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ALEXANDRE LUIS PRIM

Operational capabilities' development: a co-evolutionary perspective

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Ph.D. dissertation presented to Escola de Administração de Empresas de São Paulo of the Fundação Getúlio Vargas,in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Research area: Gestão de operações e sustentabilidade
Advisor: Prof. Ely Laureano Paiva, PhD
Co-Advisor: Prof. Maneesh Kumar, PhD

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ABSTRACT

If operational capabilities is the reason for competitive advantage of companies and a way for explain performance heterogeneity across them, how do companies develop it? Putting myself in an executive position, undoubtedly I would be eager to find out. Current literature of operational capabilities has addressed limited discussion over that topic. Therefore, this study was motivated from both theoretical and managerial gaps, so, it seeks to analyze the process of operational capability development. Co-evolutionary theory was used to support this study regarding some limitations on theories used by previous studies, such as Evolutionary Theory, Resource-Based Theory, and Microfoundations. Therefore, this study is structured by three chapters: (1) explains the theoretical gap of operational capabilities and proposes a new conceptualization of its development process, as well as indicate some ways for future studies; (2) refers to a quantitative study for analyzing the impact of internal and external mechanisms on the operational capabilities development; (3) consist an inductive qualitative study for revealing ways adopted by four brewery companies regarding the quality capability development.

Keywords: Operational capabilities. Mechanisms. Co-evolution.

RESUMO

Se *operational capabilities* é um termo que refere-se à empresas com vantagem competitiva e uma forma de explicar a heterogeneidade no desempenho entre concorrentes, como estas são desenvolvidas? Executivos sem dúvida têm interesse em descobrir esta resposta. A literatura vigente de *operational capabilities* tem enfatizado uma discussão limitada sobre este tema. Portanto, este estudo foi motivado pelo gap teórico e gerencial, ao qual busca analisar o processo de desenvolvimento de *operational capabilities.* A teoria co-evolucionária tem sido base deste estudo considerando as limitações teóricas de estudos prévios, aos quais utilizaram a *Evolutionary Theory, Resource-Based Theory, and Microfoundations.* Desta forma, este estudo está estruturado em três capítulos: (1) explica o gap teórico de *operational capabilities e* propõe uma nova conceptualização de seu processo de desenvolvimento, bem como o estudo indica algumas direções para estudos futuros; (2) refere-se a um estudo quantitativo por analisar o impacto de mecanismos internos e externos sobre o desenvolvimento das *operational capabilities;* (3) consiste em um estudo qualitativo indutivo por revelar formas de desenvolvimento da *capability* de qualidade de quatro empresas da indústria cervejeira.

Palavras-chave: Operational capabilities. Mecanismos. Teoria Co-evolucionária.

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GENERAL INTRODUCTION

This study aims to explore the process of operational capability development through co-evolutionary theory lens. As a theoretical gap in OM field (Dangol, Bahl, & Karpak, 2015; Peng, Schroeder, & Shah, 2008), it seeks to address upon unanswered questions from OM literature. Therefore, this research was driven for the following questions: (a) How do firms develop their operational capabilities? (b) What is the role of internal and external mechanisms on that process?

Operational capabilities have been conceptualized as "the strength or proficiency of a bundle of interrelated routines for performing specific tasks" (Peng et al., 2008:734). Besides a conceptualization coming from strategy field, Winter (2003) had a similar concept for arguing operational capabilities as "how we earn a living now" by "producing and selling the same product, on the same scale and to the same customer population" (p.992).

Regarding a limited discussion over the process of capabilities development and its mechanisms, this research was built through three chapters. The first paper shows the state of art of operational capability and previous research for the mechanisms of its development. Built upon OM, strategy and management field, this study proposes a procedural framework based on five mechanisms for the phenomenon of capabilities development: sensing (identification of opportunities and threats),seizing (evaluation), reconfiguring (adaptation), and internal and external feedback. Finally, a research agenda is provided for future studies.

The second paper addressed a discussion on a question from the first paper: "*To what extent internal and external mechanisms impact on the operational capabilities development? "*Data from HPM was adopted to analyze studies' hypothesis. Results revealed that internal resource of firms influence operational capabilities development (when measured by customer and supplier market knowledge, effective processes implementation, continuous improvement and anticipation of new technology).However, they are sensible for influences coming from the operational performance (internal perspective) and partners (external perspective).

The third paperis aligned to prior ones for analyzing the mechanisms adopted by brewery companies for the quality capability development. Based on an inductive study, we adopted multiple case studies to explain six alternatives adopted by companies to develop their quality capabilities – cooperating, following rules and anticipating – both internal and externally.

At last, the structure of this dissertation is following the order of three chapters.

PAPER 1 – THEORETICAL PAPER

The first paper, entitled "Understanding operational capabilities development viewed through the co-evolutionary lens: a theoretical conceptualization" seeks demonstrate the theoretical gap of the operational capabilities literature in the operations management field. From this, the paper proposes a new way based on co-evolutionary theory as a fruitful theoretical avenue to understand the operational capability development phenomenon. Furthermore, the paper address a set of alternatives for future research, and at the same time connect it to the second and third paper of this PhD dissertation.

This paper was presented in the 2nd Becoming an international researcher: doctoral workshop, Cardiff, Wales; 28th Production and Operations Management Society (POMS), Seattle, US; and also was submitted to 20th Simpósio de Administração da Produção, Logística e Operações Internacionais (SIMPOI) and to 41st Encontro da ANPAD (Enanpad), São Paulo, Brazil; where have received feedbacks, which all of them were carefully reflected to be added into the text.

Understanding operational capabilities development viewed through the co-evolutionary lens: a theoretical conceptualization

Abstract

Single sentence summary

This paper proposes a conceptual framework for demonstrating how operational capabilities are development-based on the co-evolutionary theory lens, and provides three ways for future research.

Purpose

The purpose of this paper is to develop a conceptual framework for the process of operational capabilities development.

Design/methodology/approach

The authors have adopted a structured literature review method to analyse the current knowledge of capabilities in operations management, strategy, and general management fields. Based on these, a conceptual framework is developed for the operations field.

Findings

There has been limited debate addressing the process of operational capabilities development and its mechanisms. The results from this study contribute toward advancing operational capabilities literature by providing a conceptual framework and mechanisms of its development. Jointly, internal and external mechanisms demonstrate how to analyse the process of adaptation of companies, as well how it affects capabilities development.

Originality/value

This is the first study that proposes a framework for the operational capabilities development process; thus, it matches previous studies to co-evolutionary theory to provide five internal and external mechanisms. Seeking to extend the current knowledge on the operational capabilities topic, three ways for future research are shown in this paper.

Keywords: operational capability development; co-evolutionary theory; internal mechanisms; external mechanisms.

1. Introduction

Why do firms' performances differ? This is a central debate in operations strategy literature. Historically, there is a preferential approach to investigate operational capabilities (OC) development based on companies' internal aspects. The alignment between operational and corporate strategy, integration, practices, technology, and OC have been subjects deeply investigated by operations management researchers over the last forty years. Specifically, the operational capabilities topic has been debated by researchers through two perspectives: (a) first, focusing on developing single capability (e.g. cost, quality or delivery) for a firm and ignoring other capabilities, according to the trade-off conception (Boyer & Lewis, 2002; Pagell, Melnyk, & Handfield, 2000; Skinner, 1969; Wheelwright, 1984); or (b) considering a cumulative adoption of operational capabilities (Ferdows & De Meyer, 1990; Flynn & Flynn, 2004; Rosenzweig & Easton, 2010; Rosenzweig & Roth, 2004; Schroeder, Shah, & Peng, 2010). Nevertheless, both perspectives affirm capabilities as the strength of firms for performing a bundle of inter-related operational processes that provides a competitive advantage over rivals. However, the extant literature mostly focuses on 'what' and 'why' factors, but have limited discussion on 'how' to develop operational capabilities (Dangol, Bahl & Karpak, 2015).

Though majority of the OC studies focuses from internal organisation perspective, still there are evident gaps in understanding OC development overtime. For example, only few studies have addressed mechanisms to support operational capability development. Specifically, this gap has been debated by studies about operations management (Peng, Schroeder, & Shah, 2008; Schoenherr, Power, Narasimhan, & Samson, 2012), strategy (Rockart & Dutt, 2015) and general management (Hoopes & Madsen, 2008) fields. Another important gap is related to the absence of an external perspective in the OM field. Previous studies have used distinct theories to support operational capabilities, such as Evolutionary theory (Helfat & Peteraf, 2003; Winter, 2012), Resource-based theory (Rockart & Dutt, 2015; Wu, Melnyk & Flynn, 2010), and the Microfoundations approach (Felin, Foss, Heimeriks & Madsen, 2012); however, they are limited in focus for not considering simultaneous evolution among organizations, entities, and their environment. Rather, refusing these existent perspectives, we extend the current knowledge about operational capabilities by considering the role of internal and external mechanisms in their development process. Therefore, this study aims to analyse the operational capability development from a multilevel perspective using a co-evolutionary theoretical lens. Co-evolutionary theory originates from the natural sciences field, and it has been applied to

social sciences research to explain the joint evolution between distinct organizations and their environment (Cafferata, 2016). Co-evolutionary theory can help us to understand the capability development phenomenon by integrating internal and external mechanisms simultaneously.

More particularly, co-evolutionary theory sheds light on the interdependent result of managerial action, the industry and the institutional environment to explain the market dynamics. The theory is supported by a set of five properties – multilevelness and embeddedness, multidirectional causalities, non-linearity, positive feedback, and path and historical dependence – in which multiple actors interplay on a causal ambiguity view over time (Lewin & Volberda, 1999; Lewin et al., 1999; Lewin & Volberda, 2009). Thus, co-evolutionary theory does encapsulate all the features to explain how internal and external mechanisms work for the OC development.

We argue the process of operational capabilities development is based on internal and external mechanisms for synthesizing joint current literature on OC and co-evolutionary theory. Internal mechanisms incorporate elements within a firm, such as identification of opportunities and threats, evaluation, adaptation, and results reached with its current resources. Therefore, four internal mechanisms support this study, ‘sensing’, ‘seizing’, and ‘reconfiguring’ according to Teece's (2007) study; and, ‘internal feedback’ for indicating adaptations coming from a managerial comparison between a firm’s expected and actual results obtained. We explain ‘external mechanisms’ from co-evolutionary theory perspective and argue that companies may stimulate joint adaptations in the market and the external players. Based on this premise, we define ‘external feedback’ as a mechanism for measuring influences on a company affected by adaptations from external players, such as suppliers, customers, competitors, entities, and institutions.

As the main contribution, this study provides a conceptual framework to analyse the operational capability development process rather than testing it. This study proposes that the operational capabilities development of firms occurs through joint evolution among firms and the environment. This process includes intra-firm influences due to the internal resources of firms, and external influences from the meso- and macro-level. The evolution happens across five phases: sensing (identifying opportunities and threats), seizing (evaluating opportunities and threats), reconfiguring (adapting processes, practices and technology) (Teece, 2007), and internal and external feedback that comprise the effect from internal and external outputs respectively. From this, we show a research agenda with three alternatives for futures studies.

This study has the following structure: the current knowledge of operational capability section, discussing two central questions: What do we know about operational capability?

Moreover, what do we know about its development?; a literature review of co-evolutionary theory and its applicability to building the procedural framework; finally, we present a research agenda for future studies, conclusions and implications.

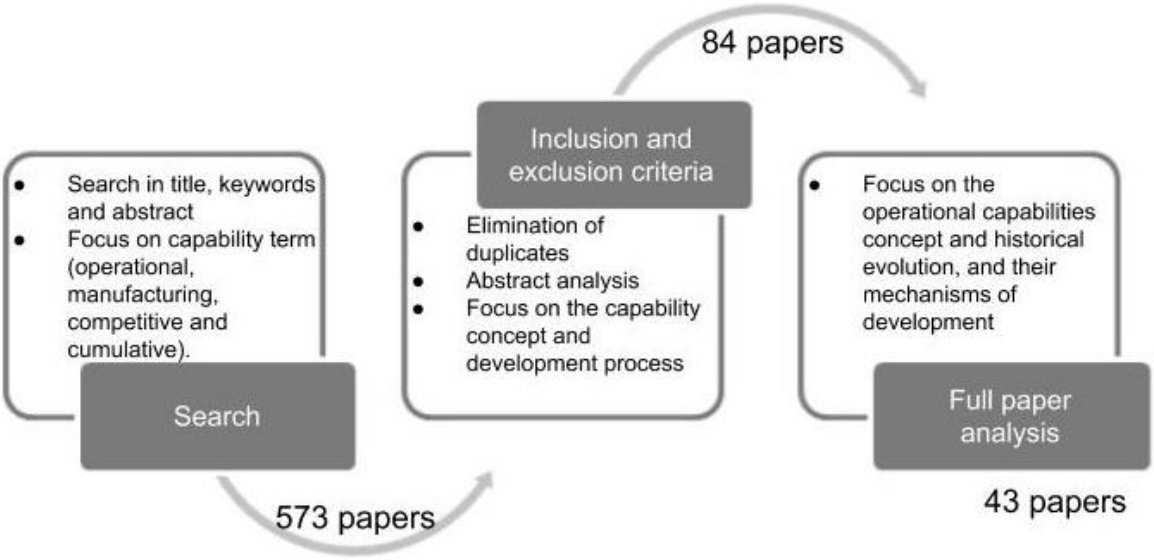
2. The current knowledge of operational capability

This section includes a review of the existing literature on OC, concerning operations, strategy, and the general management field. As these terms are close in meaning, organizational and dynamic capabilities literature has been used to support the operational capabilities discussion. Besides this, studies in the strategy and management field have addressed some mechanisms to understand capabilities development (see Table 2); therefore, we have checked the literature in order to evaluate related mechanisms and antecedents for OC development.

The literature search has been conducted in the Web of Knowledge database to identify works from the field of business management. We have used inclusion and exclusion criteria of search according to each subsection of this study. In the first subsection, named 'What do we know about operational capability?', we search for studies to conceptualize capabilities and discuss its historical evolution. Therefore, we search for the following terms in the title, abstract and/or keyword: 'operation* capabilit*', 'manufact* capabilit*', 'competitive capabilit*', 'cumulative capabilit*'. Duplicated studies and those not related to the historical evolution of capabilities topic have been removed.

For the second subsection, named 'What do we know about its development?', we add the word 'develop*' at the end of first set of keywords used above to search studies that have emphasized the process of capabilities development. Given similar studies have been conducted outside the operations management field, we have also conducted a literature search in the strategy and general management fields; such as 'dynamic capabilit* develop*' and 'organizational capabilit* develop*'. While studies that include mechanisms of capabilities development have been considered, the rest have been removed (see consolidated screening for both subsections in Figure 1).

Figure 1: Literature review screening methodology



Source: Authors (2008).

Finally, the co-evolutionary theory section was built through the seminal study of Lewin and Volberda (1999), following a snowball technique to identify seminal literature due to the wide range of literature on co-evolutionary theory. Our review process has applied inclusion and exclusion criteria to identify literature that is aligned with the aim of the study; we would not claim that the review process has entirely followed a systematic literature review methodology for each subsection.

2.1 What do we know about operational capability?

Capabilities differ from resources and routines. While resources are a set of assets controlled by a firm, capabilities refer to a firm's ability in deploying resources (Amit & Schoemaker, 1993), and routines configure a repetitive action of the same activity by multiple actors in a firm (Feldman & Pentland, 2003). The Peng et al. (2008) study has synthetized these terms, where resources are conceived as a base for firms to operate their routines, whereas a bundle of interrelated routines leads companies to form a capability. Finally, capability is understood as a firm's intangible strength.

Previous studies have had distinct interpretations of the term, capabilities, like a process of transformation (Peng, Schroeder, & Shah, 2011; Schoenherr & Narasimhan, 2012; Wu et al., 2010), a set of management practices (Escrig-Tena & Bou-Llusar, 2005; Narasimhan, Swink, & Wook, 2006; Tan, Kannan, & Narasimhan, 2007),as an outcome (Luo, Fan, & Zhang, 2012; Perunovic, Christoffersen & Mefford, 2012; Schoenherr et al., 2012). Seeking to clarify the

understanding of the term, capabilities in the operations management field, Peng et al. (2008:734) described operational capability as *"the strength or proficiency of a bundle of interrelated routines for performing specific tasks".* Thus, a capability is not developed through an individual routine, but emerges from multiple interrelated routines. Likewise, Wu et al. (2010) study created a "kitchen" metaphor by integrating resources, practices and tacit elements to demonstrate operational capabilities. They defined operational capabilities as *'firm-specific sets of skills, processes, and routines, developed within the operations management system, that are regularly used in solving its problems through configuring its operational resources'* (p. 726). While resources and practices can be transferable across firms, capabilities are unique to a firm, like a person's DNA (Wu, Melnyk & Swink, 2012). In an attempt to imitate competitors' capabilities, companies may only copy their operational resources, such as routines, practices, processes and technology. Therefore, the combination of these operational factors leads companies to possess a distinct level of capabilities over competitors (Coltman & Devinney, 2013). For example, many western companies have attempted to copy the Toyota Production System (TPS) to develop their operational capabilities and improve operational performance. However, they have failed to understand the organizational culture and ethos behind the TPS methodology, i.e. only imitating technical aspects and failing to understand the social aspect that is the key pillar to TPS success (Bortolotti, Danese, Flynn, & Romano, 2015; Hadid, Mansouri, & Gallear, 2016).

Regardless of the fact the term, capability has been applied distinctly in operations, strategy, and general management fields, they are convergent in seeking to explain heterogeneity of performance across firms. While organizational capability was conceptualized to explain the process of managing internal resources of firms in the management field (Collis, 1994), dynamic capabilities has been created from a critique on the resource-based view by Teece, Pisano, and Shuen (1997), which argues it is the ability of firms to adapt their internal resources in rapidly changing environments. In Table 1, we show some types of capabilities' and their description based on their field of origin.

Table 1: Capabilities typology

Capability type	Description	Key literature	Field of origin
Competitive capability [Skinner, 1969]	Proficiency in processes for adopting a single dimension of competitive priority, such as quality, delivery, flexibility, or cost.	(Boyer & Lewis, 2002; Corbett & Claridge, 2002; Hayes & Wheelwright, 1984; Pagell et al., 2000; Schoenherr & Narasimhan,	Operations management

		2012; Schoenherr et al., 2012)	
Cumulative capability [Ferdows & De Meyer, 1990]	Proficiency by adopting quality, delivery, flexibility, and cost dimension simultaneously through a progressive (or a combinative) conception	(Avella, Vazquez-Bustelo, & Fernandez, 2011; Flynn & Flynn, 2004; Menor, Roth, & Mason, 2001; Miller & Roth, 1994; Rosenzweig & Easton, 2010; Rosenzweig & Roth, 2004; Schroeder et al., 2010; Vokurka & Fliedner, 1998; Vokurka, Zank & Lund, 2002; White, 1996)	Operations management
Organizational capability [Collis, 1994]	"[…] organizational capabilities as the socially complex routines that determine the efficiency with which firms physically transform inputs into outputs." (p. 145).	(Dosi, Nelson & Winter, 2000; Hoopes & Madsen, 2008; Lavie, 2006; Winter, 2000, 2003, 2012; Zollo & Winter, 2002)	General management
Dynamic capability [Teece, Pisano & Shuen, 1997]	"[…] the firms' ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (p. 516).	(Di Stefano, Peteraf & Veronay, 2010; Eisenhardt & Martin, 2000; Helfat & Peteraf, 2009; Helfat & Winter, 2011; Peteraf, Di Stefano & Verona, 2013; Teece, Pisano & Shuen, 1997)	Strategy

Source: Authors (2018).

In the operations management field, the term, capability has faced a duality between single capability and based on the cumulative perspective. Skinner's (1969) study highlighted the alignment required between manufacturing policy and business strategy of firms in order to achieve competitive advantage through a competitive weapon, e.g. cost, quality and time. In turn, Wheelwright (1984) stated that manufacturing tasks are a part of all businesses and should follow a competitive priority, such as quality, dependability, speed and cost to be a contributor to the competitive advantage of the business.

Ferdows and De Meyer's (1990) study contrasted the traditional Skinner's trade-off concept through the cumulative capability concept. According to them, firms develop their manufacturing capabilities through a progressive adoption of competitive capabilities; First companies develop quality skills, then dependability, speed and cost efficiency to achieve superior manufacturing performance to competitors. Related to this, Roth and Miller (1992) stated that market leaders compete on multiple capabilities simultaneously. Based on a sample of North American, European and Korean firms, Noble (1995) found evidence that the best performing firms generally compete based on multiple capabilities. In turn, White

(1996)examined the direct relationship among competitive capabilities, such as quality, delivery dependability, flexibility, delivery speed and cost factors. According to his research, most relationships among competitive capabilities were found to be positive, whereas other studies failed to come to conclusive results. This has started a debate of preference and adoption of the cumulative capabilities theory rather than the competitive capabilities theory in the operations management literature (Menor, Roth & Mason, 2001; Miller & Roth, 1994; Rosenzweig & Roth, 2004).

Vokurka and Fliedner (1998) extended the Ferdows and De Meyer's (1990) Sand Cone model to five steps by adding agility to the term, capability before cost efficiency. Moreover, Vokurka, Zank and Lund (2002) extended this discussion in the supply chain field by arguing that all capabilities (quality, dependability, speed, agility and cost efficiency) are necessary to create and deliver value to customers in all supply chain settings. Based on a sample of high-tech manufacturers and a body of previous studies, Rosenzweig and Roth (2004) stated the Theory of Competitive Progression by affirming the cumulative effect of competitive capabilities sequentially – quality, delivery reliability, volume flexibility, and cost efficiency. Additionally, based on a meta-analysis of empirical studies, Rosenzweig and Easton (2010) reveal that, on average, managers do not report trade-offs in operations. Finally, Avella, Vazquez-Bustelo & Fernandez (2011) stated a direct and indirect effect across these capabilities, and their results found that one capability enhances another.

In contrast, the empirical study of Boyer and Lewis (2002) indicates that a firm should choose a competitive priority to develop its operational strategy. Similarly, Corbett and Claridge (2002) found no evidence of cumulative capabilities through a combinatory analysis among capabilities and its impact on a firm’s return on assets. In the same way, Pagell, Melnyk and Handfield's (2000) study argue that firms should choose a competitive capability aligned to the corporate strategies rather than invest in all of them, as it would not be a viable option considering their limited resources.

While some studies corroborated the Ferdows and De Meyer (1990) progression logic (Avella, Vazquez-Bustelo, & Fernandez, 2011; Rosenzweig & Easton, 2010; Rosenzweig & Roth, 2004), other studies have found no empirical evidence to support those hypotheses (Bortolotti et al., 2015; Flynn & Flynn, 2004; Schroeder et al., 2010). Facing this debate, previous studies have observed the contingency theory as a way to explain competitive capability development, though those studies have not confirmed a unique sequence of development of cumulative capabilities. It means that firms are embedded in a context of contingencies, e.g. industry, geography, and the external environment. So they choose different

strategies to compete, which reflects on their capabilities choices (Flynn & Flynn, 2004; Schoenherr et al., 2012; Schroeder et al., 2010). Besides this, in the previous literature there is a lack of mechanisms to explain the OC development process. Regarding this, below, we discuss a set of studies that addressed efforts on the process of its development.

2.2 What do we know about OC development?

The term, capabilities has drawn attention from several researchers covering distinct areas as a way to explain the heterogeneity of a firm's performance. However, researchers have not found any consensus about the mechanisms of its development in that literature. In Table 2, we synthesize some previous studies that have contributed toward this discussion.

Table 2: Mechanisms of Capabilities Development

Author	Concept	Mechanisms of development	Base theory or Approach	Capability type	Field
Winter (2000)	Continuous learning	*Internal*: investment in tangible assets, processes, and establishing relationships where the processes reside. *External:* not considered.	Evolutionary Theory	Organizational capability	General management
Zollo & Winter (2002)	Experience accumulation	*Internal*: (1) experience accumulation, (2) knowledge articulation, (3) knowledge codification. *External*: not considered.	Evolutionary Theory	Dynamic capability	General management
Helfat & Peteraf (2003)	Capabilities lifecycle	*Internal*: Renewal, Redeployment, Recombination, Replication, Retrenchment, and Retirement. *External*: not considered.	Evolutionary Theory	Organizational capability	Strategy
Jacobides & Winter (2005)	Capabilities development	*Internal*: (1) selection process of capabilities to match the vertical scope; (2) gains motivate reduction in transaction costs; (3) changes in scope affect the capability development *External*: (4) capability development affect industry adaptation	Co-evolutionary Theory	Organizational capability	Strategy
Lavie (2006)	Capability reconfiguration	*Internal*: (2) the nature of incumbent capabilities, and (3) the gap between pre-change capability configurations and the value maximizing capability configurations in the post-change environment. *External*: (1) the nature of technological change	Evolutionary Theory	Dynamic capability	General management
Teece (2007)	Foundations of dynamic capability	*Internal*: Sensing (identifying opportunities and threats), Seizing (evaluating these opportunities and	Evolutionary theory	Dynamic capability	Strategy

		threats) and Reconfiguring (adapting internal resources). *External*: customers, suppliers, entities and institutions.			
Felin et al. (2012)	Micro-foundations	*Internal*: Individuals, processes and structure, and their interactions. *External*: not considered.	Behavioural theory of the firm	Organizational capability	General management
Winter (2012)	Origin and ancestry	*Internal*: Origin, ancestry, path dependence, micro-foundations *External*: not considered.	Evolutionary Theory	Organizational capability	General management
Vanpoucke, Vereecke, & Wetzels (2014)	Supplier integrative capability	*Internal:* Sensing, Seizing and Transforming *External:* suppliers, market and technology, emergence of new competitors and internationalization of suppliers	Evolutionary theory	Dynamic capability	Operations management
Rockart & Dutt (2015)	'Rate' and 'Potential' terms	*Internal*: internal resources such as knowledge, skills, routines, systems and procedures. *External*: not considered.	Resource-based theory	Organizational capability	Strategy
Dangol et al., (2015)	Sequential capability development	*Internal:* Quality, cost, delivery and flexibility. *External:* co-operative relations with suppliers and customers	The relational view	Operational capability	Operations management
(Aslam, Blome, Roscoe, & Azhar, 2018)	Market sensing capability	*Internal: supply chain processes External: market trends, customers and competitors.*	Evolutionary theory	Dynamic capability	Operations management

Source: Authors (2018).

According to Table 2, most studies have emphasized the internal mechanisms of firms to demonstrate the process of capabilities development. Few studies have used more than one level of analysis to demonstrate the capabilities development process (such as effect of industry and institutional environments). In contrast, Jacobides & Winter (2005) suggest that companies may benefit from vertical integration when their partners possess resource heterogeneity, whereas they disintegrate them in the case of homogeneity. As a cyclical process of firms, this process directly influences an industry's adaptation. Lavie (2006) demonstrates a view that firms reconfigure their capabilities based on technological changes from the industry environment. In turn, Teece (2007) explains that industry and institutional environments might be a source of information for firms to adapt their dynamic capabilities .

Furthermore, most of them used the evolutionary theory to support their theoretical argument; however, others have built on behavioural theory of the firm, resource-based theory, co-evolutionary theory, and the relational view. It indicates varied explanation of the term, capability development, depending upon the theoretical lens used in the research study.

Concerning this, we present below some issues in order to understand the process of operational capabilities development.

First, the evolutionary theory has been used to explain the adaptation process of firms in the competitive industry environment. Thus, while some firms adapt and remain in the competitive market, others die. This literature considers that firms are seen as a repository of internal resources, such as skills and tacit knowledge, which they use to develop routines. In this way, routines assume the key role in organizational capabilities development (Nelson & Winter, 1982). However, its main critic refers to the difficulty for firms changing their strategy and structure over time, because the adaptation process should consider tacit knowledge and skills in advance. According to the theory, firms always learn to adapt and respond to external changes. However, it does not recognize joint evolution among multiple actors (internal and external) interacting and affecting each other (Lewin & Volberda, 1999). The theory claims that firms adapt their resources based on their values rather than a mutual evolution across multiple actors over time, such as partners, entities and institutions.

Second, the study of Felin et al. (2012) build upon the behavioural theory of firms to explain microfoundations of routines and capabilities of firms. Specifically, the microfoundations perspective shed light on how the micro-level helps to explain a collective phenomenon (named macro-level) (Barney & Felin, 2013; Felin et al., 2012). Their study has emphasized the role of individuals, processes and structure as the main microfoundations to explain the process of routines and capabilities evolution. However, it has received some critics by overemphasizing and summarizing the individuals' action impact on the routines and capabilities settings (Hodgson, 2012).

Third, although Resource-Based Theory (RBT) has built upon the Industrial Organization of Strategy literature, its foundations are close to the evolutionary view (Barney, 2001). Empirical studies have considered RBT as a theoretical foundation to explain OC development – the inimitable internal resources are able to promote idiosyncratic results and sustained competitive advantages for firms (Coltman & Devinney, 2013; Peng et al., 2008; Vanpoucke et al., 2014; Wu et al., 2010; Zhang et al., 2016). Similar to the evolutionary theory viewpoint, RBT defends the process of capability development inside a firm by combining resources absorbed internally and externally. The main criticism of this theory is that it overemphasizes on the internal resources as a source for sustained competitive advantage, whereas it assumes the environment as predictable and static (Kraaijenbrink, Spender & Groen, 2010).

Fourth, we are not aware of any studies in the operations management field that uses co-evolutionary theory for understanding the OC development over time. In the management field,

Jacobides and Winter (2005) empirically demonstrated that firms integrate or disintegrate their vertical scope in order to develop organizational capabilities. However, such processes lead to industrial adaptations. In this case, co-evolutionary theory was used to support buyer-supplier interplay over time. We provide more discussion of co-evolutionary theory in the next section. Only, few studies have analysed the operational capability development process in the operations management field using other theoretical lenses. For example, as shown in Table 2, Vanpoucke et al. (2014) supported their supplier integrative capability on sensing, seizing and transforming mechanisms by Teece (2007), and highlighted the suppliers role in building capabilities. Supported by the relational view, Dangol et al. (2015) discussed sequential capabilities development through a co-operative relationship with suppliers and customers. Finally, Aslam et al. (2018) argue market sensing capability as an antecedent of supply chain agility and adaptability by monitoring market trends.

According to Table 2, studies from the strategy and general management field have considered processes (Barney & Felin, 2013; Winter, 2000) and technology (Lavie, 2006) as mechanisms of capabilities development. Contrasting, studies in the operations management field have emphasized integration of practices with partners to support capabilities development (Dangol et al., 2015; Vanpoucke et al., 2014). In turn, empirical studies in operations management have emphasized that processes, practices and technology perform a vital role, as they provide strength for companies to achieve better results over competitors (Chavez, Yu, Jacobs, & Feng, 2017; Fullerton, Kennedy, & Widener, 2014; Mehmood, Meriton, Graham, Hennelly, & Kumar, 2017). In Table 3, we show these three main factors and a body of studies that support them.

Table 3: Strength of process, practice and technology in the OM field

Factors	Typology	Authors
Process	S&OP	(Doering & Suresh, 2016; Olhager & Selldin, 2007; Paiva, 2010)
	Purchasing	(Chen, Paulraj & Lado, 2004; Knight, Tu, & Preston, 2014; Legenvre & Gualandris, 2017)
	Manufacturing / Service	(Chavez et al., 2017; Corbett & Claridge, 2002; Menor et al., 2001)
	Logistics	(Gligor & Holcomb, 2012, 2014; Lynch, Keller, & Ozment, 2000)
Practice	TQM	(Fullerton et al., 2014; Kannan & Tan, 2005; Prajogo & Sohal, 2006)
	Lean	(Bortolotti, Romano, Martínez-Jurado & Moyano-Fuentes, 2016; Fullerton et al., 2014; Netland, Schloetzer & Ferdows, 2015)

	JIT	(Fullerton et al., 2014; Inman, Sale, Green, & Whitten, 2011; Kannan & Tan, 2005)
	Management practices	(Bloom, Genakos, Sadun & Van Reenen, 2012; Bloom & Van Reenen, 2007)
Technology	Enterprise systems	(Hendricks, Singhal & Stratman, 2007; Kjellsdotter Ivert & Jonsson, 2010; Su & Yang, 2010)
	Manufacturing technology	(Finger, Flynn, & Paiva, 2014; Rahman & Bennett, 2009; Zhang, Vonderembse & Cao, 2006)
	Information management for Industry 4.0	(Mehmood, Meriton, Graham, Hennelly, & Kumar, 2017; Theorin, Bengtsson, Provost & Lieder, 2017; Wu, Tseng, Chiu & Lim, 2017)

Source: Authors (2018).

According to Table 3, a body of empirical studies have highlighted process, practice and technology as an influence on the operational performance, although its development level differs across firms. 'Process' is a construct that refers to all operational activities realized in firms, such as Sales and Operations planning (S&OP), Purchasing, Manufacturing and/or Service, and Logistics. In turn, 'Practice' consists of tools that executives might incorporate into their activities in order to improve their results, such as Total Quality Management (TQM), Lean manufacturing (or also Lean operations), Just in time (JIT), and Management practices. Finally, 'Technology' is stated in two ways: (a) as a set of manufacturing equipment used in the production of goods and services; and (b) information software, systems, and ways addressing data management in the operational chain, such as big data, support for making decisions, information architecture. In the current environment, technology plays a pivotal role in influencing an organization's processes and practices for improving operational performance, better integration, and flow of information throughout the organization.

In accordance with the operational capabilities concept by Peng et al. (2008), processes, practices and technology can be an internal factor of firms able to provide support to operational capability development. Besides this, companies possess distinct levels of development in their operational tasks. We claim these factors as antecedents of operational capabilities. Thus, any change in process, practice, and technology as antecedents leads firms to develop their operational capabilities. Seeking to identify mechanisms to support this process of development, we discuss co-evolutionary theory below.

3. The Co-evolutionary theory

The co-evolutionary theory was born in the biology field by Ehrlich and Raven (1964), arguing a mutual genetic evolution among butterflies and some plant species. This term was built upon the Darwinism perspective, in which two (or more) organisms reciprocally evolve with each other (Porter, 2006; Wilson & Hynes, 2009). The concept has grown in the natural sciences, and has spread to other fields. Similarly, in the social sciences, the co-evolution is applied to understand how an individual or organizations interact with their environment, while the latter simultaneously modifies their actions (Lewin & Volberda, 1999).

The theory represents an interdependent result of managerial action, industry and the institutional environment, in which it assumes a simultaneous process of multidirectional interactions between stakeholders over time (Lewin & Volberda, 1999). These relationships have distinct speeds according to the context, industry and set of players (Madhok & Liu, 2006). Five properties support the co-evolutionary theory, which makes it different from other kinds of evolutionary perspective, such as: multilevelness and embeddedness, multidirectional causalities, non-linearity, positive feedback or also negative feedback (Breslin, 2011; Van den Bosch, Volberda, & de Boer, 1999), and path and historical dependence (Lewin & Volberda, 1999). These properties were synthesized and compared with theories previously discussed in the last section (see Table 4).

Table 4: Differences and similarities between theories

Properties	**Co-evolutionary theory**	**Evolutionary theory**	**Microfoundations perspective**	**Resource-based theory**
Multilevelness and embeddedness	Represents all levels of analysis (such as micro-, meso- and macro-level), and the firms' engagement in their contexts	Emphasize the competitive environment of firms (micro-) in the industry context (meso-level)	Cover the individual level and its interactions at the micro-level	Refers to the firm environment (micro-level)
Multidirectional causalities	Actors at distinct levels can influence each other over time	Firms adapt their internal resources based on the industry competition context over time	Individuals' behaviour depends on the context	Not applicable
Non-linearity	Influences have no logical sequence, it means that a change in one variable can generate a	All firms evolve based on the industry competition context	The context influences the individuals' behaviour, just as an individual can influence the changing context	Not applicable

	counterintuitive effect on others			
Positive feedback	Each adaptation in a firm might provoke a feedback effect on markets and other firms	Not applicable	Not applicable	Not applicable
Path and history dependence	The current position of a firm can be explained based on its decisions over time	The current position of a firm can be explained based on its decisions over time	The current position of a firm can be explained based on its decisions over time	The current position of a firm can be explained based on its decisions over time

Source: Adapted from (Barney, 1991; Barney, Ketchen & Wright, 2011; Felin & Foss, 2005; Felin et al., 2012; Lewin & Volberda, 1999; Nelson & Winter, 1982).

According to Table 4 above, the Evolutionary theory, the Microfoundations perspective and Resource-based theory are limited in their scope. Firstly, these theories do not cover multiple levels of analysis, such as micro-, meso-, and macro-level interplay. Secondly, they are restricted by the directional causalities arising from distinct actors, e.g. Evolutionary theory affirms that firms combine external with internal resources and evolve in order to survive in their industry, whereas Microfoundations is limited to the individual's range level. Thirdly, while the Evolutionary theory demonstrates a linearity by arguing the continuous evolution of firms over time, the Microfoundations perspective shows a collective construction of individuals based on their background without any linearity. Finally, except co-evolutionary theory, none of the other theories mention the feedback effect of actors' decisions and outcomes. Based on these arguments, we will use the co-evolutionary theory to support our argument in the operational capability development process. Empirical studies have employed distinct methods, as well as different co-evolution modes and levels of analysis (see Table 5).

Table 5: Empirical studies of coevolution

Authors	**Co-evolution modes**	**Method**	**Level of analysis**	**Result/Contribution**
(Huygens, Baden-Fuller, Bosch, &Volberda, 2001)	Firm - industry	Longitudinal historical and comparative case study	- Firms (Island Records, Virgin Records, BMG International, Warner Music, Roadrunner Records, Independiente - Industry (music)	The competition among new entrants and existing players gave birth to new competition strategies and organizational structures.

			- Country (UK)	
(Rodrigues & Child, 2003)	Firm - Institutional environment	Longitudinal case study	- Firm (Telemig) - Industry (Telecommunication) - Country (Brazil)	Telemig took new forms over time due to institutional pressure (economic and political); telecommunication industry (especially multinationals) influenced the competition system, and regulatory adaptation
(Jacobides & Winter, 2005)	Firm - industry	Cross-sectional case study	- Firm, industry and country (Mortgage bank industry in the US and a Swiss watch-manufacturing industry)	They demonstrate that firms and industries co-evolve by integrating or disintegrating their vertical scope and developing their capabilities (taking new organizational forms over time)
(Dieleman & Sachs, 2008)	Family business - national institutions	Cross-sectional case study	- Firm (Salim group) - Macro (national institutions) - Country (Indonesia)	The study reveals the macro co-evolution between Salim's group and national institutions of Indonesia
(Koza, Tallman, & Ataay, 2011)	Headquarters - subsidiaries	Cross-sectional case study	- Firm (Renault group) - Country (France and Turkey)	The group has created a subsidiary firm in Turkey that, over time, has developed better practices that have influenced the headquarters. The head office has changed its requirements and disseminated these practices to other subsidiaries
(Child, Rodrigues, & Tse, 2012)	Firms-industry - government institutions	Cross-sectional case study	- Firm (YICT) - Industry (port) - Macro (government institutions) - Country (China)	They analysed the role of individual firms and external organizations as a relational process built over time among different actors; The YICT case has highlighted especially the political perspective in a highly institutionalized environment
(Braguinsky & Hounshell, 2016)	Individual-Firm - Industry	Cross-sectional case study and nanoeconomic method	- Individual (Yamanobe) - Firm (Osaka) - Industry (Textile) - Country (Japan)	The case explained an individual that modified the industry competition through his management ability. Over time he became a reference for the entire industry.

(Duarte & Rodrigues, 2017)	Industry institutions-government	Longitudinal case study	- Industry institutions (automotive industry) - Country (Brazil)	The case shows the role of industry institutions and government as active players in automotive industry policy. They have distinct interests, but influence each other.

Source: Authors (2018).

According to Table 5, previous empirical studies covered distinct modes of co-evolution, such as intra-firm (Koza et al., 2011), firm-industry (Braguinsky & Hounshell, 2016; Huygens et al., 2001; Jacobides & Winter, 2005), the firm-institutional environment or government institutions (Child et al., 2012; Dieleman & Sachs, 2008; Rodrigues & Child, 2003), and industrial institutions-government (Duarte & Rodrigues, 2017). Most studies used the case study method based on cross-sectional and longitudinal analysis to demonstrate these relationships and changes. However, the co-evolution phenomenon requires a longitudinal analysis in order to understand the mutual evolution among actors (Breslin, 2016; Jacobides & Winter, 2005). These empirical studies help us to understand that firms are embedded in industrial and institutional contexts (meso- and macro-levels respectively); thus, each change in one of these levels can provoke an adaptation in others.

Whereasmost studies in operations management field are cross-sectional in nature, using surveys, case studies or another prominent method for data collection, they lack longitudinal focus to understand the operational capability phenomenon. Furthermore, previous studies do not encompass the three levels of analysis - micro, meso and macro in the same study. From this point of view, we argue that co-evolutionary theory can help to extend and contribute to operations management research on operational capabilities development. More discussion about this will be addressed in the next section.

4. Toward an extended theoretical conceptualization of operational capability development

This section seeks to extend the current view of operational capabilities development to providing a procedural framework supported by co-evolutionary theory. We established from the literature review process that most studies using the evolutionary theory to explain the mechanisms of operational capability development (see section 2.2) are limited in their scope.

They consider the company evolution independently of their context evolution. However, rather than rejecting the evolutionary theory, we extend this discussion by arguing that firms adapt their operational processes based on the performance of a leading company, and/or industrial and institutional changes. These adaptations directly affect operational capabilities development. We provide detailed explanation of the procedural framework below (see Figure 2 – white boxes represent intra-firm phases and grey boxes represent external ones).

Firstly, rarely are firms embedded in blue ocean contexts; they require identifying opportunities and threats continuously – called 'sensing' by Teece (2007). This evidence can come from distinct levels of analysis, such as industry context (such as suppliers, customers, competitors) and institutional (such as government, institutions, regulatory) (Lewin & Volberda, 1999). Therefore, firms seek to identify opportunities and threats internally and externally in order to improve their processes, practices and technology.

Secondly, firms evaluate these opportunities and threats identified to implement in their operational processes – called 'seizing' by Teece (2007), based on a cost-benefit analysis. However, the firm's adaptation process is dependent on their background and history (Winter, 2012; Wu et al., 2010), and on its competitive priority (Boyer & Lewis, 2002; Corbett & Claridge, 2002; Pagell et al., 2000). Therefore, the next phase, named 'reconfiguring' by Teece (2007) means adapting the firm's processes, practices and technology according to their history, background, and competitive priority. Our framework considers these three stages by Teece (2007), and also extends these mechanisms by linking it to co-evolutionary theory.

Thirdly, the best fit among processes, practices and technology will lead to the development of operational capabilities, and consequently it will affect the firm's outcome (Peng et al., 2011; Schoenherr & Narasimhan, 2012; Wu et al., 2010). In addition, the firm's outcome becomes like a feedback about the internal resources adaptation – named internal feedback in the framework. However, any imbalance in the internal factors may influence the operational capability development over time, or suffer mutability. It means that some improvement in one of these internal resources lead to operational capabilities development.

Fourthly, the firms' outcomes are the triggers to do any organizational adaptation. For example, if the outcome of a firm will be higher than competitors, then it can provoke an adaptation in the industry and institutional contexts (e.g. Braguinsky & Hounshell, 2016). On the other hand, technological changes (Lavie, 2006), industry adaptation (Jacobides & Winter, 2005) and the institutions roles (Teece, 2007), or other uncontrolled external event can influence the process of identifying opportunities and threat (sensing), the evaluation (seizing)

and the adaptation process of firms (reconfiguring). In addition, we named external feedback mechanism to measure influences coming from market and external players.

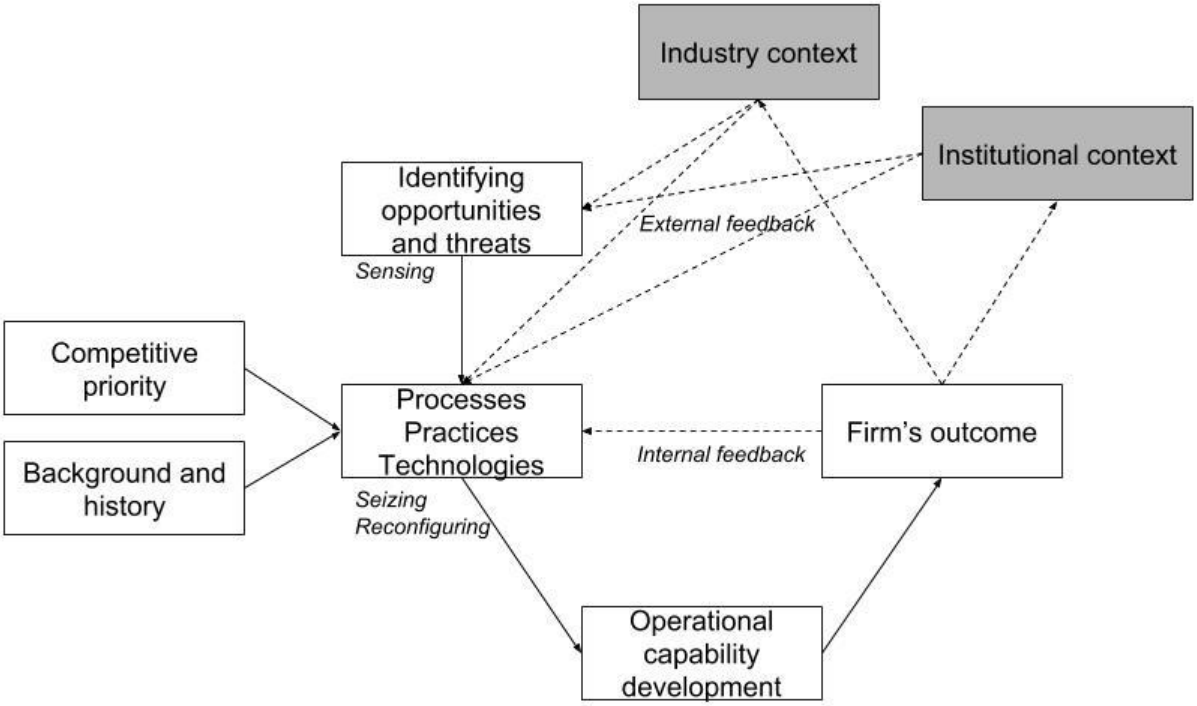
Fifthly, as a cyclical process of interplaying influences on external players, and being influenced by them, firms develop their processes, practices and technologies in order to improve their operational capabilities over time. This joint evolution has been demonstrated by empirical studies, such as intra-firm (Koza et al., 2011), firm-industry (Braguinsky & Hounshell, 2016; Huygens et al., 2001; Jacobides & Winter, 2005) and firm-institutions, and government (Child et al., 2012; Dieleman & Sachs, 2008; Rodrigues & Child, 2003). For example, Koza et al. (2011) demonstrated the evolution of operational practices in a subsidiary that influenced the headquarters' manufacturing perception, so it resulted in a dissemination of these practices to other subsidiaries. Braguinsky and Hounshell (2016) explained the role of a firm that influenced the entire textile industry by betting on their own manufacturing skill-sets. Finally, Rodrigues and Child (2003) showed a mutual process of operational structure adaptation of firms and regulatory changes from the Brazilian automotive case.

Sixthly, firms may develop their capabilities in different ways, and so a couple of contingencies need to be analysed in our framework. It is related to the Flynn and Flynn's (2004) study that indicated the process of capability development as a complex endeavour affected by many interrelated contingencies. First, firms possesses distinct processes, practices and technology maturity levels; Wheelwright and Hayes (1985) proposed a categorization of four stages of manufacturing structure development as a way to demonstrate distinct levels of manufacturing maturity. Second, most studies that demonstrate a joint evolution with industries and institutions refer to big companies; the size of the company is an important variable to determine the strength and impact range (e.g. Braguinsky & Hounshell, 2016; Dieleman & Sachs, 2008; Rodrigues & Child, 2003). Third, the level to which a firm is embedded into its environment refers to another contingency. For example, Dieleman and Sachs (2008) demonstrated a co-evolution between the Salim group and Indonesian institutions, where the Salim group helped the government to develop policies and took advantages by accessing privileged information. Fourth, the empowerment of actors in a context on the (co-)evolution of organizations, such as industry, competitors, suppliers, customers, institutions and others; Duarte and Rodrigues (2017) showed the evolution of the automotive industry in Brazil by highlighting the role of government and industry interests as mediators for stimulating or reducing the sector attractiveness.

A limited amount of literature on internal and external mechanisms were analysed for developing operational capabilities. Internally, we argued that sensing (identifying

opportunities and threats), seizing (evaluating opportunities and threats), reconfiguring (adapting internal resources) (Teece, 2007), and internal feedback mechanisms as foundations to improve internal resources (processes, practices and technology), lead to operational capabilities development. Externally, supported by co-evolutionary theory, we highlight external feedback mechanisms for indicating a response to external player's adaptations.

Figure 2: The procedural framework



Source: Authors (2018).

The framework shown is supported by five properties according to co-evolutionary theory (Lewin & Volberda, 1999, 2009; Volberda & Lewin, 2003). In the nest section, we used the co-evolutionary perspective to propose some gaps for future studies.

5. A Research Agenda

Limited operations management literature have focused their discussion on developing the operational capabilities from a multi-level perspective, or have taken a longitudinal approach to understand the process of capabilities development over time. In order to extend the current knowledge of operational capabilities development, we propose a set of three unanswered questions for future studies based on the co-evolutionary perspective.

First, recent research has highlighted the role of internal and external factors on capabilities development. Beltagui (2018) analysed the process of design capabilities development from a manufacturing company in transition to a service business model. According to the author, four reasons supported design capability development: (a) they increased product performance from interactions with customers supported by a robust virtual design, test and optimization; (b) issues outside of specifications are noted by service experts and replaced for future work of designers; (c) designers enhanced their technical skills for ensuring a manufacturing feasible; (d) they shifted from a reactive to a proactive service by checking and making recommendations on the customers' equipment. Finally, all of these happened based on a synchronous process of adaptation between the new company's business model and design capabilities focus. In turn, based on a sample of Finnish IT companies Valtakoski & Witell (2018) found that front-office service capability has a strong relationship to financial performance, whereas back-office service capability indicates a negative association over that. While front-office capability appears to affect companies' performance for delivering high-level services to customers, the counterintuitive result of back-office capability on financial performance considers the struggle of small and medium companies by interplaying a selection of right capabilities in a pool of scarce resources.

Contrasting, other studies have added an external view when considering the role of supply chain partners on the process of operational capability development. For example, Aslam, Blome, Roscoe, & Azhar (2018) argue market sensing capability as an antecedent to supply chain agility and adaptability, and efficiency and responsiveness, respectively. Market sensing capability is understood as a companies' skill by evaluating market trends, customers, and competitors. Vanpoucke et al. (2014) found the integration with suppliers for performing the sensing, seizing and reconfiguring mechanisms allow companies to create the supplier integrative capability. This capability results on improving cost efficiency and process flexibility, and market and financial performance respectively. When researching dyads – manufacturer/suppliers and manufacturer/customers, Raddats et al. (2017) identified capabilities being developed collaboratively. This study shows capabilities do not reside only

within one company, but they are built when two or more actors become engaged to create value cooperatively.

Looking to build upon these previous researches, this study proposes a new theoretical lens for the capability development process supported by five mechanisms – sensing (Aslam et al., 2018; Teece, 2007; Vanpoucke et al., 2014), seizing (Teece, 2007; Vanpoucke et al., 2014), reconfiguring(Teece, 2007; Vanpoucke et al., 2014), and internal and external feedbacks. Therefore, empirical studies can help to advance this debate ahead, so, *how do firms interplay sensing, seizing, reconfiguring, internal and external feedback mechanisms to develop their operational capabilities?* Future studies can address on this question for analysing how these mechanisms work jointly through multiple or single case studies with longitudinal or retrospective data (e.g. Beltagui, 2018; Raddats et al., 2017). Further, research can support these mechanism by performing surveys and/or analysis with secondary data (e.g. Aslam et al., 2018; Beltagui, 2018).

Second, the process of capabilities development has been highlighted as a complex endeavour affected by many interrelated contingencies (Flynn & Flynn, 2004; Schroeder et al., 2010). Empirical research have faced some contingences when analysing capabilities development. For testing the relationships among competitive priorities, operational capabilities and performance, (Peng et al., 2011) found different coefficients across countries, industries, size of plants, and capabilities degrees. Regarding these contingencies, the study suggest future research on emerging economies and new industry contexts (e.g. e-commerce, quasi-manufacturing service) due to the technological advancement over last decades.

Brandon-Jones & Knoppen (2018) found a positive effect of purchasing recognition on purchasing involvement, and it on knowledge scanning – it refers an ability of firms to get knowledge from internal and supply chain resources. In addition, knowledge scanning exerts a positive effect on cost and innovation performance. However, results of service companies are higher than manufacturing ones. This result is explained regarding the usual co-creation of value with customers faced by service-based companies, increase of outsourcing activities in supply chains, and the infancy of strategy purchasing for service companies as well.

As mentioned above, the Valtakoski & Witell's (2018) study analysed the effect of back-office and front-office service capabilities on financial performance of Finnish IT firms. Results indicated distinct effects on these relationships when moderated by firms' age. Opposite to older companies, results indicated that younger companies benefit from front-office service capabilities and later for the back-office services. It is in line to the priority of initial investment of young companies looking to a high customer experience at the first moment; in addition,

older companies have experienced back-office processes whether compared to young companies. Finally, this study reveals a way for firms choosing right capabilities to achieve success on their activities.

Building upon these previous studies, this paper proposes a set of mechanisms in which can be examined on different contexts. From this, a new question arises looking to the OC development: *How do these contingencies affect different paths of operational capabilities development?* Regarding a limited qualitative empirical focus on previous studies,future research can analyse in-depth single or multiple case studies to verify how work those mechanisms proposed by this paper. At this moment, theory-driven studies are welcome to verify them in advance of the OC literature. However, data-driven studies can be useful as well for highlighting contingency features in specific contexts.

Third, a significant attention of OM journals is coming up for the technological transition research through special or regular issues. The International Journal of Production and Operations Management (IJOPM) published a special issue focused on “Big data and business analytics”, and created two additional special issue focused on “The Use of Social Media in Operations and Supply Chain Management” and “The Fourth Industrial Revolution (Industry 4.0): Technologies' Disruption on Operations and Supply Chain Management”. The Production and Operations Management (POM) published a special issue of “Management of technology” and “Perspectives on Big Data”. Finally, the Journal of operations management (JOM) called papers for the special issue “Combining Simulation and Empirical Research Methods in Operations Management”. As the main OM journals, both are demonstrating a significant interest for research on the role of technology on operational activity of manufacturing and service companies.

Recently, the term Industry 4.0 has raised in OM field as a prominent topic for connecting their supply chain in real time, influencing real-time decision-making and managing performance remotely of their processes and people. Embracing such technological development within their processes and supply chain will provide competitive advantages over competitors. As a broad multidimensional phenomenon, a body of empirical studies have drawn on methods adopted by companies, for example, information system architecture (Theorin et al., 2017), big data (Mehmood et al., 2017) and multi-criteria decision-making structure (Wu et al., 2017).

Regarding the emergence of a new technological revolution, studies in OM which addressing on how a technological emphasis can be useful to create or develop their capabilities. As a new research field, we are not aware about any study linking operational capabilities development

to technological transition topic. Therefore, it allows a future research question arising: *how do companies link the technological transition to develop their operational capabilities?* Retrospective case studies are welcome in order to comprehend the impact of this technological revolution on companies' activities.

6. Conclusion and Implications

This paper aims to provide a procedural framework of operational capabilities development by integrating operations management literature and co-evolutionary theory. Furthermore, a literature review was employed in order to cover the current knowledge of the capabilities literature and its development process. Based on previous studies from operations management, strategy, and general management field, we propose a framework and a set of six opportunities for future studies to analyse the operational capability development process.

Little discussion in the literature was directed towardoperational capabilities development. The operations management literature faced the long debate between the traditional trade-off conception and the cumulative view of capabilities, but a limited amount of literature has attempted to explain the mechanisms of its development from a longitudinal study perspective. On the other hand, studies in the strategy and general management fields have addressed some ways to understand the dynamic capabilities and organizational capabilities development process. However, they do not cover distinct levels of analysis, and the interplay among multiple actors. Therefore, as a theoretical contribution, this study extends the current literature of operations management by arguing the simultaneous role of internal and external mechanisms in operational capabilities development.

The managerial contribution of this study is aligned to the current dynamism in manufacturing, such as Industry 4.0, in which managers should pay attention to ways to manage data and use them to make operational decisions to be able to gain a competitive advantage. Managers need to be alert to external changes arising from multiple external players, such as consumers, customers, suppliers, competitors, entities and institutions. Therefore, decision-making based on real-time data allows one to follow external trends or to evaluate internal performance of processes that are integrated with the latest technologies. Finally, this study can be useful to managers to evaluate adaptations in their operations as a way to improve their capabilities.

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PAPER 2 – QUANTITATIVE PAPER

The second paper, entitled “Interplaying internal and external mechanisms for the operational capabilities development” refers an application of the theoretical purpose from the first paper. This quantitative paper evaluates the relationship between internal and external mechanisms to explain the operational capabilities development. An international database called High Performance Manufacturing (HPM) gave us support to analyze those relationships.

Prior version of the paper was submitted to 21st Simpósio de Administração da Produção, Logística e Operações Internacionais (SIMPOI) and 42nd Encontro da ANPAD (Enanpad) conferences.Wehave been honored for receiving the “Claude Macline award” - best paper away in the 21st Simpósio de Administração da Produção, Logística e Operações Internacionais (SIMPOI).

Interplaying internal and external mechanisms for the operational capabilities development

Abstract

This study analyzed the impact of internal and external mechanisms on the process of operational capability development. While internal mechanisms consist a set of operational resources used by firms in order to improve their performance, external ones refers to the influences coming from external players. A dataset of 251 companies of fifteen countries were used from High Performance Manufacturing – HPM database. The results demonstrated that internal factors when measured by customer and supplier market knowledge, effective process implementation, continuous improvement, anticipation of new technology and operational performance positively influence operational capabilities. Furthermore, as external actors, suppliers and customers appear to affect indirectly operational capability of firms.Finally, these results demonstrate a cyclical process across internal and external mechanisms over time for the operational capability development. This study contributes to advance the understanding of operational capability development process.

Keywords: Operational Capabilities, Internal mechanisms, External mechanisms, Operational Performance.

1. Introduction

Capabilities term has been understood as a specific strength of firms by performing the same activity over competitors (Peng, Schroeder, & Shah, 2008; Wu, Melnyk, & Flynn, 2010). For doing so, most OM studies have argued idiosyncratic internal factors as antecedents to explain capability's emergence, such as manufacturing practices (Fullerton, Kennedy, & Widener, 2014; Swink, Narasimhan, & Kim, 2005), manufacturing resources (Chavez, Yu, Jacobs, & Feng, 2017), and process implementation (Huang, Kristal, & Schroeder, 2008). Further, supply chain partners have been highlighted as external actors for helping companies to build their capabilities (Chen, Su, & Ro, 2017; Dangol, Bahl, & Karpak, 2015; Vanpoucke, Vereecke, & Wetzels, 2014).

However, limited discussion have been addressed on the process of capabilities development and its mechanisms (Dangol et al., 2015). Specifically, previous studies have not

considered jointly internal and external mechanisms into the same framework and its influence on capabilities development. Therefore, this study proposes to build upon prior literature for addressing in the following research question: To what extent internal and external mechanisms impact on the operational capabilities development?

Building upon previous studies, we consider customer and supplier market knowledge (Alfalla-Luque, Machuca, & Marin-Garcia, 2018), effective process implementation (Huang et al., 2008), continuous improvement (Peng, Schroeder, & Shah, 2011), and anticipation of new technology (Finger, Flynn, & Paiva, 2014) as internal mechanisms to measure operational capabilities development. In addition, we added operational performance as an internal mechanism on its development for influencing adaptations on theinternal factors of firms over time; Thereof, it refers to an internal feedback effectsupported by co-evolutionary theory(Lewin & Volberda, 1999).

In turn, external mechanisms refer to external players and partners in which may influence adaptations on the market knowledge of firms for identifying opportunities or threats. In this study, we used customers and suppliers as external mechanisms to analyze those mutual influences across companies. At the same way, it consists an external feedback effect in which firms influence and are influenced over time, according to co-evolutionary theory (Lewin & Volberda, 1999). Therefore, we argue this whole picture leads firms to develop their operational capability over time.

Co-evolutionary theory was used in this study for a couple of reasons. First, previous studies argued their hypothesis in theories with limited scope to explain operational capabilities development process, e.g. evolutionary theory (Helfat & Peteraf, 2003; Winter, 2012), resource based theory (Rockart & Dutt, 2015), and microfoundations (Felin, Foss, Heimeriks, & Madsen, 2012). Second, co-evolutionary theory considers a joint evolution among firms and their environments over time (Lewin & Volberda, 1999; Lewin & Volberda, 2009). Third, co-evolutionary theory provides five properties able to understand the process of operational capabilities development.

Our data come from the fourth round of High Performance Manufacturing (HPM). The full database with 330 companies from fifteen countries were evaluated, but just 251 data were useful. Data was analyzed through two steps: first, we ran a confirmatory factorial analysis (CFA) to refine latent variables; second, we ran the structural model to check path loadings and significance effect among its relationships. Concerning to extend the current literature of operational capabilities, partial least square structural equation modeling (PLS-SEM) was adopted to analyze the causal assessment.

Our results demonstrate that customer and supplier market knowledge, effective process implementation, continuous improvement and anticipation of new technology refers to antecedents of operational capabilities. In addition, these antecedents were positively influenced by operational performance, as well customers and suppliers latent variables. Overall, it indicates operational capabilities development as a cyclical process based on influences coming from internal and external mechanisms. For doing so, this study contribute for advancing the current knowledge of the process of operational capability development.

Next sections of this study are organized as follow: We present a literature review of operational capabilities and co-evolutionary theory to be able to create the hypothesis development section. Further, methodology section discussesthe steps taken to operationalize our analytical framework. We test hypothesis in the data analysis and results section, and we confront results of this study to the current literature in the discussion section. Finally, in the conclusion section we provide contributions of the paper, implications and ways for future research.

2. Literature Review and Hypothesis Development

2.1 Operational capability

Operations Strategy is a topic in the OM field that have analyzed ways in which firms pursue to achieve superior operational performance over competitors. That literature has been discussed based on trade-off concept and on the cumulative way. Firstly, in his seminal study, Skinner (1969) demonstrates that firms must to choose a competitive dimension in manufacturing task (such as cost, quality, speed) in order to align it to the corporate strategy. According to his study, for choosing one dimension, firms should regret others.

Early literature of operations strategy has emphasized best practices of leader firms have adopted in their manufacturing system. It has been named as ‘manufacturing capabilities’ which means an ability of firms performing manufacturing activity based on quality, delivery, flexibility, and cost (Hayes & Wheelwright, 1984; Skinner, 1969; White, 1996). As a related term, other studies sorted it as a ‘competitive capability’ for indicating an alignment between corporate strategy and competitive priority of firms (Rosenzweig & Easton, 2010; Rosenzweig & Roth, 2004). Then, many studies have defended operational capabilities based on the trade-

off concept even decades later (Boyer & Lewis, 2002; Hayes & Wheelwright, 1984; Lapre & Scudder, 2004; Pagell, Melnyk, & Handfield, 2000).

Contrasting trade-off conception of operational capabilities, Ferdows & De Meyer (1990) pointed the cumulative capability term by arguing a progressive way for firms adopting competitive capabilities. According to the authors, firms adopt those capabilities cumulative and sequentially, starting for quality, dependability, speed and cost efficiency respectively. Besides that, empirical studies have found no one statistically significant evidence to support Ferdows and De Meyer's framework (Flynn & Flynn, 2004; Schroeder, Shah, & Peng, 2010). On the other hand, Roth and Miller (1992) found that best manufacturers compete based on multiple competitive capabilities simultaneously, and do not sequentially such as stated by Ferdows and De Meyer (1990).Noble (1995) reinforced Roth and Miller (1992) results for has found similar evidences from a sample of North American, European and Korean firms.

Assuming a combinative way of competitive capability view, Rosenzweig and Roth (2004) states the 'Competitive Progression Theory' term. According the authors, firms must follow a specific sequence of competitive capabilities such as conformance quality, delivery reliability, volume flexibility, and cost efficiency to be able to benefit from a simultaneous effect of their competitive capabilities. At the same way, Rosenzweig and Easton (2010) found from a meta-analysis that, on average, manufacturers do not face trade-offs like defended by classical trade-off conception. The debate of combinative, cumulative and trade-off concepts refer to an assumption in OM field, which it remains alive since the nineties by experts in this topic.

Even more, previous studies have understood operational capabilities term from distinct ways, such as a process of transformation in the operations system (Peng et al., 2008; Wu et al., 2010), a set of manufacturing or management practices (Brito & Sauan, 2016; Tan, Kannan, & Narasimhan, 2007), or an outcome (Schoenherr, Power, Narasimhan, & Samson, 2012). Besides a lack of consensus of operational capability concept, prior literaturehas a similar position regarding its positive effect on the operational performance (Peng et al., 2008, 2011; Schoenherr & Narasimhan, 2012; Tan et al., 2007; Wu et al., 2010).

In order to clarify that field, Peng et al. (2008) conceptualized operational capabilities as '[…] the strength or proficiency of a bundle of interrelated routines for performing specific tasks' (p. 734). Thus, capabilities are formed by a set of routines that are composed for resources in their base, specific of firms and history dependent (Wu et al., 2010). On the other hand, limited discussion have been addressed on the operational capability development process.

Looking to advance this literature, we discuss the antecedents of operational capabilities and their influence on its development process in the next section.

2.2 Antecedents of operational capabilities

Operational capabilities have been understood as a set of interrelated routines of firms for performing through their resource base (Peng et al., 2008). Translating 'routines' to operations management field, it refers to a couple of factors involved in the operational task. Built upon that, previous studies have argued as a process of transformation of inputs to outputs (Nath, Nachiappan, & Ramanathan, 2010; Wu et al., 2010), an adoption of operational practices (Brito & Sauan, 2016; Tan et al., 2007), and a process of acquisition or anticipation to the best available technology (Finger, Flynn, & Paiva, 2014) as a way for firms developing their operational capabilities.

There is no consensus in the current literature about the antecedents of operational capabilities, once it has been understood as a phenomenon composed by tangible and intangible elements. However, it has been explored by previous studies through two ways. On the one hand, previous studies have pointed out organizational knowledge as an intangible element of the organizational capabilities regarding their value for decision-making, and identifying new opportunities and threats (Grant, 1996). On the other hand, a body of empirical studies shed light on the role of tangible factors, such as operational practices and new technologies (Finger et al., 2014; Brito & Sauan, 2016; Wu et al., 2010).

As one of the most important internal resource of firms, the organizational knowledge has been understood by its internal and external perspective. While internal knowledge has been focused as a way in which firms explore their internal resources, external knowledge refers to meeting a set of opportunities and threats in the market (Paiva, Roth, & Fensterseifer, 2008). Previous studies have pointed out market knowledge as a way for firms to detect changes proactively in the market in which their supply chain operates (Alfalla-Luque et al., 2018; Lee, 2004). Further, OM studies have focused on customers and suppliers market knowledge in order to manage firms' operational activities adaptability (Alfalla-Luque et al., 2018; Paiva et al., 2008).

Regarding the tangible part of operational capabilities, a set of studies have focused on effective process implementation, continuous improvement and anticipation of new technologies. First, a body of studies have adopted effective process implementation as a precedent of operational capabilities (Garrido-Vega, Jimenez, De Los Ríos, & Morita, 2015; Huang et al., 2008; Matsui, 2007; Morita & Flynn, 1997).Effective process implementation

consists the effectiveness of firms in developing and implementing new manufacturing process and equipment (Huang et al., 2008). In the other words, it refers to an ability of firms by adapting their manufacturing processes and equipment arrangement (Morita & Flynn, 1997).

Second, continuous improvement has been comprehended like an operational practice of firms related to quality management tools (Bortolotti, Danese, Flynn, & Romano, 2015; Escrig-Tena & Bou-Llusar, 2005; Swink et al., 2005); however, on the other hand, it has been also applied as a kind of operational capability for firms performing their operational task better than competitors (Bessant & Francis, 1999; Coltman & Devinney, 2013; Peng et al., 2008, 2011; Tan et al., 2007; Wu et al., 2010). Previous studies have used the continuous improvement as an antecedent of the operational capability latent variable (Bortolotti et al., 2015; Peng et al., 2008, 2011).Third, anticipation of new technology has been understood like a competitive weapon in which companies face to improve their manufacturing task over rivals (Matsui, 2007). It is related to the Hayes and Wheelwright's (1984) matrix which competitive companies are those located in the proactive grade for anticipating their manufacturing development over external changes. Finger et al.(2014) argued the anticipation of new technologies latent variable as an antecedent of operational performance.

From these, we combine intangible and tangible elements to support our framework. Therefore, we underlie customer and supplier market knowledge, effective process implementation, continuous improvement, and anticipation of new technologies as antecedents of operational capability. The framework considers customer and supplier market knowledge as a driver for the adaptations in the resource base of firms, and consequently its effect on the operational capability development. As we argue the effect of operational performance and external players' action on antecedents of operational capabilities, co-evolutionary is shown in the next section.

2.3 Co-evolutionary theory

Co-evolutionary theory came from Biology field by demonstrating a joint evolution between butterflies and some species of plants (Ehrlich & Raven, 1964). This term was brought to Social Science by Lewin and Volberda (1999) for mentioning simultaneous interactions among managerial action, industry, and institutional and government environment. In addition, co-evolutionary theory is a macro-theory for integrating several theoretical approaches, and it refers to a promising theory to reduce the dichotomy between determinism and voluntarism view in the management literature. While in the determinism side emphasizes external factors

as determinant of the firms' adaptation, voluntarism cover factors from managerial action (internal scope) (Abatecola, 2012).

Five properties support coevolution theory and differ it from other kind of evolutionary perspective, such as multilevelness and embeddedness, multidirectional causalities, nonlinearity, positive feedback, and path and history dependence. In order to characterize a co-evolutionary phenomenon, all properties should meet together at the same time (Lewin & Volberda, 1999, 2009). These properties are detailed in the table 6 as well we described them related to our analytical framework.

Table6:Properties of co-evolutionary theory

Properties	Description	Application in our framework
Multilevelness and Embeddedness	Consist all levels of analysis (such as intra-firm, industry, and institutional), and the embedded level that a firm is	Our framework evaluate a mutual evolution among internal resource of companies, customers and suppliers as base to develop their capabilities
Multidirectional causalities	Refers to a multiple influences that came from different actors (e.g. A and B can influence C, as well as D and E can be influenced by them)	As a firm may influence external players, such as customers and suppliers, theymay influence adaptations on firms' resource base (e.g. practice, process, and technology)
Nonlinearity	Indicates that influences among actors differ over time (e.g. A may influence B, as well as B may influence A in another time)	Sequence of influences across players (company, customers and suppliers) may differ over time
Feedback	Represents a response of firms based on previous influences (e.g. A and B influenced adaptation in C; So, C may adapt its resource base in such a way that provoke adaptations in A and B). It means all action in an actor cause reaction on others	Our framework considers an internal and external feedback as mechanisms to demonstrate operational capabilities development. While external feedback come from customers and suppliers, internal ones emerges from operational performance of a firm.
Path and history dependence	Current position of a firm may be explained by their faced past decisions and challenges.	Decisions looking for improving processes, practices, and technology lead firms to develop their operational capabilities over time.

Source: adapted from Lewin and Volberda (1999).

Beside few studies have addressed a discussion on the co-evolution phenomena, empirical studies have analyzed the joint evolution among firms and supply chain partners (Chen et al., 2017; Jacobides & Winter, 2005), firms and their subsidiaries (Koza, Tallman, & Ataay, 2011), firms and industry (Braguinsky & Hounshell, 2016), and firms and institutional environment

(Cantwell, Dunning, & Lundan, 2010; García-Cabrera & Durán-Herrera, 2016). Specially in the operations management field, Chen et al. (2017) demonstrate a joint evolution between Japanese and North-American automakers with their suppliers based on the relationship quality and product quality aspects. However, that result differs across countries, while high relationship quality of Japanese automakers and their suppliers appear to precede product quality, North-American automakers benefit of product quality when they improve supplier relationship faster than competitors do.

2.4 Hypothesis development

This section shows the hypothesis development of this study. The analytical framework was built from the literature of operational capabilities, antecedents of operational capabilities and co-evolutionary theory. Summarily, figure 3 integrates that debate for providing the relationship between latent variables, as well as demonstrating hypothesis of this study.

The framework demonstrates a process of operational capability development supported by internal and external mechanisms. Internally, we consider customer market knowledge, supplier market knowledge, effective process implementation, continuous improvement and anticipation of new technology mechanisms; in addition, we added operational performance as an internal mechanism from its internal feedback effect on firms' resource base, according to the 'feedback' property from co-evolutionary theory (Lewin & Volberda, 1999). In turn, external mechanisms refer to influences coming from customers and suppliers latent variables (see figure 3).

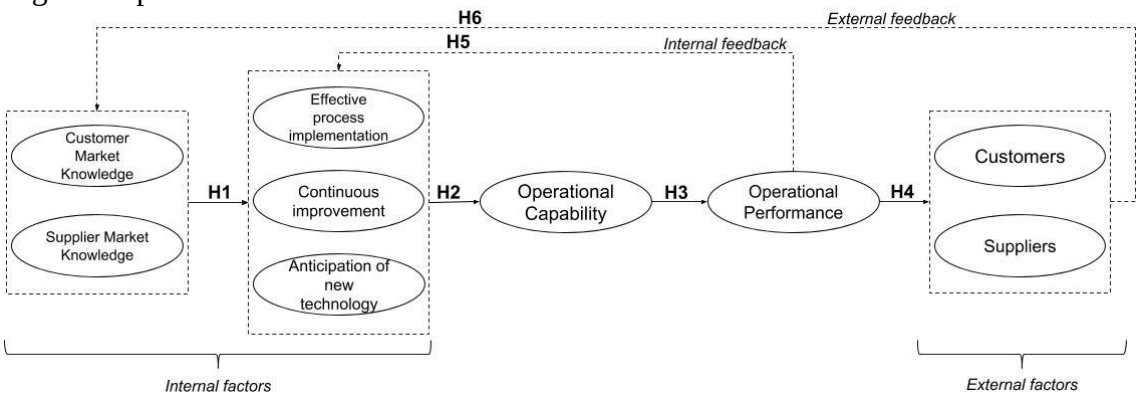
Firstly, in order to identify external opportunities and threats, firms often look at its market – usually they are competitors, suppliers, customers. Lee (2004) indicates some large US companies being more effective than low-costs and fast delivers, but also agile, adaptable and possess a good alignment over their supply chain. For doing so, companies should hold a good market knowledge. According to this argument, Paiva et al. (2008) empirically found a positive impact of the market knowledge on creating values from manufacturing resources. This result reveals the value of market knowledge on companies' adaptations. Extending that discussion, Alfalla-Luque et al. (2018) found a positive effect of adaptability capacity of firms on the operational and financial performances. Based on these arguments, we hypothesize for arguing the market knowledge as positively associated to tangible internal factors of firms.

Hypothesis 1 – Market knowledge positively influence adaptations on tangible internal factors of firms.

Secondly, operational capability term has been comprehended as an ability of firms by performing inter-related routines better than competitors (Peng et al., 2008; Wu et al., 2010). From this, previous studies in the operations management field have found effective process implementation (Huang et al., 2008), continuous improvement (Peng et al., 2008, 2011), and anticipation of new technology (Finger, Flynn, & Paiva, 2014) as base to firms to reach that. According to that literature, we hypothesize that internal factors positively influence operational capability development.

Hypothesis 2 – Internal factors positively influence the operational capability of firms.

Figure3:Operational framework



Source: The authors (2018).

Thirdly, operational capability literature raised to explain heterogeneity of manufacturing performance between firms (Hayes & Wheelwright, 1984; Rosenzweig & Roth, 2004; Roth & Miller, 1992). Beside a couple of different views of operational capabilities, such as based on trade-off concept (Boyer & Lewis, 2002; Pagell et al., 2000), cumulative capabilities (Ferdows & De Meyer, 1990; Schroeder et al., 2010), and combinative capabilities (Rosenzweig & Roth, 2004; Roth & Miller, 1992; White, 1996), both of them indicate a way to understand operational performance heterogeneity of firms. Built upon that, empirical studies have emphasized the positive effect of operational capabilities over performance, when it is measured by quality, delivery, flexibility and manufacturing costs (Peng et al., 2008, 2011; Schoenherr & Narasimhan, 2012; Tan et al., 2007; Wu et al., 2010). According to previous studies, we hypothesize that operational capability positively influences operational performance.

Hypothesis 3 – Operational capability positively influences the operational performance of firms.

Fourthly,co-evolutionary theory states a mutual relationship among companies and their environment. As base to support that phenomenon, it provides some properties, such as multilevelness and embeddedness, multidirectional causalities, and nonlinearity. While multilevelness refers to multiple actors playing together, such as firms (micro-level), supply chain partners and competitors (industry-level), and entities and institutions (macro-level), embeddedness means the degree to which a firm is involved in its context. Multidirectional causalities and nonlinearity properties explain that actors may influence each one and to be influenced over time (Lewin & Volberda, 1999). We bring those mechanisms to support our third hypothesis.

Regarding the process of operational capability development, we hypothesize over firms influencing external players through their performance,which it resultson an external adaptation. Empirical studies have used co-evolutionary theory to demonstrate it. For example, Dieleman and Sachs (2008) showed political changes in the Indonesian institutions from influences of Indonesian Salim group; in turn, Braguinsky and Hounshell (2016) highlighted the influence of Osaka company's performance on industrial policies changes in the Japanese textile industry, as well as adaptations in competitors to be able to survive in their market. From this, we hypothesize that firms' performance may influence external players to adapt their operations.

Hypothesis 4 – Operational performance of firms positively influences adaptations in external players.

Fifthly, according to the internal feedback mechanism from co-evolutionary theory, the firm's operational performance may help managers to do adaptations in the manufacturing task. From this, outcomes arrived by firms are compared to managers' expectations to promote a wave of new adaptations. It is a continuous process, in which managers expect to improve their key performance indicators for overcoming their managerial target. We described this process as an 'internal feedback' in our analytical framework, which it is related to the internal resources base of firms (see figure 3). Specifically, this issue has not been emphasized by previous studies. Thereof, supported by co-evolutionary theory, we argue operational performance – when it is measured distinctly by quality, delivery, flexibility, and manufacturing costs according to previous studies (Peng et al., 2008, 2011; Schoenherr &Narasimhan, 2012; Tan et al., 2007;

Wu et al., 2010), as positively influent on effective process implementation, continuous improvement, and anticipation of new technology.

Hypothesis 5 – Operational performance positively influences tangible internal factors of firms.

Sixthly, last hypothesis extends to previous ones for arguing adaptations in the market knowledge of firms from influences of customers and suppliers. Specifically, this phenomenon is supported by 'external feedback' mechanism regarding influences over firms coming from external players, according to co-evolutionary theory (Lewin & Volberda, 1999). Empirical studies have registered the role of external players on firms' adaptations through influences coming from supply chain partners and competitors (Braguinsky & Hounshell, 2016; Huygens, Baden-Fuller, Bosch, & Volberda, 2001; Rodrigues & Child, 2003), and entities and institutions (Child, Rodrigues, & Tse, 2012; Dieleman & Sachs, 2008).

We argue that firms develop their operational capabilities within a dynamic process, in which players exert influence and are influenced by each other over time. Supported by previous studies, we hypothesize that firms change their market knowledgefrom external influences;therefore, it leads companies to adaptations in their tangible internal factors (Alfalla-Luque et al., 2018; Paiva et al., 2008). As antecedents of operational capabilities, we propose that any imbalance in market knowledge lead to internal adaptations in which affect the operational capabilities development. Based on this argument, we present the last study's hypothesis:

Hypothesis 6 – External players' adaptations positively influence market knowledge of firms.

3. Methodology

This study uses data coming from fourth round of the High Performance Manufacturing (HPM) to test research hypotheses. HPM consists an international project that has started in 1989 by experts of University of Minnesota and Iowa State University with the aim to understand the Japanese multinationals emergence. After that, HPM project have been spread in the world over time from interest of other researchers (Schroeder & Flynn, 2001).

The fourth round data collection started at 2012 and it contains 330 respondents at the moment from fifteen countries: Brazil, China, Finland, Germany, Israel, Italy, Japan, South

Korea, Spain, Sweden, Switzerland, Twain, United Kingdom, United Stated, and Vietnam. These countries were selected due to the composition of high perform and traditional manufacturing firms, and its distinct institutional characteristics, such as cultural, industrial politics and economic development. Additionally, the project contains data from machinery, electronics, and transportation components industries, in which they were chosen to cover distinct contexts – stable and dynamic environments (Schroeder & Flynn, 2001).

All measurement items in this study came from HPM international database. Ninelatent variablesand Forty-fourindicators of five-point likert scale were used in this study to run the entire framework (see measurement items in the appendix 1). Both indicators uses an average of the perception of two respondents for each company. As the first step, we cleaned data for checking missing values. Full data with 330 respondents was 9.43% of missing values. From this, we removed incomplete responses until to reach 251 useful respondents that refers to 2.53% of missing values on data. As an acceptable condition (less than 5%), we proceed on those as mean replacement according to the most suitable treatment suggested by experts(Hair Jr., Hult, Ringle, & Sarstedt, 2014).

We used nine scales for this study: customer market knowledge, supplier market knowledge, effective process implementation, continuous improvement, anticipation of new technology, operational capability, operational performance, customers and suppliers. Customer and supplier market knowledge states an ability of firms to detect trends or changes from the market in which they operate (Alfalla-Luque et al., 2018). Effective process implementation refers to the ability of firms to develop and implement new processes (Garrido-Vega et al., 2015; Huang et al., 2008). While continuous improvement scale seeks to provide a set of proactive adaptation ability of firms (Bortolotti et al., 2015; Peng et al., 2011), anticipation of new technologies scale demonstrates an ability for moving technological structure early than rivals (Beheregarai Finger et al., 2014; Garrido-Vega et al., 2015). Operational capability scale refers to a broad ability of firms for performing their full manufacturing task (Wu et al., 2010). In turn, operational performance is measured by the traditional variables in the OM field, such as cost, quality, delivery, and flexibility (Bortolotti et al., 2015; Peng et al., 2008). Finally, customer and supplier scales refer to external players that may influence and be influenced by the focal company; therefore, both scales seek to measure adaptations in their processes and services from company's influences, as well as its impact market knowledge of them.

In order to mitigate common method bias concern, we take care through procedural and statistical remedies (MacKenzie & Podsakoff, 2012; Podsakoff, MacKenzie, Lee, & Podsakoff,

2003). First, we got data from five distinct respondents for the dependent and independent variables (see appendix 1). Second, the personal identity of respondents were not revealed. Third, respondents answered self-administered questionnaires without any external influence. Fourth, data matches the perception of two respondents per company. Fifth, Harman's one-factor revealedno emergence of a single factor with variables used in this study, in which the first factor represented just 19.37 percent of variance. These rigors suggest no concern about common method bias in our study.

We used partial least square structural equation modelling (PLS-SEM) to analyze measurement and structural models. PLS-SEM differs of covariance-based structural equation modelling (CB-SEM) for estimating a single model of parameters in order to maximize the variance explained of all endogenous construct through ordinary least squares (OLS) regressions. On the other hand, CB-SEM technique focus on estimating a set of model parameters for comparing theoretical covariance matrix with empirical covariance matrix observed in an estimation sample based on maximum likelihood (ML) or generalized least square (GLS)(Reinartz, Haenlein, & Henseler, 2009).

While CB-SEM technique looks for theory testing and theory confirmation, PLS-SEM is suggested in case of exploratory studies or when researchers are looking to extend existing structural theory. Further, PLS is preferable when a researcher is seeking to build relationships (prediction) of target constructs (Hair Jr. et al., 2014; Reinartz et al., 2009; Sarstedt, Ringle, Henseler, & Hair, 2014). For these specific reasons, we chosen run our framework with PLS-SEM rather than the CB-SEM technique. Contrasting, PLS-SEM does not provide a rigid model fit criteria such as CB-SEM, however, it is not a concern in this study regarding its building theory focus (Hair Jr. et al., 2014). Warp PLS software version 6.0 was used to run our analysis.

As suggested by previous studies, we operationalize our model with the two-stage least square (2SLS) technique due to its causal loop feature. The 2SLS considers error disturbance as part of predictors' calculation; therefore, its procedure is based on two stages: (a) replacing a problematic causal variable with new predictors and (b) running a second estimation conducted with the created predictors (Kline, 2015).Regarding the operationalization of the 2SLS technique, we found a problematic variable (Supplier) in the first stage, then it was changed to another variable with the average of all variables in that latent variable; in the second stage, we run the model again with that new variable. Beside results improved, the coefficient of 'Supplier' latent variable as predictor reduced. This procedure is also addressed to control endogeneity (Antonakis, Bendahan, Jacquart, & Lalive, 2010).

The endogeneity analysis was based on a set of procedural steps with Warp PLS software. First, we created four new variables (named as instrumental variable by the Warp PLS software) for each predictor – operational capability, operational performance, supplier and customer. These new variables contain the error term from their related predictors; therefore, they will show a correlation between the error term from independent and dependent variables. Second, after running the model, the loading and p-value of the instrumental variables should be not higher and significant to demonstrate the absence of endogeneity issues. This procedure has been ran with 2SLS simultaneously.

4. Data Analysis and Results

4.1 Measurement model and validation of measures

Followed two stage analytical procedures of structural equation modelling, we treated measurement model (reliability and validity tests), and thenthe structural model for testing hypothesis of this study. Table 7 provides some descriptive information about latent variables, such as mean, standard deviation, correlation, and square roots of AVE in diagonal (remaining data after purification of the model).

Table 7: Descriptive analysis and correlation

Construct	**Mean**	**SD**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Customer market knowledge	3.865	.657	**.815**								
Supplier market knowledge	3.921	.653	.337	**.774**							
Effective process implementation	4.027	.556	.268	.255	**.790**						
Continuous improvement	4.061	.585	.224	.217	.284	**.834**					
Anticipation of new technology	3.669	.765	.241	.284	.723	.210	**.816**				
Operational Capability	3.700	.653	.208	.272	.303	.187	.292	**.811**			
Operational performance	3.730	.712	.235	.217	.240	.198	.226	.678	**.765**		
Customers	3.758	.720	.362	.210	.255	.126	.322	.301	.339	**.764**	
Suppliers	3.935	.597	.157	.566	.239	.087	.258	.273	.201	.146	**.787**

Note: Bold numbers in diagonal refer to the square roots of AVE
Source: The Authors (2018)

Initially, we ran the measurement model to refine the latent variables of this study. Standardized indicators loading and p-value were used as criteria to remove variables with low loadings. Prior literature suggests cut-off variables with standarized loading below of .70 rate in order to improve the structural model, however, factor loadings higher than .50 are accepted in case of complex models (Hair Jr. et al., 2014).Supported by prior literature, we removed lower loading variables than .50 in the measurement model. In exception, we removed ANTICN02, GLOBLX02 and GLOBLX05 due to showing lower loadings when compared to the others. Further, IMPRVN02 variable was removed regarding its high correlation with IMPRVN03, in which after removing it, its factor loading goes down. In total, seventeen variables were removed out of our model (see variables highlighted in the table 11 – appendix B).

Remainingvariables followed an adequate composite reliability, and convergent and discriminant validity (see table 10 in appendix B). Firstly, the values of composite reliability ranged from .806 to .857, higher than suggested by literature (>0.7), reveals an adequate fit as suggested by literature (>0.7). Secondly, convergent validity was measured for the average variance extracted (AVE), in which ranged from 0.583 to 0.695, higher than recommended for the literature (>0.5). Thirdly, discriminant validity suggests how much a construct is distinct from others, and it is not a concern in this study once table 7 provides higher scores of square root of AVE than latent variables correlation(Hair Jr. et al., 2014). Overall, these results suggests a good internal consistency of data.

4.2 Structural model and hypothesis testing

We ran the structural model with Warp PLS software with two-stage least square technique regarding its feedback looping effect. However, before analyzing hypothesis tests, we addressed an analysis on the quality indices on the structural model and treatments for the endogeneity. According to the quality indices provided by Warp PLS software, all quality criteria were satisfied in our model (see details in table 8).

Table8:Goodness fit of the structural model

Quality indices	**Structural model values**	**Acceptance rate**
Average path coefficient (APC)	.185, p-value < .001	P-value < .05
Average R-squared (ARS)	.156, p-value = .003	P-value < .05
Average adjusted R-squared (AARS)	.148, p-value = .004	P-value < .05
Average block variance inflation factor (AVIF)	1.152	Acceptable if <= 5, ideally <= 3.3
Average full collinearity VIF (AFVIF)	1.500	Acceptable if <= 5, ideally <= 3.3

Tenenhaus GoF (GoF)	.348	>= .25
Simpson's paradox ratio (SPR)	.957	Acceptable if >= .70, ideally = 1
R-squared contribution ratio (RSCR)	.997	Acceptable if >= .90, ideally = 1
Statistical suppression ratio (SSR)	1.000	Acceptable if >= .70
Nonlinear bivariate causality direction ratio (NLBCDR)	.935	Acceptable if >= .70
Standardized root mean squared residual (SRMR)	.088	Acceptable if <= .10
Standardized mean absolute residual (SMAR)	.068	Acceptable if <= .10
Standardized chi-squared with 350 degrees of freedom (SChS)	16.565, p-value < .001	P-value < .05
Standardized threshold difference count ratio (STDCR)	.973	Acceptable if >= .70, ideally = 1
Standardized threshold difference sum ratio (STDSR)	.906	Acceptable if >= .70, ideally = 1

Source: Adapted from Kock (2017).

Treatment for the endogeneity was analyzed with a set of procedural steps of Warp PLS software for creating new variableswith the disturbance of error among relationships(named as instrumental variable 1, 2, 3 and 4 in the structural model). Instrumental variables are exogenous in their existence, therefore it may be considered as an indirect test to check the correlation among any structural error term from an independent with dependent variables (Antonakis et al., 2010; Ketokivi & McIntosh, 2017). According to Kock (2017), endogeneity is assumed for the loading size and p-value quality criteria by instrumental variables. Results from our model indicated a low correlation loading between structural error of dependent variables to predictors, and a non-significant p-value among them (see details in table 9). From this, endogeneity is not a concern in our model.

Table 9: Endogeneity treatment

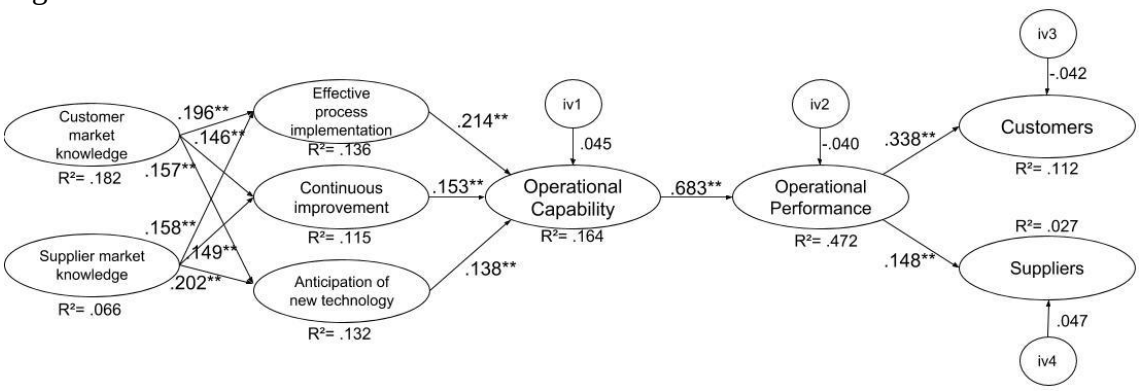
Instrument variable	**Effect**	**Correlation load**	**P-value**
iv1	Customer market knowledge and Suppliers market knowledge → Operational capability	.045	.236
iv2	Effective process implementation, Continuous improvement and anticipation of new technology → Operational performance	-.040	.264
iv3	Operational capability → Customers	-.042	.251
iv4	Operational capability → Suppliers	.047	.227

Source: The authors (2018).

Considering a good fit of quality indices and the absence of any endogeneity bias in the structural model, we go ahead for the hypothesis testing. Results from the structural model indicate apositive relation among customer market knowledge and supplier market knowledge with effective process implementation (.196, p-value<.001 | .158, p-value= .005), continuous improvement (.146, p-value=.009 | .149, p-value= .008), anticipation of new technology (.158, p-value=.006 | .202, p-value< .001), respectively. These results support hypothesis one.

Regarding hypothesis two, we found a positive relation among effective process implementation (loading=.214, p-value< .001), continuous improvement (loading= .153, p-value= .007), and anticipation of technology (loading= .138, p-value= .013) and operational capability. These evidences support hypothesis two. At the same way, we found support to confirm third hypothesis, in which operational capability exert positive influence on operational performance of firms (loading= .683, p-value< .001) (see figure 4).

Figure4:Structural model



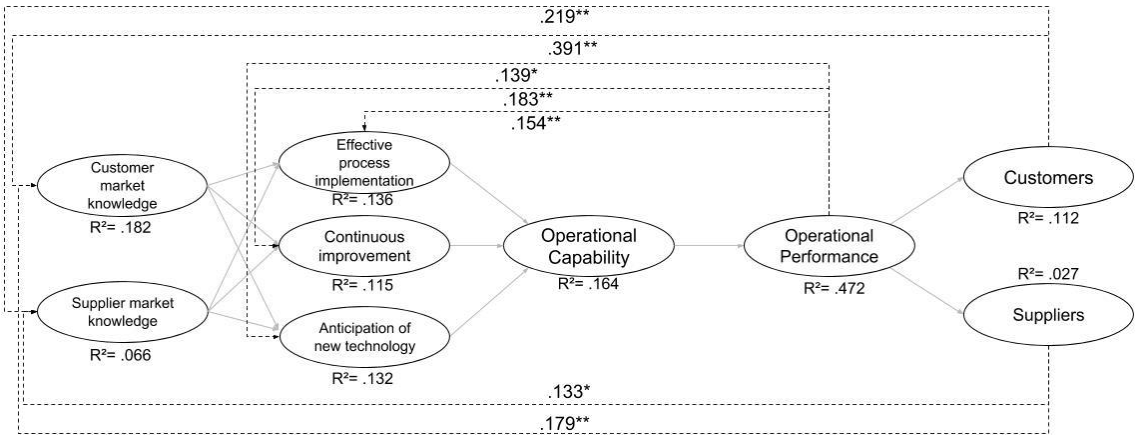
Note: **p-value < .01, *p-value<.05.
Source: The Authors (2018)

The fourth hypothesis considers the influence of operational performance of a company on their external partners (measured by customers and suppliers). Our results indicate that operational performance positively influences customers (loading= .338, p-value < .001), and suppliers (loading= .148, p-value = .009) adaptations (see figure 4). Therefore, it provides support to confirm the fourth hypothesis.

The fifth and sixth hypothesis seek to test the feedback effect on internal factors of firms. Besides the model was ran in the same time, we are providing feedback looping analysis in figure 5 in order to avoid lot of information in the same figure. So, figure 5 provides results of last set of hypothesis. Results indicate that operational performance is positively associated to effective process implementation (loading= .154, p-value= .007), continuous improvement

(loading= .183, p-value= .001), and anticipation of new technology (loading= .139, p-value= .012). These evidences provide support to confirm the fifth hypothesis.

Figure 5: Analysis of the feedback looping effect



Note: **p-value < .01, *p-value<.05.
Source: The Authors (2018)

The sixth hypothesis demonstrates the effect of adaptations of external players on the market knowledge of firms. According figure 5, we found a positive influence from customers' adaptations on customer market knowledge (loading= .391, p-value< .001) and supplier market knowledge (loading= .219, p-value< .001) of firms. Further, a positive influence was found from suppliers' adaptations on customer market knowledge (loading= .179, p-value= .002) and supplier market knowledge (loading= .133, p-value= .016) of firms. Therefore, these results provide support to confirm the sixth hypothesis.

5. Discussion

Previous studies have emphasized operational capabilities as a proficiency of firms for managing their operational tasks as a way to firms to reach competitive advantage (Peng et al., 2008, 2011). However, these studies do not addressed a discussion about how firms may develop them. In order to contribute to the operations management field, we propose the internal

and external mechanisms as a way to explain the process of operational capabilities development supported by co-evolutionary theory.

Regarding the wide set of antecedents of operational capabilities, that it differs across companies (Brito & Sauan, 2016), we have used following latent variables to measured internal factors, such as customer and supplier market knowledge, effective process implementation, continuous improvement, and anticipation to new technologies. In accordance to previous literature, our results indicate that customer and supplier market knowledge positively impact internal factors of firms (Alfalla-Luque et al., 2018; Paiva et al., 2008). It refers to checking opportunities and threats from customers and suppliers market operation. Furthermore, the base of internal resources of companies, when measured by effective processes implementation(Huang et al., 2008; Morita & Flynn, 1997), continuous improvement(Bessant & Francis, 1999; Coltman & Devinney, 2013), and anticipation of new technology (Beheregarai Finger et al., 2014; Matsui, 2007) positively influence firms to develop their operational capabilities.

Also, our results indicate companies that pursue capabilities may benefit for achieving higher operational performance, when measured by costs, quality, delivery, and flexibility, according to previous studies (Peng et al., 2008, 2011; Schoenherr & Narasimhan, 2012; Tan et al., 2007; Wu et al., 2010). In addition, operational performance has been conceived as a 'managerial control point' in which managers control to achieve their functional target. It confirms the operational performance as an internal feedback mechanism that positively influences the internal resources development of firms (antecedents of operational capabilities). This statement is built upon co-evolutionary theory in which states the feedback effect as a property that lead firms jointly evolve over time (Lewin & Volberda, 1999).

On the one hand, operational performance of a company may influence changes in external environment for leading to adaptations on players and partners. Our results indicate that operational performance of companies influence adaptations in their customers and suppliers. These results are aligned to previous studies that have indicated a joint evolution between companies and industry players (Braguinsky & Hounshell, 2016; Chen et al., 2017; Huygens et al., 2001; Rodrigues & Child, 2003).

On the other hand, changes in an environment or companies lead to new organizational forms or adaptations of existing ones, according to the basic premise of co-evolutionary theory (Lewin, Long, & Carroll, 1999). Based on that premise, our results indicate a positive influence from customers and suppliers on the market knowledge of firms. This result indicates that adaptations in the resource base from external influences refer an additional mechanism for the

operational capability development. Table 10 summarize both mechanisms and their effects on operational capabilities.

Table 10: Mechanisms for the operational capability development

Category	Mechanism	Effects on operational capability
Internal	Internal factors	Indirect effect of customer and supplier market knowledge
		Direct effect of effective process implementation, continuous improvement and anticipation of new technology
	Internal feedback	Indirect effect of operational performance
External	External feedback	Indirect effect of customers and suppliers

Source: The Authors (2018)

Finally, table 10 indicates three main mechanisms from results of this study. The internal factors mechanism consists an influence of tangible and intangible resources of firms on the operational capabilities development. Furthermore, internal factors receive influences coming from operational performance (named as internal feedback) and external players (named as external feedback) mechanisms. Internal feedback refers to the causal effect of an outcome reached by managers; on the words, regarding the outcome reached, it provokes internal adaptations in order to reach managers' goals. In turn, external feedback representsthe effect of adaptation of external players on firms' internal factors; it implies on internal adaptations lookingfor improving processes over competitors. Consequently, it leads companies to develop their operational capabilities through a cyclical process for monitoring external players and combining it to internal expertise over time. Finally, these results are supported by the properties of co-evolutionary theory (see its application in our framework in table 1).

6. Conclusions, Implications and Limitations

This study presents a way to understand the operational capability development process. For doing so, we underline co-evolutionary theory as the base theory to support our analytical framework. The framework considers a cyclical process among internal and external mechanisms for the capabilities development process. Therefore, results of our study have demonstrated a direct influence of internal mechanisms on operational capabilities, when measured by customer and supplier market knowledge, effective process implementation,

continuous improvement, and anticipation of new technology. In turn, operational performance and external players appear to influence internal resource of firms, and consequently operational capabilities.

Previous studies have indicated operational capability development as only an internal process of development (Felin et al., 2012; Helfat & Peteraf, 2003; Jacobides & Winter, 2012; Rockart & Dutt, 2015). Building upon those, this study extends the current view of the process of operational capability development for arguing a cyclical process of development based on internal and external mechanisms. Both mechanisms can be applied regardless the kind of operational capability (e.g. cumulative capability, competitive capability or others). Therefore, results from this study extend the current knowledge of operational capability literature.

More than theoretical implications, this study provides some managerial contributions. First, managers should pay attention in the company's strengths and manage them from internal and external sources over time. Second, managers should monitors external environment (players and partners) constantly in order to adapt their internal resources when looking for developing their capabilities. Third, as a cyclical process of operational capabilities development, managers should pay attention to what extent the company is influencing or being influenced for its environment and external players.

Several limitations possess this study. We used only customers and suppliers as external actors to analyze the joint evolution between firms, however, according to co-evolutionary theory many others external players must be considered, such as competitors, consumers, entities and institutions. On the other hand, we used a cross-sectional database to analyze our models, but the co-evolutionary process suggests a longitudinal research method to be full analyzed (Breslin, 2016). Future studies can extend this debate for analyzing the effect of other set of external players, as well as considering a longitudinal dataset to understand distinct effects over time.

Appendix A – Measurement Items

Please indicate the extent to which you agree or disagree with each of these statements about this plant and organization. 1: strongly disagree, 3: neutral, 5: strongly agree

Effective Process Implementation (PE)	We often fail to achieve the potential of new process technology (PROCSR01) Once a new process is working, we leave it alone (PROCSR02) We pay close attention to the organizational and skill changes needed for new processes (PROCSR03)

	We search for continued learning and improvement, after the installation of new equipment (PROCSR04) Our processes are effectively developed and implemented (PROCSR05)
Continuous improvement (PS)	We strive to continually improve all aspects of products and processes, rather than taking a static approach (IMPRVN01) If we aren't constantly improving and learning, our performance will suffer in the long term (IMPRVN02) Continuous improvement makes our performance a moving target, which is difficult for competitors to attack (IMPRVN03) We believe that improvement of a process is never complete; there is always room for more incremental improvement (IMPRVN04) Our organization is not a static entity, but engages in dynamically changing itself to better serve its customers (IMPRVN05)
Anticipation of New Tecnology (PE)	We pursue long-range programs, in order to acquire manufacturing capabilities in advance of our needs (ANTICN01) We make an effort to anticipate the potential of new manufacturing practices and technologies (ANTICN02) Our plant stays on the leading edge of new technology in our industry (ANTICN03) We are constantly thinking of the next generation of manufacturing technology (ANTICN04)
Customer (DM)	Fast delivery is the most important criterion used by our customers in selecting us as a supplier (SPEEDN01) Our customers involve us in their time reduction efforts (SPEEDN02) Our customers can rely on us for fast delivery (SPEEDN03) We are selected by our customers because of our reputation for fast delivery (SPEEDN04)
Supplier (UM)	We provide our suppliers with sufficient technical assistance (DEVLPN01) We hold regular meetings to exchange improvement ideas with our suppliers (DEVLPN02) We encourage our suppliers to continuously improve their production processes (DEVLPN03) If necessary, we ask our suppliers to invest in significant process improvement (DEVLPN04) We offer the necessary training to our suppliers (DEVLPN05) We share our vision and supply chain policy with our key suppliers (DEVLPN06) As our suppliers strive to improve their processes, we provide assistance (DEVLPN07)
Customer Market Knowledge (DM)	In order to find potential new markets, we monitor economies around the world (CUSKNWN01) We are concerned about the needs of both our immediate customers and our ultimate consumers (CUSKNWN02) We understand the marketing strategies of our customers (CUSKNWN03)

	We are very familiar with our customers' product characteristics (CUSKNWN04) We have a very good understanding of our customers' distribution processes (CUSKNWN05)
Supplier Market Knowledge (UM)	In order to find potential new suppliers, we monitor economies around the world (SUPKNWN01) Understanding our supplier's production processes is a high priority for us (SUPKNWN02) It is important for us to have a good understanding of our suppliers' R&D activities (SUPKNWN03) We are very familiar with our suppliers' product characteristics (SUPKNWN04) We have a very good understanding of our suppliers' distribution processes (SUPKNWN05)

Please circle the number that indicates your opinion about how your plant compares to its competitors in its industry, on a global basis. 1: poor, much worse than global competitors, 3: average, 5: superior, much better than global competitors

Operational Capability (PM)	Quality improvement program (DISTIX06) JIT and lean manufacturing (DISTIX10) Agile manufacturing (DISTIX11)
Operational Performance (PM)	Unit cost of manufacturing (GLOBLX01) Conformance to product specifications (GLOBLX02) On time delivery performance (GLOBLX03) Fast delivery (GLOBLX04) Flexibility to change product mix (GLOBLX05) Flexibility to change volume (GLOBLX06)

Respondents: PE – Process Engineer; PS – Plant Supervisor; PM – Plant Manager; UM – Upstream Supply Chain Manager; DM – Downstream Supply Chain Manager.

Appendix B – Confirmatory Factorial Analysis

Table 11: Confirmatory factorial analysis before data purification

Latent variable	Items	Standarized loading	R^2	SE	P value	Composite reliability	AVE
Customer market knowledge	CUSKNWN01	0.731	0.534	0.056	**	0.831	0.499
	CUSKNWN02	0.665	0.442	0.056	**		
	CUSKNWN03	0.689	0.475	0.056	**		
	CUSKNWN04	0.507	0.257	0.058	**		
	CUSKNWN05	0.424	0.180	0.059	**		
Supplier Market knowledge	SUPKNWN01	0.725	0.526	0.056	**	0.835	0.507
	SUPKNWN02	0.558	0.311	0.057	**		
	SUPKNWN03	0.799	0.638	0.055	**		
	SUPKNWN04	0.382	0.146	0.059	**		
	SUPKNWN05	0.449	0.202	0.058	**		
Effective process implementation	PROCSR01	0.059	0.003	0.062	**	0.746	0.394
	PROCSR02	0.180	0.032	0.061	**		
	PROCSR03	0.662	0.438	0.056	**		
	PROCSR04	0.515	0.265	0.058	**		
	PROCSR05	0.778	0.605	0.055	**		
Continuous improvement	IMPRVN01	0.693	0.480	0.056	**	0.827	0.490
	IMPRVN02	0.595	0.354	0.057	**		
	IMPRVN03	0.478	0.228	0.058	**		
	IMPRVN04	0.452	0.204	0.058	**		
	IMPRVN05	0.727	0.529	0.056	**		
Anticipation of new technology	ANTICN01	0.616	0.379	0.057	**	0.864	0.614
	ANTICN02	0.584	0.341	0.057	**		
	ANTICN03	0.728	0.530	0.056	**		
	ANTICN04	0.829	0.687	0.055	**		
Operational capabilities	DISTIX06	0.744	0.554	0.056	**	0.852	0.658
	DISTIX10	0.622	0.387	0.057	**		
	DISTIX11	0.708	0.501	0.056	**		
Operational performance	GLOBLX01	0.772	0.596	0.055	**	0.868	0.526
	GLOBLX02	0.584	0.341	0.057	**		
	GLOBLX03	0.679	0.461	0.056	**		
	GLOBLX04	0.670	0.449	0.056	**		
	GLOBLX05	0.553	0.306	0.057	**		
	GLOBLX06	0.592	0.350	0.057	**		
Customers	SPEEDN01	0.464	0.215	0.058	**	0.822	0.540
	SPEEDN02	0.537	0.288	0.058	**		
	SPEEDN03	0.730	0.533	0.056	**		
	SPEEDN04	0.713	0.508	0.056	**		
Suppliers	DEVLPN01	0.065	0.004	0.062	**	0.856	0.460
	DEVLPN02	0.978	0.956	0.053	**		
	DEVLPN03	0.588	0.346	0.057	**		
	DEVLPN04	0.335	0.112	0.06	**		

DEVLPN05	0.338	0.114	0.06	**
DEVLPN06	0.480	0.230	0.058	**
DEVLPN07	0.707	0.500	0.056	**

Note: grey indicators were removed; **p-value< 0.01, *p-value<0.05.
Source: The Authors (2018)

Table 12: Confirmatory factorial analysis after data purification

Latent variable	Items	Standarized loading	R^2	SE	P value	Composite reliability	AVE
Customer market knowledge	CUSKNWN01	0.706	0.498	0.056	**	0.855	0.664
	CUSKNWN02	0.641	0.411	0.057	**		
	CUSKNWN03	0.759	0.576	0.055	**		
Supplier market knowledge	SUPKNWN01	0.631	0.398	0.057	**	0.817	0.599
	SUPKNWN02	0.613	0.376	0.057	**		
	SUPKNWN03	0.648	0.420	0.056	**		
Effective process implementation	PROCSR03	0.670	0.449	0.056	**	0.832	0.624
	PROCSR04	0.535	0.286	0.058	**		
	PROCSR05	0.752	0.566	0.055	**		
Continuous improvement	IMPRVN01	0.578	0.334	0.057	**	0.820	0.695
	IMPRVN05	0.675	0.456	0.056	**		
Anticipation of new technology	ANTICN01	0.593	0.352	0.057	**	0.857	0.666
	ANTICN03	0.687	0.472	0.056	**		
	ANTICN04	0.821	0.674	0.055	**		
Operational capabilities	DISTIX06	0.732	0.536	0.056	**	0.852	0.658
	DISTIX10	0.618	0.382	0.057	**		
	DISTIX11	0.723	0.523	0.056	**		
Operational performance	GLOBLX01	0.660	0.436	0.056	**	0.847	0.585
	GLOBLX03	0.644	0.415	0.057	**		
	GLOBLX04	0.676	0.457	0.056	**		
	GLOBLX06	0.664	0.441	0.056	**		
Customers	SPEEDN02	0.594	0.353	0.057	**	0.806	0.583
	SPEEDN03	0.681	0.464	0.056	**		
	SPEEDN04	0.537	0.288	0.058	**		
Suppliers	DEVLPN02	0.637	0.406	0.057	**	0.830	0.619
	DEVLPN03	0.741	0.549	0.056	**		
	DEVLPN07	0.582	0.339	0.057	**		

Note: **p-value< 0.01, *p-value<0.05.
Source: The Authors (2018)

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PAPER 3 – QUALITATIVE PAPER

The paper “The microscopic view of quality capability development: an empirical study of coevolution” completes the third part of this thesis. In this paper, we demonstrated empirically four cases of quality capability development from brewery sector. Based on an inductive study, data reveals six mechanismsadopted by companies for developing its quality capabilities.These results help OM field for advancing operations capabilities literature.

This paper was still not submitted to any conference. Then, we are planningto submit a first draft to national conferences, such as Enanpad, SIMPOI, or related.

The microscopic view of quality capability development: an empirical study of coevolution

Abstract

This study analyzed the process of quality capability development. As a dimension in manufacturing task, quality capability refers to a proficiency for managing variations in their processes over competitors. As a prominent literature for explaining operational heterogeneity across firms, limited discussion have been addressed for its mechanisms of development. Data from four in-depth case studies of brewery industry were analyzed froman inductive approach. Our findings suggest that companies have developed their quality capabilities through six mechanisms – cooperating, following rules, and anticipating – both internally and externally. Results of this study contribute for advancing capabilities understanding in OM literature.

Key-words: Quality capability.Co-evolutionary theory. Mechanisms of capabilities development.

1. Introduction

Operations strategy literature has given emphasis on the heterogeneity of operational performance across companies. From this, capability term comes up as a concept focused on explaining intangible strengths of companies (Bortolotti, Danese, Flynn, & Romano, 2015; Peng, Schroeder, & Shah, 2008; Wu, Melnyk, & Flynn, 2010). However, limited discussion has been addressed on how capabilitiesare created, developed, or declined along the time (Dangol, Bahl, & Karpak, 2015). Previous studies from strategy and general management fields have supported their mechanisms on evolutionary theory (Winter, 2012), resource-based theory (Rockart & Dutt, 2015), and microfoundations (Felin, Foss, Heimeriks, & Madsen, 2012). Therefore, these studies overemphasized the internal resources role on the capabilities development. On the other hand, operations management (OM) studies have highlighted supply chain partners as an important external element to developing capabilities of companies (Dangol et al., 2015; Vanpoucke, Vereecke, & Wetzels, 2014). Besides, still there is a gap in the capability literature regarding a simultaneous analysis to join internal and external mechanisms on the process of capabilities development.

Quality capability is a dimension of operational capability (Dangol et al., 2015). Previous studies on QC have indicated internal elements such as learning, sensing signals and resilience

(Su, Linderman, Schroeder, & Van De Ven, 2014), and internal quality practices (Wu & Zhang, 2013). Contrasting, external elements were mentioned as a cooperative relationship with supply chain partners (Dangol et al., 2015), exploring quality practices in supply chain partners (Wu & Zhang, 2013), and reducing rejections during the whole supply chain(Power, 2014). Building upon previous literature, this study seeks to analyze the development of the quality capability based on the coevolutionary theory. Based on this purpose, this study focus on the following question: How are quality capabilities developed over time?

Co-evolutionary theory was adopted to support empirical discussion of quality capability development and its mechanisms. This theory sheds light on the role of multiple actors interplaying where each one may influence adaptations on the others over time(Lewin & Volberda, 1999), as well as new organizations structure arise from those existent (Lewin, Long, & Carroll, 1999). Co-evolutionary theory was chosen due to: (a) providea set of properties to analyze quality capability development, such as multilevelness and embeddedness, multidirectional causalities, nonlinearity, feedback, and path and history dependence; (b) support internal and external elements; (c) assist multiple actors involved in the capabilities development process.

Seeking to pick up a theoretical sample able to provide answers for this above-mentioned gap, four in-depth cases from brewery sector were selected. This sector was chosen for three main reasons: (a) its fast clock-speed feature and technology advance for the industry (Fine, 2000); (b) its fast grow in Brazilian market over the last ten years; (c) the challenge for small and/or medium companies to manage quality standards in their manufacturing processes over time. For example, any variance in time, pressure and temperature, as well as exposure to oxygen after fermentation may affect product flavor (Pellettieri, 2015; Spedding, n.d.). While large companies usually ensure standardized processes and technological equipment, smaller companies have limited resources for addressing on. Finally, forty interviews and observational data from companies' visits supported our analysis.

Results revealed six mechanisms for the quality capability development – cooperating, following rules, and anticipation – internally and externally. They provide two main theoretical contributions: (a) extending the current knowledge of the process of quality capability development for a joint analysis of internal and external mechanisms; (b) moving OM literature in advance about the intangible elements embedded in best manufacturing companies. In addition, these mechanisms proposed by this study may help other kind of capabilities, including strategy and general management fields. Finally, these mechanisms found may support managers to make-decisions looking to improve their operational capabilities over time.

This study has the following structure: a literature review of quality capabilities and co-evolutionary theory; a method section to discuss the methodological steps employed in this study; a section of coding and analysis by showing the codification process; a discussion section regarding contributions for this study on the current literature; finally, we present conclusion and limitation sections with theoretical and managerial implications, suggestions for future studies as well.

2. Theoretical background

2.1 Quality Capability

Quality term possess a broad meaning in the OM field. It has been recognized by researchers as a competitive priority (Boyer & Lewis, 2002; Pagell, Melnyk, & Handfield, 2000; Schoenherr & Narasimhan, 2012), a set of operational practices for managing production and services (Dora, Kumar, & Gellynck, 2016; Netland, Schloetzer, & Ferdows, 2015; Zhang, Linderman, & Schroeder, 2012), a dimension of manufacturing capabilities (Hayes & Wheelwright, 1984; Schoenherr, Power, Narasimhan, & Samson, 2012; Skinner, 1969), as well as a conformance of product and services to attend customers' needs (Peng et al., 2011; Schroeder et al., 2011; Zhang, Linderman, & Schroeder, 2012). Respectively, quality term has been conceived as an orientation in the input or transformation process phases, as an output when measured by a product or service delivered to their customers as well.

Another debate regarding quality term refers to its tangible or intangible feature. On the one hand, a body of studies have highlighted the adoption of quality practices in order to reduce variability and errors in the process e.g. operational procedures (Poksinska, Jörn Dahlgaard, & Antoni, 2002), standardization (Psomas & Antony, 2015), Total quality management (Kaynak, 2003), lean manufacturing (Bortolotti, Romano, Martínez-Jurado, & Moyano-Fuentes, 2016), and six sigma (Shafer & Moeller, 2012). On the other hand, quality has been related to a cultural philosophy. For example, the collectivism from national culture was associated to the efficacy of lean practices (Wiengarten, Gimenez, Fynes, & Ferdows, 2015), which it leads to high relationship quality in the entire supply chain (Chen, Su, & Ro, 2017). Regardless the quality feature, those companies with high quality performance level are recognized for possess a capability.

Quality capability refers to a proficiency of firms for managing quality on products and services in order to reach conformance at the customers specifications(Chang, Lin, Yang, & Sheu, 2003). In addition, quality capability has been used by OM researchers as a dimension in manufacturing capabilities (Chavez, Yu, Jacobs, & Feng, 2017), competitive capabilities (Schoenherr et al., 2012), and cumulative capabilities (Rosenzweig & Easton, 2010). Both literature state operational performance heterogeneity for a singular ability of firms over competitors. Table 13 shows some empirical studies in OM field for the development of quality capability.

Table 13: Quality capability studies

Authors	Description	Dimensions and mechanisms	Involved actors
(Chang et al., 2003)	Quality capability as a firm's relative performance on seven quality dimensions	*Dimensions:* performance of the product or service, product features, reliability, defect rate, after-sales maintenance services, product appearance, corporate image and reputation	Main company
(Su et al., 2014)	Quality as a competitive dimension for the sustained advantage of firms	*Dimensions:* practices, leadership, external, environment, strategy, and quality system *Distinguished mechanisms across firms:*(1) meta-learning, (2) sensing weak signals, and (3)resilience to quality disruptions.	Managers, competitors, market, suppliers, employees, and customers
(Dangol et al., 2015)	Quality as a dimension of operational capability (quality, costs, delivery and flexibility)	*Mechanisms:* Cooperative relationship with supply chain partners, such as suppliers and customers.	Main company, suppliers and customers.
(Wu & Zhang, 2013)	Quality as a set of management practices for monitoring processes and developing new products and processes	*Mechanims:* Exploitative- and exploratory-oriented for the internal and external practices	Main company, suppliers and customers.
(Power, 2014)	Quality capability is a manufacturing performance improvement over time	*Mechanisms:*Reduction of percentual of rejects in four parts of the entire supply chain (incoming material, processing, final inspection, and from the customer)	Plants in industrialized and emergent economies, and their suppliers and customers

Source: The Authors (2018).

According to table 13, previous studies have emphasized dimensions of quality and assessment and construct validity for the quality topic. Most of studies consider quality as a multidimensional topic, which it means a concern for the entire supply chain looking to deliver a product or service at the consumer. In addition, most studies have considered beyond main company as the actor concerning quality, such as supply chain partners, competitors, and external players in the general market. Although away of quality capability topic, Zhang, Gregory, and Neely's (2016) study highlights the importance of a strong network for developing capabilities of companies.

Besides quality management is a broadly discussed topic in OM, limited discussion have been addressed regarding the process of quality capabilities development. Seeking to extend quality capability literature, co-evolutionary theory is shown in the next section for supporting this study theoretically.

2.2 Co-evolutionary theory

The co-evolution phenomenon refers to a simultaneous process of multidirectional interactions among managerial action (micro-level), industry (meso-level) and environment (macro-level) (Lewin & Volberda, 1999; Lewin & Volberda, 2009). This phenomenon happens among individuals (organism or firm), dyads (two organisms or firms in a collaborative relationship) or groups (group of organisms or firms) (Wilson & Hynes, 2009). Thereof, five properties support the coevolution theory and differ it from other kind of evolutionary perspective, such as: multilevelness/embeddedness, multidirectional causalities, nonlinearity, positive feedback, and path and history dependence (Lewin & Volberda, 1999, 2009). Both of them are described below.

The multilevelness and embeddedness property refers to all levels of analysis such as intra-firm, industry, country. Multidirectional causalities refer to a reciprocal relation among actors over time. In turn, nonlinearity means that do not have any rule on influence process of actors. The feedback represents an response of environment or another firm from the adaptation of a firm – while some authors point positive effect (Lewin & Volberda, 1999; Lewin & Volberda, 2009), another authors highlight the negative effect too (Breslin, 2011; Van den Bosch, Volberda, & de Boer, 1999). Finally, path and history dependence does mention about all decisions and challenges faced for firms during their existence (Lewin & Volberda, 1999). Both of these five properties help us to support this study.

Empirical studies have underlined a co-evolutionary process to develop their organizational capabilities based on different levels of analysis. For example, the joint evolution

among firms and partners (Chen et al., 2017; Jacobides & Winter, 2005), firms and their subsidiaries (Koza, Tallman, & Ataay, 2011), firms and industry (Braguinsky & Hounshell, 2016), firms and institutional environment (Cantwell, Dunning, & Lundan, 2010; García-Cabrera & Durán-Herrera, 2016). Moreover, still little explored in the literature, the micro co-evolution phenomena (intra-firm) is suggested to explain the joint evolution of internal resources of firms (McKelvey, 1997; Volberda & Lewin, 2003).

As a complex phenomenon, quality capability is described by empirical studies in table 13 distinctly with different mechanisms to measure it, and many involved actors for building and developing it. From this, co-evolutionary theory support this study for their set of five properties as base to understand quality capability development.

2.3 A theoretical intersection

This section seeks to integrate quality capability to co-evolutionary theory. According to previous studies, quality term has been understood as an internal factor of firms for the adoption of quality practices, such as Lean and Six sigma (Bortolotti et al., 2016; Shafer & Moeller, 2012); a conformance with their processes' specifications (Chang et al., 2003); a cultural philosophy for continuous improvement (Wiengarten et al., 2015); and an expertise developed gradually (history) (Chavez et al., 2017).

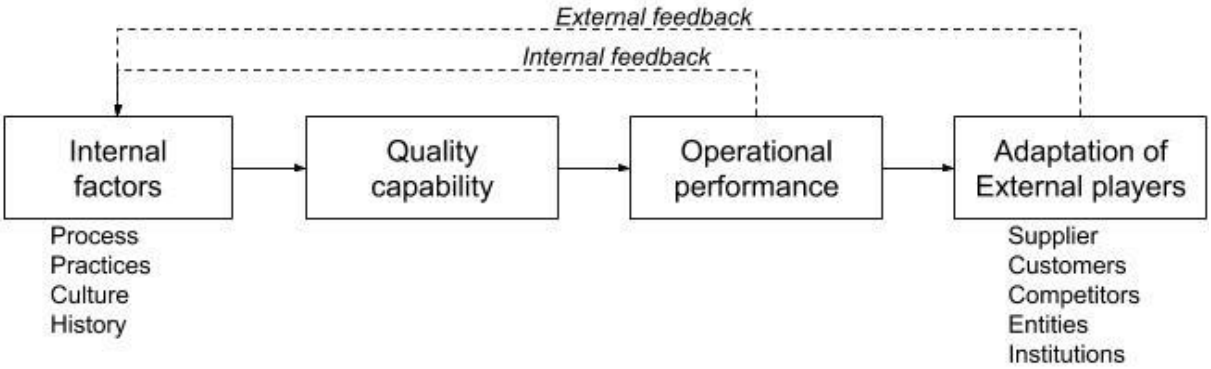
On the other hand, according to the current literature, companies that perform quality dimension over competitors possess a quality capability. It refers to a specific expertise for doing and managing quality in products, services and processes (Peng et al., 2008). When it comes to mechanisms for its development, previous studies have highlighted internal efforts of firms for improving processes (Chang et al., 2003; Su et al., 2014), and an internal exploration and exploitation of quality practices (Wu & Zhang, 2013). On the other hand, other studies have indicated some external causes as mechanisms for the quality capability development, such as cooperative relationship with suppliers and customers (Dangol et al., 2015), reducing defects in the entire supply chain (Power, 2014), and exploration and exploitation of external quality practices (Wu & Zhang, 2013).

Building upon these previous studies, we are looking to advance quality capability development based on co-evolutionary theory. Co-evolutionary theory considers a simultaneous evolutionary process among multiple players, such as company, industry, and environment (Lewin & Volberda, 1999, 2009). Therefore, from co-evolutionary lens, previous studies were limited in their research scope for focusing internally, or do not considering all causal elements in their analysis.

Co-evolutionary lens make to extend current knowledge of quality capability development through a couple of reasons. First, co-evolutionary theory integrates internal to external levels. Second, it covers multiple causalities among actors in distinct levels. Third, a causal linearity is not expected, once any actor may influence adaptation in others, Forth, a joint evolution across companies is expected after a feedback effect; it refers to a causal sequence influence-adaptation-influence. For example, company A influence adaptations in company B, later, results from adaptations of company B may influence company A for changes. Fifth, companies can be understood based on their past decisions and historical trajectory.

Based on that view, we present the analytical framework to explain how co-evolutionary theory may works in advance of quality capability development (see figure 6). According to the framework, quality capabilities are developed from internal factors, such as processes, practices, culture and history of firms. However, outputs of quality capability may stimulate a managerial action or external actors' adaptations. Both lead to changes in the internal factors of firms in order to reach managerial goals; external actors parity in case of supply chain partner or competitors; and to follow a new regulatory in case of new policies for entities and institutions. As consequence, they lead companies to develop their quality capabilities through an indirect way.

Figure 6: The analytical framework



Source: The Authors (2018).

Besides this section provides a theoretical intersection between quality capability and co-evolutionary literature, this study proposes look at the field through an inductive way in order to arise empirical elements for the development of quality capabilities. Next section we discuss steps taken for the empirical research.

3. Methodology

Case study is considered a powerful research method in the operations management (Voss, Tsikriktsis, & Frohlich, 2002) for helping researchers comprehend why a phenomenon occurs or do not (Meredith, 1998). Empirical studies have increased its use in the operations management field over time, especially for applying on the theory building focus (Barratt, Choi, & Li, 2011). Therefore, looking to that focus, we selected the inductive multiple case method to analyze that phenomenon.

The multiple case approach have been chosen for a set of reasons: (a) its capacity to explore a phenomenon by linking variables and explaining how and why it occurs (Voss et al., 2002; Yin, 2008); (b) they can enhance the external validity and to reduce the observer bias (Voss et al., 2002); (c) multiple cases are more robust, generalizable, and testable theory than single case research (Eisenhardt & Graebner, 2007); (d) multiple cases have been more used in the inductive way (Barratt et al., 2011), then they can be useful to build or extend theories (Eisenhardt & Graebner, 2007; Siggelkow, 2007; Yin, 2008). Finally, we selected best small brewery companies regarding a theoretical sampling (Eisenhardt & Graebner, 2007; Eisenhardt, 1989). See our research protocol in the appendix 1.

3.1 Case selection

Brewery sector was selected for this study regarding three main reasons: (a) the fast clock-speed feature of this industry, once is possible to comprehend a full picture of the sector and companies in a short time of analysis (Fine, 2000); (b) its fast grow rate in the Brazilian market – higher than 700% over last ten years (MAPA, 2018); (c) their complex biological process control for maintaining the same product quality over time. From this, brewery sector demonstrates to be a good field to be explored in order to arise answers for the process of operational capabilities development.

The companies are located in the South region of Brazil. This region possess the unique Beer College in the Latin America, therefore, many breweries are moving there to acquire new knowledge about the sector. Blumenau metropolitan area in South of Brazil received the title of the Brazilian National Capital of Beer.

The case selection process was made based on a comparison analysis among brewery companies. In order to identify the manufacturing capabilities of those companies, the authors built a score as a way for materializing their quality capability and its process of development. It was made in three main steps: Firstly, the authors run an exploratory step with 13 interviews

to buildan interview protocol. During this step, the name of eleven companies raised as the best quality practices. Secondly, before starting interviews, the protocol interview was discussed withtwo experts from the brewery sector (see interview protocol in appendix 2). Thirdly, eleven companies were ranked by our interview protocol items (see a comparison of 11 companies in appendix 3). Fourth, four best practices companies were selected for an in-depth analysis.

3.2 Data gathering

Considering many critics on the case study method for its lack of rigor (Stuart, McCutcheon, Handfield, McLachlin, & Samson, 2002), we adopted some concerns seeking to minimize aspects like researcher biases and misjudging in the data collection process (Voss et al., 2002; Yin, 2008). First, all interviews were recorded and transcribed before the analysis phase. Second, we guaranteed the interviewers' anonymity. Third, companies' ranking were validated by informants before any comparison. Fourth, we interviewed external actors when mentioned by companies' informants in order to comprehend the all process of quality capability development. Fifth, we triangulate different sources of information, such as interviews and observation to be able to arrange each case. We got 25 interviewswith an average of 42 minutes each one, as well as interview time ranged from 30 to 75 minutes. The interviews were recorded, transcribed, and evaluated through content analysis by Nvivo software. Table 14 provide details about the interviews of each case study.

Table14: Interview overview

Case	**Production volume-monthly**	**Informant(s)**	**Company**	**Number of Interviews**
A	~280.000 liters	Production Manager (A1)	Plant	1
		Administrative analyst (A2)	Plant	1
		Brewmaster (A3)	Headquarters	1
		Logistic Manager (A4)	Headquarters	1
		Financial Manager (A5)	Headquarters	1
		Planning Manager (A6)	Headquarters	1
		Laboratory Manager (A7)	Plant	1
B	~140.000 liters	Owner (B1)	Plant	1
		Production Manager (B2)	Plant	1
		Brewer (B3)	Plant	2
		Main Director (B4)	Equipment supplier	1
		Sales manager (B5)	Raw material supplier	1
		Production Manager (A1)	Competitor	-
		Administrative Manager (B6)	Competitor	1
C	~100.000 liters	Production manager (C1)	Plant	2

		Lab expert (C2)	Plant	1
		Brewer (C3)	Plant	1
		Owner (C4)	Plant	1
D	~40.000 liters	Production Manager (D1)	Plant	2
		Commercial Manager (D2)	Plant	2
		Purchasing Manager (D3)	Customer	2

Note: Text analysis uses codes in brackets.

3.3 Data analysis

The data analysis process follows within-case and cross-case steps. While within-case is usually applied to analyze internal details and to get up patterns of each case from a big volume of data, cross-case analysis refers a comparison of case pairs by contrasting similarities and differences between them (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Yin, 2008).

Although the firm is the unit of analysis of this study, there are multiple subunits of analysis to consider as internal the firm: relationship among staff and departments, and head-subsidiary; in the supply chain (external the firm) as suppliers and customers; as well as competitors.Therefore, we used embedded case study design due to use information from each case study to explain a main phenomenon(Yin, 2008).

Content analysis was employed to analyze the data collected. “Content analysis is a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the context of their use” (Krippendorff, 2004:18). Additionally, we used the ‘pattern matching’ technique for analyzing data because it compares empirical evidences with a predictive one; it is able to strength the internal validity of the study (Yin, 2008). Table 15 provides codes raised from data of this study. In addition, evidence of coded data is shown in appendix 4.

Table15: Description of coding categories

Sustaining pattern	**Coding category**	**Description**
Cooperating	Company-supplier co-evolution	Instance in which the interviewees discuss about the joint evolution between the company and their suppliers (equipment, raw material).
	Informal network co-evolution	Instance that interviewees discuss about an informal network as a way for exchanging quality knowledge and solutions collaboratively.

	Manufacturing-marketing department co-evolution	Instance that interviewees made mention on a collaborative work between manufacturing and marketing departments.
	Staff co-evolution	Instance in which the interviewees discuss about a collaborative evolution between staff, e.g. brewer, brewer master, or others.
Following rules	Competitors-company co-evolution	Instance in which the interviewees discuss about the evolution of its company based on competitors influences.
	Head-subsidiary co-evolution	Instance in which the interviewees discuss about the evolution of its plant from Head influences.
	Chief-Staff co-evolution	Instance in which the interviewees refers to the evolution of staffs by attending direct boss's demands.
Anticipating	Company-competitors co-evolution	Instance in which the interviewees discuss about the evolution of competitors based on company's influences.
	Company-costumers co-evolution	Instance in which the interviewees discuss about the evolution of customers based on company's influences.
	Company-quality system co-evolution	Instance in which the interviewees discuss about the evolution of quality systemaligned to the corporate strategy
Capability	Capability	Instance in which the interviewees discuss about the company manufacturing proficiency, e.g. quality management.

Source: The Authors (2018).

3.4 Research accuracy

Meredith (1998) highlighted that case studies require the same level of rigor that statistical approaches, although it is demonstrated from distinct ways. Seeking to enhance the accuracy of this study, we have paid attention on quality criteria for dealing with case study according to (Yin, 2008): (a) Construct validity: multiple source of evidences, interviews with key informants, an exploratory phase, and validation of interview protocol with experts were adopted to measure correctly concepts that are being studied; (b) Internal validity: the pattern matching technique was adopted in this study to establish a causal relationship among codes; (c) External validity: as it follows a formal protocol (see research protocol in appendix 1), future studies may reapply it for other sectors, as well as to check distinct kind of capabilities; (d) reliability: a research protocol was provided for future studies (see research protocol in appendix 1).

4. Within-case analysis

4.1 Case A

Company's brand was founded in 2002 as a family business. As one of the brewery pioneers in the Blumenau region, the company started its production seeking to provide craft beer according to Germany purity law from 1516. Located in the biggest Germany colony in Brazil, the company used that background to strengthen its brand and reputation. Little time later, the company was acquired by a large Brazilian company in 2008; a Brazilian group in 2011; and finally, a multinational group acquired them in 2017. Despite those transitions time, the company has maintained its craft beer essence.

The quality in their products and processes were a concern since the beginning, in which it has been a competitive priority for the company (A1) and a competitive differential over competitors (A2). Further, it has received some improvements from acquisition of those players previously mentioned (A2, A3, and A7). After acquisition of the Brazilian group, all raw material analysis has been made by a corporative laboratory, whereas company's manufacturing plant have focused on the process quality control. The Brazilian group have invested in their plant for requiring an upgrade in their process control, so, more than 1 million of equipment were invested to control product and process quality, from 1 staff to 4 staffs in laboratory to manage quality, and twenty four hours of process control. In addition, new procedures were implemented, such as laboratory staff should check each manufacturing lot before to advance for the filling sector (A7).

After the multinational group has acquired the company, the quality concern has going forward. Regarding the competitive priority of the multinational group be focused in quality issues, it has strategically addressed focus on developing high level of quality standards in the company process and products, such as operational controls and raw material laboratorial analysis (A3). In addition, some equipment were acquired looking to reduce any variability in the brewing and carbonation phases, such as equipment for the measurement of must extract and equipment to measure the incorporation of carbon dioxide in the final product (A7).

Its quality capability was developed through new equipment investment looking to reduce process variability (A7), dissemination of best practices coming from Brazil Kirin (A7) and Heineken (A4), a benchmarking of operational indicator among Heineken subsidiaries around the world (A6), and processes standards looking to maintaining the production lots repeatability over time (A1 and A2). This mutual evolution leads company plant improve their quality

capability, as well as to reduce any possibility of the Brazilian and multinational groups losing reputation by product quality variations coming from them over time.

On the other hand, as brewery technology has been developed many times since its foundation, their regional competitors started their operations based on more technological equipment (A1). While the companyhas influenced regional competitors to decide about their operational process when they were born, they were influencing the company to improve their operational equipment in order to arrive the same operational productivity. Besides that, their quality remain higher than regional competitors.

4.2 Case B

For seven years, the owner of the company just commercialized beer in the Blumenau region, in which has the majority of his population with German origin. After many incentives from friends and customers, he decided to create his own beer brand. His company started its manufacturing activities in 2015 with advanced technology processes compared to the local breweries. This aspect allows it to pursue high standards of quality in its processes and final products when matching it to operational procedures and cleaning practices (B1).

The company developed a quality management capability from a joint effort among staff, equipment and raw material suppliers. Manufacturing plant was built jointly by an equipment supplier and the company's staff, with the premise for using the highest technology known in the brewery sector. The supplier was focused on soft drink equipment for long time, but looked for new opportunities in the brewery Brazilian market. The company was the third company to acquire that brewery equipment, but the first one to run them (B3). Looking to improve processes, the company made a couple of suggestions on the supplier's equipment during initial phases of manufacturing (B2, B3 and B4), in which ithasimplied on the supplier's expertise for developing new equipment (B4). Therefore, while equipment supplier have acquired expertise in the brewery process, the company became the most technological brewery company in its region (B1, B2, B3 and B4). Finally, both companies have benefit through a joint evolution.

More than that equipment acquired, the company imported a centrifugal equipment to improve liquid homogeneity after fermentation process from another supplier (B2). Beside expensive, the equipment help brewery companies to remove some remaining yeast looking to a maintaining the same beer feature over time (B2). Both decisions have influenced local competitors to upgrade their manufacturingequipment (B6 and A1) looking to improve the quality of their process. One example is a visit of a local brewery in the company to understand

how centrifugal equipment works; later they invested in a more technological equipment than the company acquired (B2 and B6).

As the Brazilian weather is not friendly for farming hop, it implies for the importation of hop by intermediaries from United States, Europe, Australia, and New Zealand (B3). Besides hop has a long time validity, it goes losing its natural properties over years. While all importers were managing their own hop inventory, a raw material supplier was the pioneer in Brazil for importing with future market contracts, as well as maintaining quality and delivery according to the contract (B5). The company was the first brewery company to sign a formal contract (B5), then it has benefited both for receiving hop from new harvests e delivery on time (B3). While it improved the company's product and process quality for a hop more stable (B3), raw material supplier benefited for establishing long term contracts and reducing their hop inventory variations (B5). Finally, other regional breweries were analyzing future market after an influence for quality from the company (B5).

Finally, evidences from interviews indicated that staff have made improvement in the company processes from results reached. Company's brewers have created a routine to test small part of each beer tank daily, so it promotes a technical discussion across brewers looking for some adjusts in the process (B2 and B3). Required adjusts are implemented in the technical sheet and updated next production lots (B2 and B3). So, outputs of beer lots lead to an improvement in the process searching to achieve best results than those reached previously.

4.3 Case C

Founded in 2014, this company has received many award for their labels from national and international fairs. Therefore, as a quality concern for maintaining the same product flavor over time, the company has invested in technology (manufacturing and laboratory), standardized processes, qualified managers workers as well (C1, C2 and C4). From that, quality management capability has been developed based on four main factors: (a) an equalization processes to competitors; (b) a mutual relationship among staff in order to reach the same beer quality over time; (c) a support of external network of production manager; and (d) a technical support from raw material suppliers.

Seeking to equalize quality concerns to competitors, the company hired an experienced production manager in 2015 (C4). From this, contamination risks during manufacturing were mitigated, processes standardized by a set of operational procedures, quality controls were implemented in each part of the process, and equipment were changed in order to reach similar productivity and quality of competitors (C1 and C3). In addition, a laboratory was implemented

to control some variability during entire manufacturing process and provide measurable elements for decision makers (C1, C2 and C4). As large companies, the company has established a rigorous process by laboratory department evaluating each manufacturing lot before moving forward to the cellaring step (C2). These elements were implemented regarding internal manufacturing opportunities to catch up their rivals.

Before hiring a chemical expert, limited tests and analysis allowed brewers to evaluate carefully beer quality in progress. Therefore, an expert working at laboratory allowed brewers receive constantly feedbacks about their production lots (C3). So, just in case of an unexpected result, they manage prior manufacturing lots and correct next ones in order to reduce any variance on the product (C2 and C1). In addition, brewers perform sensory tests daily to check flavor acceptance in order to provide a feedback due to laboratorial propagation of yeasts (C1). This joint evolution between brewers and lab lead them to reduce variances in the manufacturing lots (C3), and on the improvement of next beer manufacturing lots due to an upgrade in the technical sheet (C1 and C3).

As a fast growing sector in Brazilian market, beer companies are seeking to innovate in distinct manufacturing methods to achieve singular results e.g. flavor, aroma, combination of exotica ingredients (C4). Although the company is looking to a continuous improvement focus in the manufacturing department, they are usually exchanging information with an informal network of practitioners as a way for taking experience of others. For example, it happened for the hops introducing method (named dry-hope), active cleaning chemical products, and as well specific issues regarding changing some raw material or a way for producing it (C1 and C3). Finally, as stated by the operations manager, he usually ask a particular opinion to experts regarding a new product before submitting into a fair or market. In a reciprocal relationship, both are looking to strengthen that network for a future help (C1).

Finally, raw material suppliers have provided a set of technical workshops looking to clarify the use of malted barley and hops. All of that information contribute to the companies to improve their knowledge about raw materials and their utility. For example, the company has implemented material standard calculations, as well as changed a hops of their portfolio for do not reach expected quality and reduced filtration time for adding a compound into mash conversion process by experts recommendations (C1). For understanding better the raw material used, it leads companies to improve their processes as well quality issues. So, for doing that, raw material suppliers gain from customer’s loyalty (C1).

4.4 Case D

The company was founded in 2003 in the Blumenau metropolitan region. It started its operations for maintaining around six to eight thousand beer liters monthly. With continuous financial losses, the company was almost closed. In 2015, new owners placed the company on a new position in the market for doing dual investments on quality in manufacturing and marketing departments. Looking to support its growth, two experienced managers in the manufacturing and marketing area were hired. During that time, the company has grown from 8.000 liters to around 40.000liters monthly (D1), and disposed from 9 to 106 clients over just three years (D2). That results raised from simultaneous efforts between manufacturing and commercial areas.

During next three years they built a close relationship to customers for being constantly present in their store (D2), attending full-time, providing direct contact to vendors when necessary, and establishing handle trainings to customers (D3). A near relationship provided credibility to customers, which it led them to trust in the company (D2). As a current marketing practice in the company, customers were invited to visit company's manufacturing process in order to understand their high concern about quality seeking to provide reliability to customers (D1 and D2). On the other hand, quality of beer was understood for managers as an internal and external concern (D1). Internally, staff must to follow a standardized processes to achieve the same beer quality over time (D1); in turn, externally, the company should provide good practices to customers looking to maintain product quality during its validity time (D1 and D2). From that, quality management has been supported by aset of four elements, such as assimilating manufacturing processes to competitors, relationship between manufacturing and commercial departments, and joint evolution of staff and and informal network.

Based on previous experiences, operations manager brought a couple of quality practices into the manufacturing process looking to assimilate that to best quality competitors. Therefore, he created standards on raw material analysis and manufacturing processes across brewers, improved asepsis from manual to mechanical method as well implemented a method for checking clean level of that, implemented new manufacturing practices e.g. dry hopping, changed fermentation process for removing yeasts decanted weekly in order to reduce any likely of variations of pH of the product, and implemented inventory controls in order to does not use old raw material and reduce its stocks (D1).

Besides an expressive internal quality jump, marketing department had perceived some customers still complaining of beer quality (D2). After checking that, manufacturing department concluded that customers have had some wrong care for storing, handling, and

cleaning barrel of beer (D1). Then, vendors have received some training to provide guidance to customers when visiting them (D2 and D3). That decision led the company to reduce customers claims during last months (D1). At last, manufacturing and marketing were interplaying together on quality concern and corporation's outputs e.g. new product development, and delivering promised product (D1 and D2).

At the same way, a mutual internal evolution between staff of the company occurs through beer outputs. First, each month a brew master experienced for more than fifty years came into the company to check their lots of beer; it provide a debate across brewers looking to improve processes in relation outputs reached (D1). Second, Directors of the company are all the time managing outputs looking to do improvements on manufacturing department e.g. investments on new technology (D1 and D2). Finally, an informal network has provided support for the production manager to implement or upgrade successfully quality process into the manufacturing department e.g. how to measure carbonation in beer without sophisticated equipment or a lab? (D1).

5. Cross-case analysis

According to the last section, companies performed their quality management capability in distinct ways. We have used the macro codes, named as cooperation, following rules, and anticipation to structure our cross-case analysis, followed by internal and external contexts (see table 16). While 'cooperating' refers to a friendly joint evolution among company and external actors, 'following rules' consists some mandatory adaptation in the internal structure regarding internal or external influences. Lastly, 'anticipating' describes early moving firms for influencing the market, industry environment, and other external players. Finally, internal and external contexts represent the action origin of capability development.

As shown in table 16, companies performed similar internal cooperation among brewers, and brewers and laboratory experts for checking results of the beer according to expected. Based on a reciprocal learning process through laboratory and sensory tests, brewers and laboratory experts improve next manufacturing lots seeking to reach beer flavor expected. In addition, a close relationship between marketing and manufacturing departments allowed company D to understand customers needs. It allows a prioritization on quality concern internally to solve quality issues in stores by customers' wrong conservation methods. On the other hand, companies have benefited from external cooperation, such as raw material and

equipment suppliers. While raw material suppliers have provided technical support about materials, supply guarantee and fixed price for long-range contracts to breweries, a new equipment supplier built a highest technological equipment for company B where acquired technical expertise for that transaction. Finally, informal network have been a common practice between brewery companies for sharing experiences and suggestions looking to advance brewery sector in Brazilian market.

Supported by HQ requirements, company A invested in laboratory equipment and process control standardized methods for maintaining same beer quality over time. These quality investments were mandatory by HQ looking to support brand growth and company's reputation. As a fast growth sector in Brazilian market, company A has suffered on productivity due to competitors had acquired high technological equipment. So, competitors have influenced company A to renew its manufacturing structure in order to ensure similar production costs and time. In contrast, company D and C hired experienced production managers looking to equate quality and productivity levels to competitors. Whereas company D tried to recover its lost market, company C as a new competitive player in the market seeks to expand its operations. Therefore, these two companies caught up a body of breweries in the south region regarding quality concern for comparing quality practices to the top tier ones.

Regarding anticipation factor of companies, we have perceived distinct ways adopted by companies in order to pursue best manufacturing methods and quality ones. For example, company A for being one of the most imposing companies in the south region, has influenced other companies to start their operations with a minimum quality level in the market. At the same way, company B started its operations with most technological equipment than competitors leading them to improve continuously. As a result, company B influenced another brewery to acquire a centrifuge better than their – centrifuge equipment is responsible for standardizing the elimination of yeasts after maturation phase. This equipment was built jointly between company B and its supplier. Lastly, while competitors were not focused for training their customer regarding storing, handling, and cleaning barrel of beer, company D provided some special guidelines looking to preserve beer quality for the consumer, as well as retain customers pleased for long term. On the other hand, company A has a structured quality system for implementing continuous improvement in their manufacturing lots through a proactive way. This system supports the company growth.

Overall, four cases above have demonstrated their quality management capability development based on internal and external contexts, such as intra- and inter-departments, and suppliers, customers, competitors and an informal networks respectively. So, their process of

development were based on a cooperative relationship, external influences on company's adaptations, and by firms anticipating adaptations over general market. Finally, both refer to ways for developing capabilities and may differ in each company regarding its history and relationship with internal and external actors. Next section we promote a debate of these results on the current literature.

Table 16: Cross-case comparison

Case	Cooperating	Following rules	Anticipating
A	*Internal:*Not applicable. *External:*Not applicable.	*Internal:* High investment in laboratory and process control equipment from HQ requirements; Following manufacturing practices from HQ. *External:* Regional competitors have influenced the company to change manufacturing equipmentto reach similar productivity	*Internal:*Formal procedures in all manufacturing processes concerning quality under supervision of laboratory department *External:*As an early moved in Brazilian south region in 2002, the company has influenced new companies making-decision about their operational processes and quality concern.
B	*Internal:* A mutual relationship among brewers. *External:*Long-range contract with raw material supplier performing benefits for both; Building technological equipment jointly with supplier in which resulted in a mutual benefits.	*Internal:* Improvements in manufacturing processes based on a technical discussion among staff for beer sensory tests. *External:* not applicable.	*Internal:* Not applicable. *External:*Its technological performance have influenced companies making-decisions about their manufacturing technology; A competitor bought a similar centrifugal equipment than them.
C	*Internal:*A mutual relationship among brewers and laboratory expert. *External:* An informal network allows production manager to successfully implement or upgrade manufacturing methods and quality concern; Technical workshops from raw material suppliers.	*Internal:* Improvements in manufacturing processes based on a technical discussion among staff and laboratory expert. *External:*Equating manufacturing processes to competitors in quality and productivity; Implementing a lab.	*Internal:*Not applicable. *External:*Not applicable.

D	*Internal:*Relationship between marketing and manufacturing departments. *External:*An informal network allows production manager to successfully implement or upgrade manufacturing methods and quality concern.	*Internal:*Staff joint evolution based on beer sensory tests. *External:*Equating manufacturing processes to competitors in quality and productivity.	*Internal:*Not applicable. *External:*Supported by manufacturing department, vendors trained customers about conservation methods of the beer.

Source: The authors (2018).

6. Discussion

A body of studies in the OM field have addressed on the manufacturing and service quality literature over last decades. Besides a convergence between previous studies regarding quality capability as a term related to proficiency by firms over competitors, they have missed how companies developed them over time. Our study seeks to extent that literature for providing mechanisms of quality capability development process based on co-evolutionary theory.

Research data has indicated that firms create and develop their capabilities for cooperating, following rules and anticipating their adaptation of processes. It does not refer to any manufacturing stage, but ways for the development of capabilities. We discuss below each mechanism and its implications. From this, propositions are provided for future research.

“Cooperating” has been broad discussed in the OM as a good way for companies develop their quality system (Su et al., 2014) and its entire supply network (Chen et al., 2017). Evidences of data research have highlighted for the internal and external cooperation. Internally, companies have stimulated staff and cross-functional cooperation for improving their process and capabilities consequently. In turn, companies demonstrated a couple of beneficial external cooperation, such as suppliers, customers, and an informal network among brew master, brewers and production managers. In the informal network case, it was perceived as something uncontrolled by companies, however it is beneficial for sharing information.

Previous studies have indicated the capability development as a collaborative process among company and suppliers (Dangol et al., 2015; Vanpoucke et al., 2014), informal network (Zhang, Gregory, & Neely, 2016), staff join evolution (Su et al., 2014; Zhang et al., 2016), and the manufacturing and marketing integration (Su et al., 2014). Building upon theses previous

studies, we offer a set of propositions for the capabilities development sustained by our research data:

Proposition 1 – Operational capabilities are developed from external and internal collaborative efforts simultaneously.

"Following rules" term explains a reactive action of companies by external and internal influences. The García-Cabrera and Durán-Herrera's (2016) study highlighted regulatory changes when multinationals such as Inditex and Coca-cola arrived in Bangladesh and India, respectively. Multinationals were helping to improve local policies, as well as new policies were changing operational activities of multinationals in those countries. Further, Jacobides and Winter (2005) explains that any change for integrating or disintegrating the vertical scope of companies affect the nature of capabilities development. On the other hand, the "following rules" term extends to the internal context as well. It refers to the managerial influences on process adaptations from results reached when compared to those expected. Beside still few explored by empirical studies, internal co-evolution is basically supported by feedback property from co-evolutionary theory (Lewin & Volberda, 1999, 2009; McKelvey, 1997).

In turn, "Anticipating" refers to move earlier than competitors for influencing adaptations over them, or an internal system of continuous improvement. Usually first movers benefit for contributing on changes in the general market and stimulate changes on the operation of new players (Lewin et al., 1999). It leads a company for a land of continuous improvement over time due to a joint evolution around (see Braguinsky and Hounshell's (2016) study). When it comes on quality focus, anticipating leads companies to be more resilient over quality disruptions (Su et al., 2014). No less important, there are companies working in a continuous improvement perspective. For example, Wu and Zhang's (2013) study found exploratory-oriented quality practices are more effective for the performance goals than exploitative ones. It indicates the continuous improvement focus as an internal practice for the quality capability development. Building upon previous studies, we offer a second proposition for the capabilities development sustained by our research data:

Proposition 2 – Exploration and exploitation of resources produce different results in the development of quality capability.

Table17: Mechanisms for the quality capability development

Mechanism	Internal	External

#1 – Cooperating	Collaborative relationship among staff and departments (e.g. brewers and lab expert, manufacturing and marketing)	Collaborative relationship with external players (e.g. subsidiaries, breweries, suppliers, customers)
#2 – Following rules	Results reached are compared to those expected ones, so it leads companies to improve processes over time (e.g. brewers working to satisfy companies requirement)	Internal adaptations based on the influence of external players (e.g. influences coming from suppliers, customers, competitors)
#3 – Anticipating	Adaptations in formal procedures of quality (e.g. initiatives for changing a processes or equipment) lead companies to increase their performance	Influence adaptations on external players for moving earlier (e.g. results reached based on past decisions for adopting processes or equipment arouses interest over competitors)

Source: The Authors (2018)

Table 17 synthesize six mechanisms for the quality capability development. They are supported by co-evolutionary theory once refers to a complex system with multiple actors interplaying simultaneously with no linear influence, but multiple interactions and causalities over time. Those actors may be embedded in distinct contexts, thus the joint evolution among them does not limit about geographical regions, but regarding their relationship level and exposure to the market. In addition, the history of a company consist as a driver for explaining the mechanisms adopted by companies looking to develop their internal processes (Lewin & Volberda, 1999, 2009). Finally, outputs of companies perform as an influencer on internal adaptations, as well as external players for changes.

At last, these mechanisms refers to an integration between three factor and two contexts identified for our data research. Both of them refers to a way adopted by companies develop their process, in which directly affect companies' quality capabilities. A company may use more than one mechanism for creating and/or improving their capabilities. Overall, companies may develop their capabilities in different ways, in a distinct time of development, as well as with multiple actors involved.

7. Conclusion and limitations

Based on the assumption that little efforts have been devoted to understanding the process of capabilities development (Dangol et al., 2015; Rockart & Dutt, 2015), this study contributes to the OM field for extending the current literature of the process of quality capability

development. For doing that, data from four cases were provided support for proposing six mechanisms of its creation and development. The mechanisms act on the process of companies, which integrate operational routines, practices, and technologies jointly at the same analysis.

Co-evolutionary theory supports this result for identifying the full process of capabilities development. First, multiple actors were identified as influent on the evolution of capabilities of companies, as well as with distinct relationship levels. Second, they interplay jointly in which one may cause adaptations in others. Third, even internally, there is a no linear relationship among them. Fourthly, results reached by companies reflect on internal adaptations, as well as influences on external players. Fifth, present status of companies represents previous decisions for cooperation, just reacting market influences, or an anticipation strategy; it can be viewed through the companies' history. Thus, co-evolutionary properties were base to build both mechanisms provided by this study.

The mechanisms showed in this study does not limit for the quality capabilities, however, it might be applied on another competitive dimension of OM field, such as cost, delivery and flexibility. Further, results from this study contribute to operational capabilities literature for extending their overemphasis on internal aspects as base for the capabilities development.

As a managerial contribution, this study presents six alternatives for companies building, creating or developing their operational capabilities. As a simple way for understanding the position in the market, companies may to analyze what is its main way for adaptation – cooperating, following rules or anticipating. Beside the brewery sector is regulated by a hard legislation, influences from regulatory and government were limited in our case studies. Therefore, to research capabilities development process in a more institutionalized sector is a recommendation for future studies. In addition, future studies may address efforts on a comparative study of capabilities development process among more regulated countries than other. Finally, future studies can address research on propositions showed by this research.

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Appendix 1 – Research protocol

1. Purpose of the research

This study aims to analyze the quality capability development process in brewery companies.

2. Research question

How are quality capabilities developed over time?

3. Theoretical support

-Quality capability: Dangol et al. (2015), Power (2014), Su et al. (2014), and Wu and Zhang (2013).

-Co-evolutionary theory: Chen et al. (2017), Lewin and Volberda (1999, 2009), and Volberda and Lewin (2003).

4. Case selection

The main criteria chosen for the selection of companies were:

-Technological limitation of small brewery companies for managing quality from biological variations in manufacturing lots;

-The fast grow rate of craft brewery sector in Brazilian market

-Companies located in the south region due to the biggest beer cluster in Brazil, as well as the presence of the unique Beer college in Latin America and National Capital of Beer according to a Brazilian legislation

5. Data gathering

Interviews were recorded and transcribed. Anonymity and validation were provided to ensure interview confidentiality:

-Interviews with brew master, brewers, owners and related ones

-Interviews with external members which contributed to companies to develop their processes

-Information about the research was provided to each interviewer before starting the interview

-Anonymity was held to interviewers and companies

6. Data analysis

-Defining research codes based on data analysis.

-Analyzing data based on within case and cross case analysis.

-Cross-case analysis linking to the literature.

Appendix 2 – Interview protocol

Company:

Name:

Position and experience:

Production volume per month:

Answer questions below indicating any evolution in your company over last five years, and how it happens (if there was any influence from internal and external players).

	Level of development		
Item	*Low*	*Intermediary*	*High*
How do you manage variations in raw materials acquired (malted barley, hops, and yeast)?			
1. MaltedBarley	Do not perform tests, nor changes datasheet	Change datasheet according to suppliers' technical report	Change datasheet according to sensory, microbiological, physical, and chemical tests

2. Hops	Do not perform tests, nor changes datasheet	Change datasheet according to suppliers' technical report	Change datasheet according to sensory, microbiological, physical, and chemical tests
3. Yeast	Do not perform tests, nor changes datasheet	Change datasheet according to suppliers' technical report	Change datasheet according to sensory, microbiological, physical, and chemical tests
How do you manage variations in the water components?			
4. Water	Do notperformtests	Change datasheet according to suppliers' technical report, and test chlorine existence in water	Realize periodical tests of pH and mineral adjustments
How do you manage variations in Milling of the grain?			
5. Milling the grain	Do notperformtests	Do sensory tests	Realize grading, powder content, and granulometry tests
How do you manage temperature and time variations in the mash conversion process?			
6. Mash conversion	Manual control of temperature ramp and time	Automatic control of temperature ramp and time	Checking mash conversion velocity and time, pH.
How do you manage variations in the lautering process?			
7. Lautering	Do notperformtests	Lautering time control, final wash extract	Wash's water pH, turbidity of the wort, delta pressure in the lautering bed
How do you manage variations in the boiling process?			
8. Boiling	Do notperformtests	Realize evaporated volume test, and full and final tub extract	pH, chemical bitterness, volume of losses (trub)
How do you control variations of temperature, pressure and time in the cooling?			
9. Wort separation and Cooling	Manual control of temperature and time	Automatic control of temperature and time	Quantification of spent refrigerant, and quantification of the thermal load used
How do you control variations in the fermentation process?			
10. Fermentation	Do notperformtests	Realize sensory tests and daily density	Perform pH tests and daily cell counts
How do you manage variations in the maturation, filtration or centrifuge, carbonatation, cellaring, pasteurization, and process transfer?			
11. Maturation	Do not perform tests	Monitoring temperature and pressure – registration for statistical process control (SPC)	Perform microbiological contamination tests, incorporation of dissolved oxygen, and other chemical tests
12. Filtration or centrifuge	Do sensory tests	Perform turbidity input and output tests	Perform microbiological contamination tests and incorporation of dissolved oxygen

13. Carbonatation	Do sensorytests	Tank's pressure and temperature test	Bottle's pressure and temperature test (carbonation test cylinder)
14. Cellaring	Do sensorytests	Realize cellaring tests	Perform microbiological contamination tests and incorporation of dissolved oxygen
15. Pasteurization	Do sensorytests	Realize pasteurization efficiency test (glycophyte test)	Perform microbiological contamination tests
16. Process transfer	Do not perform tests	Do sensory tests	Perform microbiological contamination tests and incorporation of dissolved oxygen
What kind of tests are performed to guarantee final product quality?			
17. Final product	Do not perform tests	Do sensorytests	Realize shelf-life tests, cap pressure tests, and incorporation of dissolved oxygen
What kind of tests are performed to guarantee sterilization and asepsis quality?			
18. Sterilization and asepsis	Do not perform tests	Periodically perform microbiological tests	Daily perform microbiological tests

19. What manufacturing practices support process quality (5'S, best manufacturing practices, standard operational procedure, six sigma, total quality management)?How were they implemented?
20. How have your manufacturing technologies helped to reduce any variability during the process (manual vs. automatic, lab)?
21. How have outputs of your company supported improvement on manufacturing process, practices, and technology?
22. How has your company influenced other companies (suppliers, customers, competitors, institutions, and/or entities)?
23. How have external actors influenced adaptations in processes, practices, or technology in your company (suppliers, customers, competitors, institutions, and/or entities)?

Could you provide your contact for a future occasion?
E-mail:_____
Phone number: _____

Appendix 3 – Companies' score

Companies / Processes	A	B	C	D	E	F	G	H	I	J	K
Malted barley	3	2	2	2	2	2	2	2	1	2	2
Hops	3	2	2	2	2	2	2	2	1	2	2
Yeast	3	2	3	2	2	2	2	1	1	1	2
Water	2	3	2	3	3	2	2	1	1	1	1
Milling the grain	3	3	2	3	2	3	1	2	2	2	1
Mash conversion	3	3	3	1	1	2	1	2	1	1	1

Lautering	2	3	3	2	2	2	2	2	2	1	2
Boiling	3	2	2	2	2	1	1	1	1	1	1
Wort separation and cooling	3	2	2	1	1	2	2	2	1	2	1
Fermentation	3	2	3	2	2	1	2	1	2	2	2
Maturation	3	2	2	2	2	1	1	1	1	1	1
Filtration or centrifuge	3	2	2	n/a	1	1	1	1	1	1	1
Carbonatation	3	2	2	2	2	1	1	1	1	1	1
Cellaring	3	2	2	2	1	1	1	1	1	1	1
Pasteurization	3	2	2	2	1	1	1	1	1	1	1
Process transfer	3	2	2	2	1	1	1	1	1	1	1
Final product	3	3	3	2	2	2	1	1	2	2	1
Sterilization and asepsis	3	3	3	3	1	2	2	2	2	1	1
Score	**2.9**	**2.3**	**2.3**	**2.1**	**1.7**	**1.6**	**1.4**	**1.4**	**1.3**	**1.3**	**1.3**

Appendix 4 – Evidence of coded data

Case A

Capability	"Our best ability is process and product quality when comparing to our competitors. Our quality is higher due to rigid procedures in the manufacturing process, as well as laboratorial analysis end-to-end" (Production manager, Plant). "…the product quality is our best competitive weapon. Our quality is supported by a rigorous process control, and they are being developed after acquisition of the company for big players in 2008, 2011 and 2017" (Administrative analyst, Plant).
Chief-staff co-evolution	Not applicable.
Company-competitors co-evolution	"…I suppose that our main competitor will not to see the market turnaround to a high quality product, but obviously they will not be comfortable for losing market share… As they are a big player in the market, any adaptation reflects on a big impact in the market [when mentioning for a mass production company]" (Planning manager, HQ).
Company-customers co-evolution	Not applicable.
Company-quality system co-evolution	"Quality is determined by our rigid control in processes, monitored by laboratory team. They monitor all manufacturing processes, from material to the bottled beer…it is higher than most brewery companies, and it helps to manage the desired beer levels for the company" (Production manager, Plant).
Company-supplier co-evolution	Not applicable.

Competitors-company co-evolution	"Our technology is at the same level or lower than our regional competitors, even those producing less volume than us…" (Production manager, Plant).
Head-subsidiary co-evolution	"All of quality concern developed by the corporate level were disseminated to subsidiaries immediately…" (Brew master, HQ). "One of the most import evolution in our plant comes up after acquisitions, when they required an improvement in our process quality… our plant had a small laboratory with just one professional…after acquisition were hired other three professionals to cover 24 hours of quality control in processes. They required a new procedure for a technical evaluation of each manufacturing lot before advancing to the packaging department…they brought into this plant microbiological, chemical and physical controls to line checking. They invested more than one million in plant's lab" (Laboratory manager, Plant).
Informal network co-evolution	Not applicable.
Manufacturing-marketing department co-evolution	Not applicable.
Staff co-evolution	Not applicable.

Case B

Capability	"Quality is present in our process by following procedures, building a spreadsheet per each manufacturing lot, same people doing the job, and procedures". (Owner, Plant). "…today nobody in the region have the same technology than ours" (Production Manager, Plant).
Chief-staff co-evolution	"...we started to correct the minerals ofour beer; it was a big change for us. So, we meet daily – João, Mark, Diogo and me. We drank the beer… so let's change something in a beer, but as the market knows our product we cannot change suddenly" (Production Manager, Plant).
Company-competitors co-evolution	"…a competitor visited our plant to meet our technology, we possess a centrifuge that remove yeasts of the beer – late I will show you, they be interested and bought a better equipment than ours, so it is something that should be made cooperatively to develop the region…" (Production Manager, Plant).
Company-customers co-evolution	Not applicable.
Company-quality system co-evolution	Not applicable.
Company-supplier co-evolution	"...because hops may suffer a lot of variability, so we required a higher material from our supplier…we have a formal contract with a hops supplier then they ensure quality and delivery on time that is another important thing,

	once a hops differs among harvests…so by a contract they ensure their supply when we need" (Brewer, Plant). "…ensuring supply for our client is the biggest gain for the contract, besides we give some discount. Both gain because I will supply hops to them when necessary and it is good to me manage our inventory" (Sales manager, Raw material supplier). "They developed and built our equipment. They have a know-how and we were talking about some adaptations…" (Production manager, Plant). "There are some things which we look, the mill was the first equipment manufactured by them… They came here, made a study, and hired a professional to develop it over our advising…today they evolved a lot in equipment development…" (Owner, Plant).
Competitors-company co-evolution	Not applicable.
Head-subsidiary co-evolution	Not applicable.
Informal network co-evolution	Not applicable.
Manufacturing-marketing department co-evolution	Not applicable.
Staff co-evolution	"…we also have daily analysis in the beer's tank by drinking a sip of beer from each lot when ready, and we discuss if it is a little bitter or something missed. Then it will influence the next production lots of this kind of beer, we will improve something" (Brewer, Plant).

Case C

Capability	"...**as we** gain **a couple of awarded labels,** we are controlling our product all the time, with best practices in the process and laboratory. We have qualified professionals inmostmanufacturing positions. As the beer is manufactured by many professionals, they should be prepared all the time with seminars, training, quality and market knowledge, laboratory, technology, controls…" (Owner, Plant).
Chief-staff co-evolution	"...he does not have any experience with industrial brewery. He was with lot of vicious in his job, and then I fired him. I fired many vicious guys and hired new workers, and I have trained them with my way, as a like to work. For prioritizing clean, tank cleaning, ground cleaning, internal cleaning, disassemble equipment and cleaning, cleaning, cleaning..." (Production manager, Plant).
Company-competitors co-evolution	Not applicable.
Company-customers co-evolution	Not applicable.

Company-quality system co-evolution	Not applicable.
Company-supplier co-evolution	"For example, we go there [main supplier], they provide seminars about hops, malted barley as well, their characteristics, then we were able to implement and improve our processes, such as performance of materials, their calculations. For understanding more our materials, we are able to use them better, then we can aggregate much more quality" (Production manager, Plant).
Competitors-company co-evolution	"Our company improved their equipment over the last two years. We worked with bad equipment with high loses in the process…for example we bought a German malt grinder, it maintain the same standard in the grain, this is perfect. This help us to improve our process performance (Brewer, Plant). "We were adjusting, improving prescriptions, changing equipment…we had a bad wort separation and cooling because that got away much bark of grain, then we changed that equipment, improved its chimney due to its weak evaporation…" (Production manager, Plant).
Head-subsidiary co-evolution	Not applicable.
Informal network co-evolution	"...we share information with other breweries, other brewers. I really like to work in that way. Sometimes when I need test hops for example, before testing it I ask to my network if they know something about that…if they tested we exchange information. So, if they reached close to my target, I will test it as well, if not I leave" (Production manager, Plant).
Manufacturing-marketing department co-evolution	Not applicable.
Staff co-evolution	"For example, sometimes when I to taste a beer and it is apparently sweet, so sweet, no liked it, so heavy. Then, laboratory results comes up with details about extracts, higher than our limit, we need to reduce it to 3, 3.5. Based on that way we are correcting. We analyze sensory test and laboratory jointly" (Production manager, Plant).

Case D

Capability	"In order to maintain our beer quality, we are implementing manufacturing procedures…as I started my career in a large **company; I am implementing those procedures here". (Production Manager, Plant).** **"We are doing a close job with our clients, that is fundamental… because if we face a problem we go for it anytime, always providing a good assistance for our clients, we bring them to our team" (Production manager, Plant).**

Chief-staff co-evolution	"…the company's competitive differential, I think we have a master brewer graduated in Germany…He is old, so old, but he is transferring his knowledge to me. He comes once per month to taste our beer, then we share lot of information regarding his large experience in the brewery industry" (Production manager, Plant).
Company-competitors co-evolution	Not applicable.
Company-customers co-evolution	"…they are recognized as one of the most important in perceived quality…we had small issues regarding quality but it was something so distant…we have a direct contact and they provide a good assistance to us" (Purchasing manager, Customer). "…I provide a training to them of all brewery and put myself as available for their team…if they need a training for their team…what is my duties? Deliver the products, check storage, give them product validity" (Commercial manager, Plant).
Company-quality system co-evolution	Not applicable.
Company-supplier co-evolution	Not applicable.
Competitors-company co-evolution	"When I arrived here raw material analysis are not made…other thing we changed was be focused on fresh materials once they come German, United States…other thing is asepsis which is base to maintain a good final product…the same process, standardization…" (Production manager, Plant).
Head-subsidiary co-evolution	Not applicable.
Informal network co-evolution	"Today brewers exchange information…suppose a problem that you faced but I never, so I can learn by your experience for solving a problem rather than losing time about the same problem. But if I to hided information just for me, later no one guy will help me…I have some experienced colleagues with around 40, 50 years working in breweries. I have a colleague with 72 years old, retired, graduated in Germany…" (Production manager, Plant).
Manufacturing-marketing department co-evolution	"Once in a while I call him [production manager] come on lets to visit a client. Even in new ones. That is a competitive differential; it is hard to see a brewery allows visits from its brewer master" (Commercial manager, Plant). "According to Commercial Director, our sales increased around 30 percent. It was a joint work between marketing and production; because we are doing a product with quality…we embraced our public…" (Production manager, Plant).
Staff co-evolution	Not applicable.

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GENERAL CONCLUSION

Based on three chapters, this study looked to unansweredquestions about the process of operational capabilities development.Specifically, it was driven by the following research questions: (a) howdo firms develop their operational capabilities? (b) What is the role of internal and external mechanisms on that process? Jointly, three papers have addressed on through anintegrative debate.

According to the first paper, previous studies were limited regarding the mechanisms for the capabilities development process. From this, we built upon them, in specific Teece's (2007)paper, for arguing that companies may adopt five mechanisms for the capabilities development: sensing (identification of opportunities and threats),seizing (evaluation), reconfiguring (adaptation), and internal and external feedback. For indicating two additional mechanisms over previous studies – internal and external feedback, this paper proposed some ways for future studies.

Following a way from the first paper, the second study analyzed the impact of capabilities' antecedents on its development process. Results have confirmed the effect of internal and external mechanisms as suggested by the first paper. From this, the customer and suppler market knowledge appear to direct influence tangible internal factors of firms. In the sequence, tangible factors, when measured by effective process implementation, continuous improvement and anticipation of new technology were positive related to operational capabilities. In turn, operational capabilities were found as positive associated to operational

performance. Once operational performance have been identifiedto influence adaptations on external players when measured by customers and suppliers (external feedback), it also impliedadaptations on capabilities' antecedents (internal feedback). Finally, adaptations on suppliers appear to affect resource base of companies. These results indicated that capabilities development process is a continuum, where it is dependent for the daily managerial decisions regarding the operational task and external influences.

The third paper extends prior discussion of capabilities development process due to an in-depth analysis in four brewery cases. Results indicated that companies pursue distinct ways for capabilities development over time; however, they are convergent for using multiple similar mechanisms. Through an inductive method, research data has revealed six mechanisms that supported quality capability development – cooperating, following rules, and anticipating – both internal and externally. In practice, these mechanisms extended 'internal' and 'external feedback' concepts from the first paper of this dissertation.Moreover, they are aligned to the second paper for indicating how adaptations on capabilities' antecedents works. More than internal and external influences, as indicated for the second paper, companies may to anticipate for adapting their internal resources, cooperate, as well as just to follow external trends.

Overall, the three chapters are integrated among them. Besides each one tells a part of capabilities development story, they are contributing for the OM field to advance with capabilities literature. While internal overemphasis has been given for the capabilities debate (Felin et al., 2012; Rockart & Dutt, 2015; Winter, 2012), few studies have pointed out external elements (Dangol, Bahl& Karpak, 2015; Vanpoucke, Vereecke& Wetzels,2014). From this, we argued that capabilities development does not depends of internal decisions, but how companies maintain its relationship with external players, such as suppliers, customers, competitors and others – for positing through a cooperative way, just following rules, or anticipating to the market changes. Finally, this debate helps OM field to advance regarding ways suggested for companies developing its operational task.

In the managerial perspective, this research contributes for indicating how companiesare performing adaptations in order to develop their operational task. Therefore, managers need to pay attention for identifying opportunities and threats, evaluate them, reconfigure their operational task, and to check results for a new round of adaptation (internal feedback). Furthermore, managers need to monitor external changes in order to adapt their operational capabilities. As technological changes are faster than past decades, managers face a challenge for adapting internal resources of companies in order to maintaining alive in the red

ocean.Especially for the data-drive era brought by industry 4.0 concept, in which companies will need to adapt their operational structure based on technology in order to be alive.

Finally, this study provided answers for each research question described above. I hope these papers contribute to the advance of operational capabilities literature in the OM field. Limitations were present in this study; however, they were described particularly in each chapter.

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