme remained dormant to operations management scholars during most of the second decade of the period analyzed. Within 2000 and 2009, the conceptualization of ambidexterity was refined, as some authors claimed that exploration and exploitation are complementary and mutually beneficial (Danneels 2002; Holmqvist 2003; Rothaermel and Deeds 2004; Andriopoulos and Lewis 2009; Cao, Gedajlovic, and Zhang 2009), while others defended that the trade-off actually exists (Ebben and Johnson 2005; Gupta, Smith, and Shalley 2006; Uotila et al. 2009).

It was also during the second decade that researchers conducted the first empirical tests of the ambidexterity hypothesis. However, results were mixed and some authors found that companies do not benefit from ambidexterity (Ebben and Johnson 2005), while most of them indicated that OA leads to superior performance (Gibson and Birkinshaw 2004; He and Wong 2004; Tokman et al. 2007; Hill and Birkinshaw 2008; Uotila et al. 2009). Some researches noted boundaries and contingencies to the performance implications of E&E, suggesting that firm size might play a significant role in this relationship (Lin, Yang, and Demirkan 2007), as well as absorptive capacity (Raisch et al. 2009) and the level of analysis (Lavie and Rosenkopf 2006); the latter refuting that firms can achieve high levels of E&E within a single domain, but do so across domains and over time. Raisch and Birkinshaw 2008 and Simsek et al. 2009 summarized these findings on their respective frameworks that include antecedents, outcomes, and moderators.

As the conceptual debate was evolving on the second decade, scholars looked for ambidexterity-building tools from the strategic, organizational design, leadership, and innovation perspective. Authors emphasized that high levels of E&E can be achieved by structural separation or centralization/decentralization mix (Benner and Tushman 2003; Siggelkow and Levinthal 2003; O'Reilly III and Tushman 2007; Jansen, Bosch, and Volberda 2006; Jansen et al. 2009), organizational context (Birkinshaw and Gibson 2004), and leadership (Smith and Tushman 2005; Lubatkin et al. 2006; O'Reilly III and Tushman 2004).

After one decade not participating on the debate, it was only at the end of the second decade that operations management scholars returned to the conversation. The return of operations management to this conversation started when Adler et al. 2009 suggested that the productivity dilemma can be transcended by embracing contradictions and seeking a higher-order resolution to the conflicting forces and called for more operations-oriented E&E research.

The most recent period, from 2010 onwards, has been marked by the multiplication of contexts, central issues, levels of analysis, and research methods on E&E. The conceptualizations around the theme were further refined with respect to its dimensions, on which some scholars

advocated for viewing E&E as separate, mutually enabling factors (Farjoun 2010; Birkinshaw and Gupta 2013), its temporal dynamics (Mudambi and Swift 2014; Raisch and Tushman 2016), and related attributes' characteristics such as the process management concept (Ng et al. 2015) and exploitation types (Piao and Zajac 2016). However, O'Reilly III and Tushman 2011 noted that the term "organizational ambidexterity" is still ambiguous.

Most recent studies have identified positive relationships between OA and performance, on various contexts and level of analysis, such as organizational learning at the business unit level (Lin et al. 2013), multilevel strategy (Voss and Voss 2013), firm-level corporate social responsibility (Hahn et al. 2016), firm-level strategy (Kang, Kang, and Kim 2017), and multilevel innovation (Zhang et al. 2017). Boundaries and contingencies were found on the degree of centralization and resource munificency at a multilevel (Jansen, Simsek, and Cao 2012), the erosion of knowledge value through time (Posen and Levinthal 2012), firm-level resource coordination flexibility (Wei, Yi, and Guo 2014), organization size (Csaszar 2013), and the level of absorptive capacity (Swift 2016). Literature-wide mixed results were reconciled by Junni et al. 2013, which found that OA-performance relationships are influenced by how E&E is operationalized, the level of analysis, research methods and industry context.

The recent period also reinforced ambidexterity-building tools, such as structural ambidexterity (Fang, Lee, and Schilling 2010; Blindenbach-Driessen and Ende 2014; Stettner and Lavie 2014), vacillation (Boumgarden, Nickerson, and Zenger 2012; Kang, Kang, and Kim 2017), and the role of technological capability (Zhou and Wu 2010), industrial upgrading (Azadegan and Wagner 2011), leadership (O'Reilly III and Tushman 2013; Lin and McDonough III 2014; Kammerlander et al. 2015; Zimmermann, Raisch, and Birkinshaw 2015; Knight and Paroutis 2017), human resources and performance incentives (Tschang and Ertug 2016; Lee and Meyer-Doyle 2017; Lin et al. 2017), and corporate governance (Choi, Kumar, and Zambuto 2016). Benner and Tushman 2015 summarized a great extent of E&E research in the period by noting that we have learned that structural ambidexterity, contextual ambidexterity, and vacillation are complementary and characterized by firm-product evolution.

E&E research in the operations management context has intensified in the last decade, spanning topics such as supply chain strategy (Kristal, Huang, and Roth 2010; Wong, Wong, and

Boon-Itt 2013), manufacturing strategy (Azadegan and Wagner 2011; Patel, Terjesen, and Li 2012), and product variety (Fernhaber and Patel 2012; Kortmann et al. 2014; Salvador, Chandrasekaran, and Sohail 2014; Um et al. 2017). However, we can notice certain heterogeneity regarding research methods, as all of those studies employed quantitative, cross-sectional, empirical research, mostly based on surveys and, sometimes, secondary data. Respective findings relate to consequences on performance as well as ambidexterity-building tools. Although most papers have found that pursuing high levels E&E is positively associated with the firm's performance (Patel, Terjesen, and Li 2012; Wong, Wong, and Boon-Itt 2013; Salvador, Chandrasekaran, and Sohail 2014), Kristal, Huang, and Roth 2010, counterintuitively, did not find any significant evidence of trade-offs between exploration and exploitation. Furthermore, scholars have also analyzed industrial upgrading (Azadegan and Wagner 2011), product configuration (Fernhaber and Patel 2012), and product variety management strategies (Um et al. 2017) as ambidexterity-building tools and found that they are significantly effective ways to improve the OA-performance relationship.

2.7. Connecting E&E, operations management, and new product introductions

From an operational perspective, we can view new product introductions as similar to introducing innovations within a firm (Mapes, New, and Szwejczewski 1997), which is closely related to exploration. On the other hand, firms that continuously work with their established products can be considered as less innovative, which is related to the exploitation.

With respect to operational performance trade-offs, (Mapes, New, and Szwejczewski 1997) proposed that companies with higher rates of new product introductions and wider assortment will present poorer operational performance metrics (e.g. quality consistency, speed of delivery, and delivery reliability) in comparison with companies that work with established products and/or narrower assortments. This idea is corroborated by Crippa et al. 2010, which noted that new product introductions and product variety are associated with higher manufacturing costs, slower lead times, and higher inventory levels, highlighting that these consequences are more pronounced as the degree of product-level innovativeness (i.e. degree of newness) increases.

Another aspect of new product introductions is that it can be associated with assortment increase (Mapes, New, and Szwejczewski 1997), whenever the company does not employ proper product portfolio complexity management, which is the case of some small / young firms (Fernhaber and Patel 2012). Although production assortment is mostly a managerial decision, which can be controlled by product portfolio complexity management procedures, new product introductions are usually associated with certain increase in assortment size, which represents more SKUs to manage internally, drives manufacturing complexity, and reduces the effectiveness of demand management practices (Lee 2002).

For the purposes of the empirical part of this thesis (chapters 3, 4, 5, and 6), we adopt the trade-off view, in which exploration & exploitation are two ends of a continuum (i.e. the middle column in table 2.10). This perspective is, to some authors, conditioned to the level of analysis (i.e. references in the the top-right cell in table 2.10), such that the orthogonal view is applicable to higher levels of analysis –e.g. the firm– and the trade-off, continuous view is applicable to lower, narrower levels of analysis –e.g. business unit and a plant.

Bearing the trade-off view of E&E, in the empirical part of thesis we consider an operation to be more explorative as they present higher rates of new product introductions; likewise, an operation is more exploitative as they focus on an established product base. Hence, new product introductions can be viewed as closely related to the E&E continuum. Moreover, the event of a new product introduction is closely related to product variety/assortment, as the former will directly impact the latter, when not coupled with a corresponding product retirement/proper assortment management.

These ideas are summarized in figure 2.3 and will be examined in the following chapters.

2.8. Discussion and directions for future research

Dealing with E&E is an old-time issue faced by companies; yet, in an increasingly competitive market, firms must be both innovative and efficient in order to survive in the long run. For almost three decades, researchers have been working on the answers to several questions

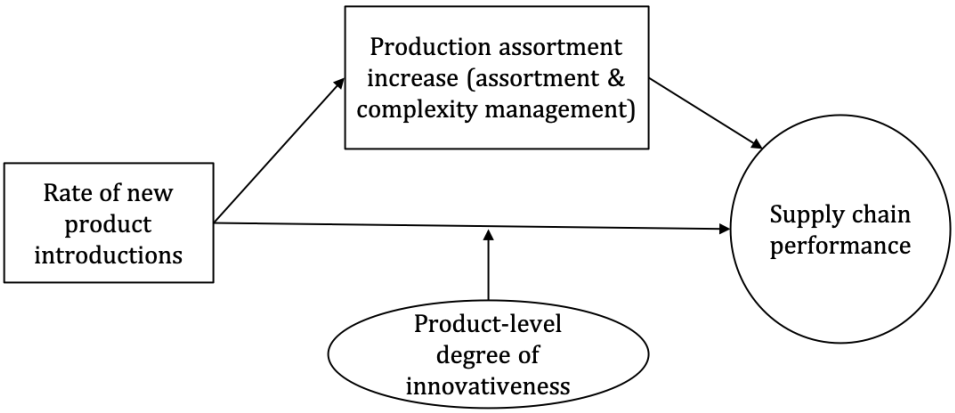

Figure 2.3: *Exploration & exploitation, new product introductions and supply chain performance*

related to this relationship and, although that conversation started from the organizational learning context, it now spans diverse disciplines, including operations management, which have employed the E&E lenses to analyze efficiency *versus* flexibility issues, as well as topics related to technology sourcing and innovation.

As the concept of organization ambidexterity evolves, as well as research on its antecedents, moderators, and consequences, it leaves its actual implementation as an open question, which Birkinshaw and Gupta 2013 suggested as one of the most promising areas for E&E research. The implementation question paves the road for extended research from the operations perspective. As a discipline that deals with how organizations actually get things done, operations management is equipped with the tools to take E&E research to the next level, answering questions on how to resolve the productivity dilemma at the field operation level.

Despite early attempts to promote E&E research within the discipline, it was only recently that operations management scholars started to devote more attention to those types of questions. Yet, these initial efforts are mostly based on cross-sectional survey data, not employing objective measures from the operations. The need for longitudinal analyses on E&E research has been acknowledged by several operations management scholars (Kortmann et al. 2014; Fernhaber and Patel 2012; Kristal, Huang, and Roth 2010; Rothaermel and Alexandre 2009) as well as as researchers from other disciplines (Tokman et al. 2007; Raisch et al. 2009; Nosella, Cantarello, and Filippini 2012; Lavie and Rosenkopf 2006; Boumgarden, Nickerson, and Zenger 2012). Moreover, we also identified calls for more research using primary data

within the papers reviewed (Jayanthi and Sinha 1998; Mudambi and Swift 2014). Future research would benefit from longitudinal operational primary data for its direct link to what actually happens on the field through time. It also seems that by observing E&E from the operations management context, we are better positioned to explore the relationship of E&E and operational performance metrics, departing from the traditional growth and finance views.

As E&E literature crosses the operations frontier, it opens a sea of opportunities and we expect to see research to get done on the relationship between E&E and several operational aspects of a firm, such as forecasting & planning, procurement, quality management, manufacturing, customer service, inventory management, warehousing, and distribution logistics, to name a few. For example, what is the impact of pursuing high levels E&E on supply chain performance? How does an exploration-and-exploitation-enabling supply chain strategy look like?

Moreover, as the digital revolution pushes the locus of innovation beyond the boundaries of the firm to open or peer communities (Benner and Tushman 2015), it makes more evident to conduct research on the relationship between E&E and the stakeholders within a supply chain. For example, how can suppliers better deal with the conflicting demands for innovation and service level from buyers? How can supply chains remain efficient –or even become more efficient– while absorbing new products and/or services?

Questions following these proposed avenues will require the use of different data sources, unit of analyses, and research approaches, as compared to what has been done so far on operations-oriented E&E research. For example, operations-oriented E&E research currently lacks the use of primary operational data at the plant/ project/ process and cross-boundary levels, which are essential to the within-company and supply chain natures of operations management. We also consider that, by following the macro-questions proposed, E&E research will advance to a new level, one that better defines how the pursuit of high levels of E&E configuration is actually implemented, operationally.

This study contributes to the literature, as it summarizes the evolution of E&E research to date, being the first one to do so from an operations management perspective, highlighting the need for employing operational data and operational performance metrics. We hope to

raise the attention of operations management scholars to intensify research on the topic, aiming at clarifying the operational mechanisms to dealing with E&E implementation. Moreover, we believe that this research can be helpful to practitioners as it can be a source of information to those dealing with E&E in their businesses.

2.9. Next steps

On the next chapters we develop some of the research gaps identified on the literature review. In the context of our research, we view exploration as related to innovation –represented as new product introductions– and exploitation as maintaining a similar set of products –i.e. the absence of new product introductions. Thinking about exploration and exploitation as two ends of a continuum (Gupta, Smith, and Shalley 2006; March 1991), on which the rate of new product introductions will represent the E&E configuration, we analyze the impact of new product introductions on supply chain performance, which we represented by three distinct concepts: service level, inventory freshness, and product quality conformance.

Later on this thesis, we use longitudinal operational primary data from a manufacturing company to conduct our data analyses, and theory-building and action-research case research data to conduct our qualitative analyses. We tackle several operations-oriented E&E research questions, such as the following: how does the introduction of new products impact the operations of a CPG manufacturing firm? To what extend does the introduction of new product impact CPG manufacturing operations? Does this impact vary according to short-term or long-term perspectives? What are the factors that must be considered when crafting exploration-and-exploitation-enabling supply chain strategies to support new product introductions into consumer packaged goods manufacturing operations?

We will also refer to operations in different, embedded, levels of analysis: in chapters 3 and 6 we analyze operations from the business unit level, while in chapters 4 and 5 we view it from one level below, from a product category –i.e. groups of similar products– perspective.

Apart from finding the research gaps, we also use this literature review as lenses for analyzing our findings. We read our results from the perspective of the E&E literature.

Chapter 3

Understanding how new product introductions impact operations: preliminary interviews in a consumer packaged goods manufacturing company

3.1. Introduction

In chapter 2, we identified the need to investigate exploration & exploitation (E&E) implementation issues and claimed that operations management, as a discipline that deals with how organizations actually get things done, is equipped with the tools to take E&E research to the next level, answering questions on how to resolve the productivity dilemma at the field operations level. In our quest to developing a framework for dealing with product portfolio exploration & exploitation in consumer packaged goods (CPG) manufacturing operations, we identified the real-world situation of a CPG manufacturing company that faces the productivity dilemma. The company in the case frequently introduces new products into its operations –sometimes at the cost of some efficiency loss– and frequently wonders about the extent to which it should keep increasing its product assortment and about how to better deal with its conflicting objectives of being innovative and efficient at the same time. We decided that, in order to properly propose a theoretical framework to address those questions, we needed to take a step back and first understand the impact of product innovation in the operations of a CPG manufacturing company.

In this chapter, we build some basic knowledge for analyzing E&E from the new product introductions (NPI) perspective, within the supply chain management context. We conducted a set of preliminary interviews within an innovative CPG manufacturer to devise a set of testable hypotheses relating the operational impact of NPI on supply chain performance. All

hypotheses can be viewed both in the short-term and the long-term perspectives.

We found evidence that NPI directly jeopardize the supply chain performance, mostly due to attention shifts and learning curves. We also found an indirect impact associated with increased assortments. Moreover, the case shows that the magnitude of this impact can be exacerbated as the product-level degree of innovativeness increases.

The following sections in this chapter are organized as follows: section 3.2 introduces the context that inspired our study and defines the research question, section 3.3 explains our research methods, section 3.4 provides the results of our analysis; section 3.5 develops a set of hypotheses and a conceptual model devised from our results, and section 3.6 concludes and discusses the results of this study, also providing directions for future research.

3.2. Motivation: MeatCo's productivity dilemma

This research has been motivated by a real-world problem faced by MeatCo[1], a regionally-leading manufacturer of processed meat products based in Southern Europe. Founded in 1990, MeatCo is a medium-sized company, directly employing roughly 500 people at the time of the research, despite its leadership position. The company targets a population superior to 50 million people and follows a differentiation competitive strategy (Porter 1980) by offering a wide assortment of customizable products, focusing on superior quality, and delivering high service levels. That approach has led the company to consistently outgrow its market during several years; yet, at the cost of diminishing profitability.

Serving large supermarkets and distributors who sell to small shops, MeatCo offers six categories of meat-based products: (1) seasoned, (2) chopped, (3) breaded, (4) non-breaded pre-cooked, (5) ready-meals, and (6) canned. Some product examples are chicken wings, hamburgers, chicken nuggets, meat balls, meat lasagna, and canned meat. Large retailers have the choice to buy any of those products under MeatCo's brand or under their own private label and can customize the products to a great extent. To distributors, however, only MeatCo's brand is offered and customization is limited.

[1]The true name of the company has been disguised for confidentiality reasons.

In order to remain at the forefront of the market, MeatCo heavily invests in new product development. As an illustration, during 2016 and 2017 the firm has introduced more than 300 new SKUs, consequently –accounting for product retirement– increasing product assortment from 223 to 302 SKUs. Those new products, however, are heterogeneous with respect to their degree of innovativeness, ranging from simple, client-specific, customizations to more relevant novelties within the company's market.

MeatCo has experienced double-digit annual growth rates from 2012 to 2017, largely outgrowing the market in the same period and eventually reaching the leadership position. Nevertheless –although the company has invested on improving its operations by conducting process improvement initiatives, implementing new IT systems, and acquiring new equipment– that fast-pace growth has come at a price, as the company has experienced a gradual-and-consistent drop on profitability within the period.

Inspired by MeatCo's productivity dilemma and using the lenses of the exploration & exploitation literatures, we analyzed the operational impact of NPI into a CPG manufacturing supply chain (SC), viewing exploration and exploitation as part of a continuum (trade-off view) that has NPI as the core variable (see 2.7). The objective of this part of the research is understanding the operational consequences –and the way it happens– of new product introductions. We aim at addressing the following research question: how does the introduction of new products impact the operations of a CPG manufacturing firm? To answer this question we conducted 33 semi-structured interviews with the company's employees involved in several SC functions and discovered that NPI qualitatively imply an impact on supply chain performance, spanning several functions such as procurement, logistics, production, maintenance, and quality control, for example. Based on this analysis we developed a framework of nine testable hypotheses, summarizing the impact of NPI on the SC performance.

3.3. Research methods

To tackle our research question, we conducted an explanatory qualitative analysis at MeatCo. Case studies – even single ones – are appropriate to tackling "how" questions that deal with operational links of contemporary events out of the researcher's control (Yin 1994). Case stud-

ies can also provide theoretical, analytical, generalization (Ketokivi and Choi 2014; Yin 1994), which is suitable to our goal of developing a set of testable hypotheses regarding the impact of NPI on SC performance. We followed some of the case study design guidelines as proposed by Yin 1994: systematically registered the data collection by tape-recording and transcribing the interviews, created database of evidences, conducted pattern matching, triangulated results with theory, and had key informants review the draft report of the analysis. We consider this study relevant to better understanding the underlying phenomena, linking the literature to an empirical setting and establishing the ground for our subsequent analyses.

Our data consisted of semi-structured interviews with 33 MeatCo's employees working in the following areas: general management, finance, research & development, marketing & sales, production planning, procurement, production, logistics, infrastructure & maintenance, process & project management, information technology, and infrastructure & facilities. We have chosen these areas because they are all, to a certain extent, related to the company's supply chain management (Mentzer et al. 2001), as explained in section 2.2.1. Interviewees included employees from diverse hierarchical levels, ranging from top managers (e.g. CEO and CFO) to field-operations leaders (e.g. production line shift leaders and warehouse leaders). See table 3.1 for a summary of the interviewees' profiles.

The interviews took, on average, 36 minutes, ranging between 17 minutes to 78 minutes. With the exception three cases, all the interviews were tape-recorded, with the consent of the interviewees, and were later automate-transcribed with the assistance of the Trint software (Trint Ltd. 2018). A single interviewer took notes during the interviews and coded the results in NVivo 12 (QSR International Pty Ltd 2018).

The coding strategy concentrated on identifying the key aspects on which new product introductions impact the company's operational activities. Upon identifying those key points we returned to the company to validate the results with its top managers, then proceeding to the analysis of the results.

#	Function	Title/rank	Duration (min.)	Recorded & Transcribed?
1	General Management	C.E.O.	60	No
2	Logistics	Logistics Director	78	Yes
3	Procurement	Procurement Director	52	Yes
4	Research & Development	R&D Project Manager	54	Yes
5	Logistics	Warehouse supervisor	38	Yes
6	Engineering & Infrastructure	Engineering & Infrastructure Manager	21	Yes
7	Research & Development	R&D Analyst	38	Yes
8	Information Technology	I.T. Director	30	No
9	Research & Development	R & D Analyst	23	Yes
10	Package Design	Designer	37	Yes
11	Logistics	Warehouse Supervisor	36	Yes
12	Finance	C.F.O.	30	No
13	Quality & Food Safety	Quality & Food Safety Director	61	Yes
14	Sales	Key Account Manager	41	Yes
15	Quality & Food Safety	Quality Analyst	44	Yes
16	Quality & Food Safety	Quality Analyst	30	Yes
17	Logistics	Warehouse Supervisor	24	Yes
18	Logistics	Picking Supervisor	30	Yes
19	Logistics	Warehousing Manager	30	Yes
20	Sales	Export Manager	17	Yes
21	Laboratory	Laboratory Manager	18	Yes
22	Market Intelligence	Market Intelligence Manager	71	Yes
23	Quality & Food Safety	Food Safety Lead	36	Yes
24	Research & Development	R&D kitchen lead	28	Yes
25	Projects & Processes	Project manager	27	Yes
26	Maintenance	Maintenance Manager	20	Yes
27	Projects & Processes	Time & Motion Analyst	27	Yes
28	Production	Production Planning Lead	59	Yes
29	Projects & Processes	Process Analyst	25	Yes
30	Production	Shift Manager	20	Yes
31	Production	Supervisor - Production Line A	25	Yes
32	Production	Supervisor - Production Line B	19	Yes
33	Production	Supervisor - Production Line C	19	Yes
	Total		1168	

Table 3.1: *List of interviews and interviewees' profile*

3.4. Results

We identified six key areas that are impacted by new product introductions at MeatCo: (1) demand management; (2) procurement; (3) production; (4) logistics & inventory management; (5) infrastructure & maintenance; and (6) quality control & food safety, which are all related to supply chain management, as discussed in section 2.2.1. In the following subsections, we provide the details on the impact reported on each area.

3.4.1. Demand management

The introduction of a new product into MeatCo's operations increases the complexity of company's demand management activities. When it is not coupled with proper assortment/complexity management, NPI is associated with increased product assortment, thus increasing the variability of the demand patterns and, consequently, decreasing forecasting accuracy (Lee 2002). Even when it is not associated with larger assortment, NPI still makes demand assortment more intricate, as noted by one interviewee:

> *There's the case of a new SKU that has been introduced into a specific client two months ago and still does not have a stable, predictable, demand pattern –they keep ordering between 200 and 500 units. When we talk about our 'barbecue' products, it is even harder, because we offer that to all of our clients, who gradually adopt the product, without previous notice*

Demand forecasting for new products follow a subjective process due to lack of historical demand patterns and precise information from expected orders from clients. It takes time until the demand pattern is stable and the company builds sufficient historical information to be able to predict orders at an acceptable level of accuracy.

3.4.2. Procurement of raw materials

> *The company must procure everything on time. Recently, we had a situation on which the new product required a new type of label, which was delayed, frustrating our order fulfillment.* (Interviewee)

The degree of novelty of a new SKU, with respect to the company's current offering, can vary substantially at MeatCo. From the procurement perspective, a new SKU can have little-to-no

modifications compared to the existing products, using the same ingredients already in use by the firm, or represent relevant changes, such as the introduction of new ingredients. Both cases can pose additional challenges to the procurement function.

In the first case, the impact of NPI on procurement derives from the above-mentioned demand management issues, especially when it is associated with assortment increase. Due to the increased demand complexity, the introduction of new products will increase the variability of the amount of raw material needed in the operations flow. As noted by one employee:

> *New product introductions are usually urgent, but half of the ingredients are missing. Sometimes, new ingredients will remain out-of-stock for a few days... during the past two months we have increased the number of SKUs manufactured per day and we have noticed that more ingredients are missing.*

In the second case, as mentioned during the interviews, the introduction of new ingredients will cause at least some temporary attention shift from procuring regular materials to procure the new materials. If the new materials are not offered by the current set of suppliers, the company will also need to look for or develop the suppliers of the desired raw material. As a further consequence, it can also increase the number of procurement items, augmenting the overall sourcing complexity.

As evidenced by our data, NPI raises the likelihood of procurement inefficiency. We found that it is mostly due to consequences from the impact on demand management, attention shift, and overall sourcing complexity.

3.4.3. Production

> *The impact of new product introductions in production is high, especially during the first days and when the factory is operating at capacity.* (Interviewee)

New product introductions directly and indirectly impact production. First, the development phase that precedes NPI require industrial tests that may disrupt production, when conducted within the same production lines as those of the regular operations. As quoted below:

> *We usually try to schedule industrial test on days of low production volume or to periods*

in-between production shifts... however, sometimes the impact is inevitable, as sometimes we need to do it in a rush, due to tight promised time-to-market.

Later, independently of whether or not NPI it is associated with assortment increase, the introduction of a new product requires the factory-floor workers and the company itself to learn how to properly produce that good. New products may require the design and implementation of new manufacturing processes and technologies, which may increase the complexity related to NPI. That learning curve can be steeper for workers if the new product is more complex and different to what the company currently does. As quoted below:

Sometimes the factory floor workers do not know what to do, when manufacturing a new product. There is a learning curve for making new products, especially when the new product is more innovative and requires different production processes.

Second, when associated with assortment increase, new product introductions lead to inefficiencies due to increased number of changeovers required to manufacturing a larger variety of products (Adler, Goldoftas, and Levine 1999). It can also lead to suboptimal production scheduling, decurrent from increased demand variability (Lee 2002).

3.4.4. Logistics & inventory management

We observed on the interviews that logistics is directly affected by NPI. Independently of assortment increase, each time a new product is introduced a series of logistics decisions must be made, such as the SKU position in the warehouse and its handling requirements, which can alter distribution routes and nodes. Depending of the physical form of the new SKU, it may impact the way other products are handled. These consequences are exacerbated when new product introductions are tied to assortment increase. In this case, warehousing logistics becomes more complex due to the larger number of SKUs.

Interviewees also mentioned that the uncertainties related to new products and the increase in the number of SKUs augments the need for inventory, overall, in order to maintain high service levels. However, that is an obstacle to providing fresh products, as higher inventory levels tend to lead to more inventory obsolescence.

3.4.5. Infrastructure & maintenance

Contingent on the degree of process and technology innovation embedded in a new product, MeatCo has to adjust its production infrastructure in order to be able to manufacture the new SKU. It, sometimes, can lead to a cascading impact, whenever the reorganization or addition of one production line crosses the area required by neighboring production lines to properly flow – especially in constrained physical spaces, which was the case of MeatCo.

New product introductions also have an indirect impact on infrastructure. Our interviewees pointed that assortment increase, a usual consequence of new product introductions, can also lead to increased changeovers, which may increase the likelihood of equipment failure and calls for changes on preventive maintenance policies.

3.4.6. Quality control & food safety

New product development requires putting together the technical aspects of the new products, a task that involves coordinating with several departments within the company. Being a firm within the food industry, MeatCo needs to comply to food safety rules from government authorities, independent accreditation organizations (e.g. BRC and UKAS), and even certain clients. The company is subject to frequent, planned and unplanned, audits from those parties. New product introductions bring additional risks to food safety, especially when a new allergenic ingredient is introduced. Different allergens are subject to distinct sets of rules, which, besides increased risk, increased compliance complexity, as evidenced by our data:

> *It is not usual to find a company that produces, within the same plant, products based on meat, fish, poultry, vegetables, mushrooms, etc. There are so many allergens involved and sometimes it is difficult even for external food safety auditors to monitor us... sometimes the certifying and auditing bodies have trouble in finding an auditor that is able to deal with such a broad range of allergens.*

Moreover, interviewees mentioned that, as NPI increases manufacturing complexity and variability, it is associated with greater incidence of quality non-conformity issues. The introduction of new products makes more plant operations harder to cope with, which in turn increases the likelihood of mistakes and quality-related claims.

3.5. Conceptual model

Our quest to building a conceptual model depicting the impact of new product introductions on supply chain performance firstly requires identifying and defining proper metrics that can represent supply chain performance, a topic that we discussed in section 2.2.2. This task can be quite demanding, as supply chain performance can be measured in on different perspectives, including suppliers, production, delivery performance, cost, and customer satisfaction (Gunasekaran, Patel, and McGaughey 2004). Griffis, Cooper, and Goldsby 2004 suggests that the selection of performance measures should be based upon the firm's strategy; thus, following MeatCo's case, we observed that the firm's operational strategy is mostly related to providing high service levels, producing superior quality goods, and delivering fresh products –which implies high inventory turnover. We, therefore, consider a set of three well-known components as representatives of supply chain performance in our context: service level, inventory freshness, and product quality conformance.

Based on the analysis of MeatCo's data, summarized in section 3.4, and also from the analysis of the literature on exploration & exploitation (chapter 2), we developed a conceptual model consisting of a set of nine hypotheses relating the impact of new product introductions on supply chain performance, which is described in the following subsections and is graphically depicted in figure 3.1. Each hypothesis can be viewed both the short-term and in the long-term perspectives. Note that we present the hypotheses in sets of three, representing the different components selected as representatives of supply chain performance.

3.5.1. The direct impact of new product introductions on supply chain performance

Evidences from our case suggest that new product introductions imply direct and indirect impact on the performance of several operational functions, including –but not limited to– production planning, procurement, production, logistics & inventory management, infrastructure & maintenance, and quality & food safety. We observed that the direct impact is mostly related to attention shifts (March 1991; Ocasio 2011) and learning curves (Adler and Clark 1991; Wright 1936; Carlson 1961).

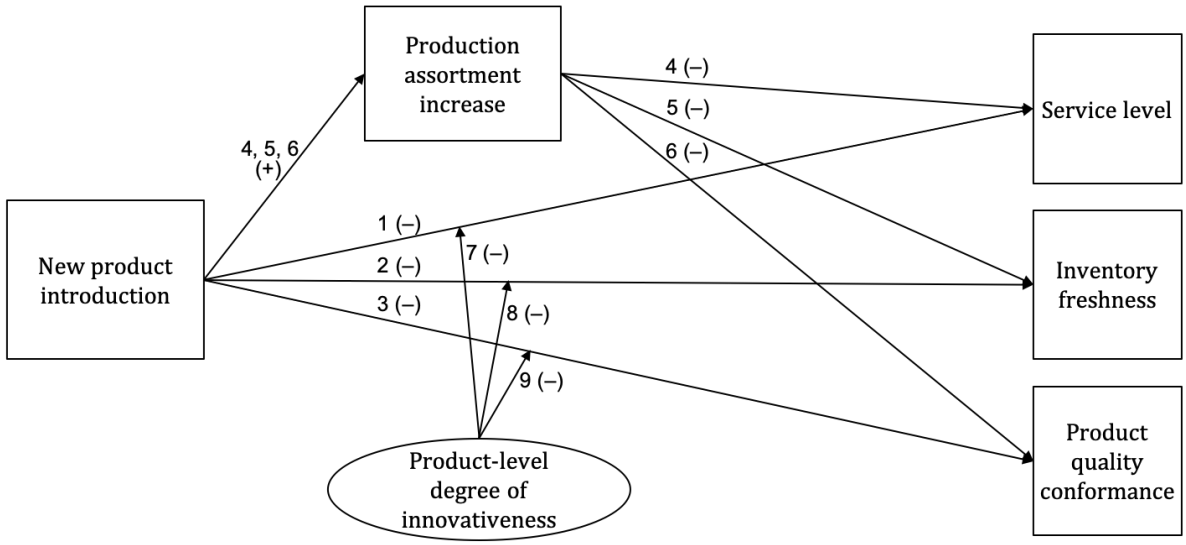

Figure 3.1: *Conceptual model for the short-term and long-term impact of new product introductions on the supply chain performance of a food manufacturing company*

We saw that when a new product is introduced within a CPG manufacturing operation, it decreases forecasting accuracy (section 3.4.1), shifts procurement attention (section 3.4.2), and increases the likelihood of production disruptions (section 3.4.3). Also, the associated increase of logistics complexity (section 3.4.4) can directly impact the supply chain performance of the company, leading to our first set of hypotheses, stated as follows.

Hypothesis 1 *New product introductions into a CPG manufacturing operation directly jeopardizes its service levels.*

Hypothesis 2 *New product introductions into a CPG manufacturing operation directly jeopardizes its overall inventory freshness.*

Hypothesis 3 *New product introductions into a CPG manufacturing operation directly jeopardizes its product quality conformance.*

3.5.2. Assortment-mediated impact of new product introductions on supply chain performance

The indirect impact of new product introductions on supply chain performance is related to the mediating role of variations in production assortment.

On the one hand, companies that do not have a proper assortment and complexity management in place, mostly common in small/new firms (Fernhaber and Patel 2012), will increase production assortment due to NPI. That is the case of MeatCo, as observed from the interviews.

On the other hand, production assortment increase will negatively impact supply chain performance. The reasons include higher demand complexity and uncertainty due to the larger number of SKUs, the larger number of items to be procured, and the greater manufacturing complexity, e.g. changeovers and larger likelihood of mistakes due changing processes, as also noted by Mapes, New, and Szwejczewski 1997. Larger assortments also lead to the increased risk of food cross-contamination, as noted by the interviewees.

This leads to our second set of hypotheses, stated as follows.

Hypothesis 4 *The negative impact of new product introductions on the service level of a CPG manufacturing operation is mediated by production assortment.*

Hypothesis 5 *The negative impact of new product introductions on the inventory freshness of a CPG manufacturing operation is mediated by production assortment.*

Hypothesis 6 *The negative impact of new product introductions on the product quality conformance of a CPG manufacturing operation is mediated by production assortment.*

3.5.3. The innovativeness-moderated impact of new product introductions on supply chain performance

We also found evidence that the impact of new product introductions is moderated by the product-level degree of innovativeness of the product being introduced. We learned from the case that as the greater is the novelty of a new product, the greater is the demand uncertainty and also sourcing complexity. Production also suffers from innovative-product introductions, as it usually implies steeper learning curves, which can disrupt operations and increase the likelihood of mistakes. Furthermore, high-novelty products can also increase complexity of quality & food safety controls. This leads to our last set of hypotheses, stated below.

Hypothesis 7 *The negative impact of new product introductions on the service level of a CPG manufacturing operation is exacerbated by the degree of innovativeness of the new product.*

Hypothesis 8 *The negative impact of new product introductions on the inventory freshness of a CPG manufacturing operation is exacerbated by the degree of innovativeness of the new product.*

Hypothesis 9 *The negative impact of new product introductions on the product quality conformance of a CPG manufacturing operation is exacerbated by the degree of innovativeness of the new product.*

3.6. Conclusions

New product introductions and supply chain management are, by definition, related to one another, as the latter is the require adapting the company's operations (Pero et al. 2010). From our interviews, we were able to identify and describe the operational impact of new product introductions in several functions of a CPG manufacturing company, such as demand management, procurement, production, logistics & inventory management, infrastructure & maintenance, and quality control & food safety.

In accordance with findings from previous scholars, we found evidence that introducing new products directly impact three components of supply chain performance: (1) service level, which can be represented as fill rate (Pero et al. 2010); (2) inventory freshness, which can be represented as inventory turnover (Ferdows and De Meyer 1990); and (3) product quality conformance (Sethi 2000), which can be represented as the rate of product returns. That makes sense from a theoretical standpoint, as well as from the perspective of the particular company in our case, as these concepts and metrics are closely associated with their business strategy (Griffis, Cooper, and Goldsby 2004).

Evidences from our case indicate that the direct impact of new product introductions on the supply chain performance is mostly related to attention shifts – as the company need to dedicate scarce resources to the innovation-related activities (March 1991)– and learning curves –as the firm becomes prone to mistakes related to new products and processes. We also have indications from our case that the extent of the direct impact may be moderated by product-level degree of innovativeness, as the more innovative products are more likely to introduce variability into the system. Still, we believe literature could benefit from further

quantitative testing and measuring of the hypotheses developed in this chapter using econometric methods.

Likewise, new product introductions indirectly impact supply chain performance through its association with changes in production assortment, which is the case of small/young firms, such as the one in our case. Positive changes in assortment size leads to increased complexity, represented by more SKUs to manage internally, increased manufacturing complexity, and reduced the effectiveness of demand management practices (Lee 2002). Moreover, in the particular case of the company in our study, an increase in the number of SKUs represents an increased risk of food contamination, whenever new allergen ingredients are introduced into the system.

This study has been grounded on extensive qualitative evidence from a single CPG manufacturing company based in Southern Europe. Although it provides meaningful insights, we believe that expanding this analysis to conducting case studies in additional settings would improve our understanding of how new product introductions impact the supply chain performance of a CPG manufacturer. Possible additional settings could be, for example, cases of companies based on different geographic regions, cases on different CPG segments, and larger companies. That would provide an improved foundation for identifying the nuances of the relationship between new product introductions and supply chain performance.

This investigation contributes to theory by evaluating how new product introductions impact supply chain performance in a CPG manufacturing firm, providing a set of testable hypotheses and a conceptual model explaining this relationship. It also carries managerial implications, as it improves the understanding about the how new product introductions impact supply chain performance, which can be relevant to decision making within innovative companies.

3.7. Next steps

In this chapter, we identified and described how new product introductions impact supply chain performance in a CPG manufacturing company. Still, a natural next step for this research is finding further empirical evidence to corroborate to our claims by quantitatively testing and

measuring this relationship.

In the next two chapters we dive deeper into this research by subjecting our hypotheses to extensive statistical tests. Aiming at developing a solid analysis, we were paid special attention to the endogeneity issue and followed the recommendations from Stock and Watson 2011 and Ketokivi and McIntosh 2017 to aviod threats to the internal validity/endogeneity in our study.

However, at a certain point, we faced the issue that our product-level degree of innovativeness variable, a core component to testing hypotheses 7-9, was prone to measurement error, thus consisting of a threat to the internal validity of our study (Stock and Watson 2011). Due to the importance of such variable, we did not want to simply dismiss it –although we were not willing to jeopardize the quality of this work. Thus, we decided to follow a two-stage approach, devoting a chapter to each one: in chapter 4, we excluded the moderator variable, being able to evaluate only hypotheses 1 to 6 –this has allowed us to develop an analysis with no apparent threats to internal validity. In chapter 5, we included the moderator variable –although we are aware that it threatens internal validity to a certain extent. We then compared the results obtained in both stages and analyzed the results in light of the existing literature. Moreover, the findings from this chapter served as a core input to the analyses developed in chapter 6, on which we developed an action-research-based framework for building E&E-enabling supply chain strategies.

Chapter 4

Measuring the direct operational impact of new product introductions

4.1. Introduction

In the previous chapter we analyzed how new product introductions (NPI) impact the supply chain performance of a consumer packaged goods (CPG) manufacturing firm. We proposed a conceptual model in that NPI directly and indirectly impact supply chain performance, which can be represented by three components: service level, inventory performance, and product quality conformance (figure 3.1). The direct impact is originated mainly from attention shifts (March 1991; Ocasio 2011) and learning curves (Adler and Clark 1991; Wright 1936; Carlson 1961). On the other hand, the indirect impact is associated with changes in production assortment. Furthermore, the direct impact is moderated by product-level degree of innovativeness, as more innovative products tend to require more operational changes, exacerbating its impact. We also added that these relationships can be viewed both in the short-term and the long-term perspectives.

In this chapter we test the hypotheses from chapter 3 using longitudinal data from a manufacturing company's operations –yet, we leave the moderation effects of product-level degree of innovativeness to the next chapter, for the reasons explained in section 3.7, on the previous chapter. We developed ran groups regression models using using a sample of six product categories over 105 weeks.

We found evidence that new product introductions are associated with lower supply chain performance. Yet, that association is more pronounced when it is sustained during longer

periods, not allowing operations to adapt to changes. Moreover, we found indications that assortment changes is a relevant factor in this relationship.

This research contributes to the exploration & exploitation literature by analyzing the impact of new product introductions –which is closely related to the exploration & exploration (E&E) continuum, as explained in section 2.7– on supply chain performance, based on real-world longitudinal operational data, at the product category level of analysis, thus addressing research gaps discussed in section 2.8. This study is also employs a methodology that allows interpreting short-term and long-term results and is robust to multiple treats to validity. Furthermore, we believe that the findings from this research are helpful to practitioners dealing with E&E-related questions.

The following sections in this chapter are organized as follows: section 4.2 reviews the hypothesis background and explains the metrics used, section 4.3 extensively explains the research methods employed, section 4.4 describes the results of the analysis, in section 4.5 we discuss our findings, and in section 4.7 we conclude with the limitations of this study, providing directions for future research.

4.2. Hypotheses and constructs

We tested a subset of six hypotheses drawn from the conceptual model presented in section 3.5 (hypotheses 1 to 6). Each hypothesis was evaluated in the short and in the long-term perspectives. These hypotheses relate the unmoderated direct and the indirect impact of new product introductions on supply chain performance and are represented by figure 4.1 and stated as follows.

Hypothesis 1 *New product introductions into a CPG manufacturing operation directly jeopardizes its service levels.*

Hypothesis 2 *New product introductions into a CPG manufacturing operation directly jeopardizes its overall inventory freshness.*

Hypothesis 3 *New product introductions into a CPG manufacturing operation directly jeopardizes its product quality conformance.*

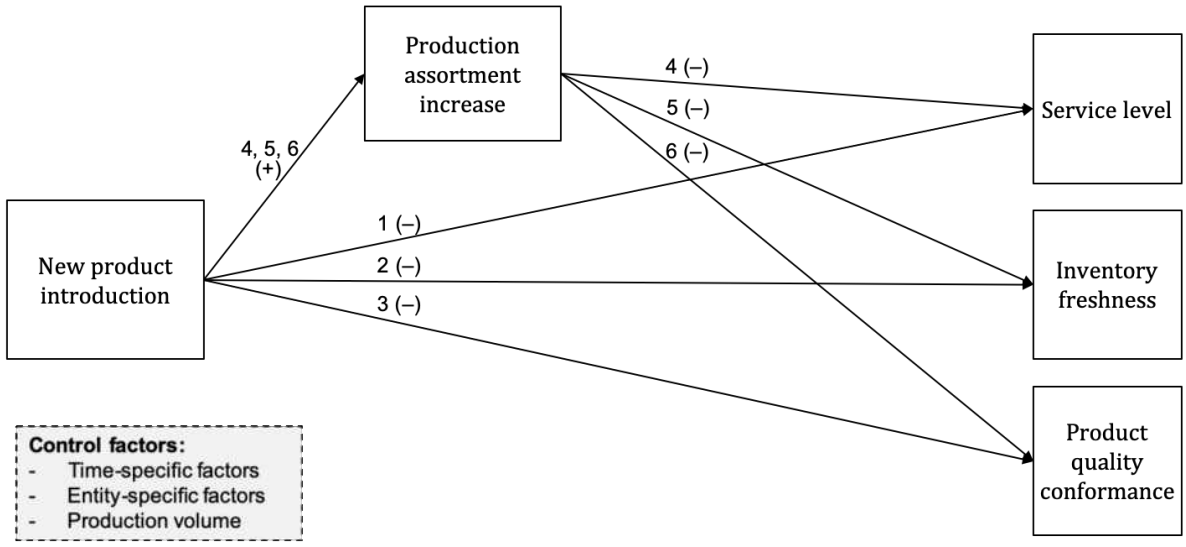

Figure 4.1: *Graphical representation of the hypotheses tested in chapter 4*

Hypothesis 4 *The negative impact of new product introductions on the service level of a CPG manufacturing operation is mediated by production assortment.*

Hypothesis 5 *The negative impact of new product introductions on the inventory freshness of a CPG manufacturing operation is mediated by production assortment.*

Hypothesis 6 *The negative impact of new product introductions on the product quality conformance of a CPG manufacturing operation is mediated by production assortment.*

Our set of hypotheses is related to six key constructs, including two regressor variables (production assortment size and new product introductions), three regressand variables (i.e. service level, inventory freshness, and product quality conformance), and three control factors (total production volume, time-specific factors, and entity-specific factors). The respective description of each variable is developed as follows.

Suppose that a given company is able to manufacture several unique, ready-to-sell, stock keeping units (SKUs), $i \in A = \{1, \ldots, n\}, A \in \mathbb{R}^+$. Based on the similarity of their characteristics, such as product type and/or the use of similar production lines and processes, each SKU, i, is associated with a product category group, $j \in G = \{1, \ldots, m\}, G \in \mathbb{R}^+$. Let t represent a given period of observation, where $t \in T = \{1, \ldots, z\}, T \in \mathbb{R}^+$. Our unit of analysis is the weekly operation of one product category. Constructs are operationalized as follows:

1. **New product introductions** are denoted by NPI_{jt} and represent the number of different SKUs that are manufactured for the first time. It is given by equation 4.1.

$$NPI_{jt} = \sum_{i=1}^{n} FSTPROD_{ijt},\ \forall j \in G,\ \forall t \in T, \tag{4.1}$$

Where the event of producing product i, from product category j, for the first time, is denoted by $FSTPROD_{ijt} = \begin{cases} 1, \text{ if true} \\ 0, \text{ otherwise} \end{cases}$

2. **Production assortment** is denoted by $ASSORT_{jt}$ and represents the number of different SKUs that are manufactured in the period and is given by equation 4.2.

$$ASSORT_{jt} = \sum_{i=1}^{n} PROD_{ijt},\ \forall j \in G,\ \forall t \in T, \tag{4.2}$$

Where the event of producing product i, from product category j, in the period t, is denoted by $PROD_{ijt} = \begin{cases} 1, \text{ if true} \\ 0, \text{ otherwise} \end{cases}, \forall i \in A,\ \forall j \in G,\ \forall t \in T.$

3. **Service level** is denoted by $FILLRATE_{jt}$ and represents the weight-based fill rate, the percentage of product orders, by weight, thats are actually fulfilled on time by the company. It is given by equation 4.3.

$$FILLRATE_{jt} = \frac{\sum_{i=1}^{n} SALES_{ijt}}{\sum_{i=1}^{n} SALES_{ijt} + LOSTSALES_{ijt}} \times 100,\ \forall j \in G,\ \forall t \in T, \tag{4.3}$$

Where $SALES_{ijt}$ represents the volume, in weight, sold (and delivered on time) of product $i \in A$, from product category $j \in G$, at time $t \in T$; and $LOSTSALES_{ijt}$ represents the volume, in weight, ordered (but not delivered on time) of product $i \in A$, from product category $j \in G$, at time $t \in T$. Note that the sum of sales and lost sales represents the demand.

The weight-based fill rate is a variation of the unit fill rate (Closs, Nyaga, and Voss 2010). In order to achieve a fill rate of 100%, the firm must completely fulfill all of its orders on time. Failing to complete an order on time –even it is fulfilled afterwards, e.g. next day– will negatively account to the fill rate, i.e. the model assumes no backorders.

4. **Inventory freshness:** we chose the inventory turnover ratio to represent the idea of inventory freshness in our problem. Inventory turnover is defined as the ratio of throughput to average inventory (Hopp and Spearman 2008), thus representing how many times the inventory turned over on a given period, which is closely related to the notion of inventory freshness –i.e. higher inventory turnover indicates that average inventory is newer, thus fresher. We use the label $ITURNS_{jt}$ to represent the average turnover ratio of the inventory of finished goods in the period t in product category j, as given by equation 4.4.

$$ITURNS_{jt} = \frac{\sum_{i=1}^{N} SALES_{ijt}}{\sum_{i=1}^{N} ILEVEL_{ijt}}, \ \forall j \in G, \ \forall t \in T, \tag{4.4}$$

Where $ILEVEL_{ijt}$ represents the average inventory level, in weight, of product $i \in A$, from product category $j \in G$, at time $t \in T$.

5. **Product quality conformance:** to represent this idea we chose the rate of product returns metric, the percentage of the production volume, in weight, that is defective and returned either from internal or from external sources (i.e., returns from clients). We use the label $RRATE_{jt}$ to represent it on equation 4.5.

$$RRATE_{jt} = \frac{\sum_{i=1}^{N} INTRETURNS_{ijt} + EXTRETURNS_{ijt}}{\sum_{i=1}^{N} PRODVOL_{ijt}} \times 100, \ \forall j \in G, \ \forall t \in T, \tag{4.5}$$

Where $INTRETURNS_{ijt}$ and $EXTRETURNS_{ijt}$ represent the volume, in weight, of the product, $i \in A$, from product category $j \in G$, that is returned by internal and external sources, respectively, at time $t \in T$; and $PRODVOL_{ijt}$ represent the amount, in weight, produced of product $i \in A$, from product category $j \in G$, at time $t \in T$.

6. **Total production volume** is denoted by $PRODVOL_{jt}$ and represent the amount, in weight, of all products produced from product category $j \in G$, at time $t \in T$.

7. **Time-specific factors** represent all omitted factors that vary through specific points in time, but are common to all entities (i.e. product categories).

8. **Entity-specific factors** represent all omitted factors that are specific characteristics of each entity, but do not vary through time.

4.3. Research method and sample

4.3.1. Data from a real-world operation

Our original data set consisted of information from MeatCo's operations –at the SKU level, by week, with most variables covering the entire period from January of 2016 to January 2018–, including product descriptions, production batches, sales (orders fulfilled), lost sales (orders not fulfilled), average inventory levels, and product returns. Inventory-related data, however, are not available for the entire period mentioned, but only from October 2016 to January 2018.

We chose to aggregate data per week, as it seems to be reasonable for balancing a proper sample size and the matching of NPI and supply chain performance effects. Had we chosen a daily aggregation, we would have obtained a large sample size, still the period would seem too small to allowing the emergence of the performance effects of NPI, as it may not be always visible within a single day (clients and products may have different lead times, inventory may have long cycles, and quality conformance issued may be found out days later). On the other hand, had we chosen a monthly data aggregation period, we would have more time to capture the performance effects of NPI, but our sample size would be meaningfully reduced. Thus, we chose a weekly data aggregation by considering that it allows the performance effects to be visible, while not jeopardizing sample size too much.

First we looked at the data behavior to see if there were any apparent pattern at the business unit level. Over the period within our dataset, MeatCo introduced 302 new products (figure 4.2), which has contributed to increasing its production assortment up to a certain point, when the company started retiring some of its products (figure 4.3). We can also notice some improvement on the company-wide fill rate (figure 4.4) and changing trends on the inventory turnover (figure 4.5). The rate of product returns increased (figure 4.6). Overall, production volume is trending upwards (figure 4.7).
Then, as the company was producing a heterogeneous mix of goods, we decided to split our final dataset into the level of MeatCo's six product categories. We noticed that each product category had their own characteristics with respect with the number of new product introductions (figure 4.8), production assortment (figure 4.9), fill rate (figure 4.10), inventory turnover (figure 4.11), rate of product returns (figure 4.12), and production volume (figure 4.13).

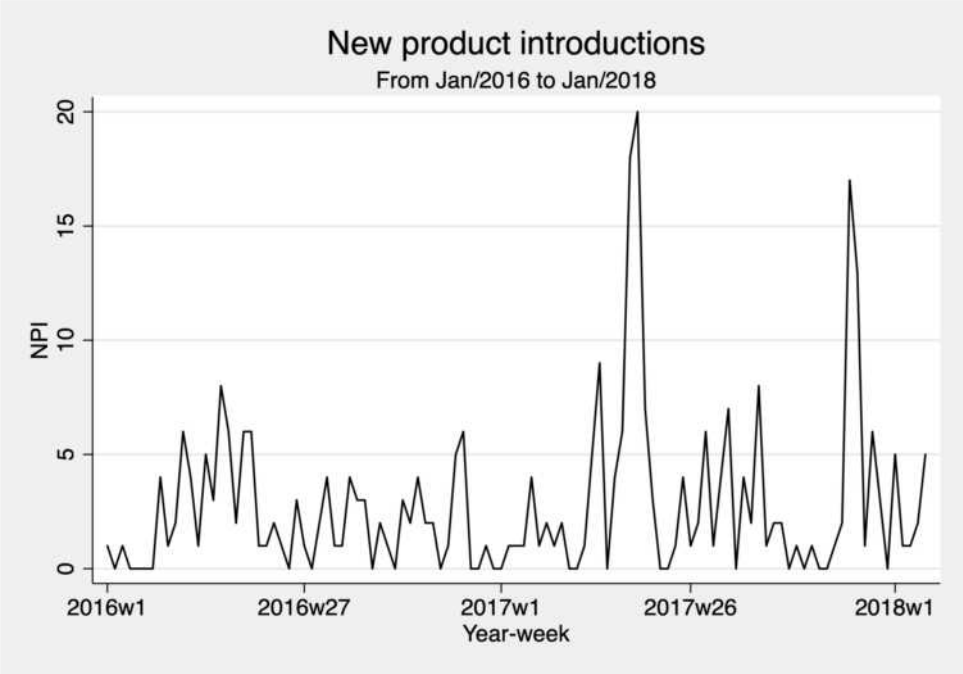

Figure 4.2: *New product introductions (cumulative) at MeatCo, from January 2016 to January 2018*

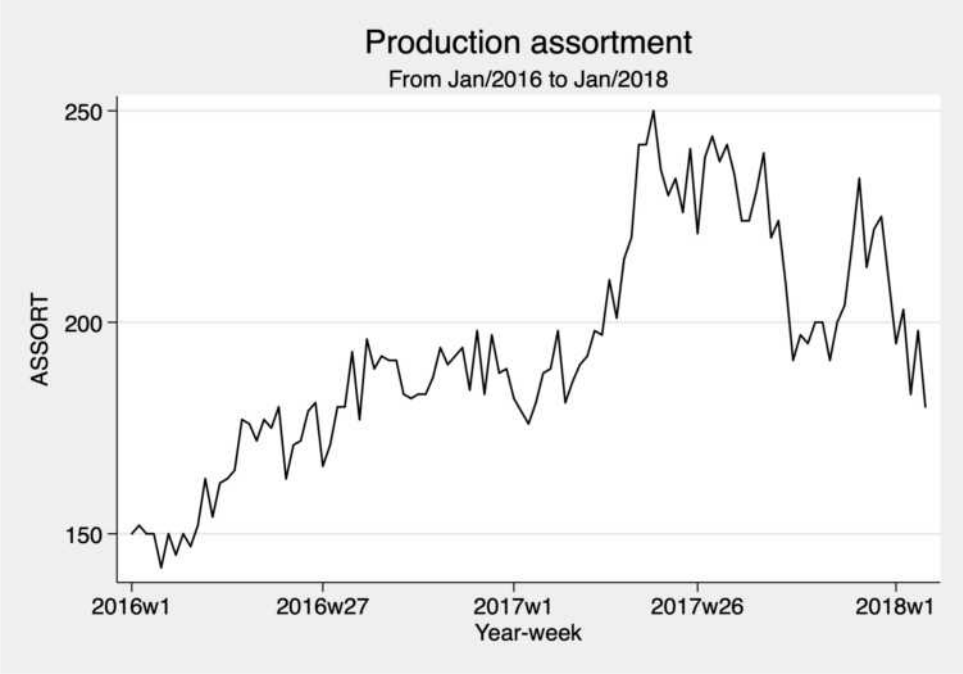

Figure 4.3: *Production assortment at MeatCo, from January 2016 to January 2018*

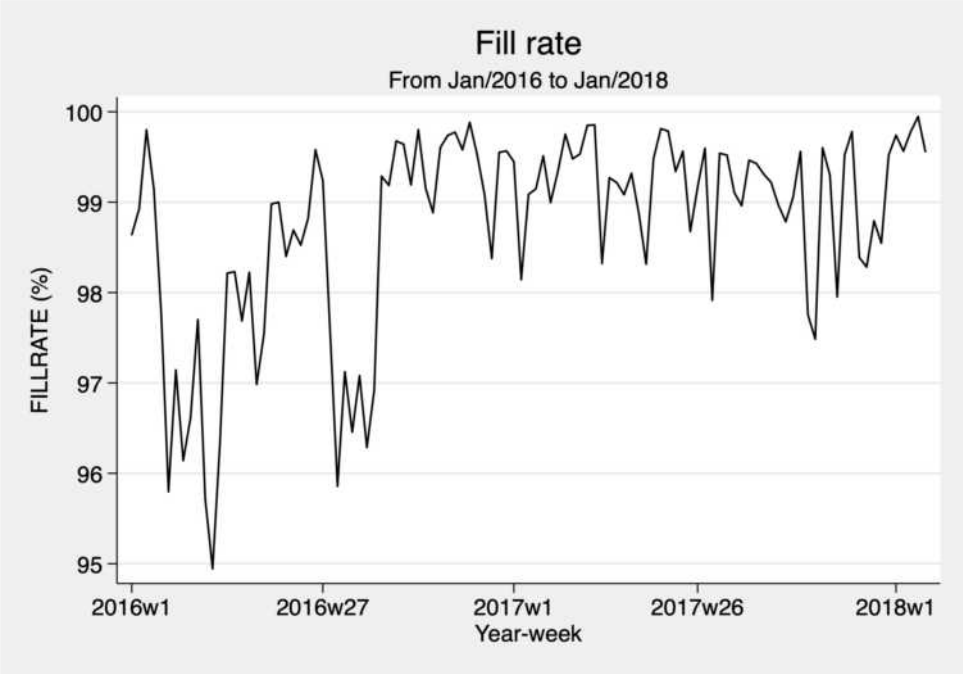

Figure 4.4: *Service level at MeatCo, from January 2016 to January 2018*

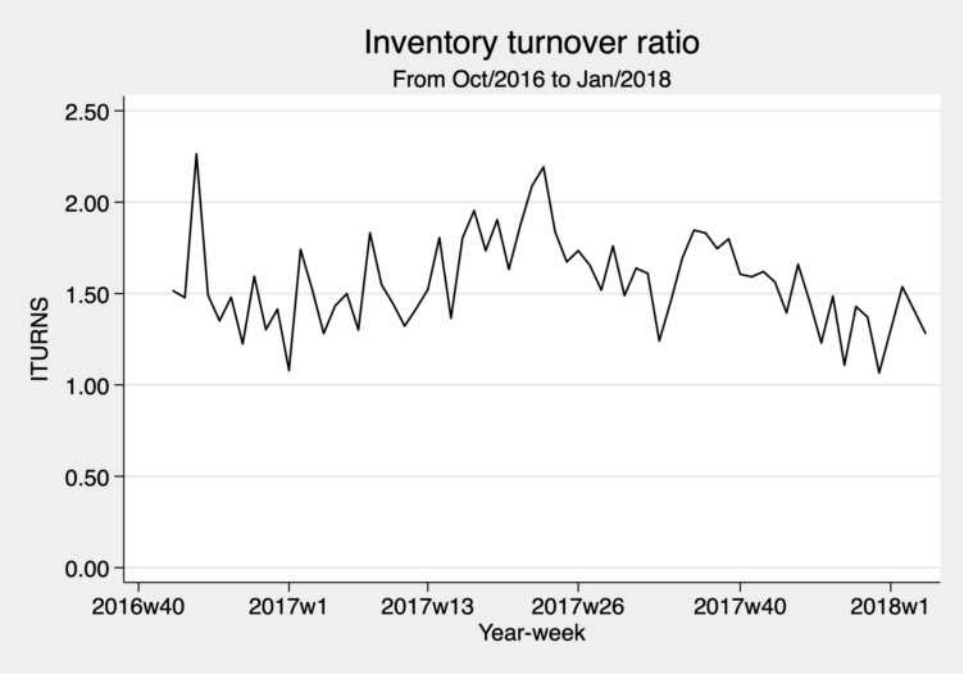

Figure 4.5: *Inventory turnover at MeatCo, from October 2016 to January 2018*

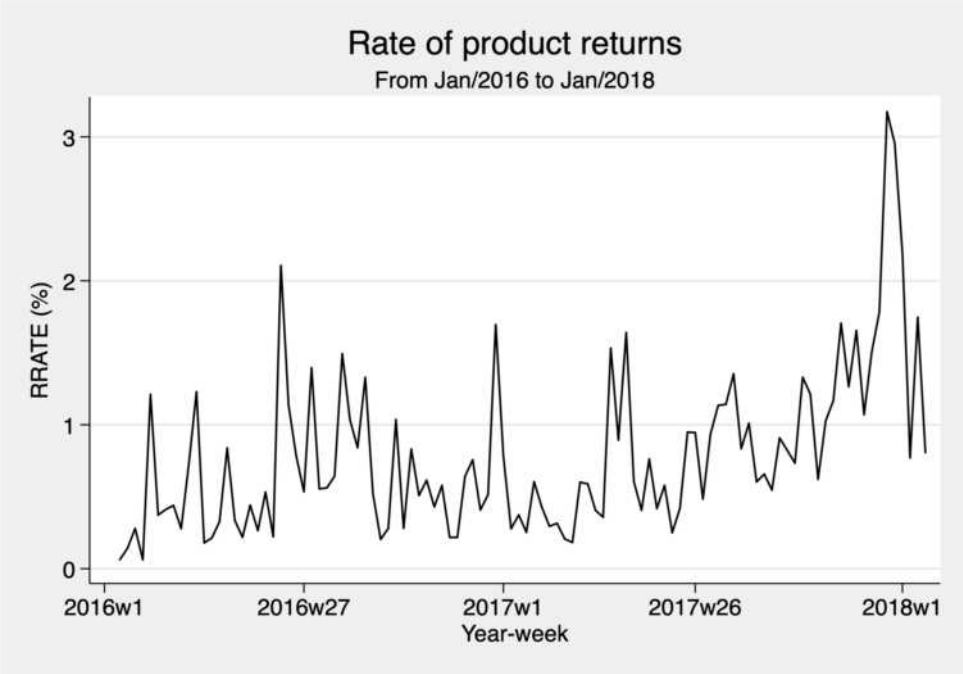

Figure 4.6: *Rate of product returns at MeatCo, from January 2016 to January 2018*

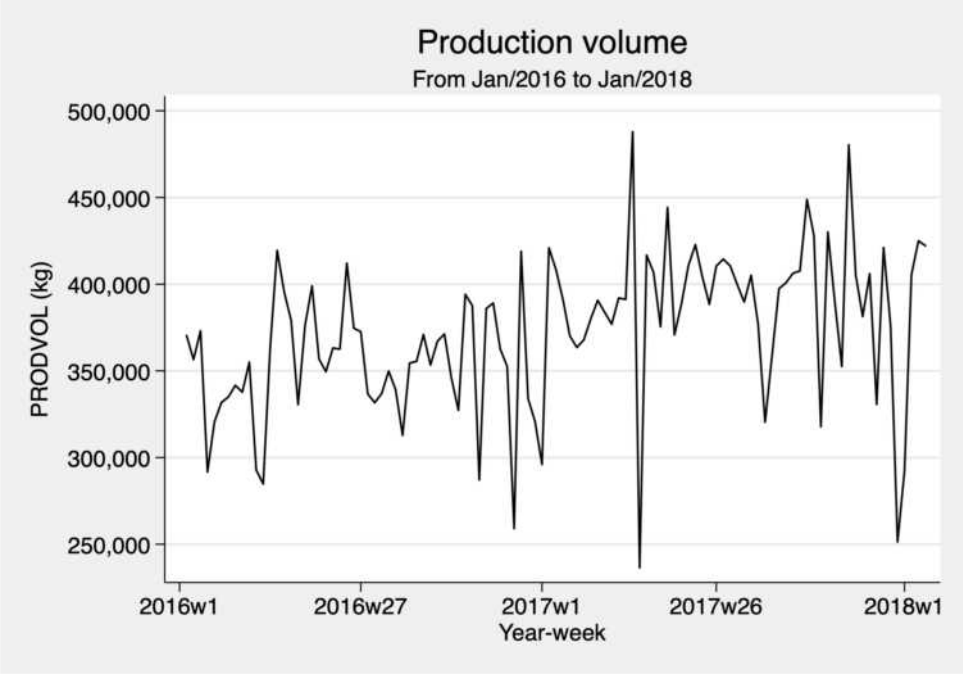

Figure 4.7: *Production volume at MeatCo, from January 2016 to January 2018*

Overall, our dataset has 105 weekly observations for each of the six product categories, which sums up to 630 observations per variable, except for the inventory-related *ITURNS*, with has only six 69 weekly observations per each category, summing up to 414 week-category observations.

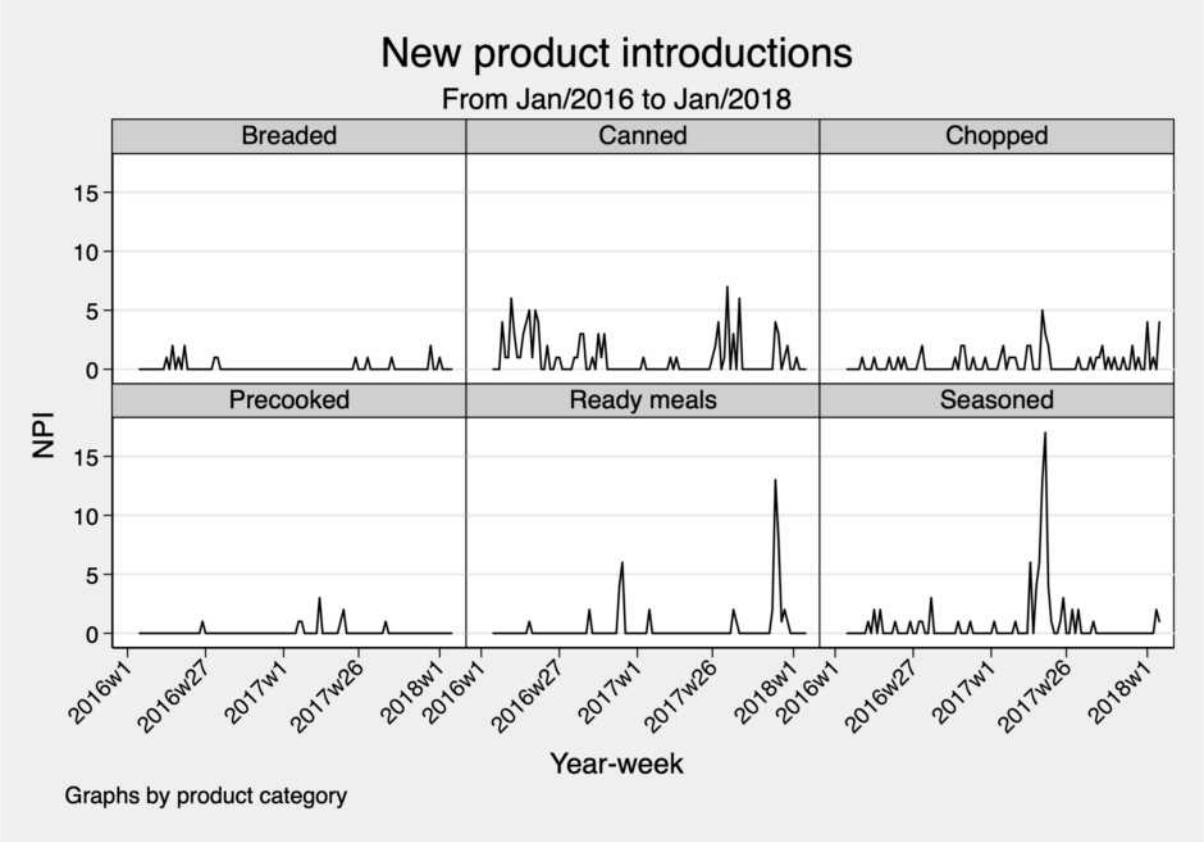

Figure 4.8: *New product introductions (cumulative), by product category, at MeatCo, from January 2016 to January 2018*

4.3.2. Hybrid fixed effects & random effects modelling

From the analysis of the consolidated data (figures 4.2, 4.3, 4.4, 4.5, 4.6, and 4.7) we can notice overall pattern changes within the company, especially after around 2017w1 –maybe due to volume growth, organizational learning, and process improving. A simple time-series analysis using the consolidated data could lead to biased conclusions, as the organization itself is in the process of learning and improving its operations (section 3.2); therefore, we looked for a method that would control for the firm's evolution and changing characteristics through time. On top of that, we identified that we also needed to control for the time-invariant

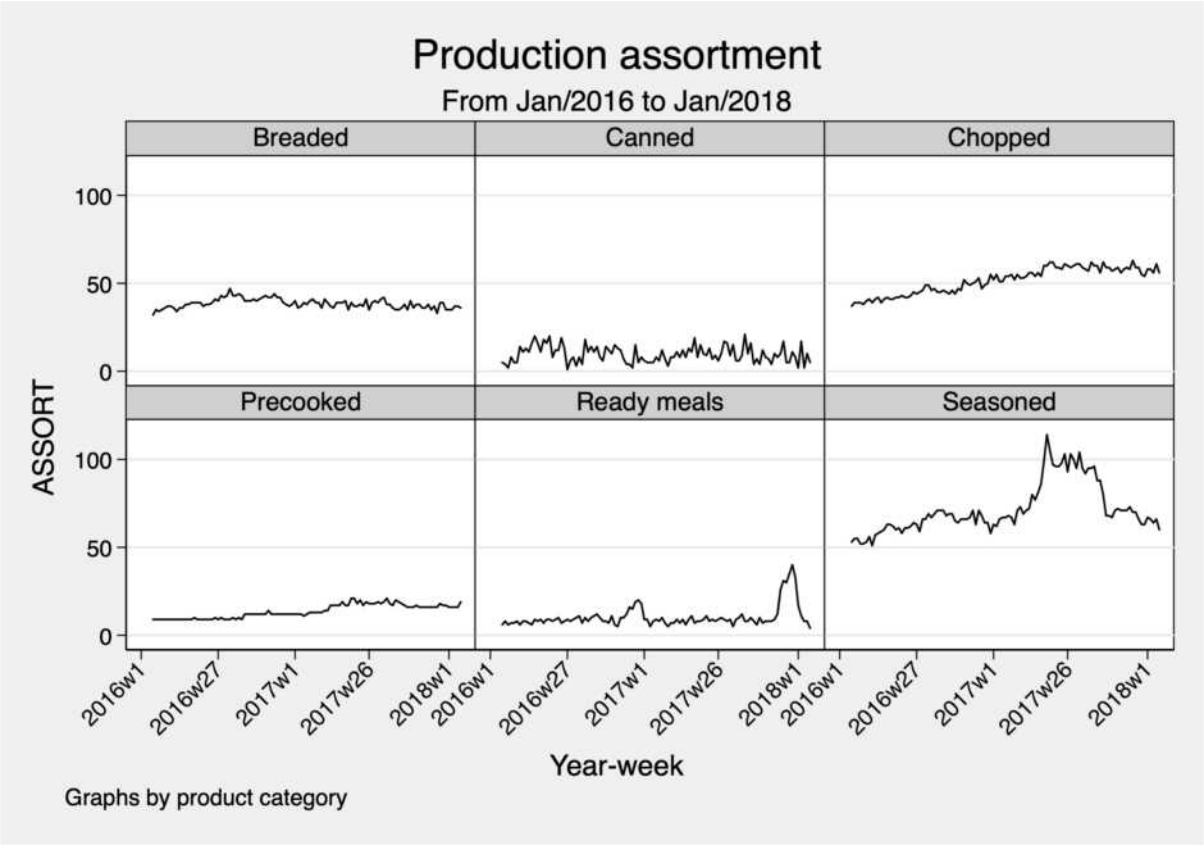

Figure 4.9: *Production assortment, by product category, at MeatCo, from January 2016 to January 2018*

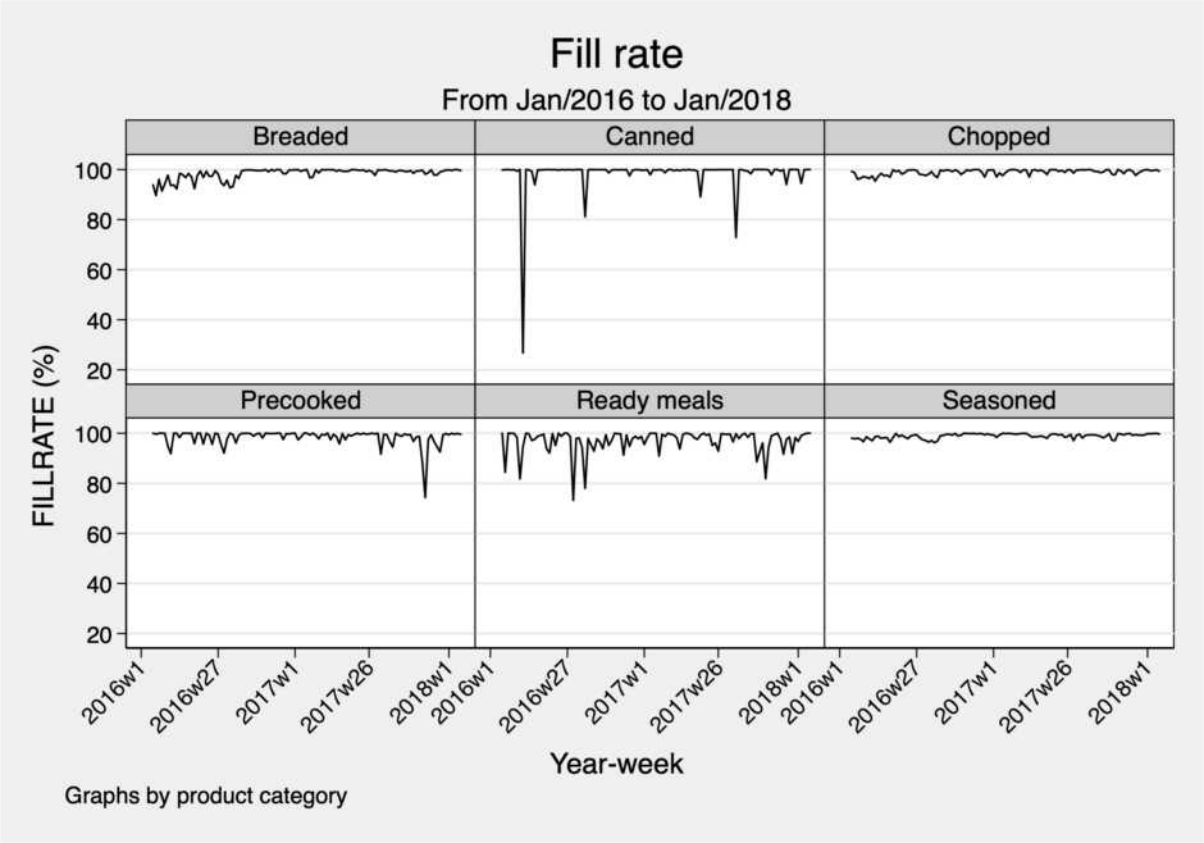

Figure 4.10: *Service level, by product category, at MeatCo, from January 2016 to January 2018*

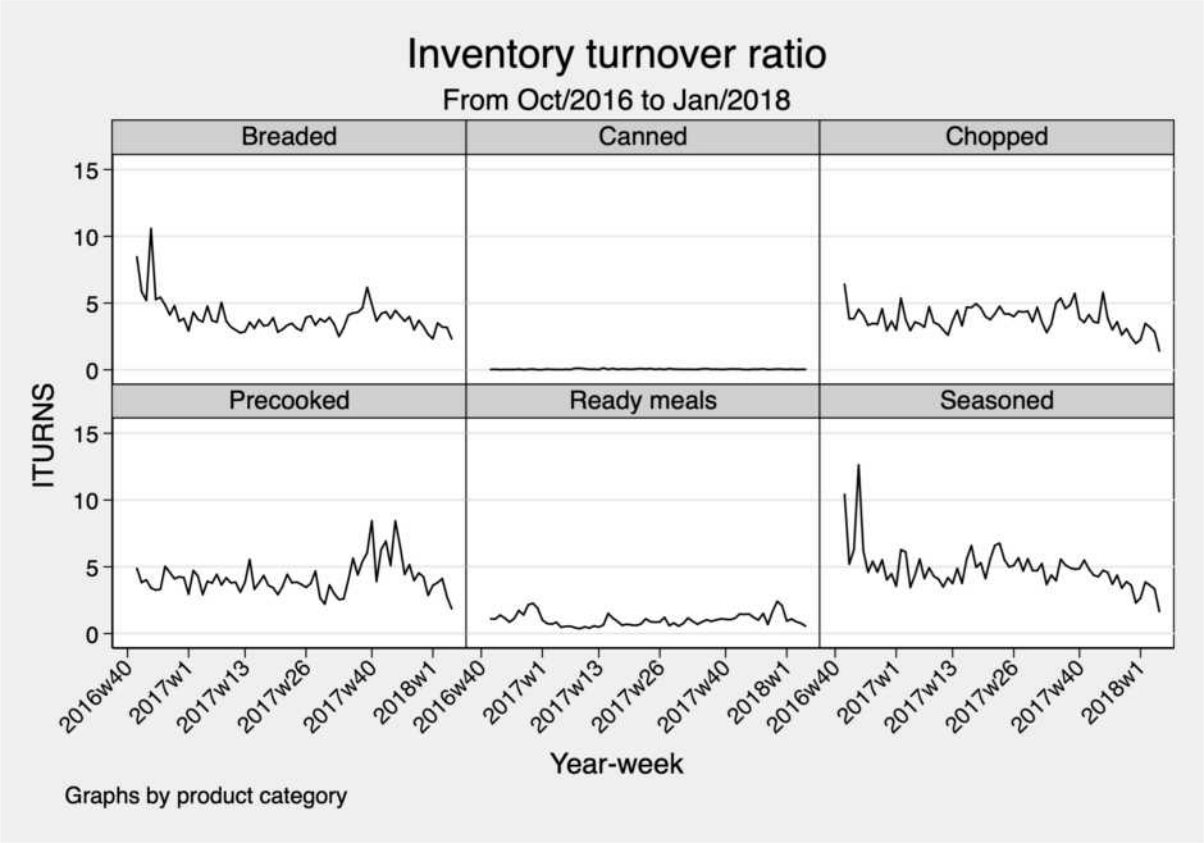

Figure 4.11: *Inventory turnover, by product category, at MeatCo, from October 2016 to January 2018*

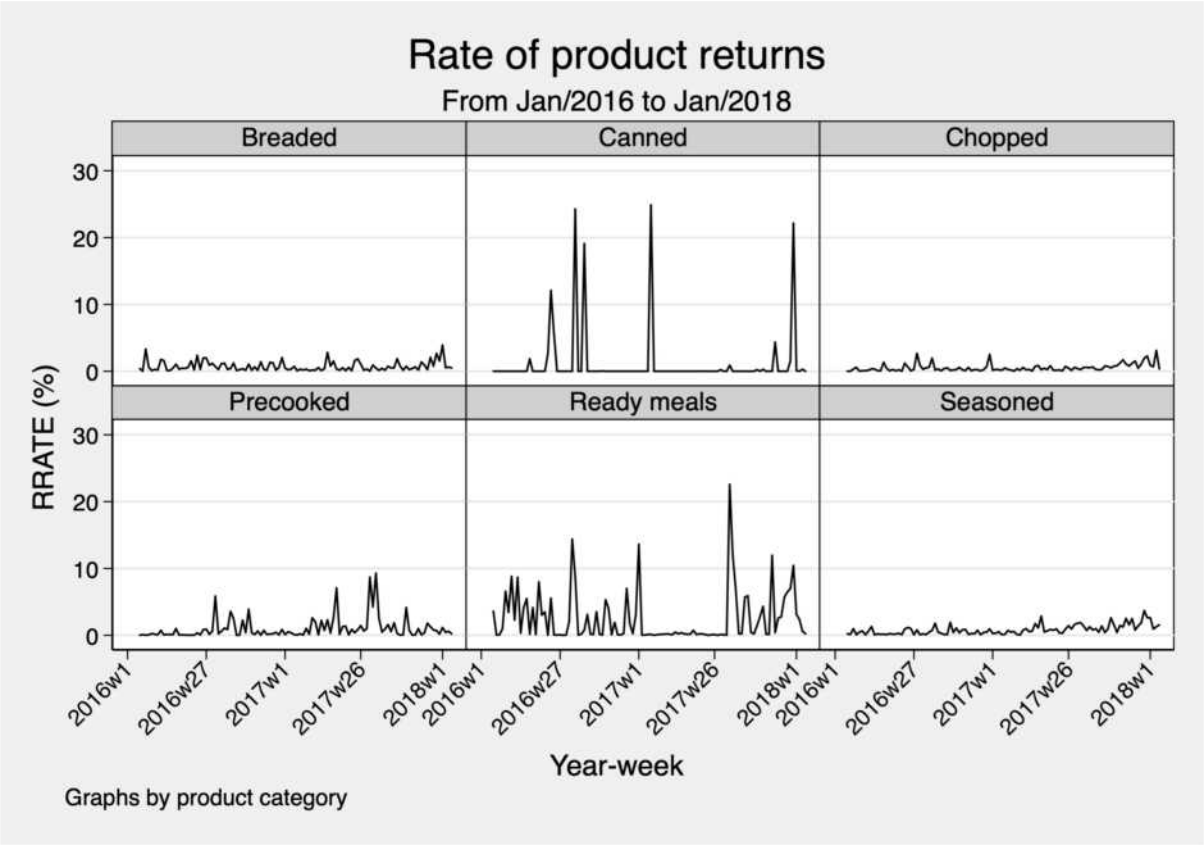

Figure 4.12: *Rate of product returns, by product category, at MeatCo, from January 2016 to January 2018*

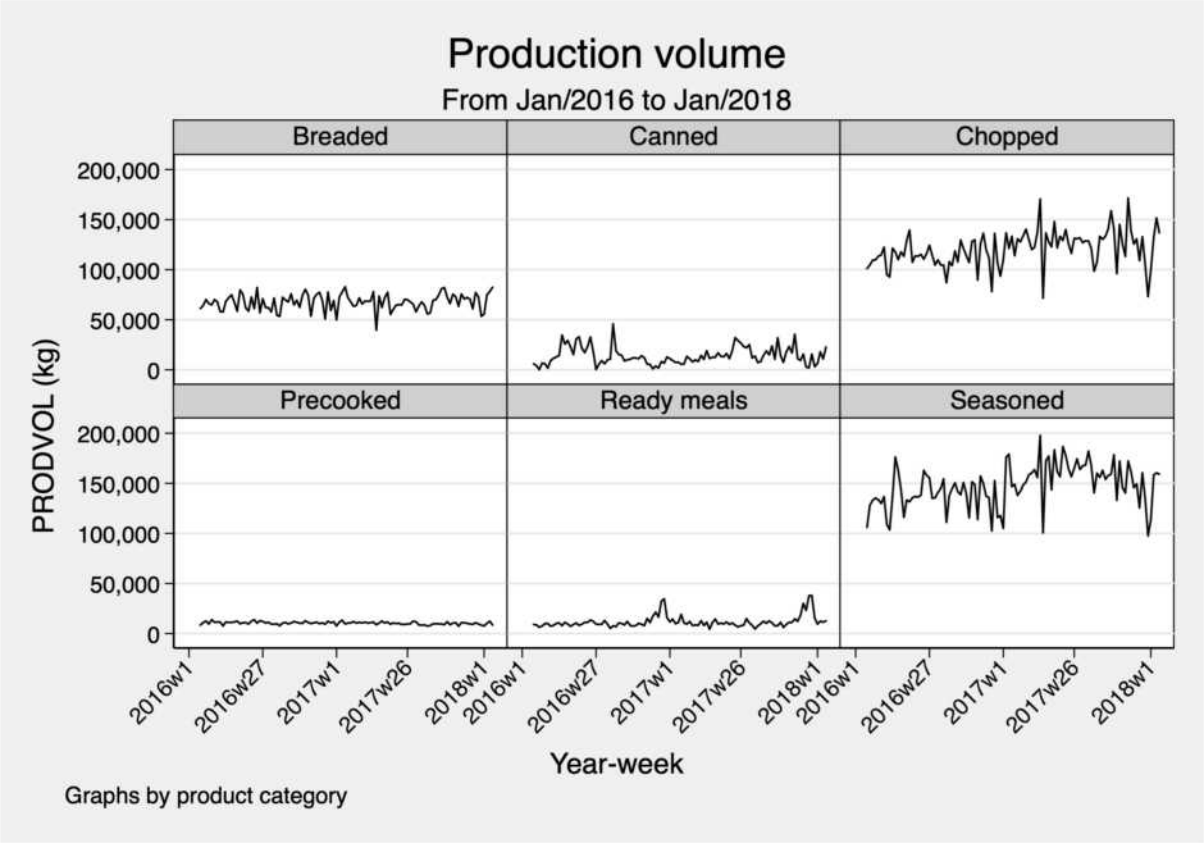

Figure 4.13: *Production volume , by product category, at MeatCo, from January 2016 to January 2018*

characteristics of each product category.

We found that a cross-sectional time series (i.e. panel data) analysis is ideal for this type of problem, as it can control for all product-category-specific characteristics that does not change through time and also control for all time-specific factors that does not vary across product categories (Stock and Watson 2011), thus addressing both issues. When building panel data models, two mainstream models arise: fixed effects and random effects, which are described in the following subsections.

Fixed effects regression models

Suppose that we have a set of entities $(i = 1 \ldots, N)$ measured at two or more points points in time, i.e. periods $(t = 1, \ldots, T)$. Let y_{it} be our dependent variable. We have a set of time-variant independent variables represented by the vector $\mathbf{x}_{it}$ and a set of time-invariant independent variables represented by the vector $\mathbf{z}_i$. Our basic model is given by Equation 4.6 (Stock and Watson 2011; Allison 2009):

$$y_{it} = \mu_t + \beta \mathbf{x}_{it} + \gamma \mathbf{z}_i + \alpha_i + \varepsilon_{it} \tag{4.6}$$

Where μ_t is a time-specific intercept, β and γ are vectors of coefficients, α_i represents the entity-specific, time-invariant, error term, and ε_{it} is the entity-specific, time-variant, error term, which represents random variation at each period. If we want to estimate Equation 4.6 using ordinary least squares (OLS), the following assumptions must hold (Stock and Watson 2011; Allison 2009): each ε_{it} has mean zero, constant variance (for all i and t), and is statistically independent of everything else, except for y (Allison 2009). At any point in time, ε_{jt} is independent of $\mathbf{x}_{jt}$ at any other point in time (i.e. $\mathbf{x}_{jt}$ is *strictly exogenous*).

When variables are observed at only two periods $(T = 2)$, we can estimate our model by evaluating the first difference, as shown in Equation 4.7.

$$
\begin{aligned}
y_{i1} &= \mu_1 + \beta \mathbf{x}_{i1} + \gamma \mathbf{z}_i + \alpha_i + \varepsilon_{i1} \\
y_{i2} &= \mu_2 + \beta \mathbf{x}_{i2} + \gamma \mathbf{z}_i + \alpha_i + \varepsilon_{i2} \\
\Rightarrow y_{i2} - y_{i1} &= (\mu_2 - \mu_1) + \beta(\mathbf{x}_{i2} - \mathbf{x}_{i1}) + (\varepsilon_{i2} - \varepsilon_{i1})
\end{aligned} \tag{4.7}
$$

Which can be rewritten as

$$
\Delta y_i = \Delta \mu + \beta \Delta \mathbf{x}_i + \Delta \varepsilon_i
$$

Note that $\mathbf{z}_i$ and α_i were cancelled out on 4.7, so we do not need to be concerned about their possible correlation with $\mathbf{x}_{jt}$. However, we lose the possibility of estimating the coefficient of the time-invariant factors. Since $\mathbf{x}_{i1}$ and $\mathbf{x}_{i2}$ are independent of ε_{i1} and ε_{i2}, $\Delta \mathbf{x}_i$ is also independent of $\Delta \varepsilon_i$. Therefore, we can get unbiased estimates of β by doing OLS regression on the first-difference scores (Stock and Watson 2011; Allison 2009).

When we have multiple periods $(T > 2)$, however, some inefficiencies and computational challenges arise from using the first differences approach (Stock and Watson 2011; Allison 2009). Alternatively, we use fixed effects regression, which requires some dataset modifications, but produces similar results.

Fixed effects regression controls for entity-specific, time-invariant, omitted variables in panel data regression and can be used when we have several periods $(T \geq 2)$. It requires a specific data structure: one record per entity for each period, the same variable name on each record, a common identification variable for all the records of each entity, and, finally, one variable distinguishing the time periods (Allison 2009).

Fixed effects regression can be conducted by using two different algorithms: the dummy variable and the mean deviation methods, both producing exactly the same results (Allison 2009). The dummy variable method creates dummy, binary, variables, absorbing the influences of all entity-specific, time-invariant, omitted variables (Stock and Watson 2011). Time-specific dummy variables are also included, when controlling for time-specific effects.

The only problem of the dummy variable method is that it is computationally burdensome, so the mean deviation method can be used instead. This method works by computing the entity-specific means for each variable, both dependent and independent, at each period, then

subtracting the entity-specific means from the observed values of each variable. We estimate the model using ordinary regression; however, we need to adjust it to the degrees of freedom, which is easily implementable by using standard commercial statistical packages, such as the command ***xtreg*** in STATA.

Random effects vs. fixed effects regression models

Random effects models use the same equation that we used in the fixed effects model (Equation 4.6) . The main difference is that in random effects we treat α_i as a set of random variables, thus including time-invariant predictors. It is estimated by generalized least squares (GLS) and assumes that α_i is uncorrelated with all the other variables in the model. If this assumption holds, then the random effects and the fixed effects models produce consistent and unbiased estimates, which is not true otherwise (Allison 2009).

Fixed effects usually present substantially higher standard errors than random effects, so when the analysis of a problem lead to significant coefficients on random effects, but not significant on fixed effects, we first need to compare their respective standard errors. If the exogeneity assumption holds, then the random effects estimate is consistent and the less restrictive standard error –compared to the fixed effects' – is unbiased. However, when the exogeneity assumption does not hold, the fixed effects estimate is more robust, although the model is less powerful, as it produces higher and more restrictive standard errors. The explanation for that is that the random effects model does not fully control for unobserved heterogeneity, as done by fixed effects.

The trade-off is between bias and efficiency (Allison 2009). Random effects will lead to more efficient estimates, but at the risk of some bias, if assumptions are wrong. On the other hand, the fixed effects model is less prone to bias, but at the expense of efficiency. This trade-off can be resolved by using the Hausman Hausman 1978 test for the null hypothesis that both the random effects and the fixed effects coefficients are the same.

Hybrid fixed effects and random effects models

Allison 2009 proposed a hybrid fixed effects and random effects model (hybrid FE&RE) that combines some of the virtues of the fixed and the random effects models. It is implemented by transforming the time-variant independent variables $\mathbf{x}_{it}$ into deviations from their entity-specific means; however, the dependent variable y_{it} is left unchanged. We also include the entity-specific mean variables in the model. We then estimate a random effects model to ensure that the standard errors reflect multiple entity-specific observations. The coefficients and standard errors on the deviation variables and time dummies are identical to the ones obtained from the fixed effects model.

One benefit from this model is, in fact, the estimates for the time-invariant variables, e.g. the entity-specific mean, not possible to obtain from conventional fixed effects. Additionally, this approach allows us to use an alternative to the Hausman test by performing a Wald test comparing the deviation and the mean variables. If the assumptions of the random effects model are correct, then the coefficient on the deviation and the mean variables are the same.

Another advantage of the hybrid model is that, by deriving two variables, i.e. the differential and the entity mean, from the same core variable it enriches the amount of information available to the analysis. The coefficients on the differential, time-variant variables can be viewed as representative of the contemporaneous –or short-term– effect of that variable, as it changes through time and exerts an impact on a specific point in time. On the other hand, the entity mean, time-invariant variable can be interpreted as a proxy for the long-term effect of sustaining different levels on that same variable through time.

We chose the hybrid FE&RE method to model our problem because it allows the implementation of controls for both time-variant and time-invariant aspects of entity-specific effects, also taking into account the overall time-specific effects, allowing the evaluation of both short-term and long-term relationships –and also eliminating the trade-off between random and fixed effects. We find this method suitable to our problem as it is able to isolate the association of new products introductions on supply chain performance, taking into account time-specific variables (such as organizational learning and process improvement) and entity-specific factors (such as the characteristics of each individual product category).

4.3.3. Addressing threats to validity

As we wanted to be able to inform theory and practice, we looked for obtaining unbiased (i.e. the expected value of the parameter is the true value), efficient (i.e. low variance of the estimate), and consistent (i.e. trending to the true value, as the sample increases) estimates of the parameters of the model in figure 4.1 (Ketokivi and McIntosh 2017). Failing to obtaining good estimates of the model means that it is not internally valid, so the statistical inferences about causal effects are not valid for the population being studied. The main sources of threats to an econometric model's internal validity are (Stock and Watson 2011): omitted variable bias (OVB), functional form misspecification, measurement error, sample selection bias, simultaneous causality, and incorrect standard errors.

The challenge here is that we are mere observers of the variables in our dataset, with little information of where the variance come from, which could be, for example, measurement error, OVB, or simultaneous causality. So we discuss each of the threats to the internal validity, within the specific context of our study, as follows.

The OVB threat

As stated by Ketokivi and McIntosh 2017, *fixed effects regression constitutes a huge leap forward in addressing endogeneity*. It does so by controlling for all entity-specific, time-invariant, omitted variables in panel data and, when time-specifics controls are included –as we do in our case–, it also controls for all omitted factor that are constant across entities, but are time-variant (Stock and Watson 2011). As fixed effects (both entity-specific and time-specific) are, indeed, included in our hybrid mode, OVB should not be considered a severe threat to our study's internal validity.

Functional form misspecification

We considered two main plausible functional forms to our key variables: linear e logarithmic. The first was chosen for its straightforward interpretation: one unit variation in $\mathbf{x}$ produces β units of variation in y. The logarithmic function –and its sub-forms–, however, can provide interesting interpretations, as follows:

- Regressing y on $\log \mathbf{x}$ (log-linear): 1% change in $\mathbf{x}$ is associated with 0.01β change in y

- Regressing $\log y$ on $\mathbf{x}$ (linear-log): 1 unit change in $\mathbf{x}$ associated with $100\beta\%$ change in y

- Regressing $\log y$ on $\log \mathbf{x}$ (log-log): 1 unit change in $\mathbf{x}$ is associated with $\beta\%$ change in y

Thus, it is plausible the conjecture that unit changes in both regressors NPI and ASSORT will be related to percent changes in FILLRATE, ITURNS, and RRATE. We can also consider plausible that percent changes in ASSORT could be associated with changes in FILLRATE, ITURNS, and RRATE. However, we do not see a reason for the variable NPI to assume a logarithmic form, as it represents both an event (i.e. introducing a new product) and its magnitude, not being a level variable, as the others.

Functional form misspecification can be can often be detected by visually inspecting scatterplots of the data and the estimated regression function (Stock and Watson 2011). We, therefore, plotted each pair of firm-level dependent-independent variable, both in linear and in logarithmic form, when applicable, and did not see significant visual difference (Appendix B.1). If this were our only tool to choosing our functional form, we would lean towards the logarithmic form function. However, Stock and Watson 2011 propose a general approach to modeling nonlinearities as follows: (1) identify a possible nonlinear relationship; (2) specify a nonlinear function and estimate its parameters by OLS; and (3) determine whether the model improves upon a linear model. We followed Stock's approach (see Appendix B.2 for the functional-form-testing regression tables) and decided to adopt the logarithmic functional form to the following variables: ASSORT, RRATE, and ITURNS, which from now on will be denominated L_ASSORT, L_RRATE, and L_ITURNS, in order to make their functional form explicit. The remaining variables in the model will keep their original linear functional forms.

Measurement error

Our dataset has been extracted by MeatCo's employees from the company's internal information systems. We inspected the data for any pattern that could threaten its quality and found reasonable to assume that it has been properly measured. We then computed or variables of interest as described in section 4.2. Although we have no control for the actual quality of the data, we cannot find a reason to deem it invalid.

Sample selection bias

The dataset covers all of the product categories within a business unit over a continuous period. The period was based on the extent of data availability, so it can be considered as randomly chosen. No data has been expurgated or selected to the dataset based on the results of the dependent variable. Furthermore, the choice for the company has been based both on the opportunity and its characteristics (i.e. a firm that frequently introduces new products). We, thus, do not see sample selection bias as a threat to the internal validity of our study.

Simultaneous causality

Ketokivi and McIntosh 2017 suggests logical reasoning and visual inspection of a model in order to asses the threat of simultaneous causality of a model. By inspecting our model in figure 4.1, we do not find any plausible explanation for the causality to run "backwards" either from service level, inventory freshness, or product quality conformance to new product introductions or to production assortment. Therefore, we do not see simultaneous causality as a threat to the internal validity of our study.

Standard errors

Stock and Watson 2011 suggests employing of heteroskedasticity- and autocorrelation-consistent clustered (HAC-clustered) standard errors, whenever there is potential heteroskedasticity and autocorrelation of the error term in the panel data regression. This type of standard error is valid whether or not heteroskedasticity and/or autocorrelation are present. Furthermore, HAC-clustered standard errors are specially suitable to panel data econometrics, as it allows regression errors to be correlated within each entity, but not across them.

However, in the presence of cross-sectional dependence (CD), also known as spatial or contemporaneous correlation, the HAC-clustered standard errors are invalid. CD is a common issue in microeconometric datasets in which the cross-sectional units are not randomly sampled, as units are subject to both observable and unobservable common disturbances, a frequent case on datasets on which N, the number of entities, is small, and T, the number of time periods, is large (Driscoll and Kraay 1998). This issue is, however, largely ignored by several empirical researchers and most of the recent similar studies provide heteroskedasticity- and

autocorrelation consistent standard errors (Hoechle 2007).

Our microeconometric panel dataset consists of six entities observed along 105 time periods, in most cases, so our T is more than 17 times larger than our N, which constitutes a threat of potential spacial correlation to our model. Luckly, Pesaran 2004 has proposed a CD dependence test (from now on referred as Pesaran CD test), which assesses whether residuals are correlated across entities –Pesaran CD test is available in STATA by using the *xtcsd, pesaran* command. The null hypothesis is that residuals are not correlated. If we fail to reject the null hypothesis, then HAC-clustered standard errors suffices. In the cases which CD is present, Driscoll and Kraay 1998 proposed a nonparametric covariance estimator that produces standard errors that are robust to heteroskedasticity, autocorrelation and cross-sectional dependence (from now on referred as Driscoll-Kraay standard errors), which is also already implemented in STATA, by using the command *xtscc* (Hoechle 2007).

After more than 20 years of its publication, Driscoll-Kraay standard errors are still relatively unknown to operations management scholars –yet, we were able to find a few recent studies that use it (e.g. Moreno and Terwiesch 2015 and Shah, Ball, and Netessine 2017). In our study, we chose to report both the mainstream HAC-clustered and the, robust-but-unknown Driscoll-Kraay standard errors, on which our inferences will be based on.

4.3.4. Testing for mediation

Mediation refers to a third variable (i.e. the mediator) accounting for the relationship between a dependent and an independent variable (Baron and Kenny 1986), as depicted in figure 4.14. The model assumes a three-variable system and two causal paths for explaining the relationship between an independent and a dependent variable: the direct impact (path a) and the indirect, mediated, impact (path c). The model also includes the path from the independent variable to the mediator (path b).

A variable is said to be a mediator if all of the three following conditions hold: (1) there is a significant association between the dependent and the independent variable (i.e. path a), (2) there is a significant association between the independent variable and the mediator (i.e. path b), and (3) there is a significant association between the mediator and the dependent variable

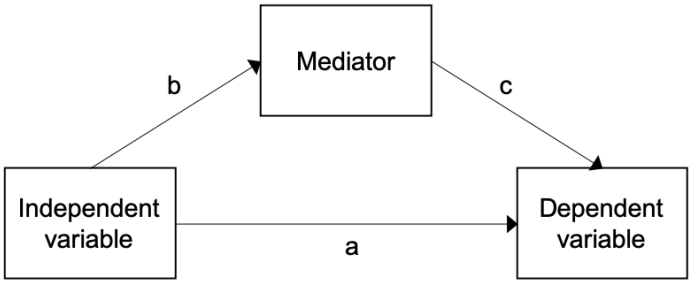

Figure 4.14: *Basic causal chain involved in mediation (adapted from Baron and Kenny 1986)*

(i.e. path c). It occurs that, under mediation effects (i.e. when paths a and b are controlled), previously significant associations between the independent and the dependent variables (i.e. path a) are often altered (Baron and Kenny 1986). When a previously significant path a is no longer significant under mediation we say that the relationship is *fully mediated*; when significance is maintained, but the size of the coefficients are reduced, we say that it is *partially mediated*. Thus, testing for mediation requires a three-step approach using regression analysis: (1) regressing the dependent variable on the independent variable, (2) regressing the mediator on the independent variable, and (3) regressing the dependent variable on the mediator.

4.3.5. A hybrid model with robust Driscoll-Kraay standard errors

We chose to use a hybrid fixed effects and random effects model (section 4.3.2), as suggested by Allison 2009 and Ketokivi and McIntosh 2017, using the robust standard errors proposed by Driscoll and Kraay 1998 (section 4.3.3)–although we also report HAC-clustered standard errors. We applied the functional form specification changes as described on the functional form part of section 4.3.3 and we performed the data modification as described on hybrid model part in section 4.3.2. Our final list of variables is described in table 4.1. Additional tests of fit reported are: test for time-fixed effects (Wald test on the time-specific dummies), F-test on production volume controls (both the mean and the deviation), and the Pesaran CD test.

We interpret the coefficient on the differential variable as representative of the contemporaneous, short-term impact of introducing, for example, one new SKU into the operations. On the other hand, the coefficients on entity mean variable are interpreted as the category-based

Variable	Role	Description	Derivation	Functional form
dNPI	Regressor	New product introductions	Deviation	Linear
dL_ASSORT	Regressor / mediator	Production assortment	Deviation	Logarithmic
dPRODVOL	Control variable	Production volume	Deviation	Linear
mNPI	Regressor	New product introductions	Mean	Linear
mL_ASSORT	Regressor / mediator	Production assortment	Mean	Logarithmic
mPRODVOL	Control	Production volume	Mean	Linear
FILLRATE	Dependent variable	Fill rate	None	Linear
L_RRATE	Dependent variable	Rate of product returns	None	Logarithmic
L_ITURNS	Dependent variable	Inventory turnover ratio	None	Logarithmic
i.YW	Control variable	Time-specific variable (year-week)	None	Dummy
i.CAT	Control variable	Entity-specific variable (product category)	None	Dummy

Table 4.1: *List of variables included in the model*

sustained, long-term effects –for example, a product category being more (or less) innovative, such as having more (or less) new products introduced per week, mNPI, on average.

We developed three groups of models, one for each dependent variable. On each group we ran a multiple hybrid regressions testing the effect of all the regressors on each dependent variable. We also performed a test for mediation by running three separate regressions (section 4.3.4).

4.4. Results

We ran three series of hybrid FE&RE regressions to test and measure the impact of new product introductions on the supply chain performance of a CPG manufacturing company. The results are summarized in tables 4.2, 4.4, and 4.3. Each table include eight regression models in versions using HAC-Clustered standard errors –models (1), (3), (5), and (7)– and Driscoll-Kraay standard errors –models (2), (4), (6), and (8). Models (7) and (8), on each table, represent our main regression models, which test and measure the joint impact of NPI and dL_ASSORT on the respective variables of interest –i.e. FILLRATE, in table 4.2,

LRRATE, in table 4.4, and LITURNS, in table 4.3. The remaining models –i.e. (1) to (6)– represent the corresponding tests for mediation; yet, because the tests for mediation share a key component, regressions (3) and (4) are repeated in tables 4.2, 4.4, and 4.3. Our regressors of interest were grouped by deviation variables and entity-specific mean variables. In every model we controlled for time-specific effects, entity-specific effects, and production volume.

The first set of regressors in each table –the differential variables dNPI and dL_ASSORT– are related to the short-term perspective. The second set, category-specific means, are related to long-term results –i.e. the effect of a product category being more (or less) innovative or more (or less) well-managed in terms of assortment.

The constants, as well as the coefficients on the time-specific controls, i.YW, and production volume controls, dPRODVOL and mPRODVOL, were omitted for parsimony, as they are of little interest to our study. Still, we reported the results for the test statistics for the significance of the time-specific and production volume controls, the Pesaran test for cross-sectional dependence, the Wald test comparing fixed effects and random effects, the overall r^2, and the total number of time-entity observations.

The main models, (7) and (8), on each table present the same coefficients; yet, different standard errors. The equations for the main models are represented on Equations 4.8, 4.9, and 4.10.

$$\begin{aligned} FILLRATE_{it} =& \mu_t + \alpha_i \\ &+ \beta_1 \times dNPI_{it} + \beta_2 \times dL\_ASSORT_{it} + \beta_3 \times dPRODVOL_{it} \\ &+ \beta_4 \times mNPI_i + \beta_5 \times mL\_ASSORT_i + \beta_6 \times mPRODVOL_i \\ &+ \varepsilon_{it} \end{aligned} \tag{4.8}$$

$$\begin{aligned} L\_RRATE_{it} =& \mu_t + \alpha_i \\ &+ \beta_1 \times dNPI_{it} + \beta_2 \times dL\_ASSORT_{it} + \beta_3 \times dPRODVOL_{it} \\ &+ \beta_4 \times mNPI_i + \beta_5 \times mL\_ASSORT_i + \beta_6 \times mPRODVOL_i \\ &+ \varepsilon_{it} \end{aligned} \tag{4.9}$$

$$
\begin{aligned}
L\_ITURNS_{it} = & \mu_t + \alpha_i \\
& + \beta_1 \times dNPI_{it} + \beta_2 \times dL\_ASSORT_{it} + \beta_3 \times dPRODVOL_{it} \\
& + \beta_4 \times mNPI_i + \beta_5 \times mL\_ASSORT_i + \beta_6 \times mPRODVOL_i \\
& + \varepsilon_{it}
\end{aligned}
\tag{4.10}
$$

It is worth noting that the Pesaran CD tests clearly demonstrate, in every case, the presence of cross-sectional dependence in our dataset, suggesting that we must focus our attention on the models using Driscoll-Kraay standard errors. Time-specific controls are significant at the 1% level in most cases –and in all cases using Driscoll-Kraay standard errors–, demonstrating that the company performs differently through time. The significance of the production volume control variable varies by regression group, although it is important to keep it in every model as it is theoretically valid. On the following subsections we will look into the details of each group of regressions.

4.4.1. Models related to service level

Short-term perspective

We did not find significant evidence that new product introductions are negatively associated with fill rates in the short term. As we can see in table 4.2, the introduction of one new product, dNPI, is not significantly associated with FILLRATE in the models using Driscoll-Kraay standard errors (2) and (8).

Still, we found that the introduction of a new product is associated with 0.06% change on production assortment in the short term and this relationship is significant at the 1% level (4). A 1% change in production assortment, on the other hand, is associated with a negative change of 0.0134 percentage points in fill rate and this relationship is significant at the 5% level (6) and (8).

Our data does not show sufficient evidence to claiming that a new product introduction, *per se*, is associated with lower fill rates either in the short-term perspective; however, production assortment changes –which are associated with new product introductions– seem to be a significant factor when analyzing fill rate changes in the short term.

Long-term perspective

No significant relationship was found for the long-term perspective of our service-level-related hypotheses.

	(1) FILLRATE	(2) FILLRATE	(3) L_ASSORT	(4) L_ASSORT	(5) FILLRATE	(6) FILLRATE	(7) FILLRATE	(8) FILLRATE
dNPI	-0.1411*	-0.1411	0.0642*	0.0642**			-0.0604	-0.0604
	(0.0577)	(0.1131)	(0.0267)	(0.0226)			(0.0386)	(0.0976)
dL_ASSORT					-1.3370*	-1.3370*	-1.2565*	-1.2565*
					(0.5616)	(0.5751)	(0.5996)	(0.5581)
mNPI	0.0558	0.0558	-0.7694***	-0.7694			1.9197	1.9197
	(0.6394)	(0.9281)	(0.1822)	(0.5450)			(1.6990)	(1.6480)
mL_ASSORT					0.3657	0.3657	2.4226	2.4226
					(0.8188)	(1.1374)	(2.1812)	(1.4851)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE type	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK
F_YW	19.533	4.194	26.528	8.623	25.388	15.821	16.929	18.324
p_YW	0.002	0.018	0.000	0.000	0.000	0.000	0.005	0.000
F_PRODVOL	5.243	2.184	400.477	27.293	0.089	0.141	0.928	1.012
p_PRODVOL	0.073	0.118	0.000	0.000	0.956	0.869	0.629	0.367
χ^2_PesaranCD	-2.713		-4.414		-2.578		-2.578	
p_PesaranCD	0.007		0.000		0.010		0.010	
F_FeRe	0.092	0.050	22.366	2.331	2.054	1.476	4.128	5.866
p_FeRe	0.762	0.824	0.000	0.130	0.152	0.227	0.127	0.004
r^2	0.240	0.240	0.905	0.905	0.246	0.246	0.250	0.250
N	630	630	630	630	630	630	630	630

Standard errors in parentheses Intercept omitted for parsimony
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.2: *FILLRATE selected hybrid models*

4.4.2. Models related to inventory freshness

Short-term perspective

We did not find sufficient evidence for directly associating the introduction of a new product with changes in inventory turnover in the short-term, as see from the low significance level of the dNPI coefficient on models (2) and (8), with Driscroll-Kraay standard errors. Moreover, it exhibits an unexpected sign, as the coefficient on dNPI in (2) and (8) are positive. However, can see that each 1% change on production assortment is, on average, associated with a 0.4% increase on the weekly inventory turnover (8).

Long-term perspective

Product categories presenting higher means of new product introductions, mNPI, and production assortment, mL_ASSORT, are significantly associated, at the 1% level, with slower inventory turnover rates, as table 4.3 demonstrates (8). However, we do not have sufficient evidence to claiming mediation, as the non-significant coefficient of mNPI in (4) violates the second condition of the mediation test (section 4.3.4)

	(1) L_ITURNS	(2) L_ITURNS	(3) L_ASSORT	(4) L_ASSORT	(5) L_ITURNS	(6) L_ITURNS	(7) L_ITURNS	(8) L_ITURNS
dNPI	0.0152*	0.0152^{+}	0.0642*	0.0642**			-0.0024	-0.0024
	(0.0076)	(0.0079)	(0.0267)	(0.0226)			(0.0058)	(0.0177)
dL_ASSORT					0.3439***	0.3439**	0.4291***	0.4291***
					(0.0560)	(0.1271)	(0.1023)	(0.1120)
mNPI	-4.6507***	-4.6507***	-0.7694***	-0.7694			-7.3817***	-7.3817***
	(0.9035)	(1.2336)	(0.1822)	(0.5450)			(0.7283)	(0.2579)
mL_ASSORT					4.3050^{+}	4.3050***	-3.6096***	-3.6096***
					(2.2229)	(1.1524)	(0.8388)	(0.2117)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE type	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK
F_YW	35.728	28.274	26.528	8.623	24.031	29.526	38.747	14.433
p_YW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F_PRODVOL	102.960	16.294	400.477	27.293	10.137	12.535	38.635	263.219
p_PRODVOL	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000
χ^2_PesaranCD	-3.559		-4.414		-3.240		-3.167	
p_PesaranCD	0.000		0.000		0.001		0.002	
F_FeRe	26.540	14.251	22.366	2.331	3.048	11.332	193.130	435.185
p_FeRe	0.000	0.000	0.000	0.130	0.081	0.001	0.000	0.000
r^2	0.890	0.890	0.905	0.905	0.677	0.677	0.943	0.943
N	414	414	630	630	414	414	414	414

Standard errors in parentheses Intercept omitted for parsimony

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.3: *L_ITURNS selected hybrid models*

4.4.3. Models related to product quality conformance

Short-term perspective

As we can see from table 4.4, we did not find significant statistical evidence for supporting the direct association between the introduction of a new product with changes in the rate of product returns in the short-term perspective. Still, we found that a 1% change in production assortment is, on average, associated with a 1.33% change in the rate of product returns (8).

Long-term perspective

Our data shows that the most innovative product categories –i.e. those with higher mNPI– are directly associated with higher rates of product returns overall and this relationship is significant at the 5% level (model (8)). That is also true for product categories presenting higher averages of production assortment, mL_ASSORT, as we can see on model (8). However, we do not have sufficient evidence to claiming mediation, as the non-significant coefficient of mNPI on (2) and the non-significant coefficient of mNPI in (4) violate, respectively, the first and the second conditions of the mediation test (section 4.3.4)

	(1) L_RRATE	(2) L_RRATE	(3) L_ASSORT	(4) L_ASSORT	(5) L_RRATE	(6) L_RRATE	(7) L_RRATE	(8) L_RRATE
dNPI	0.0091	0.0091	0.0642*	0.0642**			-0.0714+	-0.0714
	(0.0136)	(0.0275)	(0.0267)	(0.0226)			(0.0416)	(0.0438)
dL_ASSORT					1.2018***	1.2018***	1.3259***	1.3259***
					(0.2027)	(0.2761)	(0.2140)	(0.2588)
mNPI	0.8317**	0.8317	-0.7694***	-0.7694			2.5732***	2.5732*
	(0.3073)	(0.7127)	(0.1822)	(0.5450)			(0.7476)	(1.0328)
mL_ASSORT					-0.5856	-0.5856	1.7328**	1.7328*
					(0.4837)	(0.6904)	(0.6280)	(0.8205)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE type	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK
F_YW	2.958	1.7e+08	26.528	8.623	1.245	2.2e+06	1.386	39.423
p_YW	0.707	0.000	0.000	0.000	0.940	0.000	0.926	0.000
F_PRODVOL	7.207	5.689	400.477	27.293	5.450	1.383	12.001	4.318
p_PRODVOL	0.027	0.005	0.000	0.000	0.066	0.255	0.002	0.016
χ^2_PesaranCD	-7.025		-4.414		-6.977		-6.961	
p_PesaranCD	0.000		0.000		0.000		0.000	
F_FeRe	6.908	1.313	22.366	2.331	9.883	6.366	35.106	10.155
p_FeRe	0.009	0.254	0.000	0.130	0.002	0.013	0.000	0.000
r^2	0.303	0.303	0.905	0.905	0.326	0.326	0.348	0.348
N	543	543	630	630	543	543	543	543

Standard errors in parentheses Intercept omitted for parsimony

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.4: *L_RRATE selected hybrid models*

4.5. Discussion

4.5.1. The impact of new product introductions on service level

We did not find significant evidence for supporting Hypothesis 1, both in the short-term and in the long-term perspectives. Hypothesis 4 was not supported either, since it violates the first condition of the mediation test (section 4.3.4) in the short-term perspective and all of the three conditions in the long-term perspective. However, we have unintentionally found

evidence that changes on the size of production assortment, represented by dL_ASSORT, are significantly associated with lower fill rates. We can see that these secondary findings are actually aligned with the literature (Mapes, New, and Szwejczewski 1997), as demonstrated in section 2.7. Moreover, although investigated in a different setting and using slightly different operationalizations of assortment and service level, Wan, Evers, and Dresner 2012 found that product variety are negatively associated with lower fill rates.

Had we used the mainstream HAC-clustered standard errors we would have found significant statistical support for Hypotheses 1 and 4. In fact, if the relationship on Hypothesis 1 is significant, its relationship is fully mediated by changes in production assortment. These results would have supported hypotheses 1 and 4; yet, the conclusion would have been biased. The presence of cross-sectional dependence, as indicated by all of the Pesaran CD tests in table 4.2, strongly recommends the use of the more restrictive Driscroll-Kraay standard errors. The once-significant (under HAC-clustered standard errors) coefficients on the direct relationship between new product introductions, dNPI and mNPI, and FILLRATE, are no longer significant in light of the more restrictive standard errors.

4.5.2. The impact of new product introductions on inventory freshness

We found that the more innovative product categories, those with higher mNPI, are associated with slower inventory turnover ratios at the 1% significance level; notwithstanding, the differential, short-term, results of the event of a new product introduction, represented by dNPI, is hardly significant at the 10% level (even less upon the inclusion of additional variables). Even so, the sign of the coefficients goes to the opposite direction of what we hypothesized. Therefore, we can consider that Hypothesis 2 is not supported in the short term; yet, it is supported in the long-term perspective.

When accounting for the mediation effects, we see that the differential effect of new product introductions is fully mediated by production assortment. We also observe that entity-specific effects of frequently introducing new products, i.e. mNPI, is partially mediated, thus support-

ing Hypothesis 5 at the entity-specific level.

From the joint model, we see that changes and category-based level of production assortment are significantly associated, at the 0.1% level, with lower inventory turnover ratios, both in the short-term and in long-term. Yet, the short-term effects of changes in production assortment take a direction that is different to our expectations –i.e. a positive coefficient sign. It may be the case that the long-term effect denoted by mNPI and mL_ASSORT support the negative impact of new product introductions on inventory freshness; nonetheless, the respective short term impact may be the other way around, as the company may face inventory shortage (thus higher inventory turnover) due to the increased forecasting complexity (Lee 2002; Wan, Evers, and Dresner 2012; Pero et al. 2010) that arises from changing assortment size.

4.5.3. The impact of new product introductions on product quality conformance

The direct impact (Hypothesis 3) is supported for the long-term perspective, but not for the short-term perspective, when controlling for the entity-specific mean production assortment size and changes in production assortment.

We see that the more innovative product categories (i.e. higher mNPI) are associated with higher rates of product returns in the long run. However, that is modeled as an intrinsic characteristic of each product category. Yet, the event of introducing new products, represented by dNPI, is not statistically significant.

The hypotheses of production assortment-mediated impact of new product introductions on product quality conformance (Hypothesis 6) is not supported by our data, either in the short-term perspective or in the long-term perspective.

Moreover, we –again– unintentionally found secondary results for the relationship between production assortment and the rate of product returns. The coefficients of both the short-term perspective, i.e. dL_ASSORT, and product-category-specific, long-term perspective, i.e. mL_ASSORT, variables are significantly associated with higher rates of product returns, at

the 0.1% and at the 5% level, respectively. That is in line with the previous findings from the literature (Fisher and Ittner 1999; MacDuffie, Sethuraman, and Fisher 2001; Mapes, New, and Szwejczewski 1997) that claims that higher product variety jeopardizes quality.

4.6. Analysis of the results as a whole

Table 4.5 summarizes our hypothesis testing. Yet, the results of our analysis were not exactly what we expected, as the hypotheses were derived from strong evidence from our qualitative research (chapter 3). Still, we believe that the statistical analysis lead to meaningful insights.

DV	Hypothesis	Short term (differential)	Long term (category-based)	Conclusions
FILLRATE	Direct (H1)	Not supported	Not supported	No support to H1 and H4. Secondary findings: assortment changes impacts fill rate, yet not necessarily related to NPI
	Indirect (H4)	Not supported	Not supported	
	Secondary results	Negative impact of assortment changes	None	
ITURNS	Direct (H2)	Not supported	Supported	H2 only supported in the long-term. No support to H5. Secondary findings: opposite signs from long and short term impact indicate different behaviors through time
	Indirect (H5)	Not supported	Not supported	
	Secondary results	Positive impact of assortment changes	Negative impact of average assortment	
RRATE	Direct (H3)	Not supported	Supported	H3 only supported in the long-term. No support to H6. Secondary findings: assortment changes and size impacts quality, yet not necessarily related to NPI
	Indirect (H6)	Not supported	Not supported	
	Secondary results	Positive impact of assortment changes	Positive impact of average assortment	

Table 4.5: *Summary of hypothesis testing and secondary findings*

When assessing the short-term impact of NPI on supply chain performance, production assortment seems to be a more relevant factor than the event of a new product introduction, *per se*, as we did not find support to any of our hypotheses in the short-term perspective. On the other hand, we incidentally found evidence that, in the short term, changes in production assortment are significant related to lower service level and lower quality conformance; yet, its association with inventory freshness takes an unexpected direction –a plausible explanation is that it may be due to stock outs due to larger complexity leading to lower product availability.

The long-term effect of a product category being more innovative –i.e. higher long-term average level of new product introductions– is associated with higher rates of product returns (i.e. lower quality conformance), and lower inventory freshness. We did not find evidence to support the long term impact of new product introductions on the service level.

Overall, the conclusions from our data analysis support that, in the short term, it is cru-

cial to have a proper product portfolio/complexity management in place, such that new product introductions do not lead to relevant assortment variations, which is in line the findings from Lee 2002. In the long term, we found evidence that the more innovative –i.e. presenting higher rates of new product introductions– and large product portfolio product categories are associated with poorer inventory turnover and product quality conformance. That is, the isolate event of introducing a new product may not be harmful to a company's operation; yet, frequently introducing new products –and not properly managing product portfolio/complexity– leads to lower operational performance.

4.7. Conclusion, limitations, and directions for future research

This study provides an academic contribution by testing and measuring the impact of new product introductions on the supply chain performance in a CPG manufacturing firm using robust panel data econometrics, based on cross-sectional longitudinal operational data. Additionally, this study uses a novel level of analysis that enables capturing E&E variance across product categories –i.e. some categories are expected to behave differently in terms of exploration and exploitation–, thus enabling panel data analysis within single business units by treating each product category as a representative of a different operation. These results can be also helpful to practitioners, as it provides information that can support decision-making when dealing exploration & exploitation issues.

We found evidence that high long-term average frequencies of new product introductions may be harmful to a company's operations; although the differential impact, in the short term perspective, received no support. In light of that, companies should rationalize its new product introduction strategies and avoid introducing products into its operations at a too-fast pace. Companies must take their time to adapt to the changes required by a new product introduction, in order to avoid jeopardizing its operational performance.

We also found secondary evidence for the direct effects of larger production assortments and production assortment changes. In light of that, companies should invest in proper product portfolio management practices. Firms should have a clear strategy to keeping a certain number of SKUs in production, avoiding unnecessary changes in assortment. This

relates to NPI in that, once a company has a clear rationale for its assortment, it can drive decisions of corresponding product retirements following events of new product introductions.

Exploration and exploitation can be seen as part of a continuum, with the rate of new product introductions as a central variable. *Ceteris paribus*, higher levels of exploration lead to lower operational performance. In light of the exploration & exploitation literature, the degree of the impact of that relationship could be changed by increasing the level of a company's resource coordination flexibility (Wei, Yi, and Guo 2014). Further investigation of the conditional influence of such aspects on the relationship between exploration & exploitation and operational performance would meaningfully enlighten this research stream.

It may also be the case that the contingent effects of firm size has also influenced our results. Due to lacking of large structure and abundant resources, small and medium enterprises, such as MeatCo, cannot afford structural separation and must resort to contextual ambidexterity (Lubatkin et al. 2006). Further research on the contingent effects of the degree of structural ambidexterity on the relationship between new product introductions and operational performance would be beneficial to improving our understanding of this issue.

Furthermore, we identified three additional limitations. First, our data considers a single company. Although the panel data analysis has considered a heterogeneous set of product categories, it would be beneficial to take this analysis into a different setting and, even, using a multi-company panel data analysis on different geographies. We believe, however, that results can be generalized to any company in an industry with similar characteristics, such as medium-sized manufacturers of perishable CPG that regularly introduce new products.

Second, our analysis only considers the contemporaneous relationship between independent and dependent variables. Although inclusion of time-invariant entity-specific means is similar to carrying the long-term effects of individual characteristics, analyzing differential results of innovation on the firm's operational performance through time would improve our understanding of the dynamics of these relationships.

It may be the case, however, that the absence of product-level degree of innovativeness

controls is biasing our inference. The importance of taking the product-level degree of innovativeness into account has been acknowledged by Pero et al. 2010 and is also part of our original conceptual model (figure 3.1), which was based on empirical evidence. Still, the moderating role of the product-level degree of innovativeness will be discussed in chapter 5. It may also be the case, however, that the company is using its supply chain strategy to properly address the, apparently, conflicting objectives of frequently introducing new products, while maintaining steady service levels (Lee 2002; Pero et al. 2010), inventory freshness, and quality (Sethi and Sethi 2009). This topic will be further discussed in chapter 6.

Third, this analysis considers a limited set of dependent variables. It would beneficial to extend the outcome variables to other supply chain performance indicators.

4.8. Next steps

The findings from this chapter serves as a core input to the analyses developed in chapter 6, on which we developed an action-research-based framework for building ambidextrous supply chain strategies. The key takeaways are that, *ceteris paribus*, companies must have a clear standard for defining its rate of new product introductions and tactics for managing product portfolio complexity, in order to be able to be operationally efficient, while still being innovative.

This analysis has not considered the moderating effects of product-level degree of innovativeness, however. As mentioned earlier, we paid special attention to the endogeneity issue and followed the recommendations from Stock and Watson 2011 and Ketokivi and McIntosh 2017 to aviod threats to the internal validity/endogeneity in our study. For that reason, we decided to leave this chapter free of severe threats to its internal validity (section 4.3.3).

On the other hand, the product-level degree of innovativeness variable is still a core component for analyzing the hypotheses derived from hypotheses 7-9 and, although prone to measurement error, it is an important variable and could still lead to meaningful insights. Thus, on next chapter we extend our analysis to develop the concept and metric for the product-level degree of innovativeness and include it as a new moderator variable within our analysis –although we are aware that it threatens internal validity to a certain extent.

Chapter 5

Investigating the moderating role of the product-level degree of innovativeness on the relationship between NPI and supply chain performance

5.1. Introduction

Evidences from our case study (section 3.5) suggest that product-level degree of innovativeness moderate the impact of new product introductions on supply chain performance. In chapter 4 we tested the unmoderated impact of new product introductions on supply chain performance. Now, in this chapter, we extend our previous model (figure 4.1) to include product-level degree of innovativeness as a moderator variable.

As explained before, the reasons for conducting the analysis as a two-stage approach related to our product-level degree of innovativeness being prone to some measurement error, representing a threat to the internal validity of our study. Thus, we chose to leave the previous chapter free of severe threats to its internal validity by not including the product-level degree of innovativeness within the model. Still, as the product-level degree of innovativeness is a relevant concept, as demonstrated in chapter 3, we did not want to simply dismiss it, so we decided to include it in this separate chapter –yet, the reader must be aware that it can threaten the internal validity of this study to a certain extent.

In this chapter, we first elaborate and develop the concept of the product-level degree of innovativeness as a two-component metric. We then follow a similar econometric methods of analysis as in chapter 4, with the twist that now we also test for moderation.

As this is an extension of the previous chapter, we chose to omit some technical/methodological details that are similar. While being redundant is sometimes inevitable, the intention of this chapter to focus on the different insights brought by including the moderation variables, avoiding unnecessary repetition. Thus, we will refer back to chapter 4 whenever needed.

5.2. Hypotheses

We tested all the nine hypotheses from chapter 3 (section 3.5), as represented in figure 5.1. The hypotheses tested in the previous chapter (section 4.2) are included here (i.e. hypotheses 1-6) and also three additional hypotheses (i.e. hypotheses 7-9) related to the moderation effect of product-level innovativeness on the direct impact of new product on supply chain performance. Our nine hypotheses are stated as follows:

Hypothesis 1 *New product introductions into a CPG manufacturing operation directly jeopardizes its service levels.*

Hypothesis 2 *New product introductions into a CPG manufacturing operation directly jeopardizes its overall inventory freshness.*

Hypothesis 3 *New product introductions into a CPG manufacturing operation directly jeopardizes its product quality conformance.*

Hypothesis 4 *The negative impact of new product introductions on the service level of a CPG manufacturing operation is mediated by production assortment.*

Hypothesis 5 *The negative impact of new product introductions on the inventory inventory freshness of a CPG manufacturing operation is mediated by production assortment.*

Hypothesis 6 *The negative impact of new product introductions on the product quality conformance of a CPG manufacturing operation is mediated by production assortment.*

Hypothesis 7 *The negative impact of new product introductions on the service level of a CPG manufacturing operation is moderated by degree of innovativeness of the new product.*

Hypothesis 8 *The negative impact of new product introductions on the inventory freshness of a CPG manufacturing operation is moderated by the degree of innovativeness of the new product.*

Hypothesis 9 *The negative impact of new product introductions on the product quality conformance of a CPG manufacturing operation is moderated by the degree of innovativeness of the new product.*

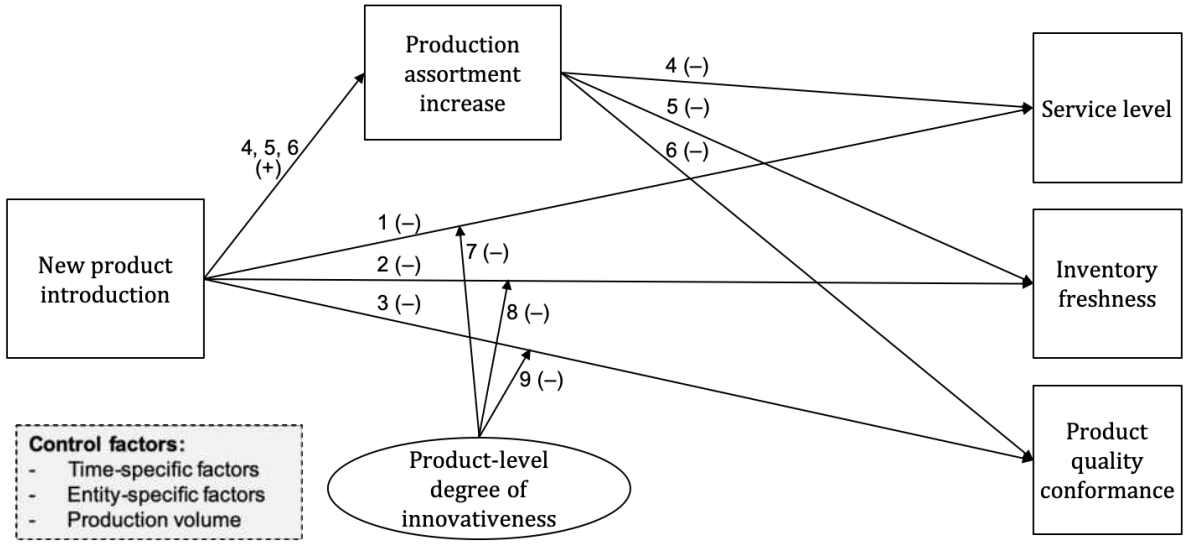

Figure 5.1: *Graphical representation of the hypotheses tested in chapter 5*

5.3. Measuring the product-level degree of innovativeness

Our product-level degree of innovativeness metric is based on whether a new product can draw on existing competences related to technologies and customers, or whether it requires new competences from the firm (Danneels 2002). It consists of two independent components, as suggested by Jones and Wan 1992: product innovativeness and process & technology innovativeness. The two-component, five-point metric of product-level degree of innovativeness is summarized in figure 5.2 and the individual components are described as follows.

The first component is measured, for each new product, on a five-point scale, according to the product's degree of innovativeness at the time of the product introduction, relative to the products then in its market area (Ali et al. 1995; Calantone, Chan, and Cui 2006). The product innovativeness scale is given by:

1. No substantial difference relative to previous products, e.g. only packaging, labeling or branding (chapter 3)

2. The product was adapted from within the firm, i.e. incremental product development (Garcia and Calantone 2002; Jones and Wan 1992; Cooper and Brentani 1991)

3. The product was a pure adoption from an outside firm, i.e. "me too" product (Jones and Wan 1992)

4. The product was adapted from outside firm, i.e. a modified product (Jones and Wan 1992)

5. The product was totally original, i.e. new to the world (Garcia and Calantone 2002; Jones and Wan 1992; Atuahene-Gima 1995; Cooper and Brentani 1991)

The second component is measured, for each new product, on a five-point scale, according to the extent to which the product required modifying existing manufacturing facilities, equipment, and processes, at the time of its introduction (Calantone, Chan, and Cui 2006; Danneels and Kleinschmidt 2001; Tatikonda and Montoya-Weiss 2001). The process & technology innovativeness scale is given by:

1. No substantial modification to existing manufacturing process/technology, e.g. in case of minor recipe modification or packaging changes (Garcia and Calantone 2002; Chandy and Tellis 2000)

2. Process/technology was adapted from within the firm, i.e. improvement of current systems (Jones and Wan 1992; Garcia and Calantone 2002; Colarelli-O'Connor 1998)

3. Process/technology was a pure adoption of from outside firm, i.e. "copycat" system (Jones and Wan 1992; Garcia and Calantone 2002; Colarelli-O'Connor 1998)

4. Process/technology was adapted from outside firm, i.e. a modification from a system existing outside of the firm (Jones and Wan 1992; Garcia and Calantone 2002; Colarelli-O'Connor 1998)

5. Process/technology was totally original, i.e. "technical breakthrough" (Jones and Wan 1992; Garcia and Calantone 2002; Green, Gavin, and Aiman-Smith 1995)

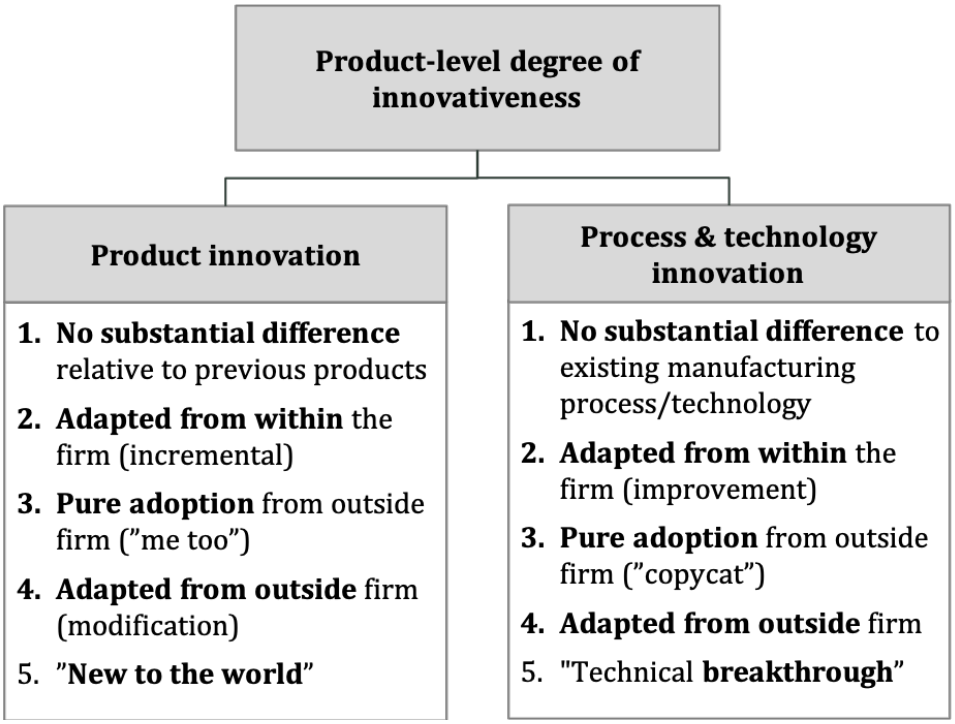

Figure 5.2: *Schematic summary of product-level degree of innovativeness metric*

5.4. Research method and sample

Our research method, database, and variables are almost the same as those used in chapter 4. The only difference is the inclusion of two moderator variables related to the product innovativeness and process & technology innovativeness for every new product introduced within the timeframe of our dataset.

Measuring the product-level degree of innovativeness

We prepared a list of all new products introduced within the period and asked MeatCo's head of research & development to rate each product with respect to its degree of product innovativeness and its degree of process & technology innovativeness. Results are summarized in table 5.1. As we can see, out of the 302 new products introduced between January 2016 and January 2018, 218 (72%) presented a low level of innovativeness, consisting mainly of incremental modifications of adaptation to existing products and processes.

It is worth noting that this metric is prone to measurement error, as we relied on the memories and subjectivity of a single respondent to rate the product-level degree of innovativeness.

Frequencies		Process/technology innovation (1-5 scale)					Total
		1	2	3	4	5	
Product innovation (1-5 scale)	1	129	3	-	-	-	132
	2	32	54	23	-	-	109
	3	10	32	6	1	-	60
	4	1	-	-	-	-	1
	5	-	-	-	-	-	-
Total		172	89	29	12	-	302

Table 5.1: *Distribution of product innovation and process/technology innovation scores, from Jan/2016 to Jan/2018*

That single respondent was the only person within the company who had participated on the introduction of every product into the company within our period of analysis, which was the reason why we consider the only person sufficiently knowledgeable to rate the degree of innovativeness of our dataset. However, we chose to mitigate measurement error by devising and adopting two separate innovativeness dummy variables. We established a cutoff point in the five-point scale to determine either the level of the two different components of product-level innovativeness was high or low, thus mitigating the likelihood of measurement error by grouping the variable in just two points, avoiding fine-grained, subtle differences in degrees of innovativeness, but still preserving the broader, and easier-to-remember, perception of the single respondent on whether the product was innovative at the time of its introduction. The product-level degree of innovativeness dummy variables are described as follows.

- $HIPRODINNOV$: binary variable representing high product innovativeness, such that $HIPRODINNOV = \begin{cases} 1, \text{ if product innovativeness = 3, 4, or 5} \\ 0, \text{ otherwise} \end{cases}$
- $HIPROCINNOV$: binary variable representing high process & technology innovativeness, such that $HIPROCINNOV = \begin{cases} 1, \text{ if process \& technology innovativeness = 3, 4, or 5} \\ 0, \text{ otherwise} \end{cases}$

Testing for moderation

We tested the moderation effects of product innovativeness and process & technology innovativeness on the direct impact of new product introductions (NPI) on supply chain performance by following the moderation test suggested by Baron and Kenny 1986. The moderation test is done by generating two interaction terms:

- $NPI\_HIPRODINNOV = NPI \times HIPRODINNOV$
- $NPI\_HIPROCINNOV = NPI \times HIPROCINNOV$

We can claim moderation effects when the coefficients on the interaction terms are statistically significant. Please refer to section 4.3 for more information about the other components of the research methods and the data.

5.5. Results

As in chapter 4, we ran three series of hybrid FE&RE regressions to test and measure the impact of new product introductions on the supply chain performance of a CPG manufacturing company. However, this time we introduced the two interaction terms as described in the previous section, in order to test for moderation. The results are summarized in tables 5.2, 5.4, and 5.3. Each table include eight regression models in versions using HAC-Clustered standard errors –models (1), (3), (5), and (7)– and Driscoll-Kraay standard errors –models (2), (4), (6), and (8). Models (7) and (8), on each table, represent our main regressions, testing and measuring the joint impact of NPI and L_ASSORT on the respective variables of interest –i.e. FILLRATE, in table 5.2, LRRATE, in table 5.4, and LITURNS, in table 5.3. The remaining models –i.e. (1) to (6)– represent the corresponding tests for mediation; yet, because the tests for mediation share a key component, regressions (3) and (4) are repeated in tables 5.2, 5.4, and 5.3. In every model we controlled for time-specific effects, entity-specific effects, and production volume. Our regressors of interest were grouped by deviation variables and entity-specific mean variables. In every model we controlled for time-specific effects, entity-specific effects, and production volume.

The first set of regressors in each table, which includes the differential variables dNPI, dL_ASSORT, dNPI_HIPRODINNOV, and dNPI_HIPROCINNOV, are related to the short-term

perspective. The second set, the category-specific means, which includes the category-based variables mNPI, mL_ASSORT, mNPI_HIPRODINNOV, and mNPI_HIPROCINNOV are related to long-term results –i.e. the effect of a product category being more (or less) innovative or more (or less) well-managed in terms of assortment.

The constants, as well as the coefficients on the time-specific controls, i.YW, and production volume controls, dPRODVOL and mPRODVOL, were omitted for parsimony, as they are of little interest to our study. Still, we reported the results for the test statistics for the significance of the time-specific and production volume controls, the Pesaran test for cross-sectional dependence, the Wald test comparing fixed effects and random effects, the overall r^2, and the total number of time-entity observations.

The main models, (7) and (8), on each table present the same coefficients; yet, different standard errors. The equations for the main models are represented on Equations 5.1, 5.2, and 5.3.

$$\begin{aligned} FILLRATE_{it} = & \mu_t + \alpha_i \\ & + \beta_1 \times dNPI_{it} + \beta_2 \times dL\_ASSORT_{it} \\ & + \beta_3 \times dNPI\_HIPRODINNOV_{it} + \beta_4 \times dNPI\_HIPROCINNOV_{it} \\ & + \beta_5 \times dPRODVOL_{it} \\ & + \beta_6 \times mNPI_i + \beta_7 \times mL\_ASSORT_i \\ & + \beta_8 \times mNPI\_HIPRODINNOV_i + \beta_9 \times dNPI\_HIPROCINNOV_i \\ & + \beta_{10} \times mPRODVOL_i \\ & + \varepsilon_{it} \end{aligned} \tag{5.1}$$

$$
\begin{aligned}
L\_RRATE_{it} = & \mu_t + \alpha_i \\
& + \beta_1 \times dNPI_{it} + \beta_2 \times dL\_ASSORT_{it} \\
& + \beta_3 \times dNPI\_HIPRODINNOV_{it} + \beta_4 \times dNPI\_HIPROCINNOV_{it} \\
& + \beta_5 \times dPRODVOL_{it} \\
& + \beta_6 \times mNPI_i + \beta_7 \times mL\_ASSORT_i \\
& + \beta_8 \times mNPI\_HIPRODINNOV_i + \beta_9 \times dNPI\_HIPROCINNOV_i \\
& + \beta_{10} \times mPRODVOL_i \\
& + \varepsilon_{it}
\end{aligned}
\tag{5.2}
$$

$$
\begin{aligned}
L\_ITURNS_{it} = & \mu_t + \alpha_i \\
& + \beta_1 \times dNPI_{it} + \beta_2 \times dL\_ASSORT_{it} \\
& + \beta_3 \times dNPI\_HIPRODINNOV_{it} + \beta_4 \times dNPI\_HIPROCINNOV_{it} \\
& + \beta_5 \times dPRODVOL_{it} \\
& + \beta_6 \times mNPI_i + \beta_7 \times mL\_ASSORT_i \\
& + \beta_8 \times mNPI\_HIPRODINNOV_i + \beta_9 \times dNPI\_HIPROCINNOV_i \\
& + \beta_{10} \times mPRODVOL_i \\
& + \varepsilon_{it}
\end{aligned}
\tag{5.3}
$$

The Pesaran CD tests clearly demonstrate, in every case, the presence of cross-sectional dependence in our dataset, suggesting that we must focus our attention on the models using Driscoll-Kraay standard errors. Time-specific controls are significant at the 1% level in most cases –and in all cases using Driscoll-Kraay standard errors–, demonstrating that the company performs differently through time. The significance of the production volume control variable varies by regression group, although it is important to keep it in every model as it is theoretically valid. We will now look into the details of each group of regressions.

5.5.1. Models related to service level, moderated by innovativeness

Short-term perspective

From the innovativeness-moderated model in table 5.2 we are not able to find significant evidence that the event of a new product introduction is associated with lower fill rates, in the short-term perspective. The coefficient on dNPI, representing new product introductions, as well as on dNPI_HIPRODINNOV and dNPI_HIPRODINNOV, representing the introduction of more innovative products, are not significant, as we can see in models (2) and (8).

Still, we found that the introduction of a new product is associated with 0.1% change in production assortment in the short term and this relationship is significant at the 1% level (4). A 1% change in production assortment, on the other hand, is associated with a negative change of 0.0126 percentage points in fill rate and this relationship is significant at the 5% level (8).

These results are similar to those found in the previous chapter (section 4.4.1), as the analysis does not show sufficient evidence to claiming that a new product introduction, *per se*, is associated with lower fill rates in the short-term perspective; however, production assortment changes –which are associated with new product introductions– seem to be a significant factor when analyzing fill rate changes in the short term.

Long-term perspective

When viewing the results from the long-term perspective, by analyzing the category-based components, we see that mNPI is significantly associated, at the 5% level, with higher service levels, which takes the opposite direction to our prediction. However, this result must be analyzed in conjunction with our innovativeness-moderated, interaction variables, mNPI_HIPRODINNOV and mNPI_HIPRODINNOV; we see evidence that the high-innovativeness product categories, in terms of product characteristics, represented by mNPI_HIPRODINNOV, are significantly associated with lower fill rates at the 1% level (8).

	(1) FILLRATE	(2) FILLRATE	(3) L_ASSORT	(4) L_ASSORT	(5) FILLRATE	(6) FILLRATE	(7) FILLRATE	(8) FILLRATE
dNPI	-0.3010**	-0.3010	0.1011***	0.1011***			-0.1770	-0.1770
	(0.1053)	(0.2525)	(0.0207)	(0.0206)			(0.1089)	(0.2409)
dL_ASSORT					-1.3370*	-1.3370*	-1.2262*	-1.2262*
					(0.5616)	(0.5751)	(0.6224)	(0.5147)
dNPI_HIPRODINNOV	0.2802*	0.2802	0.0014	0.0014			0.2819*	0.2819
	(0.1196)	(0.1992)	(0.0123)	(0.0260)			(0.1242)	(0.1965)
dNPI_HIPROCINNOV	0.1739**	0.1739	-0.0773***	-0.0773***			0.0791	0.0791
	(0.0548)	(0.2078)	(0.0215)	(0.0208)			(0.0616)	(0.1972)
mNPI	5.8192***	5.8192*	-0.3661	-0.3661			6.0365***	6.0365*
	(0.2666)	(2.5007)	(0.4490)	(0.2657)			(0.0000)	(2.7347)
mL_ASSORT					0.3657	0.3657	0.5937***	0.5937
					(0.8188)	(1.1374)	(0.0000)	(1.5198)
mNPI_HIPRODINNOV	-16.1669***	-16.1669**	-1.3528	-1.3528+			-15.3637***	-15.3637**
	(0.6710)	(5.8912)	(1.1302)	(0.7103)			(0.0000)	(5.4885)
mNPI_HIPROCINNOV	-2.2179***	-2.2179+	0.0516	0.0516			-2.2486***	-2.2486+
	(0.2181)	(1.1262)	(0.3673)	(0.0836)			(0.0000)	(1.1654)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK
F_YW	20.236	4.557	22.536	43.845	25.388	15.821	17.536	18.331
p_YW	0.001	0.002	0.000	0.000	0.000	0.000	0.004	0.000
F_PRODVOL	62.893	0.489	207.273	223.445	0.089	0.141	0.027	0.316
p_PRODVOL	0.000	0.615	0.000	0.000	0.956	0.869	0.869	0.730
chi2_PesaranCD	-2.761		-4.494		-2.578		-2.634	
p_PesaranCD	0.006		0.000		0.010		0.008	
F_FeRe	582.060	3.485	24.983	75.896	2.054	1.476	1.9e+05	3.777
p_FeRe	0.000	0.018	0.000	0.000	0.152	0.227	0.000	0.007
r2_o	0.256	0.256	0.910	0.910	0.246	0.246	0.262	0.262
N	630	630	630	630	630	630	630	630

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5.2: *FILLRATE selected innovativeness-moderated hybrid models*

5.5.2. Models related to inventory freshness, moderated by innovativeness

Short-term perspective

Our innovativeness-moderated versions of the inventory-freshness-related models, summarized in table 5.3, in the short-term perspective, provide significant evidence, at the 1% level, that new product introductions, represented by dNPI, is associated with changes in inventory turns and that it is fully mediated by changes in production assortment, represented by dL_ASSORT. In the model (2) dNPI is significantly associated, at the 1% level, with higher inventory turnover; yet, this relationship becomes non-significant upon the introduction of the assortment change variables (i.e. dL_ASSORT and mL_ASSORT) on model (8). The direction of the impact, however, exhibits an unexpected direction, as the coefficients on dNPI in and dL_ASSORT are positive.

We did not find any statistically significant evidence for the moderation hypotheses in the

short-term perspective.

Long-term perspective

Taking the long-term perspective, we see that the coefficients on the variable related to a product category being more innovative, in terms of volume –i.e. mNPI– is significantly associated, at the 1% level, with lower inventory turnover and that it is partially mediated by the average level of production assortment in that product category, mL_ASSORT.

The category-based interaction variables, mNPI_HIPRODINNOV and mNPI_HIPROCINNOV, although significant in (8), take a direction opposite direction to our expectations, as they are associated with higher inventory turns in the long term.

	(1) L_ITURNS	(2) L_ITURNS	(3) L_ASSORT	(4) L_ASSORT	(5) L_ITURNS	(6) L_ITURNS	(7) L_ITURNS	(8) L_ITURNS
dNPI	0.0855^{+}	0.0855**	0.0909***	0.0909***			-0.0108	-0.0108
	(0.0439)	(0.0273)	(0.0222)	(0.0224)			(0.0087)	(0.0137)
dL_ASSORT					0.3439***	0.3439**	0.3458***	0.3458**
					(0.0560)	(0.1271)	(0.0695)	(0.1176)
dNPI_HIPRODINNOV	-0.0587	-0.0587	0.0085	0.0085			0.0117	0.0117
	(0.0851)	(0.0425)	(0.0295)	(0.0503)			(0.0380)	(0.0220)
dNPI_HIPROCINNOV	-0.1396*	-0.1396*	-0.1323**	-0.1323*			0.0239	0.0239
	(0.0704)	(0.0616)	(0.0456)	(0.0555)			(0.0185)	(0.0327)
mNPI	-6.4283	-6.4283***	-1.1132	-1.1132**			-11.4451***	-11.4451***
	(4.9301)	(0.6302)	(1.1517)	(0.3480)			(0.0366)	(0.7865)
mL_ASSORT					4.3050^{+}	4.3050***	-4.2592***	-4.2592***
					(2.2229)	(1.1524)	(0.0518)	(0.2295)
mNPI_HIPRODINNOV	3.5613	3.5613	1.1940	1.1940			10.3118***	10.3118***
	(24.7553)	(2.7880)	(5.7932)	(1.9846)			(0.1896)	(2.6970)
mNPI_HIPROCINNOV	10.3989	10.3989***	1.5784	1.5784^{+}			17.8582***	17.8582***
	(13.8443)	(1.8702)	(3.2379)	(0.9497)			(0.0630)	(1.8755)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK
F_YW	6.029	14.320	29.017	16.789	24.031	29.526	19.208	15.456
p_YW	0.303	0.000	0.000	0.000	0.000	0.000	0.002	0.000
F_PRODVOL	8.124	145.071	99.569	183.856	10.137	12.535	1.7e+05	201.344
p_PRODVOL	0.017	0.000	0.000	0.000	0.006	0.000	0.000	0.000
chi2_PesaranCD	-4.149		-4.501		-3.240		-3.205	
p_PesaranCD	0.000		0.000		0.001		0.001	
F_FeRe	45.313	1339.058	28.630	62.855	3.048	11.332	2.4e+06	589.595
p_FeRe	0.000	0.000	0.000	0.000	0.081	0.001	0.000	0.000
r2_o	0.906	0.906	0.907	0.907	0.677	0.677	0.970	0.970
N	414	414	630	630	414	414	414	414

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5.3: *L_ITURNS selected innovativeness-moderated hybrid models*

5.5.3. Models related to product quality conformance, moderated by innovativeness

Short-term perspective

We did not find statistically significant evidence to supporting that new product introductions are directly or indirectly associated with lower quality conformance (higher product return rates), as we can see from table 5.4. Yet, we see evidence that short-term changes in production assortment, represented by dL_ASSORT, is significantly associated with higher rates of product returns in the short term.
We did not find any statistically significant evidence for the moderation hypotheses in the short-term perspective.

Long-term perspective

The long-term perspective of the innovative-moderated models related to product quality conformance does not provide any statistically significant evidence to support our hypotheses. There is only a hint that the product lines that, on average, introduce products requiring higher levels of process innovation impact the rate of product returns –which can be observed by the 10%-level significant coefficient on mNPI_HIPROCINNOV on model (8).

5.6. Discussion

5.6.1. The innovativeness-moderated impact of new product introductions on service level

Conclusions related to Hypotheses 1 and 4 are similar to their counterparts in chapter 4 (section 4.5.1). The same holds for the secondary findings related to changes in production assortment. Regarding Hypothesis 7, related to moderation, it is only supported in the long term perspective, as the product categories that on average introduce more innovative products are associated with lower fill rates.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	L_RRATE	L_RRATE	L_ASSORT	L_ASSORT	L_RRATE	L_RRATE	L_RRATE	L_RRATE
dNPI	0.0454	0.0454	0.1011***	0.1011***			-0.0702^{+}	-0.0702
	(0.0518)	(0.0569)	(0.0207)	(0.0206)			(0.0362)	(0.0645)
dL_ASSORT					1.2018***	1.2018***	1.3425***	1.3425***
					(0.2027)	(0.2761)	(0.1939)	(0.2822)
dNPI_HIPRODINNOV	-0.0295	-0.0295	0.0014	0.0014			-0.0472	-0.0472
	(0.0865)	(0.0642)	(0.0123)	(0.0260)			(0.0984)	(0.0848)
dNPI_HIPROCINNOV	-0.0449	-0.0449	-0.0773***	-0.0773***			0.0305	0.0305
	(0.0716)	(0.0511)	(0.0215)	(0.0208)			(0.0551)	(0.0633)
mNPI	-1.3468	-1.3468	-0.3661	-0.3661			0.4497	0.4497
	(1.1849)	(1.4738)	(0.4490)	(0.2657)			(0.3238)	(2.0014)
mL_ASSORT					-0.5856	-0.5856	1.6048***	1.6048^{+}
					(0.4837)	(0.6904)	(0.1340)	(0.9454)
mNPI_HIPRODINNOV	3.7640^{+}	3.7640	-1.3528	-1.3528^{+}			3.9607***	3.9607
	(2.1002)	(3.6436)	(1.1302)	(0.7103)			(0.2675)	(3.2431)
mNPI_HIPROCINNOV	1.9845***	1.9845**	0.0516	0.0516			1.4820***	1.4820^{+}
	(0.5403)	(0.7341)	(0.3673)	(0.0836)			(0.1023)	(0.8741)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK	HAC-Clust.	DK
F_YW	2.705	433.705	22.536	43.845	1.245	2.2e+06	1.309	56.232
p_YW	0.745	0.000	0.000	0.000	0.940	0.000	0.934	0.000
F_PRODVOL	3.855	4.124	207.273	223.445	5.450	1.383	113.557	2.776
p_PRODVOL	0.146	0.019	0.000	0.000	0.066	0.255	0.000	0.067
chi2_PesaranCD	-7.014		-4.494		-6.977		-6.977	
p_PesaranCD	0.000		0.000		0.000		0.000	
F_FeRe	39.405	6.862	24.983	75.896	9.883	6.366	3780.054	9.889
p_FeRe	0.000	0.000	0.000	0.000	0.002	0.013	0.000	0.000
r2_o	0.314	0.314	0.910	0.910	0.326	0.326	0.356	0.356
N	543	543	630	630	543	543	543	543

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5.4: *L_RRATE selected innovativeness-moderated hybrid models*

5.6.2. The innovativeness-moderated impact of new product introductions on inventory freshness

After introducing the product-level innovativeness controls and interaction variables, we maintain most of the results from our previous analysis, described in section 4.5.2. Yet, we find interesting results related to our moderation hypothesis. On the short term, we did not find significant evidence of moderation interactions of product-level degree of innovativeness on the impact of new product introductions on inventory freshness.

However, we found evidence that the product categories that introduce more innovative products, on average, are associated with higher inventory turnover ratios –and this relationship is significant at the 0.1% level. The interpretation of this counterintuitive sign may be similar to the one we had in chapter 4: introducing more innovative products into the system may increase its overall complexity, leading to stockout and, therefore, to higher inventory turnover ratios.

5.6.3. The innovativeness-moderated impact of new product introductions on product quality conformance

The inclusion of the innovativeness interaction terms in the analysis of the impact of new product introductions on product quality conformance have not changed our results with respect to the direct and indirect hypotheses, in comparison to what we found in section 4.5.3. Upon the introduction of the innovativeness variables, the impact of new product introductions, both in the long term and in the short term, are not significant, so neither Hypothesis 3 or Hypothesis 6 are supported.

The moderation Hypothesis 8 is not supported either, both in the short-term and in the long-term perspectives.

Regarding the secondary results, the positive long-term impact of large average assortments of a category is no longer significant, in the moderated model.

5.7. Analysis of the results as a whole

Table 5.5 summarizes our hypothesis testing. We also compared the results obtained on this analysis to those obtained in chapter 4 (section 4.6).

DV	Hypothesis	Short term (differential)	Long term (entity mean)	Comparison to chapter 4
FILLRATE	Direct (H1)	Not supported	Not supported	Similar
	Indirect (H4)	Not supported	Not supported	Similar
	Moderated (H7)	Not supported	Supported, for product innovativeness	n/a
	Secondary results	Support for impact of assortment changes	None	Similar
ITURNS	Direct (H2)	Not supported	Supported	Similar
	Indirect (H5)	Not supported	Supported	Different
	Moderated (H8)	Not supported	Not supported	n/a
	Secondary results	Positive impact of assortment changes	Negative impact of average assortment	Similar
RRATE	Direct (H3)	Not supported	Not supported	Similar
	Indirect (H6)	Not supported	Not supported	Similar
	Moderated (H9)	Not supported	Not supported	n/a
	Secondary results	Positive impact of assortment changes	None	Different

Table 5.5: *Summary of the hypotheses tested in chapter 5, secondary findings, and comparison to chapter 4*

We see that the results from chapter 4 are mostly maintained upon the introduction of the moderator term and we can notice that, in certain cases, the long-term perspective of product-level degree of innovativeness is associated with lower performance of some components of supply chain and operations performance, such as inventory freshness and product quality conformance. That is especially evident for the degree of product innovativeness, and less for the degree of process innovativeness.

5.8. Limitations and directions for future research

In this chapter we tried to overcome a limitation from chapter 4, but in turn we added certain threats to validity, as the variables related to the product-level degree of innovativeness are prone to measurement error (as we previously advised, these results must be taken with a grain of salt). Still, this study provides academic contribution by improving the product-level degree of innovativeness concept and testing its moderation effects on the relationship between NPI and supply chain performance, also improving managerial intuition that can be used when introducing new products.

We believe that the results are insightful as they indicate a potentially promising direction for

future research. Both the literature and practitioners would benefit from a deeper and more rigorous analysis on the moderation effects of the degree of product-level innovativeness on the impact of new product introductions on supply chain performance. The same metric employed here would suffice, however, more data points –and more respondents should be included on the data collection. It may also be the case that the low-degree-of-innovativeness presented by the new product introduced by MeatCo within the period did not provide sufficient variation for the model to be able to capture significant statistic associations.

5.9. Next steps

The findings from this chapter serve as input (along with the findings from all the previous chapters) to the analyses that are going to be developed in chapter 6, an action-research-based framework for crafting E&E-enabling supply chain strategies. The key takeaways are that frequently introducing products with a high degree of product innovativeness may hurt some aspects of supply chain performance, such as inventory freshness and product quality conformance. Thus, companies must take that into account when defining its new product introductions plan.

Chapter 6

Building an exploration-and-exploitation-enabling supply chain strategy

6.1. Introduction

In this part, building up on the findings from the previous chapters, we make a methodological shift to devise a conceptual framework for developing exploration-and-exploitation-enabling supply chain & strategies. The results from all the previous chapter have enlightened the development of the research for this chapter.

We conducted an action research project using the Conceptual System Assessment and Reformulation (CSAR) method (Perez-Franco et al. 2016), unveiling the major trade-offs faced by MeatCo[1], an innovative CPG manufacturing company, to answer the following research question: what are the factors that must be considered when crafting exploration-and-exploitation-enabling supply chain strategies to support new product introductions into consumer packaged goods manufacturing operations?

The starting point is a set of 33 interviews, which took place in conjunction with the data gathering from chapter 3, followed by cycles of analyses, discussions, and workshops within the studied organization in order to review its supply chain strategy aiming at enabling exploration and exploitation, supporting new product introductions, while maintaining operational efficiency.

The remainder of this chapter is organized as follows: we begin by introducing some relevant

[1]See the company's background in section 3.2

concepts, additional to those mentioned on the previous chapters, then we describe the research methods and the results. We finally conclude by developing the conceptual framework and pointing directions for future research.

6.2. Literature review and key concepts

In this section we introduce a few concepts that have not been mentioned so far in this thesis. Still, as we are about to make a methodological shift, these concepts are key to properly developing our framework.

6.2.1. Strategy

The definition of strategy has been a concern for several management thinkers during the second half of 20th century. Some examples of strategy definitions are:

- *Strategy is the determination of the basic long-term goals of an enterprise, and the adoption of courses of actions and the allocation of resources necessary to carry out these goals* (Chandler 1962)
- *Strategy is a mediating force between the organization and its environment: consistent patterns of streams of organizational decisions to deal with the environment* (Mintzberg 1979)
- *The search for a favorable competitive position in an industry, the fundamental arena in which competition occurs. Competitive strategy aims to establish a profitable and sustainable position against the forces that determine industry competition* (Porter 1985)

Although there are certain variations in the definitions, authors seem to agree that strategy includes a group of major choices undertaken by an organization in order to achieve its goals. Moreover, the establishment of strategy is meant to be applicable to a certain scope. Huff et al. 2008 identified four generic levels in a firm's strategy: inter-organizational relations (network-level strategy), intra-group (corporate-level strategy), competitive advantage (business strategy), and functional activities (functional strategies).

For the purposes of this study we will refer only to the business strategy, which can be denoted as the actions that the business unit uses to gain a competitive advantage in specific product markets (Hitt, Hoskisson, and Ireland 2007), typically articulated in the form of a

short mission statement and general statements of purpose, or strategy pillars (Perez-Franco 2010). In the particular case of this research, the business strategy will be taken as a given parameter –the common goal that the group of functional practices should work for.

6.2.2. Supply chain strategy

Supply chain strategy (SCS) can be viewed as the bridge that links the planned business-level strategy and the actual field operations of a firm (Perez-Franco 2010; Slack 1991), ultimately serving as a vehicle to materialize the business strategy. The SCS involves the configuration of supply chain management (SCM) functional activities, which concerns both operational and support activities –when related to SCM–, such as engineering, procurement, inventory management, manufacturing, warehousing, marketing, sales, transportation, human resources, information technology, and finance (Hofmann 2010; Perez-Franco 2010).

The strategic fitness of these activities to the business strategy will foster the materialization of the planned business strategy. The level of fitness of a SCM strategy is given by a set of criteria, such as clarity, feasibility, riskiness, parsimony, support, internal consistency, sufficiency, coverage, actionability, advantageousness, and external consistency (Perez-Franco et al. 2016; Perez-Franco and Sheffi 2016), which are going to be explained, in more details, in the next section.

One of the challenges in our investigation is assessing the current SCS of MeatCo, which is not a trivial task because its actual conditions are usually left tacit. The supply chain management literature presents several methodologies for documenting the SC practices (Barros, Barbosa-Póvoa, and Blanco 2013), such as the SCOR model (Bolstorff and Rosenbaum 2003), SCM Processes (Croxton et al. 2001), Quick-scan methodology (Naim et al. 2002), and the Conceptual System Assessment and Reformulation (Perez-Franco et al. 2016). Facing this challenge, in the context of MIT Center for Transportation and Logistics Supply Chain Strategy research program (SC2020), Perez-Franco 2010 and Perez-Franco et al. 2016 proposed that the supply chain strategy of a business unit can be expressed as a conceptual system, on which a set of interrelated concepts represent the supply chain strategy of the business unit. That conceptual system can be used for mapping the supply chain strategy currently in place as well as evaluating the fitness of those concepts to the business-level

strategy and, at a further stage, for supporting the reformulation of the supply chain strategy into a superior one, using the CSAR methodology (Perez-Franco 2010; Perez-Franco et al. 2016).

CSAR captures practices that express the implemented supply chain strategy and allows easy verification of the alignment between these practices and the firm's overall strategy (Barros, Barbosa-Póvoa, and Blanco 2013), thus it seems a suitable framework for our case. However, that methodology has never been employed as a research tool, one that would enlighten a subsequent investigation in the field of E&E.

6.3. Research method and sample

We conducted an action research project employing CSAR to map, evaluate, and reformulate MeatCo's supply chain strategy. By doing so, we were able to identify the exploration & exploitation-related trade-offs faced by the firm and the potential solutions that have been identified during the process. That exercise enlightened our framework for building an exploration-and-exploitation-enabling supply chain strategy into CPG manufacturing operations. The methodology is detailed in the following sections.

6.3.1. Action research

The combination of situational groundedness and the sense of generality espoused in case research can be an effective strategy for research that is both methodologically rigorous and practically relevant (Ketokivi and Choi 2014). Action Research (AR) is a variant of case study research on which the researcher actively participates into the resolution of real-world organizational and managerial problems, thus contributing both to the practical concerns of an organization and to the goals of science (Näslund, Kale, and Paulraj 2010; Westbrook 1995). It is a research approach that aims both at taking action and creating theory based on that action (Coughlan and Coghlan 2002). Westbrook 1995 concluded that *the grouded, iterative, interventionist nature of action research ensures closeness to the full range of variables in settings where those variables may not all emerge at once*.

Thus, due to the elusive nature of our problem, on which we are not aware of all the

variables that could play a role in crafting an exploration-and-exploitation-enabling supply chain strategy –and, still, due to desire to finding some practically-relevant avenues to dealing E&E in CPG manufacturing operations–, we believe that AR is a proper methodological choice for our case.

However, AR is frequently criticized for the lack of rigor of some previously published works (Näslund, Kale, and Paulraj 2010) and for its resemblance to consulting –as opposed to rigorous research– (Coughlan and Coghlan 2002). To tackle this conundrum, Näslund, Kale, and Paulraj 2010 have proposed a framework for conducting rigorous action research in supply chain management, while maintaining its managerial relevance, which was followed in our research as described as follows.

As we tackle a research question that addresses dual, practical and scientific purposes, our organization of study was involved in the entire research process, increasing the authenticity and trustworthiness of the study (Näslund, Kale, and Paulraj 2010).

Inserted within a broader thesis, we combined insights obtained from multiple research methods (chapters 2, 3, 4, and 5) to corroborate with our AR results, attacking the problem from multiple angles, increasing the validity of our analysis (Näslund, Kale, and Paulraj 2010).

We maintained well-documented study protocol, providing details on how the data was acquired and analyzed. We respected a cyclical approach in each step of the research, as suggested by Näslund, Kale, and Paulraj 2010: each main action in the research was followed by the researcher's step back for analysis, then followed by new actions. All the thoughts and ideas were shared with the studied organization in a joint project.

Perhaps the most important aspect to the validity and reliability in action research is the detailed description of the methods and procedures, such that it can be followed as an "audit trail" (Näslund, Kale, and Paulraj 2010). We tried to document every step as much as possible, as it will be demonstrated in the following sections.

6.3.2. CSAR METHODOLOGY

The Conceptual System Assessment and Reformulation (CSAR) is a holistic approach to supply chain strategizing (Perez-Franco and Sheffi 2016). The starting point is viewing supply chain strategy as a logical bridge connecting strategy and field operations (Perez-Franco 2010). That logical bridge can be expressed in several levels of abstraction and hierarchically sits right below the firm's business strategy and right above its operational activities (figure 6.1).

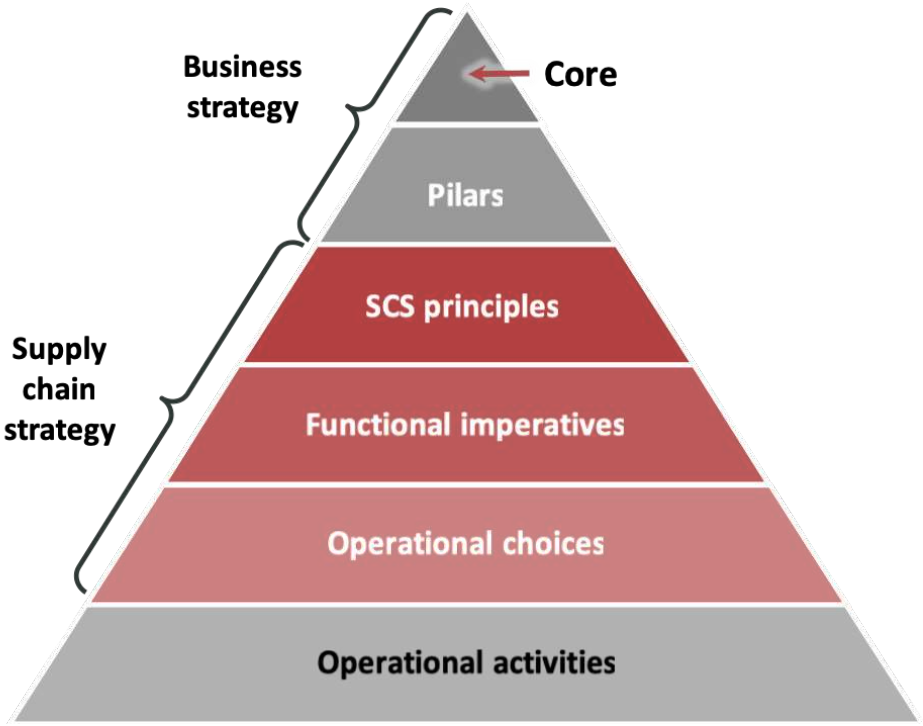

Figure 6.1: *Levels of abstraction of a supply chain strategy (Perez-Franco et al. 2016)*

The CSAR framework can be viewed as set of methodologies to capturing, evaluating, and reformulating a firm's supply chain strategy as a conceptual system (Perez-Franco 2010). In the context of this research, we have employed the CSAR approach to better understanding MeatCo's current supply chain strategy, identifying its major conflicts related to the exploration & exploitation trade-off, and then identifying the key strategic levers that can be employed to building dealing with E&E within the firm's operations. The three main phases on the CSAR methodology are delineated as follows (Perez-Franco 2010; Perez-Franco and Sheffi 2016; Perez-Franco et al. 2016):

1. Capturing the current supply chain strategy: the objective of the capturing phase is to translate the executed supply chain strategy of a firm in the form of a Functional

Strategy Map (FSM), referring to the strategy that is actually executed by a firm and considering as a main challenge the fact that most supply chain strategies are left tacit. This phase involves the analysis of the strategic statements of the firm, as well as interviews with its employees involved in the crafting of the supply chain strategy, in order to identify its actual functional and nominal strategy for further development and validation of a FSM. As demonstrated on figure 6.2, the FSM represents the supply chain strategy as a set of interrelated components. The FSM is divided into two main groups: the first is called nominal strategy and refers to the company?s established business strategy (core strategy) along with its key drivers (strategic pillars); and the second is the executed strategy, involving mainly the actually executed supply chain strategy principles, functional imperatives, and operational choices.

2. Evaluating the current supply chain strategy: the main goal of this phase is to assess the goodness of a given supply chain strategy, such as the one mapped on the previous phase. It comprises evaluating the SCS components against a set of 11 criteria (table 6.1), which can be quantified through surveys and a set of scales developed by Perez-Franco 2010.

3. Reformulating the supply chain strategy: this phase aims at stating a systematized approach for a supply chain strategy that is actually more valuable than the *status quo*. This comprises the agreement on a strategic imperative, the identification and prioritization of a list of areas of interest, based on phases one and two, and the hypothesis of new alternatives to be associated with the areas of interest, in an assembly process obeying the 11 fitness criteria rules, aiming at the main business strategy.

Our analysis began with capturing the current state of MeatCo supply chain strategy, based on semi-structured interviews with the company's personnel as well on the analysis of the company's documentation. The interviews took place in conjunction with with those described in section 3.3; yet, we had the some specific questions related to mapping the supply chain strategy, following the guidelines from Perez-Franco 2010 –see Appendix C.1 for the questionnaire.

We coded the data with the support of the NVivo 12 software package (QSR International Pty Ltd 2018). The coding method was based on the functional strategy mapping (FSM)

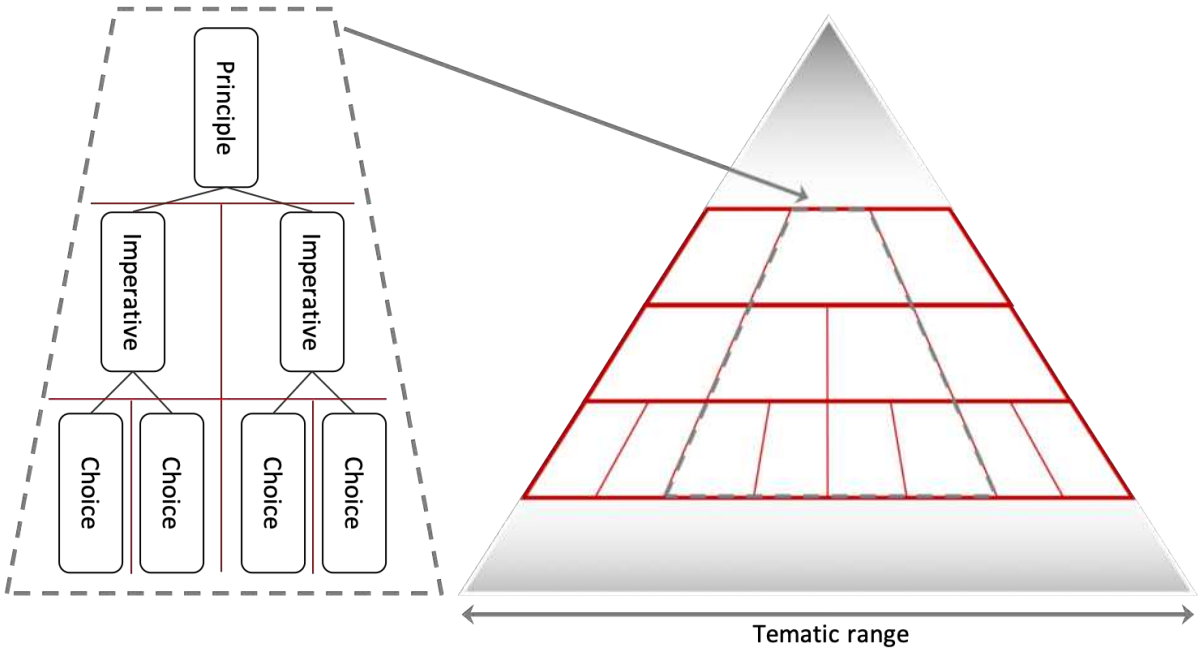

Figure 6.2: *From the levels of abstraction to a functional strategy map. Adapted from Perez-Franco et al. 2016*

Group	Criteria	Description
Individual characteristics of the components	Clarity	Components are easily understood by the decision makers
	Feasibility	Components are realizable in practice
	Riskiness	Components do not represent superior risk than the acceptable by the business
	Parsimony	Minimum usage of resources to produce the desired effect
Characteristics of the interactions between components	Support	Each component should support at least one component from one level above
	Internal consistency	Each component should be compatible with all the other components at the same level
		Components should not jeopardize the other components at the same level
		It is desirable that component reinforce other components at the same level
	Sufficiency	Components should be sufficiently satisfied by the support received from levels below
Characteristics of the SCS as a whole	Coverage	The SCS tematic range should be complete and cover all the areas of interest
	Accionability	A good SCS serves as a guide for decision making
	Advantageousness	A good SCS promotes competitive advantage
	External consistency	A good SCS is consistent with its external context

Table 6.1: *CSAR's goodness criteria for evaluating a conceptual system. Adapted from (Perez-Franco et al. 2016; Perez-Franco and Sheffi 2016)*

model. The FSM has been divided into two main groups: the first is called nominal strategy and refers to the company's established business strategy (core strategy) along with its key drivers (strategic pillars); and the second is the executed strategy, involving mainly the actually executed functional and operational practices.

Upon crafting and validating the FSM with MeatCo's top executives, we surveyed the company's employees regarding the 11 SCS goodness criteria and presented the evaluation results to the company, on a workshop. Details about the survey items are going to be presented in section 6.4.2.

We then proceeded to conducting a workshop to craft a new, improved, supply chain strategy to MeatCo, trying to overcome the identified (some of them related to the exploration & exploitation trade off) shortcomings of the supply chain strategy in place. We finally used the insights provided by the three steps of the CSAR exercise to identifying a set of key levers that can be used to building an E&E-enabling supply chain strategy.

6.3.3. The data

For the mapping phase, our data consisted of semi-structured interviews with 33 MeatCo's employees working in the following areas: general management, finance, research & development, marketing & sales, production planning, procurement, production, logistics, infrastructure & maintenance, process & project management, information technology, and infrastructure & facilities. We have chosen these areas because they are all, to a certain extent, linked to the company's supply chain management (Mentzer et al. 2001). Interviewees included employees from diverse hierarchical levels, ranging from top managers (e.g. CEO and CFO) to field-operations leaders (e.g. production line shift leaders and warehouse leaders). See table 3.1 for a summary of the interviewees' profiles. For instance, the interviews took place in conjunction with the interviews used in chapter 3.

A subset of the interviewees, composed by 15 respondents, participated in the surveys from the evaluation phase. The same group was involved in the reformulation, the subsequent step.

6.4. Results

6.4.1. Mapping MeatCo's as-is supply chain strategy

MeatCo's As-Is supply chain strategy is represented on the Functional Strategy Map in figure 6.3. The concepts are organized hierarchically, from the left to the right. The two levels on the left –i.e. core and pillars– represent MeatCo's planned business strategy, while the three levels on the right –i.e. principles, imperatives, and choices– represent MeatCo's executed SCS. All of the concepts described on the map served as inputs to the subsequent, evaluation and reformulation, stages.

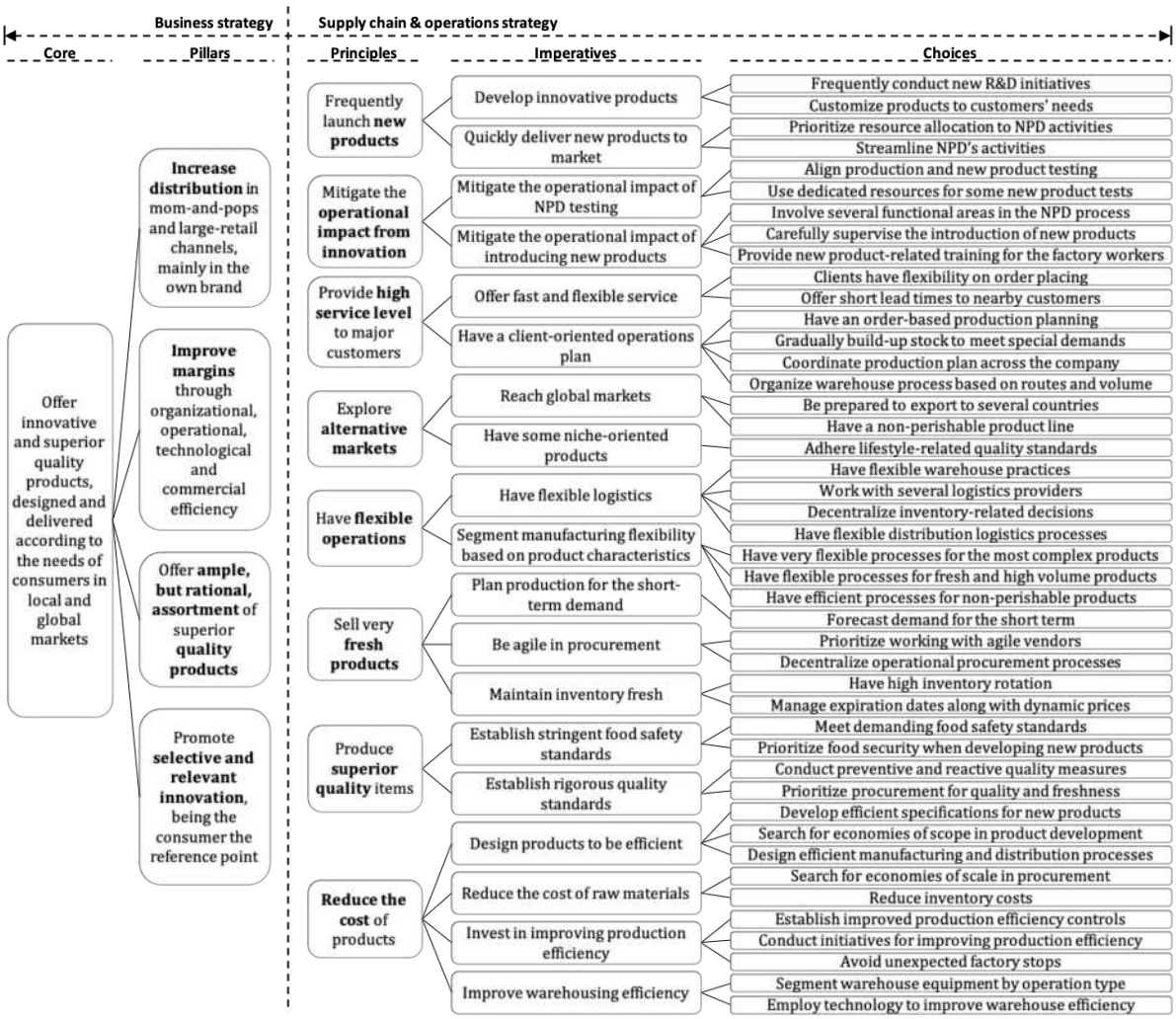

Figure 6.3: *MeatCo's AS-IS supply chain strategy map*

6.4.2. Evaluating the fitness of MeatCo's supply chain strategy

Evaluation of the characteristics of MeatCo's SCS as a whole

The overall SCS evaluation included a set of questions related to the coverage, actionability, advantageousness, and external consistency criteria. Respondents were asked to answer *yes* or *no* to a set of items related to the criteria, such that an *yes* answer is worth one point and a *no* answer is worth two points. The averages of the answers for each criterion is represented in table 6.2.

Criteria (applied to the overall SCS)	Evaluation (average grade)
Coverage	1.29
Accionability	1.54
Advantageousness	1.53
External consistency	1.25
Riskiness	1.42

Table 6.2: *SCS overall evaluation: evaluation of the criteria applied to the overall SCS*

The first item was related to the *coverage* criterion. Respondents were asked whether they agree with the following statement: *"our current supply chain strategy is comprehensive, such that all areas of interest are properly covered"*. The average grade of 1.29 shows that the majority of the respondents consider it true. The coverage blind spots were related to the integration of the supply chain-related functions, demand management, and information technology, as noted by some respondents: *"we don't have an integrated supply chain management, instead each function works independently of the others"*, *"we don's have an area dedicated to demand management nor production control and analysis"*, *"we need more involvement from information technology department"*.

The second item was related to the *actionability* criterion. Respondents were asked whether they agree with the following statement: *"our current supply chain strategy is actionable, such that it serves as a guide for decision making"*. The average grade of 1.54 shows that the majority of the respondents consider it false. Most of the issues noted by the respondents were related to the availability of information for supporting managerial decision, for example: *"we need credible information"*, *"we need a dashboard"*, *"we have a coordination problem and we do not have enough data for managerial analysis"*.

The third item was related to the *advantageousness* criterion. Respondents were asked whether they agree with the following statement: *"our current supply chain strategy improves our competitive advantage"*. The average grade of 1.53 shows that the majority of the respondents consider it false. Most of the issues noted by the respondents were related to the trade-off between efficiency and high service level or between efficiency and innovation, as noted by some employees: *"the degree on which we can adapt to clients' needs is a competitive advantage"*, *"our SCS give us an unique capability to adapt to clients' needs, at the cost of time and resources"*, *"we are overly client-oriented and this requires operating at our limits"*, *"it would be a competitive advantage if we could be more efficient"*.

The fourth item was related to the *external consistency* criterion. Respondents were asked whether they agree with the following statement: *"our current supply chain strategy is consistent with our local context, including its current regulations and market"*. The average grade of 1.25 shows that the majority of the respondents consider it true, which was reinforced by positive comments, such as *"our company is well-positioned on the market"* and *"I think it is consistent with our country's context"*; however, some efficiency-related issued were pointed. As noted by one of the company's employees *"the reality of our market demand maximum efficiency"*.

The fifth item was related to the *riskiness* criterion. Respondents were asked whether they could identify an element of the SCS that was particularly risky. The average grade of 1.42 shows that the majority of the respondents consider the risk to be low; however, several respondents consider the innovation-orientated, high-service, and low inventory strategy to be risky, as evidenced by the following comments:*"our high-service promise makes us work at the limit and, sometimes, we cannot meet expectations"*, *"we have an excessively diverse assortment"*, *"we have low level of cost control"*, *"we do not have metrics to control production efficiency"*, *"our low inventory levels imply that any logistics contingency could interfere on service levels"*, and *"we have too many products and we customize them too much; however, our market asks for low prices"*.

Evaluation of the characteristics of MeatCo's individual SCS components

Feasibility at the highest level of abstraction of the SCS (i.e. SCS principles) was the only individual criterion evaluated at this stage. However, the *parsimony* and then *clarity* criteria were considered as relevant factors during the reformulation stage. To evaluate the feasibility of the SCS principles, each respondent was asked whether each one of the principles were a feasible goal. Each *yes* and *no* answer received one and two points, respectively. *No* answers were required a follow-up descriptive answer. table 6.3 summarizes the quantitative answers.

Principles	Feasibility
Provide high service level to major clients	1.00
Produce superior quality items	1.00
Reduce the cost of products	1.06
Explore alternative markets	1.16
Frequently launch new products	1.25
Sell very fresh products	1.32
Mitigate the operational impact from innovation	1.35
Have flexible operations	1.47

Table 6.3: *SCS feasibility: degree of feasibility of the SCS principles at MeatCo*

As we can see, the average grades in table 6.3 are all below 1.5, indicating that most answers consider the top level SCS components to be feasible. However, some respondents were concerned about the company's focus on flexibility and innovation, as indicated by the following comments: *"our commitment to offering high service levels exacerbates the operational impact of innovation, thus it cannot be low", "every innovation costs more than it appears", "the impact of innovation depends on the degree of innovativeness", "our commitment to high service levels is an obstacle to flexibility", "it is hard to be flexible when you sell highly perishable products"*.

Evaluation of the characteristics of the interactions between MeatCo's SCS components

The evaluation of the characteristics of the interactions between MeatCo's SCS components considered the *support*, *sufficiency*, and *internal consistency* criteria at the SCS principles level and also, within each principle-originated branch, the functional imperatives and operational choices. To the *internal consistency* criterion, we applied the compatibility variant.

At the top, SCS principles, level we first evaluated the degree of support provided by each SCS principle to each of the business strategy pillar. To each pair of SCS principle and business strategy pillar (32 in total), we asked the following question: *does <SCS principle> help us <business strategy pillar>?* Answers were given according to a 7-point scale, plus a blank choice, as demonstrated in table 6.4.

Scale	Definition
(1)	Yes! It provides crucial reinforcement
(2)	Yes. It provides significant reinforcement
(3)	It may provide reinforcement, but only a little
(4)	It makes very little or no difference
(5)	It may be detrimental, but only a little
(6)	No. It is significantly detrimental
(7)	No! It is absolutely detrimental
(x)	I am not sure

Table 6.4: *Support evaluation scale*

Answers are summarized in table 6.5. As we can see, the business strategy pillar *"improve margins though organizational, operational, technological, and commercial efficiency"* receives low support from the SCS principles. Actually, most of the SCS principles are detrimental to it. We can also see that, despite the adequate support, some SCS principles are detrimental to *offering ample, but rational, assortment of superior quality products* as well as *"promoting selective and relevant innovation"*. Furthermore, we see that the SCS principles related to product freshness and high service level provide little support to the overall business strategy.

As we can see, MeatCo's SCS is, sometimes, in conflict with the overall business strategy. It may happen because there are closely related conflicts at the business strategy level itself. For example, operational efficiency *vs.* innovation.

After evaluating the interactions between the SCS and the business strategy, we moved down to evaluating the compatibility of the components within the highest level of abstraction of the SCS, that is, we evaluated the compatibility of each SCS principle with every other unique SCS principle. To each pair of SCS principle (28 in total), we asked the following question: *is <SCS principle> compatible with <SCS principle>?* Answers were given according to a 4-point scale, plus a blank choice, as demonstrated in table 6.6.

Average grades	Increase distribution in mom-and-pops and large-retail channels. mainly in the own brand	Improve margins through organizational. operational. technological and commercial efficiency	Offer ample. but rational. assortment of superior quality products	Promote selective and relevant innovation. being the consumer the reference point	**Average support offered**
Frequently launch new products	1.67	6.00	5.00	3.00	**3.92**
Mitigate the operational impact from innovation	3.67	1.67	2.33	3.33	**2.75**
Provide high service level to major clients	1.33	6.00	5.00	4.00	**4.08**
Explore alternative markets	2.67	6.00	3.00	4.33	**4.00**
Have flexible operations	2.00	4.67	4.00	3.33	**3.5**
Sell very fresh products	3.67	4.67	5.67	4.67	**4.67**
Produce superior quality items	1.33	5.67	2.00	2.33	**2.83**
Reduce the cost of products	1.33	1	2.67	3.33	**2.08**
Average support received	**2.21**	**4.46**	**3.71**	**3.54**	

Table 6.5: *Strategic support matrix: degree of support provided by the SCS principles to the business strategy pillars at MeatCo*

Scale	**Definition**
(1)	Yes, they are totally compatible
(2)	They are somewhat compatible
(3)	They are somewhat incompatible
(4)	No, they are totally incompatible
(x)	I am not sure

Table 6.6: *Compatibility evaluation scale*

Answers are summarized in table 6.7. As we can see, the SCS principle related to cost reduction, on the average opinion of the respondents, has some degree of incompatibility with five other SCS principles, including the *"frequently launch new products"* principle, exemplifying the exploration & exploitation trade-off.

Average grades	Frequently launch new products	Mitigate the operational impact from innovation	Provide high service level to major clients	Explore alternative markets	Have flexible operations	Sell very fresh products	Produce superior quality items	Reduce the cost of products
Frequently launch new products								
Mitigate the operational impact from innovation	3.23							
Provide high service level to major clients	2.51	1.59						
Explore alternative markets	1.77	1.71	2.04					
Have flexible operations	2.08	1.51	1.71	1.31				
Sell very fresh products	1.82	1.43	1.94	2.42	1.71			
Produce superior quality items	1.87	1.85	1.72	1.12	1.75	1.59		
Reduce the cost of products	3.04	1.4	2.53	1.64	2.32	2.19	2.19	

Table 6.7: *SCS compatibility matrix: degree of compatibility between the SCS principles at MeatCo*

The main sources of conflict within the highest level of abstraction of MeatCo's SCS is graphically depicted on figure 6.4. At the core, there's a triangulated direct conflict among three SCS principles: *"frequently launch new products"*, *"provide high service levels to major clients"*, and *"reduce the cost of products"*. We also see a direct conflict between *"mitigate the operational impact from innovation"* and the frequent launching of new products itself. Moreover, we have also identified a set of sources of potential, less evident, conflicts, such as those related to flexibility, superior quality, product freshness, and market exploration.

The conflicts identified so far, as shown in tables 6.5 and 6.7, the latter graphically represented in figure 6.4, can be viewed as indications of a trade-off. Employees and executives at MeatCo

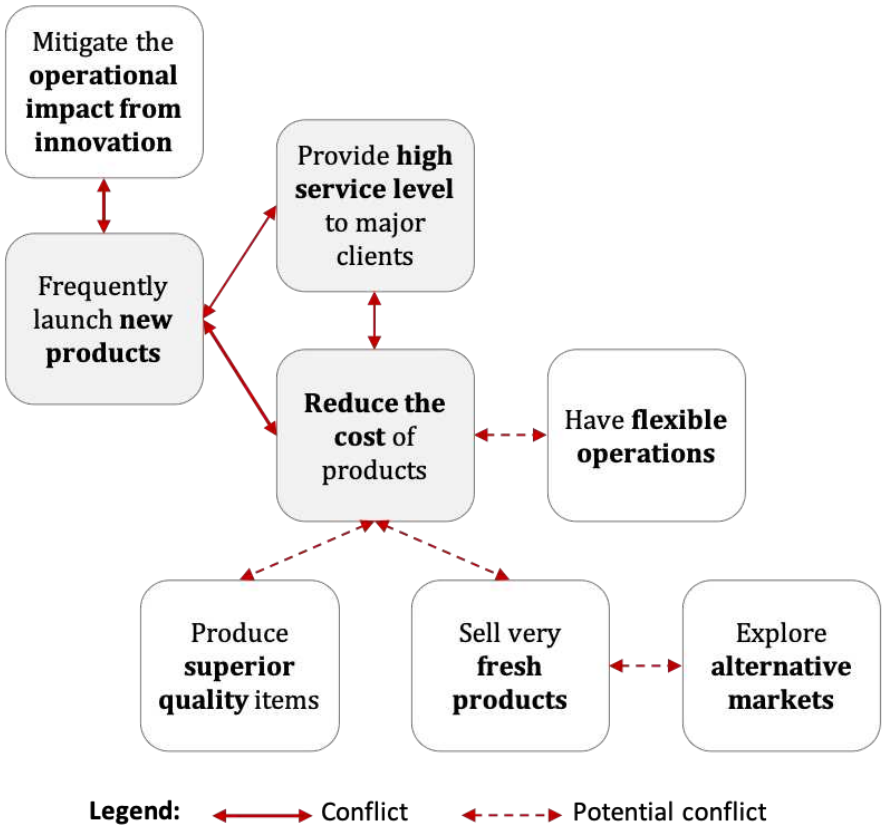

Figure 6.4: *Graphical representation of the main sources of conflict within MeatCo's SCS*

perceive product innovation and efficient, as concurrent objectives.

Moving down to a lower level of abstraction in the SCS, we evaluated the coverage, compatibility, and sufficiency of the internal components of each SCS principle, i.e. the functional imperatives and operational choices within the ramification of each branch of the SCS principles. For each SCS principle branch we had one survey item related to the *coverage* criterion on which respondents were ask whether or not MeatCo needs to do anything else in order to achieve the objectives of the related SCS principle. Answers were given on a *yes* or *no* basis, which are worth one and two points, respectively.

Description	Coverage (internal components)
Frequently launch new products	1.00
Mitigate the operational impact from innovation	1.00
Provide high service level to major clients	1.33
Explore alternative markets	1.00
Have flexible operations	1.00
Sell very fresh products	1.33
Produce superior quality items	1.00
Reduce the cost of products	1.00

Table 6.8: *Evaluation of the coverage of the internal components of the SCS principles*

The averages of the answers related to each SCS principle are represented in table 6.8. We can see that respondents considered most of the internal topics to be fully covered. However, blind spots were found on within the functional imperatives and operational practices related to providing high service level and to selling very fresh products, as exemplified by the following comments: *"we need to manage our demand on a weekly basis, not daily"*, *"we should take actions to increase the shelf life of our products"*, *"we need to 'educate' our clients to place orders in advance"*, *"we need an integrated sales & operations planning"*, *"we should ask clients for credible order forecasts"*.

Moving to our next criterion, we analyzed, within each SCS principle branch, the degree of compatibility of its internal components. Respondents were asked, for each branch headed by one SCS principle: *"are the activities that we conduct to <SCS principle> compatible among themselves?"*. Answers were given on a 4-point, plus one blank choice, basis, using the same scale as in table 6.6.

The averages of the internal compatibility answers related to each SCS principle are represented in table 6.9. We have not found clear evidence of strong internal conflicts within any of the branches.

Principles	Compatibility (internal components)
Produce superior quality items	1.32
Sell very fresh products	1.48
Reduce the cost of products	1.54
Explore alternative markets	1.59
Mitigate the operational impact from innovation	1.78
Have flexible operations	1.87
Frequently launch new products	2.19
Provide high service level to major clients	2.4

Table 6.9: *Evaluation of the compatibility of the internal components of the SCS principles*

For each SCS principle branch we had one survey item related to the *sufficiency* criterion on which respondents were ask to grade, on a 4-point, plus one blank choice (table 6.11), the following: *"are the activities that we conduct to <SCS principle> sufficient to reach this objective?"*.

Scale	Definition
(1)	Yes, what we do is sufficient
(2)	To a great extent, but not completely
(3)	To some extent, but not enough
(4)	No, what we do is not sufficient
(x)	I am not sure

Table 6.10: *Internal sufficiency evaluation scale*

The averages of the grades for the coverage evaluation within each branch are summarized in table 6.11. We found evidence that the principles related to mitigating the operational impact from innovation, reducing the cost of products may not be sufficiently satisfied by the support provided by their respective functional imperatives and operational choices.

6.4.3. The long road to reformulating MeatCo's supply chain strategy

Aiming at dealing with E&E, the supply chain strategy reformulation exercise was based on all of the results previously obtained on this research. First, from our systematic literature

Principles	Sufficiency (internal components)
Mitigate the operational impact from innovation	3.11
Reduce the cost of products	3.09
Explore alternative markets	2.92
Frequently launch new products	2.61
Produce superior quality items	2.32
Have flexible operations	2.09
Sell very fresh products	1.98
Provide high service level to major clients	1.87

Table 6.11: *Evaluation of the sufficiency of the internal components of the SCS principles*

review (chapter 2) we learned the fundamentals to dealing with the exploration & exploitation conflicts, identifying a research gap on the E&E front, especially from the operational perspective. That knowledge has been carried along to the subsequent chapters, on which we took a deep dive into topics that were more specific to the context of this research: we view exploration and exploitation as part of a continuum (Gupta, Smith, and Shalley 2006; March 1991), on which the degree –or rate– of new product introductions will set the balance between these conflicting objectives.

Therefore, we analyzed the impact of new product introductions on supply chain performance from both the qualitative and the quantitative perspectives. We conducted a case study at MeatCo (chapter 3) and learned that new product introductions imply supply chain impact, including several functions, such as demand management, procurement, production, logistics & inventory management, infrastructure & maintenance, and quality control & food safety. We hypothesized that new product introductions imply both a direct and indirect impact on supply chain performance, being mediated by changes in production assortment and moderated by the product-level degree of innovativeness.

At further stages (chapters 4 and 5), we conducted in-depth statistical analyses of the hypothesized relationship between new product introductions and supply chain performance and concluded that, in the long term, a high rate of new product introductions may be harmful to certain aspects of a company's operations. We also learned that larger production assortments mediate this relationship, which can be exacerbated when the average degree of product-level process innovation requirements it high. Therefore, it is imperative to have a proper product

portfolio/complexity management in place.

Following this path, we dug to the realms of our specific situation (this current chapter) and captured and evaluated MeatCo's supply chain strategy using the CSAR methodology and uncovered the particular exploration & exploration trade-offs faced MeatCo. We learned that the company's executed supply chain strategy included several conflicting objectives that may be harmful to its operations, in light of what we learned so far.

Finally, we used MeatCo's as-is supply chain strategy map (figure 6.3) as well as the results from its fitness evaluation (section 6.4.2) and what we learned on the previous chapters to guide the crafting of an improved candidate SCS to MeatCo. We gathered the same group involved in the evaluation phase and conducted two workshops, still following the CSAR approach, aiming at identifying possible solutions for the MeatCo's SCS conflicts and shortcomings. The resulting candidate supply chain strategy, as proposed by MeatCo's employees, is represented on figure 6.5. Changes are in boldface in red, within dashed boxes. Black-font straight boxes represent components that have remained as the *status quo*. In the next section we will elaborate on these results, proposing a framework to building exploration-and-exploitation-enabling supply chain strategies, trading off new product introductions and supply chain performance.

6.5. Building an exploration-and-exploitation-enabling supply chain strategy

The impact of new product introductions on the supply chain performance of a company occurs both directly and indirectly. It affects a multitude of operational functions and can be exacerbated by the product-level degree of innovativeness, especially when concerning product innovativeness.

Exploration & exploitation in such context lies along a continuum that has the rate of new product introductions as the core variable. Configuring E&E within that supply chain strategy considers establishing apparently concurrent objectives os being both innovative and efficient and we learned from the extant literature that, in the case of medium size firms/business

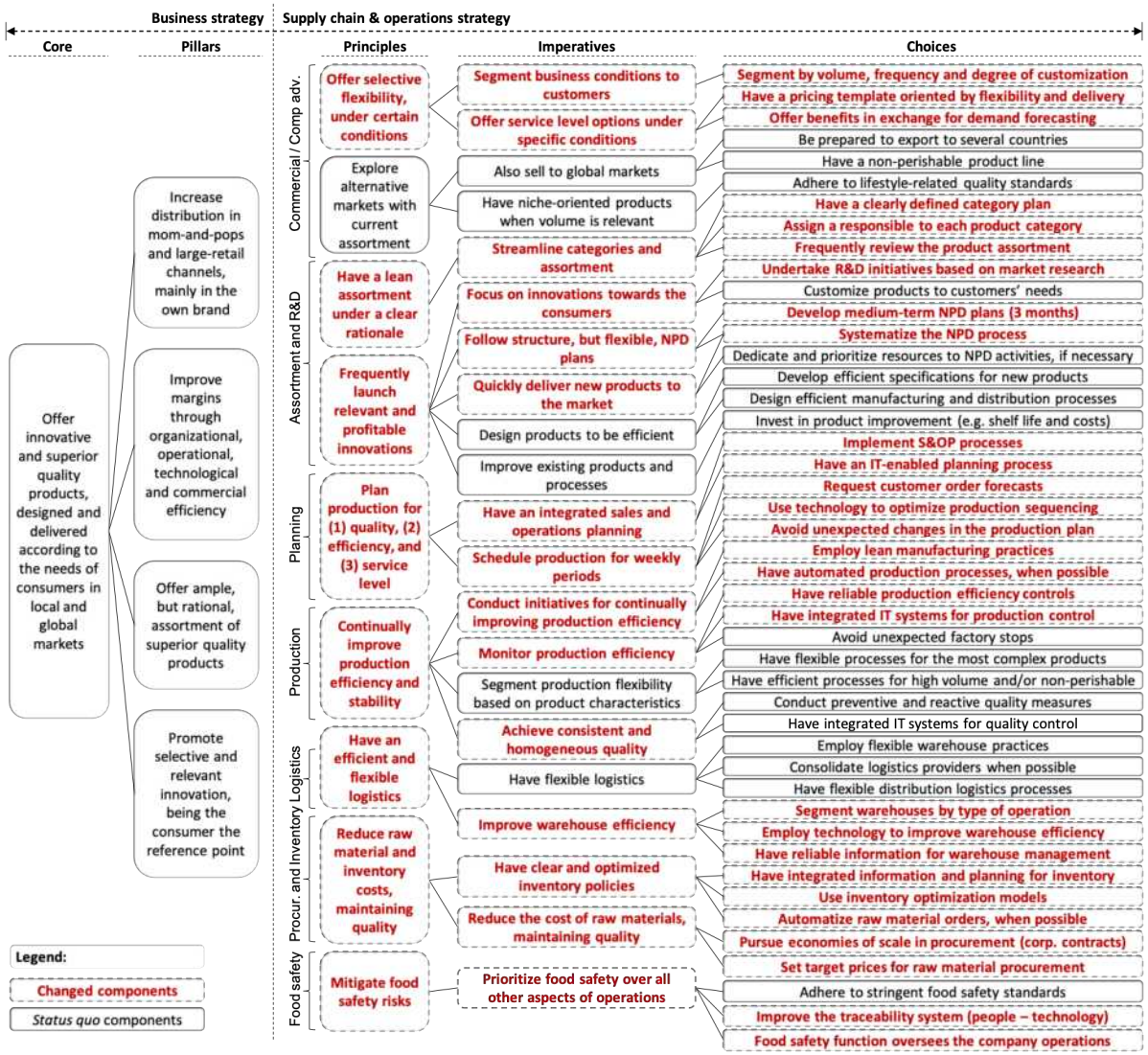

Figure 6.5: *MeatCo's formal candidate supply chain strategy*

units, such as MeatCo, it is not easily implemented through structural separation; still, the conclusions from our analyses in chapters 4 and 5 indicate that it should be done by establishing clear-and-balanced innovation policies and processes, which must be coordinated across the related operational functions that are impacted by new product introductions.

In MeatCo's case, as we can see from figure 6.5, the company has proposed a set of such company-wide, clear-and-balanced innovation policies and processes. These policies were translated as a set of goals related to improving segmentation, rationalizing assortment, having better-planned innovation policies, improving the information flow, fostering incremental innovation, and investing in cost-reduction.

Although it cannot afford structural separation, for lacking the resources (Lubatkin et al. 2006), MeatCo plans to logically separate part of its operation though customer segmentation, offering high flexibility (including the choice to customize products) only to certain clients. In that model, flexibility can be offered in exchange of better demand forecasts, mitigating part of the negative impact on demand management, procurement, and production.

The company is dealing with the frequency of new product introductions by establishing a structured, systematic new product development plan for three-month periods, avoiding unexpected new product introductions and setting an innovation pace that allow the operations to adapt to the new processes. On the other hand, by establishing a clear category plan, MeatCo aims at avoiding unnecessary assortment expansion, which could also hurt operational performance. These new policies are enabled by improving the reliability, availability, and flow of information, which runs across the entire organization and is also encouraged for clients.

Moreover, the company found other specific levers to improve its overall ability to dealing with the exploration & exploitation trade-off, such as prioritizing food safety over all other aspects of operations, investing on cost-reduction initiatives, segmenting warehouses, improve production monitoring and controls, and implementing integrated sales & operations planning. We do not view these specific policies as exclusively related to dealing with E&E, rather we see them as overall operational improvement measures that can raise the pivot of the exploration & exploitation trade-off.

A deeper analysis will say that some internal consistency conflicts remain, such as the apparent incompatibility between the quality-and-efficiency-focused production plan and the frequent launch of relevant innovation. It appears that one of the key challenges of a supply chain strategizing process aiming at E&E is overcoming what Perez-Franco calls internal consistency, especially the compatibility criterion (Perez-Franco and Sheffi 2016). We even believe that actually an ambidextrous supply chain strategy must have some degree of internal conflict, particularly in small and medium enterprises, like MeatCo, which cannot afford –due to lack of size and resources– structural ambidexterity, so they are particularly inclined to resorting to the contextual ambidexterity (Lubatkin et al. 2006).

MeatCo is a company that has been able to successfully manage innovation, to a certain extent. Its revised supply chain strategy represents an improvement on its management practices in order to assuage the negative effects of the apparent conflict between exploration & exploitation. Yet, it is likely that fully eliminating conflicting goals is not feasible in ambidextrous supply chain strategies.

6.6. Limitations and directions for future research

This research contributes to the academic community by being the first to employ CSAR as research method and for unveiling a set of supply chain trade-offs that can be faced by CPG manufacturing companies willing to craft exploration-and-exploitation-enabling supply chain strategies, also challenging the notion that a good supply chain strategy must be free of conflicting goals. We also contribute to practice by providing guidance for managers willing to build exploration-and-exploitation-enabling supply chain strategies into CPG manufacturing firms.

We understand that the results from this chapter are based on a specific company's situation. However, it brings valuable insights that can be of relevance to companies facing similar situations (e.g. another small-to-medium-sized manufacturer of fast-moving, perishable, CPG). Yet, we believe that the replication of a similar study to a broader range of cases, such as companies in other industries and with different sizes, would bring benefits both to the

academia and to practitioners.

Also, as the revision of a company's supply chain strategy constitutes an event that promotes change, we would like to see how the behavior of this particular company will be several years down the road. Particularly, how the results from chapter 4 will differ after this particular event. This would be particularly enlightening to better understand the effectiveness of the strategic supply chain changes described on the current chapter and how it will affect the relationship between new product introductions and supply chain performance.

Chapter 7

Conclusion

7.1. A practitioner's view

An E&E-enabling supply chain is one that is designed to deal with conflicting goals such as exploration –related to creativity, innovation, disruption, and variation increase– and exploitation –related to efficiency, productivity, and variation decrease. How can companies be, at the same time, innovative and efficient? That is the object of this research, on which we studied the impact of this dichotomy in a CPG manufacturing operation, and how such conflicts might be managed better.

Companies have to innovate to survive, but it is not hard to see how conflicts can arise from new product introductions (NPI) at every level, from physical incompatibilities on production lines to the distraction of management attention and quite simply increased complexity. Impacts of greater or lesser importance might be expected across several functions: for example demand management, procurement, production, logistics & inventory management, infrastructure & maintenance, and quality control & food safety.

Exploration & Exploitation have been a research topic off and on for over thirty years, although not often from a supply chain perspective. Early researchers saw three general ways to dealing with such conflict. Structural ambidexterity physically separates new product activities from existing production: separate facilities, management teams, even a separate business unit. However, that is generally only viable for fairly large organizations. Vacillation separates the activities temporally: the organization would switch from exploration mode to exploitation mode, and back again, which sounds good in theory but may be difficult to envisage in practice. Contextual ambidexterity sees individuals or operations moving between the two modes

as required, hopefully supported by some sort of structure (or meta-routines) to determine priorities, and this of course is how most small and medium enterprises operate.

A competitive strategy of continuous NPI, usually in response to consumer suggestions and customer demands, has raised MeatCo to a market-leading position, but at the cost of diminishing profitability. In 2016 and 2017 the firm introduced more than 300 new SKUs and even allowing for product retirement that raised the product assortment from 223 to 302 SKUs. It is a reasonable hypothesis therefore to suppose that E&E-related issues are at least part of the explanation for declining profits.

A survey of the company's personnel identified clear differences between departments on the way innovations are perceived, which could undermine efforts to develop a coherent NPI strategy. For example, the marketing department might support more product variants and hence SKUs to meet the demand from ever-smaller customer segments. The supply chain function, on the other hand, prefers to keep the number of SKUs –and hence the level of complexity– to a minimum.

MeatCo's operational strategy is mostly related to providing high service levels, producing superior quality goods, and delivering fresh products: achievement of these goals can be assessed through the metrics of service level (fill rate), product quality conformance (rate of returns), and inventory freshness (turnover).

Our analysis showed that NPI has both direct and indirect impacts. By testing a series of hypotheses, we were able to examine not only the instance of these impacts on service, quality, and freshness, but also the extent to which these impacts are moderated by product-level degree of innovativeness. Direct impacts mostly showed in terms of attention shifts and learning curves. Indirect impacts were associated largely with the complexities arising from a larger assortment: for example, increased demand uncertainties, more frequent production changeovers, and an increased risk of food cross-contamination (more and more varied allergens present in the assortment). The idea that innovativeness exacerbates the impact of NPI is mostly related to the degree of changes required by the new product.

We observed that the impact of NPI is more pronounced in the long-term time frame. Sustaining frequent new product introductions in the long run may jeopardize performance proportionally more than individual NPI events. Also, NPI can cause uncontrolled assortment growth if not coupled with clear product portfolio management practices, leading to operational disruptions due to increased complexity.

In what may be a first use in this sort of research, we also applied Conceptual System Assessment and Reformulation (CSAR) techniques to map, evaluate and reformulate MeatCo's supply chain strategy. (CSAR is a methodology developed at MIT Supply Chain Strategy Lab, under the leadership of Dr. Perez-Franco and Prof. Sheffi.) We employed CSAR as an enabler to identify and suggest potential solutions to the exploration & exploitation trade-offs faced by MeatCo. At the highest level we found a three-way conflict between the supply chain strategy principles of "frequently launching new products", "providing high service levels to major clients", and "reducing the cost of goods sold". We also unveiled direct conflict between frequent product launches and mitigating their operational impact and, less evidently, potential conflicts related to flexibility, quality, freshness, and exploration of new markets.

What to do? The analysis suggested a framework for dealing with this dilemma at the supply chain strategy level. Companies in similar situation should establish structured, systematic innovation plans, avoiding random new product introductions and setting an innovation pace that its operations can cope with. Companies must have the time to adapt to innovations –and the faster they can do it, the more innovative it is allowed be without disrupting operations. On the other hand, by establishing clear category plans, companies can avoid unnecessary assortment expansion caused by NPI, which could also hurt operational performance, if not well managed. Moreover, these actions should be enabled by improving the reliability, availability, and flow of information across the entire organization –which should also be encouraged for client-supplier relationships.

Nonetheless, it is natural that some degree of internal consistency conflicts will remain – indeed, we believe that for an exploration-and-exploitation-enabling supply chain strategy in an SME that cannot afford the structural separation of exploration and exploitation activities, some degree of conflict is inevitable. SMEs may be better served by building leadership-based

contextual ambiguity where individuals make (reasoned and guided) choices between exploration and exploitation activities on a daily basis.

While the analysis was conducted in the specific context of MeatCo, its findings should be applicable to any small-to-medium manufacturer of perishable CPG with regular new product introduction. Moreover, being a discipline that deals with "getting things done", supply chain management may be the next frontier of E&E research and we hope that this research will also elicit more studies at this front.

7.2. Overall conclusions from the thesis

Product innovation often introduces complexity to supply chains that hurts operational efficiency –yet companies must be innovate to survive. That is the central issue of this thesis, which has been inspired by a real-world problem faced by MeatCo, an European manufacturer of meat products. The company faces a productivity-dilemma-like situation, on which it must learn how to deal with its innovation *vs.* efficiency conflicting goals.

Drawing from the exploration & exploitation concepts, we conducted a multi-method research on building E&E-enabling, innovation-and-efficiency-oriented, supply chain strategies on CPG manufacturing firms, starting from analyzing the impact of new product introductions on supply chain performance.

In chapter 2, we systematically analyzed the relevant literature related exploration & exploitation. We called for more studies from the operations management perspective, specially noting those using longitudinal operational data, balancing new product/service introductions, and supply-chain-strategy-related studies.

In chapter 3, we conducted a single-case qualitative study to understand how new product introductions impact supply chain performance. We developed a conceptual model and hypothesized that new product introductions implies both a direct, innovativeness-moderated, and an indirect, production-assortment-mediated, negative impact on supply chain performance. This impact spans across several functions, such as demand management, procurement,

production, logistics & inventory management, infrastructure & maintenance, and quality, being mostly related to attention shifts and learning curves.

In chapter 4, we tested and measured a subset of the hypotheses from chapter 3 by employing hybrid fixed effects and random effects econometrics with Driscoll & Kraay standard errors. Using cross-sectional longitudinal operational data, we found that the size of the production assortment and changes in production assortment –which are associated with new product introductions– negatively impact supply chain performance. At that point, though, we have not considered the moderation effects of product-level innovativeness.

In chapter 5, we briefly extended the results from chapter 4, incorporating the moderation effects of product-level degree of innovativeness. The reason why it has not been included within the previous chapter is due to the threat to validity introduced by the potential measurement error –mostly related to the scant data availability and low variability within the product-level degree of innovativeness variable. However, it still provides meaningful insights, as the moderated model confirms most of the results from the previous chapters and introduces new hypotheses. We found significant support to the moderation hypothesis related to service level, in the long-term perspective.

The finding from chapters 4 and 5 would have been different, however, had we used the widely adopted HAC-clustered standard errors. We chose to rely on cross-sectional-dependence-robust, yet conservative and restrictive, Driscoll-Kraay standard errors, which we considered more appropriate for drawing statistical inference in our case. We also used hybrid fixed effects and random effects modeling, which can overcome some limitations of both of the traditional fixed effects and random effects methods. To the best of our knowledge, this is the first research study to employ both the hybrid method and Driscoll-Kraay standard errors in tandem.

Finally, in chapter 6, we conducted an action research project on crafting exploration-and-exploitation-enabling supply chain strategies using CSAR as a research method –this is the first study, to the best of our knowledge, that uses CSAR as a research method on itself. We unveiled a set of trade-offs faced by a real-world company when pursing an exploration-

and-exploitation-enabling supply chain strategy. While the conflicting goals of exploring and exploiting must remain within an exploration-and-exploitation-enabling supply chain strategy –relaxing CSAR's internal consistency criterion–, certain actions can mitigate the negative interaction of the concurrent objectives, within a supply chain perspective, such as segmentation, rationalizing assortment, better planning the exploratory activities, and improving the information flow.

Moreover, the extant literature has focused on three major approaches to dealing with exploration & exploitation within an organization: structural ambidexterity, contextual ambidexterity, and vacillation (Raisch and Birkinshaw 2008). While Siggelkow and Levinthal 2003 proposed that structural ambidexterity should be employed within the initial stages of exploration and followed by contextual ambidexterity on advanced stages, this may not be the case of small and medium businesses –which is the case of the company on which this thesis has been based–, as they lack resources to afford proper structural separation (Ebben and Johnson 2005). Also, small and medium enterprises have to rely more on the ability of their top-management team to achieve ambidexterity, mostly because they usually have a flatter hierarchy, in comparison to large firms, and top managers are likely to play both in the strategy and in operations arenas, directly facing dissonant exploratory and exploratory roles (Lubatkin et al. 2006). Thus, small and medium enterprises are better served by building leadership-based contextual ambidexterity (Kammerlander et al. 2015) –again, the case of MeatCo–, which calls for individuals to make choices between exploration and exploitation activities within a daily basis (Birkinshaw and Gibson 2004).

While this thesis has been based on data from a specific company within the meat products business, we believe that it generalizable to a certain extent. It is applicable to companies and industries with similar characteristics, such any small-or-medium-sized manufacturer of perishable CPG that introduces new products on a regular basis.

This thesis provides theoretical contribution by: (1) analyzing and summarizing the evolution of the literature stream, being among the first to do it from the operations management perspective; (2) evaluating how new product introductions impact supply chain performance in a CPG manufacturing firm, providing a set of testable hypotheses; (3) testing and measuring

the short-term and long-term impact of new product introductions on the supply chain performance in CPG manufacturing operations using robust panel data econometrics; (4) testing the moderation effects of product-level degree of innovativeness on the relationship between new product introductions and supply chain performance; (5) adding a different level of analysis –i.e. product category– to dealing with new product introductions; (6) employing the Conceptual System Assessment and Reformulation (CSAR) as a research method for the first time; and (7) unveiling a set of supply chain trade-offs that can be faced by CPG manufacturing companies willing to be both innovative and efficient, also challenging the notion that a good supply chain strategy must be free of conflicting goals.

This research is also carries managerial implications, as it: (1) provides a summary of the relevant literature on exploration & exploitation, which can be a helpful source for practitioners dealing exploration & exploitation on their businesses; (2) improves the understanding about the how new product introductions impact supply chain performance; (3) quantifies the impact of new product introductions on supply chain performance, which can be a helpful decision-making took when balancing exploration & exploitation; (4) improves managerial intuition for the conditional supply chain implications of product-level degree of innovativeness when introducing new products; and (5) provides guidance for building exploration-and-exploitation-balancing supply chain strategies into CPG manufacturing firms.

7.3. Limitations and directions for future research

We recognized the chapter-specific limitations and indicated directions for future research at the end of each chapter (sections 2.8, 3.6, 4.7, 5.8, and 6.6). In this section, we recognize additional, thesis-wide limitations and conclude with a summary of the directions for future research presented in this thesis.

From a thesis-wide perspective, one limitation of this study –apart from the chapter-specific limitations previously mentioned–, is that it does not consider some concepts, theoretical lenses, and frameworks that could contribute to improve our understanding on the relationship between NPI and SC performance, such as absorptive capacity (Fernhaber and Patel 2012; Patel,

Terjesen, and Li 2012; Rothaermel and Alexandre 2009), dynamic capabilities (Danneels 2002; Eisenhardt and Martin 2000; Um et al. 2017), resource-based view (Coates and McDermott 2002), and factory physics (Hopp and Spearman 2008), just to name a few. We believe that the literature could benefit from additional empirical, operations-oriented, studies employing different points of view regarding the relationship between NPI and SC performance.

In chapter 3, we suggested that the direct impact of NPI in supply chain performance is originated mainly from attention shifts (March 1991; Ocasio 2011) and learning curves (Adler and Clark 1991; Wright 1936; Carlson 1961); yet, these components were not explicitly included in our conceptual model for testing. Literature could benefit, from studies investigating these components as potential mediators in the path from NPI to performance. In this case, survey methodology coupled with structural equation modeling (SEM) may be an adequate methodological fit.

We referred to operations in different, embedded, levels of analyses: in chapters 3 and 6 we analyzed operations from the business unit level, while in chapters 4 and 5 we viewed it from one level below, from a product category perspective, enabling panel data analysis within a single business unit by treating each product category as a representative of a different operation. We believe that future research could benefit from employing the product category as the level of analysis, as it allows capturing E&E variance across product categories –i.e. some categories are expected to behave differently in terms of exploration and exploitation. It also can be used to integrating with the solution streams to the productivity dilemma and distinguishing categories that are more *versus* less innovative.

Moreover, this thesis has been based on operational data from a single firm. By using product categories as the level of analysis in our quantitative chapters (i.e. chapters 4 and 5), we were able to control for the nuances of multiple operations –even though it is located within a single business unit– enriching with details and insights. Still, we believe that the exploration & exploitation literature would largely benefit from similar studies employing multiple companies, especially if they span multiple industries or geographical regions.

Table 7.1 provides a summary of the directions for future research indicated in this the-

sis, differentiating between recommended methods and contents. We believe that this can serve as a seed to fostering the academic interest in the topic.

Chapter	Recommended methods	Recommended contents
Chapter 2	**Type of data**: primary operational data	E&E from the operations perspective
	Analytical methods: longitudinal analyses	-
	Research design: different levels of analysis, especially lower levels and cross-boundary	-
	-	Implementation of E&E-enabling strategies
Chapter 3	**Analytical methods**: econometrics	Testing and measuring the impact of NPI on SC performance
	Analytical methods: case study	Extending qualitative analysis of NPI impact SC performance to other contexts: firm sizes, industries, and geographies
Chapter 4	**Analytical methods**: hybrid FE&RE	Extension to multiple companies and geographies
		Testing the contingent effects of product-level degree of innovativeness, resource coordination flexibility, and firm size on the path between NPI and SC performance
		Extending the outcome variables to other supply chain performance variables
	Analytical methods: longitudinal analyses	Differential impact of NPI on SC performance through time
Chapter 5	**Analytical methods**: hybrid FE&RE	Expand the number of data points of the product-level degree of innovativeness variable, also considering multiple settings
Chapter 6	**Analytical methods**: econometrics	Differential impact of NPI on SC performance after the supply chain strategy review
	Analytical methods: CSAR-based action research	Replication to other industries and firm sizes
Chapter 7	**Analytical methods**: survey and SEM	Testing attention shifts and learning curves as mediators in the path from NPI and SC performance
	Research design: product categories as the level of analysis	-
	-	Employing different concepts, lenses, and frameworks to analyzing the impact of NPI on SC performance

Table 7.1: *Summary of thesis-wide directions for future research on the relationship between NPI and SC performance*

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Appendix A

Appendix to Chapter 2

Table A.1: *Summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[1]]	Level of analysis	Method (data)	Salient findings [group[2]]
Adler, Goldoftas, and Levine 1999	Empir.	Operations mgmt.	[6] Studies how the Toyota Production System manages the paradox of efficiency and flexibility	Plant/ project/ pro- cess	Quali., single case (NUMMI)	[1] Four balancing mechanisms: metaroutines, job enrichment, temporal separation and organizational partitioning
Adler et al. 2009	Theoret.	Operations mgmt.	[1] Compiles a series of short essays on organizational ambidexterity by various authors	Firm	Conceptual	[2] The productivity dilemma can be transcended by embracing contradictions and seeking a higher-order resolution to the conflicting forces
Andriopoulos and Lewis 2009	Empir.	Innovation mgmt.	[1] How the interplay among the paradoxes and their management fuels virtuous cycles of ambidexterity	Firm	Quali., cross-sect. (5 cases)	[1] Integration and differentiation are complementary in fostering ambidexterity. Exploration and exploitation efforts enable learning synergies

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Azadegan and Wagner 2011	Empir.	Operations mgmt.	[6] Explores the effects of industrial upgrading on innovation performance (i.e. explorative innovation)	Firm	Quant., cross-sect. (secondary data)	[1] Industrial upgrading (IU) is positively associated with exploitative innov., which partially mediate the effect of IU on explorative innov.
Benner and Tushman 2002	Empir.	Strategy & general mgmt.	[10] Explores the impact of process management activities on technological innovation	Business unit	Quant., longit. (secondary data)	[1] Process mgmt. practices reduce routine variance and influence innov. selection, driving exploitation at the expense of exploration
Benner and Tushman 2003	Theoret.	Strategy & general mgmt.	[10] Studies the contingent effect of organizational ambidexterity on process management when related to exploratory and exploitative innovations	Firm	Conceptual	[1] Ambidext. org. are composed by multiple sub-units, internally consistent but loosely coupled with one another; senior mgmt. promotes synergy

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Benner and Tushman 2015	Theoret.	Strategy & general mgmt.	[1] It reflects on new contexts that have emerged after the previous article (Benner and Tushman 2003), such as the digital revolution	Firm	Conceptual	[2] Structural, contextual ambidext. and vacillation characterize firm-product evolution. Absent complementarity, spinout dominates ambidexterity. The current locus of innov. is beyond firms' boundaries
Birkinshaw and Gibson 2004	Empir.	Strategy & general mgmt.	[2] Studies how to build ambidexterity into an organization	Business unit	Quant., cross-sect. (interviews and survey)	[1] Introduces contextual ambidexterity, which allows individuals allocate resources between exploration and exploitation
Birkinshaw and Gupta 2013	Theoret.	Strategy & general mgmt.	[1] Analyzes the growth and usage of the ambidexterity concept in scholarly work, as well as the diversity of views held on the topic	Firm	Lit. rev. (19 papers)	[2] Exploration and exploitation are separate dimensions (efficient frontier?) rather than poles on a continuum

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Blindenbach-Driessen and Ende 2014	Empir.	Org. design	[5] Investigates the effects of having a separate innovation unit on exploration, exploitation and ambidexterity	Firm	Quant., cross-sect. (survey)	[1] A separate innovation unit increases exploration, exploitation and ambidexterity in manufacturing and service firms
Boumgarden, Nickerson, and Zenger 2012	Empir.	Org. design	[2] Reviews two proposed approaches for dealing with the exploration and exploitation trade-off: organizational ambidexterity and vacillation	Multilevel	Quali., multiple cases (2 cases)	[1] Vacillation yields higher long run benefits than (contextual and structural) ambidext.; the latter is better used within vacillation periods
Cao, Gedajlovic, and Zhang 2009	Empir.	Strategy & general mgmt.	[1] Analyzes the impact of two ambidexterity construct forms (i.e. balanced and combined) on firm's performance	Firm	Quant., cross-sect. (survey)	[2] Concurrent high levels of balanced and combined dimensions of exploration and exploitation yield synergistic benefits

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Choi, Kumar, and Zambuto 2016	Empir.	Corp. gover-nance	[10] Examines the role of debt as a governance mechanism, when balancing exploration and exploitation	Firm	Quant., longit. (secondary data)	[1] Debt drives exploitation by imposing cash flow obligations, thus promoting innovation balance, by preventing suboptimal exploration
Csaszar 2013	Theoret.	Org. design	[5] Studies the relationship between organizational structure and its ability to explore and exploit	Plant/ project/ pro-cess	Math.	[4] The effects of organization size on exploration depends on the structure used, i.e. polyarchies explore more and hierarchies explore less
Danneels 2002	Empir.	Innovation mgmt.	[1] Examines the interplay of product innovation and firm competences over time	Firm	Quali., cross-sect. (5 cases)	[5] Developing and marketing new products can expand the competence base of the firm, which enables further new products
Ebben and Johnson 2005	Empir.	Strategy & general mgmt.	[3] Small firm performance in relation to efficiency and flexibility strategies	Firm	Quant., cross-sect. (survey)	[3] Mixed strategies may be counterproductive in terms of the long-term organizational health

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Fang, Lee, and Schilling 2010	Theoret.	Org. design	[5] Explores how the degree of subgroup isolation and intergroup connectivity influences organizational learning	Firm	Simulation	[1] Exploration-exploitation balance is possible by breaking an organization down into small semiautonomous subunits with few cross-group links
Farjoun 2010	Theoret.	Strategy & general mgmt.	[1] Conceptualizes stability and change as a duality as opposed to dualism	Multilevel	Conceptual	[2] Stability and change are fundamentally interdependent –contradictory but also mutually enabling
Fernhaber and Patel 2012	Empir.	Operations mgmt.	[10] Investigates the moderating role of ambidexterity and absorptive capacity on the effects of product portfolio complexity on firm performance	Firm	Quant., cross-sect. (survey)	[1] Young firms can better manage product portfolio complexity by adopting a balanced innovation perspective through ambidexterity
Ghemawat and Costa 1993	Theoret.	Org. learning	[10] Analyzes information processing as a tool to improve the organization's fixed beliefs or reconsider the beliefs themselves	General	Math.	[5] There is a tendency towards extremes when allocating resources between static and dynamic efficiency initiatives

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Gibson and Birkinshaw 2004	Empir.	Strategy & general mgmt.	[3] Analyzes the antecedents and consequences of contextual ambidexterity	Business unit	Quant., cross-sect. (interviews and survey)	[3] Contextual ambidexterity is positively related to the performance of business units
Gupta, Smith, and Shalley 2006	Theoret.	Strategy & general mgmt.	[1] Four central issues on exploration-exploitation: definitions, orthogonality, ambidexterity vs. vacillation and duality vs. specialization	Firm	Conceptual	[2] Ambidexterity is easier to achieve at the system level. Exploration and exploitation are part of a continuum within a single domain
Hahn et al. 2016	Theoret.	Corp. social responsib.	[10] Analyzes ambidexterity relation to corporate social performance	Firm	Conceptual	[3] Ambidextrous firms are more likely to achieve higher social performance by pursuing instrumentally and morally driven to social initiatives
He and Wong 2004	Empir.	Innovation mgmt.	[3] Tests the interaction of exploratory and exploitative innovation strategies on firm performance	Firm	Quant., cross-sect. (survey)	[3] There's significant evidence that an ambidextrous innovation strategy leads to superior sales growth rate

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Hill and Birkinshaw 2008	Empir.	Corp. venturing	[3] Studies the impact of exploration-exploitation orientation and the locus of opportunity on corporate venture units' performance and survival	Business unit	Quant., cross-sect. (interviews, survey, and secondary data)	[3] Venture unit organizational alignment is associated with higher performance and its survival is associated to its engagement in exploitation
Holmqvist 2003	Theoret.	Org. learning	[7] Analyzes a dynamic model of organizational learning within and between organizations	Multilevel	Conceptual	[2] Exploration and exploitation occur both within and between organizations and are interlaced through intra and interorganizational learning
Holmqvist 2004	Empir.	Org. learning	[8] Examines how exploration and exploitation within and between organizations are interlaced	Firm	Quali., longit. (sigle case)	[5] Exploration/exploitation and intra/inter-org. learning are tied by opening-up & focusing and extension & internalization, respectively
Jansen, Bosch, and Volberda 2006	Empir.	Innovation mgmt.	[10] Examines the influence of formal and informal coordination mechanisms on a business unit's exploratory and exploitative innovation	Business unit	Quant., cross-sect. (survey)	[1] Centralization negatively affects exploration and formalization positively influences exploitation. Environmental dynamism as a moderator

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Jansen et al. 2009	Empir.	Leadership	[4] Studies formal and informal leadership integration mechanisms and their mediating role between structural differentiation and ambidexterity	Firm	Quant., cross-sect. (survey)	[1] Effect of structural differentiation on ambidexterity operates through informal senior team and formal organizational integration mechanisms
Jansen, Simsek, and Cao 2012	Empir.	Org. design	[10] Studies how structural and resource attributes of the organizational context shape the relationship between ambidexterity and performance	Firm	Quant., cross-sect. (survey)	[4] Ambidextrous units increase performance when organization is less centralized, more resource munificent and less resource interdependent
Jayanthi and Sinha 1998	Empir.	Innovation mgmt.	[10] Conceptualizes and empirically tests the process of innovation implementation in high technology manufacturing as a chaotic process	Plant/ project/ pro- cess	Quant., longit. (firm's operations data)	[2] There is empirical support for the conceptualization of innovation implementation in high technology manufacturing as a chaotic process

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Junni et al. 2013	Theoret.	Strategy & general mgmt.	[3] Reconciles the mixed results that prior research obtained from examining the organizational ambidexterity-performance relationship	General	Quant., cross-sect.	[4] Ambidexterity conceptualization, level of analysis, methodology and industry influence the exploration/exploration-performance relationships
Kammerlander et al. 2015	Empir.	Leadership	[4] Investigates the effects of CEO's chronic regulatory focus on the level of SMEs engagement on exploration and exploitation	Individual	Quant., cross-sect. (survey)	[1] CEO's promotion focus is positively associated with firm-level ambidexterity; prevention focus is associated with lower exploration
Kang, Kang, and Kim 2017	Empir.	Strategy & general mgmt.	[5] Empirically examine the performance implications of organizational vacillation	Firm	Quant., longit. (secondary data)	[3] The frequency and scale of vacillation have inverted U-shaped relationships with firm performance
Kim and Lim 2015	Theoret.	Org. learning	[1] Analyzes a robust multiarmed bandit problem in which a decision maker accounts for distrust in the nominal model	General	Math.	[6] Proposes an alternative formulation for the multiarmed bandit model that can be used for studying the exploration-exploitation trade-off

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Knight and Paroutis 2017	Empir.	Leadership	[4] Studies the role of senior management in enabling tensions to become salient, in the presence of assimetric cross-level interpretations	Individual	Quali., longit. (multiple cases)	[1] Leaders can manage tensions for other actors by orchestrating interpretive interplay between poles, enabling synergies rather than choices
Kortmann et al. 2014	Empir.	Operations mgmt.	[10] Studies the mediating role of mass customization and ambidexterity on the relationship between flexibility and efficiency	Firm	Quant., cross-sect. (survey)	[1] Ambidexterity and mass customization capability balance the flexibility-efficiency trade-off; strategic flexibility can increase efficiency
Kristal, Huang, and Roth 2010	Empir.	Operations mgmt.	[6] Analyzes the ambidextrous supply chain strategy influence on market share and profit level	Business unit	Quant., cross-sect. (survey)	[3] Counter to conventional wisdom, the paper finds no evidence of significant trade-offs in supply chain exploration and exploitation

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Lavie and Rosenkopf 2006	Empir.	Org. alliances	[8] Studies how firms balance exploration and exploitation tendencies over time and across domains (alliance formation decisions)	Firm	Quant., longit. (secondary data)	[4] Refutes that firms balance exploration and exploitation within each domain; yet, shows that balance is achieved across domains and over time
Lee and Meyer-Doyle 2017	Empir.	Human resources mgmt.	[10] Examines how performance incentives impact individual behavior to explore new ideas or to exploit existing ideas	Individual	Quant., longit. (firm's commercial data)	[1] Individual motivation and incentives are important factors in whether individuals engage in more exploration or exploitation
Leonard-Barton 1992	Empir.	Strategy & general mgmt.	[10] Investigates how to take advantage of core capabilities without being hampered by their dysfunctional flip side	Plant/ project/ pro-cess	Quali., multiple cases (multiple cases)	[1] Project managers who challenge the firms' established paradigms may redefine/initiate new core capabilities, promoting org. renewal
Levinthal and March 1993	Theoret.	Org. learning	[7] Examines the processes of experiential learning as an instrument of organizational intelligence	Firm	Conceptual	[2] The imperfections of learning suggest a certain conservatism in expectations when attempting to improve organizational learning capabilities

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Lin, Yang, and Demirkan 2007	Empir.	Org. alliances	[3] Examines the ambidexterity hypothesis on strategic alliances and its boundary conditions for firm-level performance improvement	Cross-boundary	Quant., cross-sect. (archival data)	[4] Ambidextrous alliance formation benefits large firms but a focused formation of exploratory or exploitative alliances benefits small firms
Lin et al. 2013	Empir.	Org. learning	[10] Examines the impact of learning capabilities on innovation ambidexterity and innovation ambidexterity's effect on business performance	Business unit	Quant., cross-sect. (survey)	[3] Innovation ambidexterity plays a mediating role between learning capability and business performance
Lin and McDonough III 2014	Empir.	Psychology	[10] Tests the notion that cognitive frames play a role in enabling learning mechanisms that lead to innovation ambidexterity	Business unit	Quant., cross-sect. (survey)	[1] Managing the tension that arises from exploration and exploitation begins with the presence of dual cognitive styles
Lin et al. 2017	Empir.	Org. alliances	[2] Explores the effects of aligning knowledge assets on a firm's ability to pursue ambidexterity	Firm	Quant., cross-sect. (survey)	[1] Combining organizational capital, human capital and social capital has a positive impact on ambidexterity

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Lubatkin et al. 2006	Empir.	Leadership	[4] Analizes the role of top management team behavioural integration on ambidexterity at SMEs	Firm	Quant., cross-sect. (survey)	[1] Senior team behavioral integration is associated with the ambidextrous orientation of SMEs, which is associated with the firm's performance
March 1991	Theoret.	Org. learning	[7] Analyzes the general trade off between exploration and exploitation in organizational learning	Firm	Simulation	[2] There is a trade-off between exploration and exploitation, as they compete for scarce resources
Miller et al. 2006	Theoret.	Org. learning	[7] Adds the interpersonal learning component to March's exploration-exploitation model	Firm	Simulation	[2] Decentralized interpersonal learning is important in overcoming rigidities of firm-level focus on exploitation and aversion to exploration
Mudambi and Swift 2014	Empir.	Innovation mgmt.	[5] Analyzes the impact from switching between exploration and exploitation on a firm's innovative performance	Firm	Quant., longit. (secondary data)	[5] Abnormal changes in R&D expenditure indicate exploration-exploitation transitions and are associated with higher firm performance

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Ng et al. 2015	Empir.	Strategy & general mgmt.	[10] Reconceptualizes process management and develops a scale based on process exploration and process exploitation	Firm	Quant., cross-sect. (survey)	[2] Process management is an organizational capability that employs mutually supportive practices for process exploration and exploitation
Nosella, Cantarello, and Filippini 2012	Theoret.	Strategy & general mgmt.	[9] Explores the intellectual structure of the ambidexterity literature	General	Quant., bibliometric (137 articles)	[2] Identified a four-factor model describing the intellectual structure of the organizational ambidexterity literature
O'Reilly III and Tushman 2007	Theoret.	Leadership	[4] Outlines how the leadership from the senior team can promote organizational ambidexterity	Firm	Conceptual	[1] Offers a set of propositions outlining a set of senior team processes and actions that permit simultaneous exploration and exploitation

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
O'Reilly III and Tushman 2004	Empir.	Org. design	[2] Analyzes the characteristics of ambidextrous firms by examining innovation projects and the effectiveness of balancing mechanisms	Business unit	Quali., cross-sect. (multiple cases)	[1] The structure of ambidextrous organizations allows cross-fertilization among units while preventing cross-contamination
O'Reilly III and Tushman 2013	Theoret.	Strategy & general mgmt.	[1] Analyzes the trajectory, the current state and avenues for future research on organizational ambidexterity	General	Conceptual	[2] The term "organizational ambidexterity" is still ambiguous and its generic use simply refers to the ability to do two things simultaneously
O'Reilly III and Tushman 2011	Empir.	Leadership	[4] Examines how leaders within organizations actually implement organizational ambidexterity	Firm	Quali., cross-sect. (multiple cases)	[1] The senior leader's actions and choices plays a key role in adapting and reconfiguring resources to simultaneous explore and exploit

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Patel, Terjesen, and Li 2012	Empir.	Operations mgmt.	[6] Studies absorptive capacity and ambidexterity as capabilities that may moderate the uncertainty-flexibility-performance relationship	Business unit	Quant., cross-sect. (survey and secondary data)	[3] Absorptive capacity and ambidext. moderate the relationships between uncertainty and flexibility and between the flexibility and performance
Piao and Zajac 2016	Empir.	Org. learning	[1] Studies the underlying mechanism in the exploration-exploitation trade-off by contrasting between repetitive and incremental exploitation	Firm	Quant., longit. (secondary data)	[2] Exploitation can be incremental or repetitive; the former may inhibit short-term exploration; yet, the latter can drive long-run exploration
Posen and Levinthal 2012	Theoret.	Org. learning	[10] Explores the mechanisms by which environmental change acts to make purposeful efforts at organizational adaptation less (or more) valuable	Firm	Simulation	[4] The appropriateness of a exploration strategy is a function of the extent to which knowledge is devaluated by environmental turbulence

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Raisch and Birkinshaw 2008	Theoret.	Strategy & general mgmt.	[1] Develops a conceptual model for organizational ambidexterity with antecedents, outcomes and moderators	Firm	Conceptual	[2] The paper proposes a framework with antecedents, moderators and outcomes for organizational ambidexterity
Raisch et al. 2009	Theoret.	Org. design	[1] Analyzes four ambidexterity tensions: differentiation vs. integration, locus, statics vs. dynamics and internal vs. external perspectives	Firm	Conceptual	[4] Ambidext. depends on integrating internal and external knowledge; the latter relies on external brokerage and internal absorptive capacity
Raisch and Tushman 2016	Empir.	Corp. venturing	[2] Analyzes corporate venture units' evolving interactions with their core organizations during transitions to scale	Multilevel	Quali., longit. (6 cases)	[5] The locus for managing exploration-exploitation tension shifts from the corporate to the unit level when new businesses transition to scale
Rothaermel and Deeds 2004	Empir.	Org. alliances	[10] Examines the formation of exploratory and exploitative alliances on different stages of the new product development process	Firm	Quant., longit. (archival data)	[5] Exploration alliances predict products in development, that in turn predict exploitation alliances, which predict products on the market

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Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Rothaermel and Alexandre 2009	Empir.	Operations mgmt.	[10] Applies the ambidexterity perspective to analyzing a firm's technology sourcing strategy	Firm	Quant., cross-sect. (survey)	[1] There is an inverted U-shape relating technology sourcing mix and firm performance; absorptive capacity captures the benefits of ambidext.
Salvador, Chandrasekaran, and Sohail 2014	Empir.	Operations mgmt.	[2] Investigates the specific capabilities that firms develop to successfully compete when offering configurable products	Business unit	Quant., cross-sect. (survey and secondary data)	[3] Product configuration ambidexterity, moderated by product complexity, drives responsiveness, which mediates impact on firm performance
Sethi and Sethi 2009	Empir.	Innovation mgmt.	[10] Investigates the effectiveness of cross-functional teams in developing innovative new products in quality-orientated firms	Plant/ project/ process	Quant., cross-sect. (survey)	[1] Cross-functional teams allows quality-oriented organizations to develop innovative products. Quality orientation can support innovation

Continued on next page

Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Siggelkow and Levinthal 2003	Theoret.	Org. design	[5] Explores how different organizational structures moderate the balance of exploration and exploitation	Multilevel	Simulation	[1] A tradeoff exists between the short-term costs of decentralized exploration and the long-term benefits of reaching higher performance
Simsek et al. 2009	Theoret.	Strategy & general mgmt.	[9] Develops a typology of organizational ambidexterity	General	Lit. rev.	[2] Proposes four archetypes of organizational ambidexterity: harmonic, cyclical, partitional and reciprocal
Smith and Tushman 2005	Theoret.	Leadership	[4] Analyzes the mechanisms by which top management teams might successfully manage the contradictions of both exploring and exploiting	Firm	Conceptual	[1] Ambidext. implies paradoxical cognition embraced by senior managers, which can be implemented by a leader- or team-centric approach
Stettner and Lavie 2014	Empir.	Org. design	[2] Analyzes ambidexterity implementation by a combination of internal organization, alliances and acquisitions	Firm	Quant., longit. (secondary data)	[1] Balancing exploration and exploitation across modes is more beneficial than balancing it within modes

Continued on next page

Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Swift 2016	Empir.	Innovation mgmt.	[5] Analyzes the implications of transitioning between exploration and exploitation on firms' survival	Firm	Quant., longit. (secondary data)	[4] Firms that maintain higher levels of absorptive capacity are more capable of surviving the leap from R&D-based exploitation to exploration
Tokman et al. 2007	Empir.	Org. alliances	[6] Examines the relationship between supply chain portfolio strategies of exploration and exploitation on supply chain partner satisfaction	Firm	Quant., cross-sect. (survey)	[3] Higher proportions of exploration-oriented alliances are associated with the firm's satisfaction with its relationship portfolio
Tschang and Ertug 2016	Empir.	Human resources mgmt.	[10] Studies the impact of human capital tenure on the quality of explorative and exploitative innovations of aging firms	Firm	Quant., longit. (secondary data)	[1] Firm's age increases exploitative innov. quality and decreases explorative innovation quality, which can be mitigated by low employee tenure

Continued on next page

Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Tushman and O'Reilly III 1996	Theoret.	Strategy & general mgmt.	[10] Deals with the challenges of overcoming inertia and implementing innovation and change	Multilevel	Conceptual	[1] Autonomous business units that are culturally independent but unified by ambidextrous senior managers facilitate ambidexterity
Um et al. 2017	Empir.	Operations mgmt.	[10] Investigates the relationships between product variety management strategies and supply chain performance	Firm	Quant., cross-sect. (survey)	[1] A product variety management strategy achieves supply chain flexibility and agility, balancing product variety and supply chain performance
Uotila et al. 2009	Empir.	Strategy & general mgmt.	[3] Analyzes the relationshiop between exploration and exploitation on financial performance	Firm	Quant., longit. (secondary data)	[3] There is an inverted U-shaped relationship between the relative share of explorative orientation and financial performance

Continued on next page

Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Voss and Voss 2013	Empir.	Strategy & general mgmt.	[8] Analyzes how small and medium-sized enterprises achieve ambidexterity in both product and market domains	Multilevel	Quant., longit. (survey)	[3] Cross-domain ambidexterity have complementary interaction effects on revenue; single-domain ambidexterity only benefits larger firms
Wei, Yi, and Guo 2014	Empir.	Org. learning	[10] Explores how firms should dynamically reconfigure resource portfolios to leverage learning ambidexterity for new product development	Firm	Quant., cross-sect. (survey)	[4] The optimal balance along the continuum from exploitation to exploration is contingent on the level of resource and coordination flexibility
Wong, Wong, and Boon-Itt 2013	Empir.	Operations mgmt.	[6] Examines the individual and combined effects of internal and external supply chain integration on product innovation	Cross-boundary	Quant., cross-sect. (survey)	[3] External and complementary integration are positively associated with product innovation, but internal and balanced integration are not

Continued on next page

Table A.1 (continued): *summary of the articles reviewed on the study*

Reference	Study type	Contextual emphasis	Central issue [group[3]]	Level of analysis	Method (data)	Salient findings [group[4]]
Zhang et al. 2017	Empir.	Innovation mgmt.	[8] Studies the balance of exploration and exploitation simultaneously across two domains: technology-related and market-related innovations	Multilevel	Quant., cross-sect. (survey)	[3] Cross-domain ambidexterity have positive effects on firm performance; yet, cross-domain focus on exploration or exploitation are conflictive
Zhou and Wu 2010	Empir.	Innovation mgmt.	[10] Examines the role of technological capability in product innovation	Firm	Quant., cross-sect. (survey)	[1] Technological capability has an increasingly positive effect on exploitation but an inverted U-shaped relationship with exploitation
Zimmermann, Raisch, and Birkinshaw 2015	Empir.	Strategy & general mgmt.	[2] Studies how frontline managers interact with senior executives for the adoption of an ambidextrous charter for their organizational unit	Cross-boundary	Quant., cross-sect. (4 cases)	[1] When ambidexterity comes from the bottom, dissonance can arise and consensus is restored maily through the actions of frontline managers

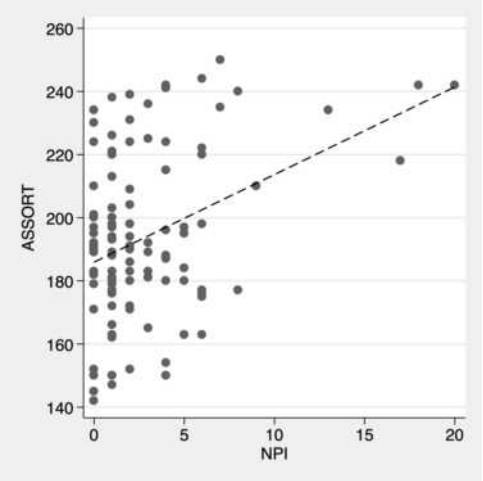
[3] Issue groups are: [1] E&E & ambidext., [2] Ambidext. building, [3] Performance conseq., [4] Top mgmt., [5] Ambidext. Strategies, [6] Operations strategies, [7] Learning dynamics, [8] Cross-domain ambidext., [9] Literature structure and [10] Special topics

[4] Finding groups are: [1] Ambidext.-building tools, [2] Conceptualization, [3] Consequences, [4] Boundaries, [5] E&E dynamics and [6] Conceptualization

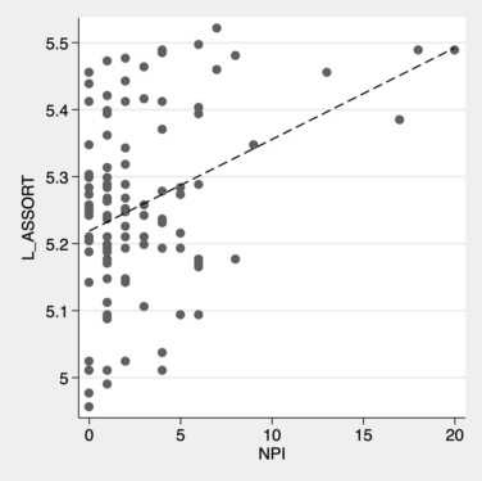
Appendix B

Appendix to Chapter 4

B.1. Scatterplots comparing the functional forms of the main variables in the model

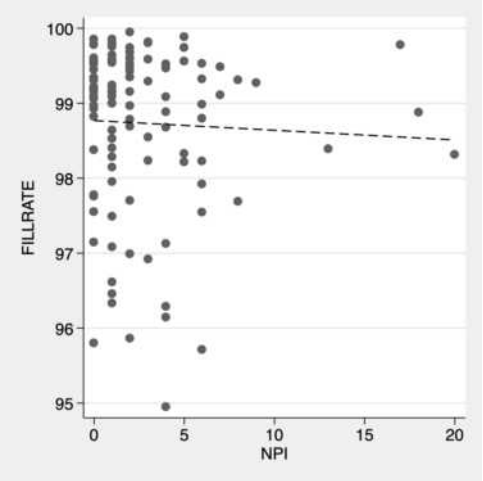


(a) *NPI vs. ASSORT*

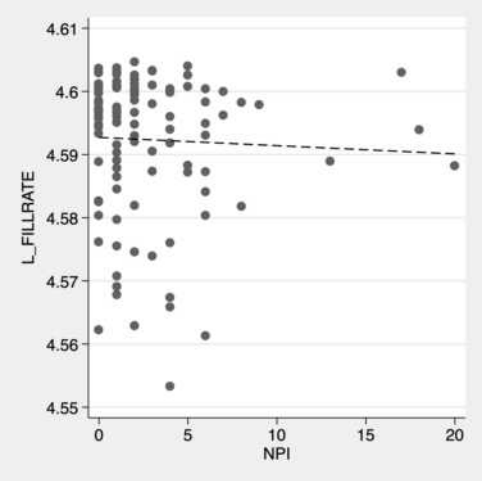


(b) *NPI vs. L_ASSORT*

Figure B.1: *NPI vs. ASSORT: comparison of functional specifications*

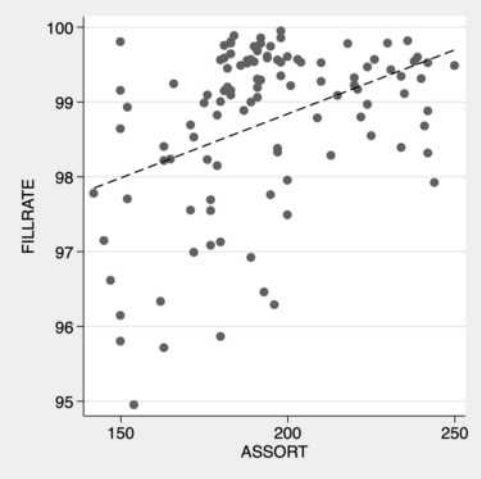


(a) *NPI vs. FILLRATE*

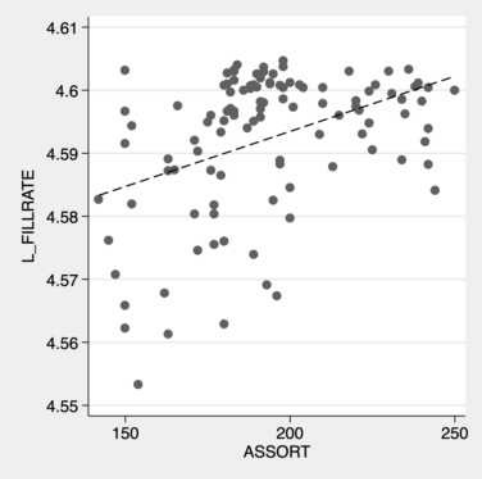


(b) *NPI vs. L_FILLRATE*

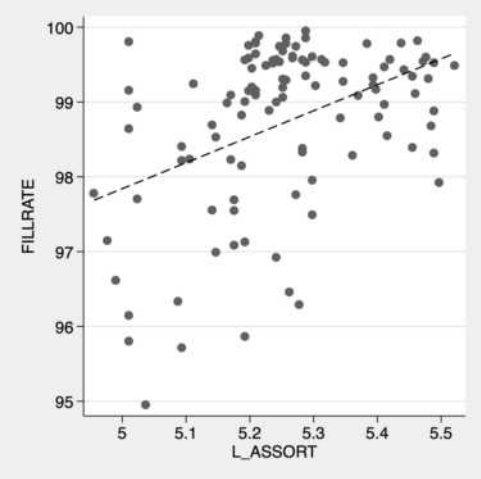
Figure B.2: *NPI vs. FILLRATE: comparison of functional specifications*



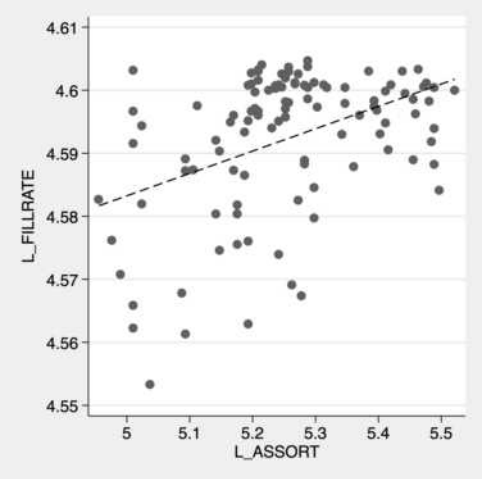
(a) *ASSORT vs. FILLRATE*



(b) *ASSORT vs. L_FILLRATE*

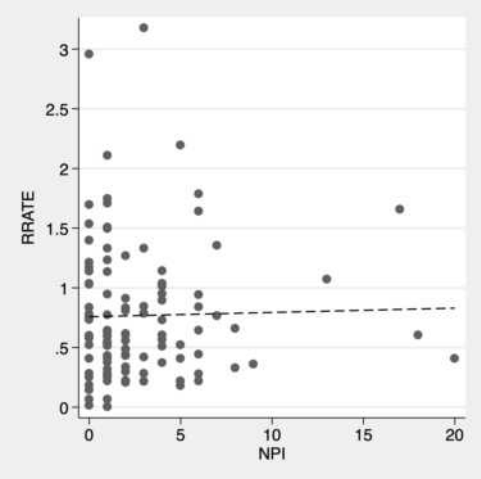


(c) *L_ASSORT vs. FILLRATE*

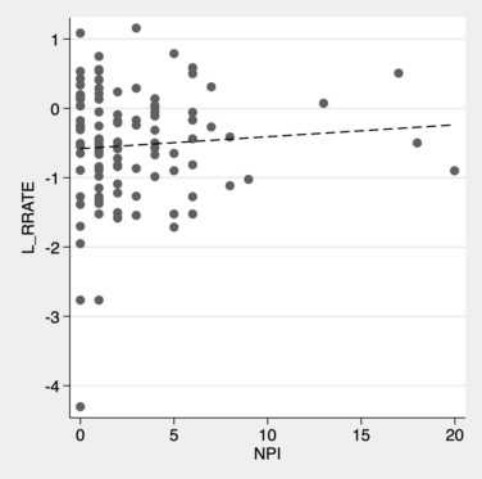


(d) *L_ASSORT vs. L_FILLRATE*

Figure B.3: *ASSORT vs. FILLRATE: comparison of functional specifications*

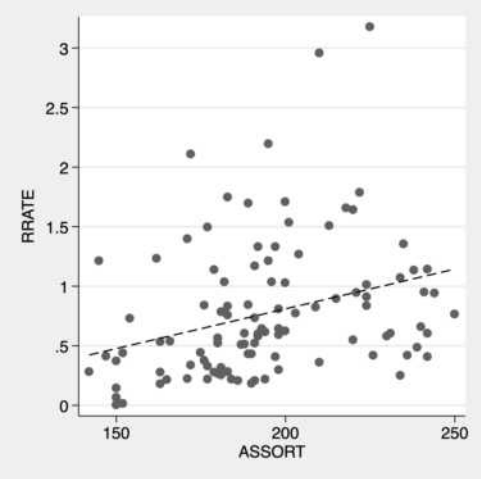


(a) *NPI vs. RRATE*

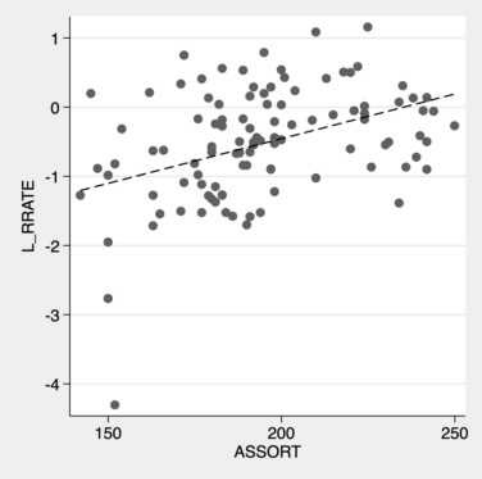


(b) *NPI vs. L_RRATE*

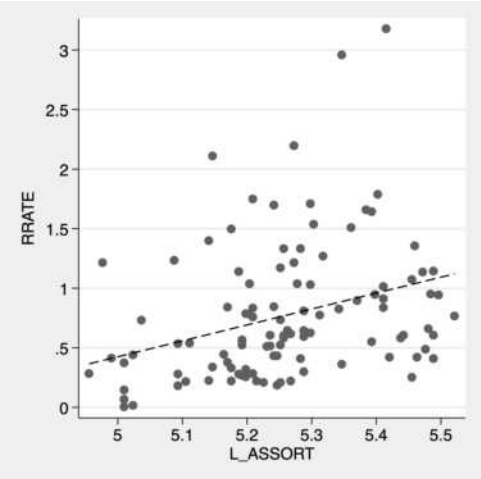
Figure B.4: *NPI vs. RRATE: comparison of functional specifications*



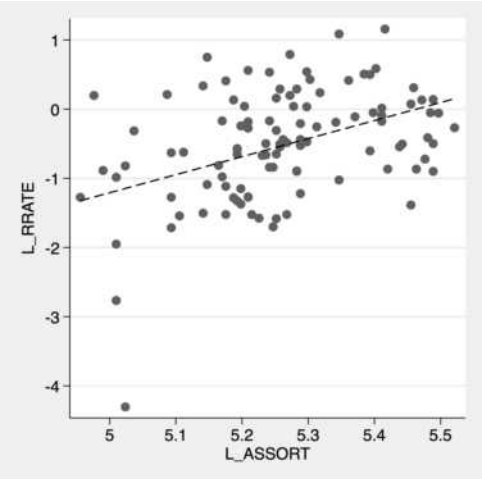
(a) *ASSORT vs. RRATE*



(b) *ASSORT vs. L_RRATE*

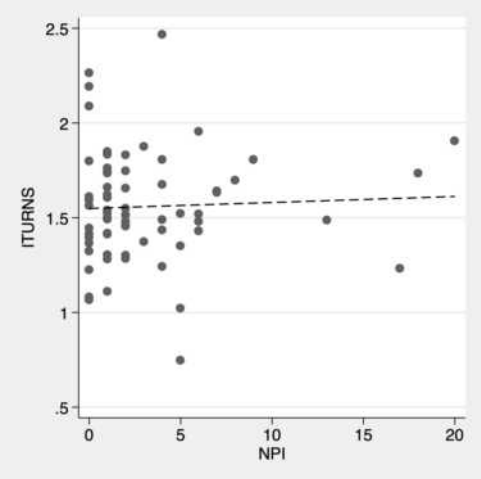


(c) *L_ASSORT vs. RRATE*

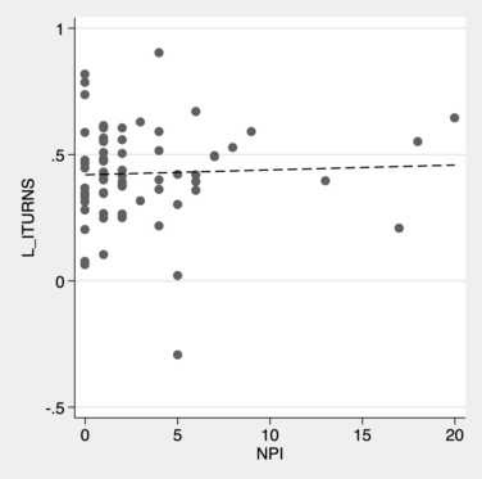


(d) *L_ASSORT vs. L_RRATE*

Figure B.5: *ASSORT vs. RRATE: comparison of functional specifications*

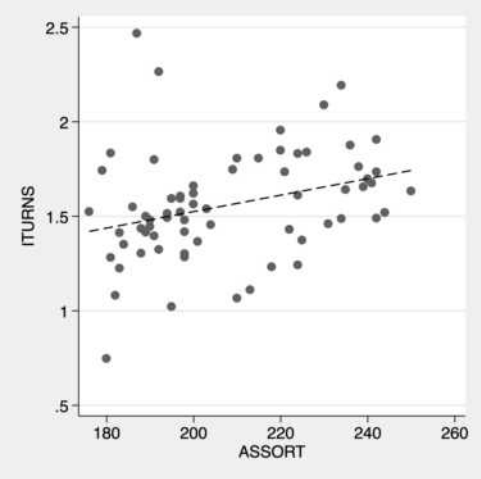


(a) *NPI vs. ITURNS*

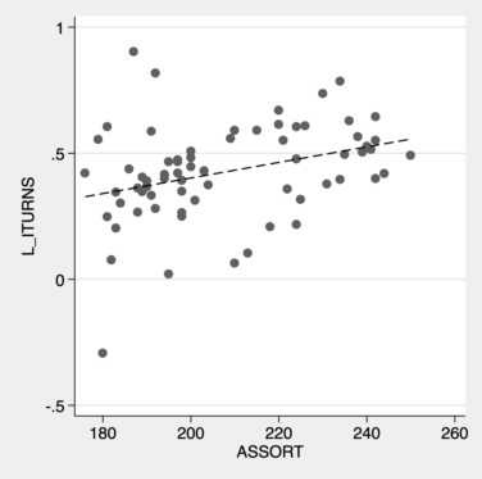


(b) *NPI vs. L_ITURNS*

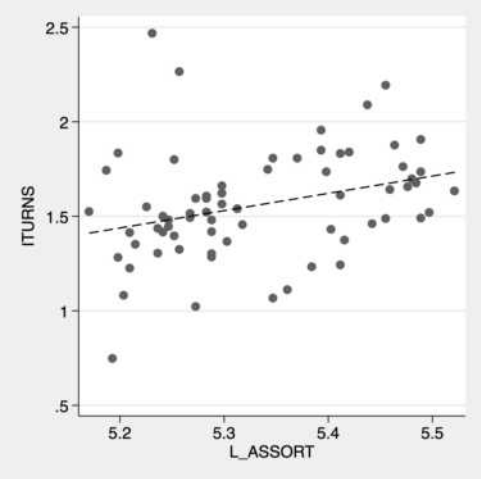
Figure B.6: *NPI vs. ITURNS: comparison of functional specifications*



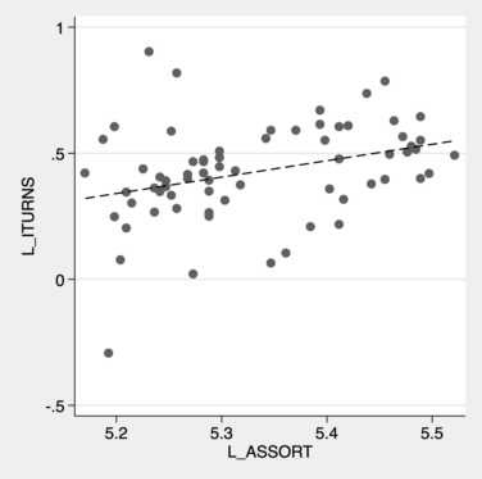
(a) *ASSORT vs. ITURNS*



(b) *ASSORT vs. L_ITURNS*



(c) *L_ASSORT vs. ITURNS*



(d) *L_ASSORT vs. L_ITURNS*

Figure B.7: *ASSORT vs. ITURNS: comparison of functional specifications*

B.2. Complete regression tables

	(1) FILLRATE	(2) ASSORT	(3) L_ASSORT	(4) FILLRATE	(5) FILLRATE	(6) FILLRATE	(7) FILLRATE	(8) FILLRATE	(9) FILLRATE
dNPI	-0.1411*	1.6504***	0.0642*				-0.0487	-0.0727	-0.0604
	(0.0577)	(0.1702)	(0.0267)				(0.0483)	(0.0537)	(0.0386)
dASSORT				-0.0148	-0.0480+		-0.0112	-0.0415+	
				(0.0116)	(0.0246)		(0.0137)	(0.0249)	
dL_ASSORT				-1.1771*		-1.3370*	-1.1513*		-1.2565*
				(0.5114)		(0.5616)	(0.5343)		(0.5996)
mNPI	0.0558	-5.5975**	-0.7694***				2.0741	0.0682	1.9197
	(0.6394)	(2.1447)	(0.1822)				(1.7206)	(0.6322)	(1.6990)
mASSORT				-0.0238	-0.0005		-0.0392	0.0022	
				(0.0163)	(0.0391)		(0.0357)	(0.0338)	
mL_ASSORT				0.5605		0.3657	2.9087		2.4226
				(0.7973)		(0.8188)	(2.3414)		(2.1812)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE type	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.
F_YW	19.533	16.892	26.528	24.859	25.614	25.388	23.952	17.138	16.929
p_YW	0.002	0.005	0.000	0.000	0.000	0.000	0.000	0.004	0.005
F_PRODVOL	5.243	368.058	400.477	3.604	2.760	0.089	0.612	0.334	0.928
p_PRODVOL	0.073	0.000	0.000	0.165	0.252	0.956	0.737	0.846	0.629
χ^2_PesaranCD	-2.713	-6.787	-4.414	-2.552	-2.615	-2.578	-2.559	-2.628	-2.578
p_PesaranCD	0.007	0.000	0.000	0.011	0.009	0.010	0.011	0.009	0.010
F_FeRe	0.092	12.210	22.366	5.639	0.627	2.054	5.384	0.752	4.128
p_FeRe	0.762	0.000	0.000	0.060	0.428	0.152	0.146	0.687	0.127
r^2	0.240	0.945	0.905	0.247	0.242	0.246	0.251	0.242	0.250
N	630	630	630	630	630	630	630	630	630

Standard errors in parentheses Intercept omitted for parsimony

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.1: *FILLRATE hybrid models*

Table B.2: *L_FILLRATE hybrid models*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	L_FILLRATE	ASSORT	L_ASSORT	L_FILLRATE	L_FILLRATE	L_FILLRATE	L_FILLRATE	L_FILLRATE	L_FILLRATE
dNPI	-0.0024^{+}	1.6504***	0.0642*				-0.0012	-0.0015	-0.0013
	(0.0014)	(0.1702)	(0.0267)				(0.0012)	(0.0013)	(0.0012)
dASSORT				-0.0002*	-0.0007*		-0.0001	-0.0005*	
				(0.0001)	(0.0003)		(0.0001)	(0.0002)	
dL_ASSORT				-0.0154*		-0.0178**	-0.0148*		-0.0160*
				(0.0061)		(0.0060)	(0.0065)		(0.0068)
mNPI	-0.0052	-5.5975**	-0.7694***				0.0099	-0.0051	0.0087
	(0.0059)	(2.1447)	(0.1822)				(0.0169)	(0.0056)	(0.0165)
mASSORT				-0.0002	0.0002		-0.0003	0.0000	
				(0.0002)	(0.0005)		(0.0004)	(0.0003)	
mL_ASSORT				0.0106		0.0087	0.0218		0.0181
				(0.0072)		(0.0074)	(0.0230)		(0.0212)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE type	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.
F_YW	23.308	16.892	26.528	26.750	18.474	27.500	24.258	19.260	18.846
p_YW	0.000	0.005	0.000	0.000	0.002	0.000	0.000	0.002	0.002
F_PRODVOL	11.638	368.058	400.477	0.094	0.034	0.803	0.227	0.762	0.417
p_PRODVOL	0.003	0.000	0.000	0.954	0.983	0.669	0.893	0.683	0.812
χ^2_PesaranCD	0.947	-6.787	-4.414	1.193	1.067	1.181	1.155	1.020	1.146
p_PesaranCD	0.344	0.000	0.000	0.233	0.286	0.237	0.248	0.308	0.252
F_FeRe	0.188	12.210	22.366	8.349	1.538	6.233	7.993	1.308	5.429
p_FeRe	0.665	0.000	0.000	0.015	0.215	0.013	0.046	0.520	0.066
r^2	0.216	0.945	0.905	0.221	0.217	0.221	0.222	0.218	0.222
N	630	630	630	630	630	630	630	630	630

Standard errors in parentheses Intercept omitted for parsimony

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.3: *RRATE hybrid models*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	RRATE	ASSORT	L_ASSORT	RRATE	RRATE	RRATE	RRATE	RRATE	RRATE
dNPI	-0.0264	1.6504***	0.0642*				-0.0829	-0.0761	-0.0603
	(0.0472)	(0.1702)	(0.0267)				(0.0752)	(0.0726)	(0.0683)
dASSORT				0.0154	0.0233^{+}		0.0216	0.0301	
				(0.0187)	(0.0138)		(0.0221)	(0.0201)	
dL_ASSORT				0.2808		0.4465	0.3246		0.5268
				(0.4677)		(0.3561)	(0.4616)		(0.3955)
mNPI	0.3532	-5.5975**	-0.7694***				-2.3427	0.3867	-2.0974
	(0.6860)	(2.1447)	(0.1822)				(1.4410)	(0.7034)	(1.5084)
mASSORT				0.0450***	-0.0094		0.0624*	0.0060	
				(0.0116)	(0.0468)		(0.0299)	(0.0357)	
mL_ASSORT				-1.3055^{+}		-0.9378	-3.9578*		-3.1850^{+}
				(0.7484)		(0.7706)	(1.9609)		(1.9194)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE type	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.
F_YW	19.874	16.892	26.528	26.954	26.554	18.298	29.722	29.069	18.143
p_YW	0.001	0.005	0.000	0.000	0.000	0.003	0.000	0.000	0.003
F_PRODVOL	3.398	368.058	400.477	0.519	0.586	3.767	3.437	0.557	3.108
p_PRODVOL	0.183	0.000	0.000	0.772	0.746	0.152	0.179	0.757	0.211
χ^2_PesaranCD	-2.372	-6.787	-4.414	-2.406	-2.460	-2.340	-2.440	-2.494	-2.350
p_PesaranCD	0.018	0.000	0.000	0.016	0.014	0.019	0.015	0.013	0.019
F_FeRe	0.319	12.210	22.366	9.018	0.355	1.626	10.123	0.857	3.962
p_FeRe	0.572	0.000	0.000	0.011	0.552	0.202	0.018	0.652	0.138
r^2	0.225	0.945	0.905	0.236	0.226	0.233	0.249	0.228	0.243
N	630	630	630	630	630	630	630	630	630

Standard errors in parentheses Intercept omitted for parsimony

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.4: *L_RRATE hybrid models*

	(1) L_RRATE	(2) ASSORT	(3) L_ASSORT	(4) L_RRATE	(5) L_RRATE	(6) L_RRATE	(7) L_RRATE	(8) L_RRATE	(9) L_RRATE
dNPI	0.0091	1.6504***	0.0642*				-0.0919*	-0.0664*	-0.0714+
	(0.0136)	(0.1702)	(0.0267)				(0.0437)	(0.0320)	(0.0416)
dASSORT				0.0190	0.0411+		0.0249	0.0467+	
				(0.0246)	(0.0220)		(0.0253)	(0.0248)	
dL_ASSORT				0.9359+		1.2018***	1.0132*		1.3259***
				(0.5172)		(0.2027)	(0.4741)		(0.2140)
mNPI	0.8317**	-5.5975**	-0.7694***				2.1596***	1.1245***	2.5732***
	(0.3073)	(2.1447)	(0.1822)				(0.6054)	(0.2551)	(0.7476)
mASSORT				0.0489**	0.0145		0.0302**	0.0460***	
				(0.0163)	(0.0365)		(0.0100)	(0.0101)	
mL_ASSORT				-0.9653*		-0.5856	1.1529+		1.7328**
				(0.4562)		(0.4837)	(0.5886)		(0.6280)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE type	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.
F_YW	2.958	16.892	26.528	1.753	1.719	1.245	2.020	1.831	1.386
p_YW	0.707	0.005	0.000	0.882	0.886	0.940	0.846	0.872	0.926
F_PRODVOL	7.207	368.058	400.477	0.586	0.298	5.450	45.548	38.364	12.001
p_PRODVOL	0.027	0.000	0.000	0.746	0.861	0.066	0.000	0.000	0.002
χ^2_PesaranCD	-7.025	-6.787	-4.414	-7.009	-7.068	-6.977	-7.015	-7.093	-6.961
p_PesaranCD	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F_FeRe	6.908	12.210	22.366	6.524	0.310	9.883	20.011	35.223	35.106
p_FeRe	0.009	0.000	0.000	0.038	0.577	0.002	0.000	0.000	0.000
r^2	0.303	0.945	0.905	0.341	0.317	0.326	0.357	0.338	0.348
N	543	630	630	543	543	543	543	543	543

Standard errors in parentheses Intercept omitted for parsimony

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.5: *ITURNS hybrid models*

	(1) ITURNS	(2) ASSORT	(3) L_ASSORT	(4) ITURNS	(5) ITURNS	(6) ITURNS	(7) ITURNS	(8) ITURNS	(9) ITURNS
dNPI	0.0119	1.6504***	0.0642*				-0.0461	-0.0439	-0.0136
	(0.0152)	(0.1702)	(0.0267)				(0.0445)	(0.0428)	(0.0333)
dASSORT				0.0321	0.0157		0.0300	0.0351	
				(0.0307)	(0.0138)		(0.0247)	(0.0310)	
dL_ASSORT				0.3164		0.1680	0.1244		0.5075
				(0.5546)		(0.3224)	(0.3999)		(0.5740)
mNPI	-3.8797***	-5.5975**	-0.7694***				-3.6068+	-3.1827***	-3.1078
	(0.9328)	(2.1447)	(0.1822)				(2.1707)	(0.7101)	(2.1124)
mASSORT				0.1067+	0.2506+		0.1339**	0.1250**	
				(0.0601)	(0.1400)		(0.0452)	(0.0406)	
mL_ASSORT				3.4456*		4.2851*	-0.6325		0.9336
				(1.5538)		(1.8033)	(2.9872)		(2.7348)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE type	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.
F_YW	18.799	16.892	26.528	7.001	7.312	6.305	7.645	7.776	5.852
p_YW	0.002	0.005	0.000	0.221	0.198	0.278	0.177	0.169	0.321
F_PRODVOL	24.484	368.058	400.477	12.140	11.974	23.045	1.969	8.552	4.868
p_PRODVOL	0.000	0.000	0.000	0.002	0.003	0.000	0.374	0.014	0.088
χ^2_PesaranCD	-5.839	-6.787	-4.414	-5.978	-5.860	-5.859	-5.919	-5.893	-5.955
p_PesaranCD	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F_FeRe	17.219	12.210	22.366	5.106	3.029	4.744	31.259	20.961	16.355
p_FeRe	0.000	0.000	0.000	0.078	0.082	0.029	0.000	0.000	0.000
r^2	0.750	0.945	0.905	0.750	0.631	0.718	0.793	0.792	0.756
N	414	630	630	414	414	414	414	414	414

Standard errors in parentheses Intercept omitted for parsimony

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.6: *L_ITURNS hybrid models*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	L_ITURNS	ASSORT	L_ASSORT	L_ITURNS	L_ITURNS	L_ITURNS	L_ITURNS	L_ITURNS	L_ITURNS
dNPI	0.0152*	1.6504***	0.0642*				-0.0064	0.0048	-0.0024
	(0.0076)	(0.1702)	(0.0267)				(0.0080)	(0.0148)	(0.0058)
dASSORT				0.0127	0.0086		0.0002	0.0239	
				(0.0216)	(0.0062)		(0.0048)	(0.0177)	
dL_ASSORT				0.8386*		0.3439***	0.3894***		0.4291***
				(0.3447)		(0.0560)	(0.0610)		(0.1023)
mNPI	-4.6507***	-5.5975**	-0.7694***				-7.7941***	-4.4694***	-7.3817***
	(0.9035)	(2.1447)	(0.1822)				(0.3542)	(0.8039)	(0.7283)
mASSORT				0.0415	0.2085		0.1002***	0.0316	
				(0.0602)	(0.1711)		(0.0071)	(0.0386)	
mL_ASSORT				3.9578+		4.3050+	-4.8671***		-3.6096***
				(2.0708)		(2.2229)	(0.4804)		(0.8388)
hasYW	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
hasPRODVOL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SE type	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.	HAC-Clust.
F_YW	35.728	16.892	26.528	12.613	17.567	24.031	59.370	13.133	38.747
p_YW	0.000	0.005	0.000	0.027	0.004	0.000	0.000	0.022	0.000
F_PRODVOL	102.960	368.058	400.477	3.242	5.203	10.137	144.584	0.713	38.635
p_PRODVOL	0.000	0.000	0.000	0.198	0.074	0.006	0.000	0.700	0.000
χ^2_PesaranCD	-3.559	-6.787	-4.414	-3.663	-3.441	-3.240	-3.196	-4.100	-3.167
p_PesaranCD	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.002
F_FeRe	26.540	12.210	22.366	2.436	1.393	3.048	1183.668	30.951	193.130
p_FeRe	0.000	0.000	0.000	0.296	0.238	0.081	0.000	0.000	0.000
r^2	0.890	0.945	0.905	0.694	0.465	0.677	0.968	0.899	0.943
N	414	630	630	414	414	414	414	414	414

Standard errors in parentheses Intercept omitted for parsimony

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix C

Appendix to Chapter 6

C.1. Supply chain strategy mapping - interview questionnaire

- **Objective:** Learn about MeatCo's tacit supply chain strategy
- **Introduction:** Explain the project, ask for permission for recording, explain that the data is confidential, and ask for the need for additional clarification.
- **Initial questions:** What is the name of your current position? Who do you report directly to? Do you participate directly in crafting the business strategy of the firm?
- **Open questions**: an open conversation that should be allowed to run freely
  - **Type 1:** What would you say are the main activities of your position? Think of a typical week of month: what are the things that take most of your time and attention?
  - **Type 2:** Could you tell me which positions report directly to you? What would you say are the key activities of such-and-such position? What are the main activities of the people under your supervision?
  - **Probing questions:** What? Why? How? What is the underlying idea of this? Could you give me an example of that?
- **Semi-open questions:** What is the main challenge of your position? How would you define your business? Who is your client? What are the main needs of your client? What is your value proposition?