The dissemination of operational capabilities in manufacturing networks: a coevolutionary perspective

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Abstract: Although scholars have agreed on the relevance of capabilities to operations strategy and the competitive advantage of firms, the process by which they are disseminated among networks remains mostly unexplored. Since operational capabilities are difficult to imitate or acquire, manufacturing networks represent a favourable environment for exchanging experiences, knowledge and capability development speed. This research aims to understand how operational capabilities are disseminated between headquarters and the plants in manufacturing networks based on the coevolutionary theoretical perspective. The study used multiple case studies to explore four organisations in three different industries. The findings demonstrate a possible relationship between the manufacturing stages proposed by Wheelwright and Hayes (1985) and the coevolutionary theory. The coevolution of manufacturing units and the dissemination of capabilities is a gradual process, comprise cumulative motivational factors, and involve actors from different dimensions that absorb these capabilities at different speeds.

Keywords: operational capabilities; dissemination; manufacturing networks; subsidiary; headquarters; coevolutionary theory; manufacturing stages; case study; efficiency; complexity; maturity.

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1 Introduction

Over recent decades, operations management literature has been exploring the process by which operational capabilities are developed that focuses on how specific capabilities influence performance and how they are developed (e.g., Li, 2000; Ethiraj et al., 2005; Menor et al., 2007; Wu et al., 2010; Konlechner et al., 2018). Such studies are generally motivated by the fact that capabilities comprise the application of a firm's resources and the transfer of knowledge, and they evolve as a reflection of the firm's learning process (Su et al., 2019).

Operational capabilities, however, are difficult to imitate or acquire (Ethiraj et al., 2005). In their pioneering work, Wheelwright and Hayes (1985) stated that most competitive companies are likely to attribute credibility to their manufacturing decisions, and therefore, become interested in developing and disseminating their operational capabilities.

There is also consistent literature on how firms, institutions and sectors co-evolve (Braguinsky and Hounshell, 2016; Duarte and Rodrigues, 2017; Mckelvey, 1997; Lewin et al., 1999). Some of these studies investigated the influence of the variation-selection-retention aspects of developing capabilities between two or more actors in a coevolutionary relationship (Koza et al., 2011; Murmann, 2012). Existing research has focused on knowledge transfer (e.g., Tsai, 2001; Lang et al., 2014; Szász et al., 2019). Few studies, however, have explored in depth what is involved in the dissemination process of capabilities within a manufacturing network.

As operational capabilities are considered an essential aspect of manufacturing-based competitive advantage (Krause et al., 2014), their dissemination among manufacturing plants can be a significant challenge for managers. Bozeman et al. (2015) stated that the transfer of practices, routines, or technologies does not mean that a capability will be necessarily replicated.

This study, therefore, aims to understand how operational capabilities are disseminated between the different parts of a manufacturing network, including the headquarters and plants. Based on this, the research question is: *how are operational capabilities disseminated within manufacturing networks?* To address this proposed research question, we adopted a case study approach (Eisenhardt, 1989). We analysed multiple cases from three different sectors: the auto parts, metallurgical and food industries.

We contribute to operations and supply chain management literature by discussing the relation between Wheelwright and Hayes's (1985) framework related to manufacturing stages and the coevolutionary theory. We analysed the process of capabilities dissemination within a manufacturing network. Our results are unique by proposing a continuous and gradual process based on the relationships among the units leading to the adoption of their routines and competing priorities. This process allows companies to develop operational capabilities through different dimensions, actors and speeds.

The sequence of this paper is structured as follows: Section 2 presents a literature review of manufacturing networks, operational capabilities and the coevolutionary theory and discusses possible synergy with the operational strategy. Section 3 describes the methodological steps, followed by the results of the within-case and cross-case analyses, and the discussion of the findings in Section 4. Finally, section 5 presents the implications for theory and practice and the main conclusions and guidance for future studies are presented in Section 6.

2 Theoretical framework

This section presents a brief background of the manufacturing networks, operational capability dissemination processes and coevolutionary theory-building blocks. Further, the combination of the theoretical approaches is addressed by observing the possible synergies' between the four potential mechanisms that might drive coevolutionary patterns and the manufacturing roles continuum. We conclude the section by presenting a research framework that guides the investigation.

2.1 Manufacturing network and the operational capability dissemination process

A manufacturing network is a set of plants that are part of the same corporation, but with different locations (Ferdows, 1989; Rudberg and Olhager, 2003; Cheng et al., 2011). Vereecke et al. (2006) proposed a manufacturing network typology based on a subsidiary's position concerning the plant core role (Bruch et al., 2020) and knowledge exchanged in the network. The authors identified four distinct types of participation:

1 Isolated units – There is little innovation; they rarely receive visitors or send employees to other manufacturing units.

2 The recipients – They also act in isolation, but receive innovations from other units and absorb them into their process.

3 Benchmarking, or best-practices units – Plants that behave as a reference for the others; they are centres of knowledge sharing, frequently visited by other units.

4 Actively interactive units – They continuously receive and send human resources to other units to learn best practices and share lessons learned with sister companies.

Operational capabilities are considered the 'secret ingredient' of manufacturing's competitive advantage (Wu et al., 2010). Understanding operational capability as a complex set of skills and knowledge that are purposefully built and accumulated over time, with the idea of transferring operational practices, routines (Maritan and Brush, 2003), or technology (Bozeman et al., 2015; Chen et al., 2015; Lin and Berg, 2001) is no guarantee that the capability will be effectively shared (Sangaiah et al., 2015; Su et al., 2019).

Since capabilities are difficult to replicate, and because several factors are necessary for establishing them, there is no apparent convergence in the literature on the operational capability dissemination process within a network. Manufacturing networks, however, are a favourable environment for the exchange of experiences and knowledge (Su et al., 2019).

Capability dissemination is related to inter-organisational learning, absorption, and applying the knowledge acquired and adapted to fit a specific context (Chen et al., 2015; Van Den Bosch et al., 1999). Helfat and Raubitschek (2000) argued that organisational capabilities and knowledge construction are a coevolutionary process. The authors developed a model that emphasises the continuous coevolution of knowledge and products over time.

2.2 The building blocks of coevolutionary theory

The coevolutionary perspective stems from the 19th-century biology field, which explores how species and their environment co-evolve over time. According to Norgaard (2005), coevolution involves the relationship between entities that directly affect each other and comprises several attributes, some of which shape the coevolutionary perspective.

The starting point is the presence of at least two (heterogeneous) actors, and their need to exist (ontology). This approach considers companies, actors, and competitive environments to be the results of managerial decisions and external influences (changes in technology and socio-economic issues, for example). According to Volberda and Lewin (2003), a firm's organisational strategies co-evolve with the environment in which it is embedded. Consequently, different institutions, firms, actors, and/or environments provide opportunities for learning and change (Dangol et al., 2015; Dooley and Van de Ven, 1999; McKelvey, 2002).

Secondly, coevolution develops as a result of the variation and diversity of a specific phenomenon. It refers to different forms of valuation, knowledge, organisation, or way of doing things that emerge from different skills, the availability of resources, and the experience gained over time by each agent in the environment (Norgaard, 1994; Winder

et al., 2005; Kallis, 2007). In this sense, coevolution encompasses a multilevel perspective (at the micro, meso and macro-levels) by simultaneously affecting multiple dimensions, such as the internal resources of firms, their supply chains, the industry itself, and institutions (Braguinsky and Hounshell, 2016; Child et al., 2012; Duarte and Rodrigues, 2017; McKelvey, 1997).

The selection attribute emerges from the need and often from the pressure to change. This attribute consists of factors taken from the macro or micro-context that influence the current order, such as new technologies or the scarcity of resources (Kay et al., 2018). In this sense, actors disregard previous behaviour or routines in favour of better or more modern practices (Braguinsky and Hounshell, 2016).

Looked at from the coevolutionary viewpoint, the establishment of an operational capability is balanced by both the resources and the environment in which firms are embedded. Changes in the environment influence the need for new or improved capabilities that are required to maintain the competitiveness and survival of the organisation. Organisations are seen to influence other organisations and their environments systematically and are also influenced by them (Braguinsky and Hounshell, 2016). This phenomenon is called feedback cycle (Lewin and Volberda, 1999; McGlade and Garnsey, 2006) and affects the relationship between the actors in different directions over time (Murmann, 2012) and in a path-dependent process (McGlade and Garnsey, 2006). In this sense, organisational trajectories are constructed by adaptations over time, which directly or indirectly impact the way organisations interact (Lewin and Volberda, 1999; McGlade and Garnsey, 2006).

Operational capabilities are developed over time and become path-dependent by identity; they assimilate and exploit new knowledge and experiences drawn from the environment. Therefore, the attributes mentioned above suggest that firms, industries, and environments co-evolve, each at its own pace, with distinct, interdependent patterns of change, but with multidirectional influences (Raddats et al., 2017; Lewin et al., 1999).

2.3 The synergies between the coevolutionary theory and operations strategy

Each of the plants in a manufacturing network can access knowledge from its partners, such as customers, suppliers and third parties (Dyer and Hatch, 2006). Thus, a manufacturing network might favour the sharing of knowledge among several units (Pla-Barber et al., 2018). It does not mean, however, that each unit will absorb the same level of knowledge, develop the same capabilities or achieve the same outcomes (Almeida and Phene, 2004; Wiech and Friedli, 2020).

Ferdows (2012) compared the operational performance of several units of the same manufacturing network that have the same product mix, similar, previously established routines and the same operations strategy. He realised that some of them were unable to achieve similar outcomes. According to the author, this can be caused by location constraints, an unstructured business strategy, or management constraints.

Vereecke et al. (2006), on the other hand, argued that it might be caused by the maturity level of the manufacturing network. They categorised four different ways a subsidiary can participate in the development process: by acting alone, being open to receiving new initiatives, acting as a reference for the others, and finally, by sharing and absorbing experiences from others.

Table 1 Conceptual alignment between the coevolutionary theory and a manufacturer's strategic role

Stages in manufacturing's strategic role (Wheelwright and Hayes, 1985)	*Coevolutionary stages (Volberda and Lewin, 2003)*	*Capability dissemination focus*
1st stage – internally neutral Minimises negative manufacturing potential. Outside experts are called in to make decisions about strategic manufacturing issues. Internal, detailed management control systems are the primary means for monitoring manufacturing performance. Manufacturing is flexible and reactive. Short-term view.	Naïve selection Continuous cycle between variation, selection (caused by resource constraints) and retention. Top management is passive and not involved in operations. May reflect operational inertia.	Micro/micro
2nd stage – externally neutral Industry practice is followed. Seeks and achieves parity with the competition by implementing standard market practices. Investments are the primary way to achieve manufacturing competitiveness.	Managed selection Continuously realigns routines based on the intra-organisational environment. Top leadership is limited, but no longer detached from operations.	Meso -> micro
3rd stage – internally supportive It provides credible support for the business strategy. Manufacturing investments are screened for consistency with the business strategy. Manufacturing strategy is formulated and pursued. Long-term strategies and trends are systematically accessed.	Hierarchical renewal Top management-driven process reshaping. Top-down adaptations, action plan definition and results measurement. Coevolution occurs in a purposeful way involving sharing of practices, indicators and action plans.	Macro -> meso -> micro
4th stage – externally supportive Pursues the competitive advantage of the manufacturer. Efforts are made to anticipate the potential of operational practices and technologies. Marketing, manufacturing, and engineering decisions are addressed jointly. Long-term operations strategies are pursued to develop capabilities in advance of needs.	Holistic renewal Considers that the changes are not influenced by top management, but from a cognitive connection among those involved of the whole in the coevolutionary process. Those involved are connected and driven by beliefs and ideologies.	Macro -> meso <-> micro

Source: Adapted by the authors

The discussion about operations management and the different maturity levels of units for advancing operational capabilities is not new. Wheelwright and Hayes (1985) presented manufacturing roles in a four-stage continuum of development and explained the challenges and choices faced by managers at each stage (Table 1). At the first stage, internally neutral, the manager has no influencing power, the aim being to minimise potential risks emerging from the company's manufacturing.

On the other hand, at the fourth stage, externally supportive, manufacturing is considered to be a competitive advantage of the company, and the manager can anticipate the potential for new practices and technologies and develop an extensive relationship between its partners. Thus, both practices and routines can be shared among units from the headquarters to the plants (Wheelwright and Hayes, 1985). The deployment of an operations strategy, however, seems to be more complex and demands time and frequent interactions between actors to evolve (Volberda and Lewin, 2003).

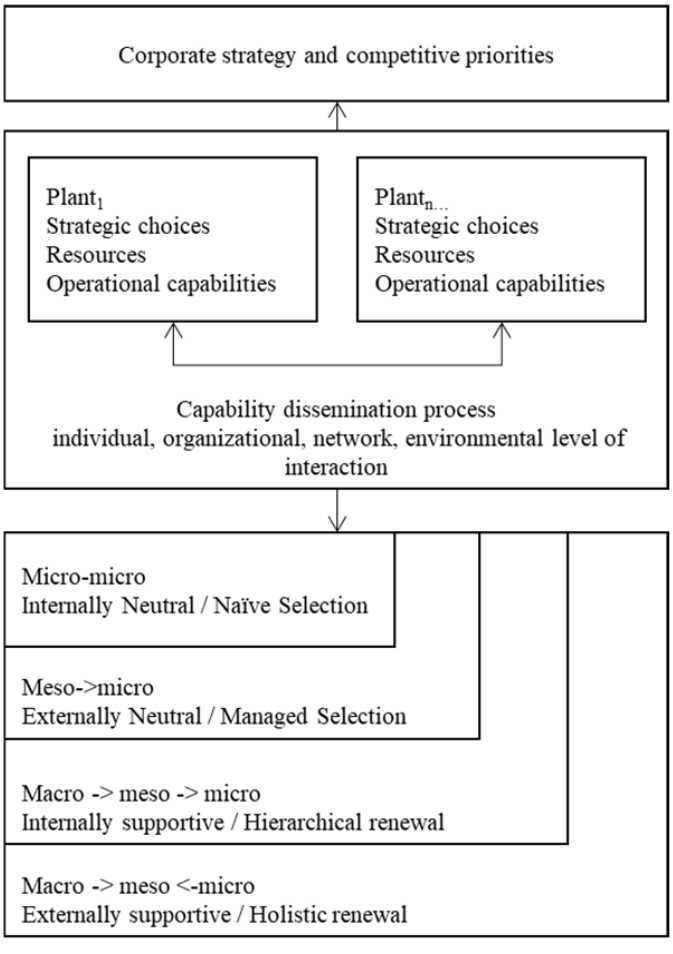
A possible path to understanding this phenomenon was inspired by Volberda and Lewin (2003). The authors propose four possible mechanisms that might drive coevolutionary patterns. These mechanisms explain how companies co-evolve, based on the intentions of top management, the kind of coevolution sought, and, consequently, the primary outcomes of this interaction.

The first mechanism is naïve selection (Table 1), where coevolution is based on a cycle of continuous variations arising from random initiatives, a selection that is caused mainly by the scarcity of resources. Routines and capabilities are disseminated between plants by way of interactions among the sub-units of the company, including its departments, functions, and divisions (Volberda and Lewin, 2003). On the opposite side, there is the holistic renewal, which differs from the others and considers that changes are addressed because of a collective, cognitive connection between those involved in the coevolutionary process. Similar beliefs and ideologies connect those involved and all perceive the environment in a very similar way. In this sense, new forms of work, and consequently, new strategies emerge.

Analysis of the coevolutionary mechanisms proposed by Lewin and Volberda (2003), combined with the stages of the strategic manufacturing role (Wheelwright and Hayes, 1985), allowed for the preparation of a conceptual model that could support analysis of the operational capability dissemination process. Previous studies of the competitive advantage of operational capabilities explored one-way perspectives, such as RBT. However, when studying the dissemination of capabilities, it is possible to combine both theoretical approaches in a broader context and enable observation of the phenomenon from a multi-dimensional perspective (Duarte and Rodrigues, 2017).

In sum, the research framework (Figure 1) considers that the starting point of disseminating capabilities is the operational strategy and the competitive priorities definition. Each unit/plant develops its strategic choices based on resource availability and the operational capabilities based on these directions. The extent to which the dissemination will occur depends on the individual, organisational, network, and environmental level of interaction. That said, the manufacturing roles and the coevolutionary interaction seem to cover this process. It evolves from the micro-level to a dynamic micro-meso-macro level of interaction.

Figure 1 Research framework



Source: Devised by the authors

3 Method

The present study adopted a qualitative research method using multiple case studies (Miles et al., 2014). This research approach is indicated for a contextually rich phenomenon (Bhakoo and Choi, 2013) and allows for a deep understanding of how operational capabilities can be disseminated between headquarters and plants in a manufacturing network. Eisenhardt (1989) proposes a five-stage structure for case study research. According to this model, a case study should analyse the following steps: the research question (already presented), case selection, data gathering, data analysis and replication. This section was structured following the structure proposed by this author.

3.1 Case selection

We chose companies that belong to industries known for applying best practices in operations management: auto parts (Holweg and Pil, 2008), metal mechanical (Ferdows, 2006) and food (Christopher and Lee, 2004; Roth et al., 2008). After identifying suitable companies for our research purposes, we invited managers to participate by email or telephone. A confidentiality agreement was sent to those who accepted, indicating that we would not disclose the names of the companies or participants. The following cases were then selected:

Case A a Brazilian food company with three plants

Case B a Swedish machinery company with 12 plants

Case C a German auto parts company with 170 plants

Case D a Swedish auto parts company with 130 plants.

3.2 Data gathering

Data was gathered by way of in-depth interviews using a semi-structured protocol (Miles et al., 2014), direct and non-participatory observation (Angrosino and Rosenberg, 2011), and analysis of documents, company statements on the organisation's website and articles in the business press (Miles et al., 2014). Depending on the hierarchical level, the discussion sought to focus on different aspects:

1 With top management the focus was on competitive priorities and the translation of the organisational strategy into an operations strategy.

2 With middle management the focus was on the deployment of the operations strategy and the way it is conducted.

3 With staff directly involved in the daily operations the focus was on the dissemination of capabilities among the units.

The informants chosen for the final sample were identified using the snowball technique (Miles et al., 2014).

Interviews lasted about one hour on average. The number of informants was defined by content saturation when the informants' statements became repetitive and did not result in any new or relevant information being added to the context (Eisenhardt, 1989). In total, 31 executives were interviewed (Table 2).

The direct and non-participatory observation included attending meetings with company leaders, visits to plants, and staying for a few days in the departments observing the dynamics and the interaction between actors. The direct observation allowed for an understanding of the characteristics of each company when disseminating capabilities, and the link between executive statements and company practices. Non-participatory observation notes were consistently taken immediately after the visits to record the data in as rich detail as possible.

Table 2 Description of cases

Case	*Revenue (USD millions)*	*# workers*	*Headquarters*	*# plants*	*Facilities*	*Informant's title (interview length)*
A	150	2,200	Brazil	3	Brazil	CEO (67′46″)
						Industrial director (43′51″)
						Plant manager 1 (81′53″)
						Plant manager 2 (57′22″)
						Plant manager 3 (72′24″)
						Quality manager (49′42″)
						R&D manager (49′54″)
						Human resources manager (62′27″)
						Engineering manager (39′53″)
						Continuous improvement coordinator (31′41″)
						Sustainability coordinator (69′04″)
B	570	1,700	Sweden	12	Worldwide	CEO (35′21″)
						Production manager (62′11″)
						Innovation manager (103′50″)
						Supply chain manager (82′02″)
						Human resources manager (54′45″)
						Sales manager (58′35″)
						Logistics and transport coordinator (48′32″)
C	5.8	22,916	Germany	170	Worldwide	Latin America business director (67′23″)
						Project manager 1 (77′01″)
						Project manager 2 (58′33″)
						Engineering manager (63′24″)
						Quality manager (57′11″)
						Field and customer services manager (40′45″)
D	5.5	46,039	Sweden	130	Worldwide	CEO (67′45″)
						Global procurement director (23′55″)
						Regional procurement manager (91′37″)
						Quality manager (71′23″)
						Logistics manager (50′48″)
						Project manager (68′23″)
						Six Sigma projects coordinator (61′13″)

Source: Prepared by the authors

Table 3 Quality criteria application

Criteria	*Definition*	*How to cope with the criterion*
Internal validity	The degree to which findings correctly map out the phenomenon in question (Lincoln and Guba, 1985).	• Four cases from three different industries known for their excellent reputation in applying best practices in operations management • Interviews with professionals from different hierarchical levels, with at least seven interviews per company • Propositions presented • The theoretical framework presented
External validity	The degree to which findings can be generalised to fit other settings similar to the one in which the study occurred (Lincoln and Guba, 1985).	• Specification of the unit of analysis and the context • Dense context description (within-case analysis)
Reliability	The extent to which findings can be replicated or reproduced by another investigator (Lincoln and Guba, 1985).	• Research protocol might be provided upon request to the authors, including the semi-structured questionnaire • Documentation of all the procedures performed during the case studies • Data analysis using proper software (NVivo) • Transcription of the interviews • Use of multiple researchers
Objectivity	The extent to which findings are free from bias (Lincoln and Guba, 1985).	• Raw material presented, including interviewee declarations • Create a case selection criterion

Source: Prepared by the authors

3.3 Data analysis

The interviews were recorded with the informants' approval and transcribed by the researchers. Within-case and cross-case analyses proposed by Eisenhardt (1989) provide detailed transcriptions and notes of the interviews, concept codifications, tabulation, data analysis, and lastly, the final interpretation of the results.

3.4 Replication

The process of ensuring the accuracy of the information collected began before the data was gathered (Yin, 2014). According to Lincoln and Guba (1985), a researcher using a qualitative technique needs to adopt quality criteria to ensure the accuracy and quality of the multiple case study (Table 3).

4 Data analysis and discussion

4.1 Within-case analysis

4.1.1 Case A

Founded in 1967, Case A has three units in Brazil that manufacture candies and snacks (peanuts). The organisation operated with just one plant until 1980. The owners acquired Plant 2 in the 1980s and Plant 3 in the 1990s. Several decades later and each unit have retained its particular characteristics, with little effort being made to seek any possible standardisation. There has been no formalised procurement strategy and no proposal for an effective industrial reorganisation.

Consequently, each unit organises its production process individually, even though they all produce similar products. In mid-2010, the second generation assumed the business. The new CEO decided to restructure its operations and hired a former production manager from a multinational Swiss food corporation that is known for its quality and operational excellence. The new operations manager gradually sought to restructure the company's operations. The tentative of deploying of the operations strategy between units is based on informal relationships and with little governance of all of the processes.

The company is at the preliminary stages of implementing an operations strategy. Although employees have been in the company for many years, there are no clearly established practices or documented routines, and no lessons seem to have been learned. Despite seeking to standardise company processes quickly and train employees, few results have been perceived so far. The fact is that the company's CEO does not have a planned, structured vision to follow, and consequently, because of the company's competitive priorities, short and medium-term goals are not clear to anybody.

The relationship between the plants and the HQ is unilateral. There is no established relationship between the units for sharing practices, establishing priorities or problem-solving. Because of its lack of knowledge of the institutional environment and the competition, the company does not understand how the environment can impact it internally. The interviews showed that this manufacturing network is poorly integrated (Vereecke et al., 2006).

Decision-making and innovation are also centralised in a single unit because top management still does not exploit the complexity of the other business units. It explains why, despite being poorly qualified, managers are retained because of ties of friendship, trust, and long-term experience in the field. Processes are poorly documented. Even with the initiatives introduced by the technical management (maintenance and engineering) and quality management that are common to the units, managers still find it challenging to get to know the processes in any depth. Top management does not encourage integration between the HQ and the plants. Expressions of the type 'there is no control', 'there is no way of integration' are common responses given by the managers in the questionnaire. As each unit has its own informally-established processes, the company finds it difficult to track its operational efficiency level.

Company A is not even fully aware of the market it belongs to. Despite being in existence for approximately 50 years, the company does not have a clear, structured demand plan. This reflects the historic leadership the company has had over the years. With the arrival of new entrants, however, the company realised that it had lost a

significant part of its market share, and it has developed reactive actions to try to recover the market. From this perspective, the company believes it needs to acquire more modern equipment and invest in facilities.

The company finds it difficult to establish its competitive priorities. The practices currently adopted by the units involve operational modes in which there are no clear goals or efficiency objectives. Its processes are suffering significant losses and it has material and inventory management problems. Despite believing it is the market leader in terms of the technology, it uses for producing bubble gum and candies, the company is still unable to say in which market it operates. When asked about these aspects, all the interviewees agreed that the company does not have any clear competitive priorities, does not communicate well, and has no medium/long-term strategy.

In general, each unit establishes its priorities, defines its own routines and reshapes them over time. The three manufacturing plants do not record or follow-up best practices or exchange knowledge. Each unit's priority is to solve its short-term problems. There is no evidence of integration between the units, nor is there any exchange of experiences between managers or employees. Each one develops its owns practices and routines from the resources available and in line with the direction that is received from top management. As soon as the routine is adopted, it is put into practice and disseminated throughout the plant. With the emergence of any variation, which may, for example, be new customer demand, operational inefficiency, or quality problems, this practice is reformulated. The role of top management is limited to monitoring the results (HQ monitoring). The top management has little influence on the operations strategy.

4.1.2 Case B

Company B is headquartered in Sweden and is one of the biggest manufacturers in the market for iron and other metal powders. The company has 18 plants worldwide, is one of the industry leaders, and sells especially to the automotive industry in the Latin American market (about 70% of the company's turnover). The export volume is relatively low (10%) and mostly between its units. In recent years, however, due to its high dependence on the automotive industry, the company has faced substantial demand issues and its financial performance has been inconsistent.

Intending to recover the competitiveness of its operation in Brazil, one of the unit's central policies was to explore internal knowledge and information. The sharing of results information and short and medium-term objectives was driven primarily by its HR manager. This orientation was because the area was sufficiently competent to "speak the different languages of the corporation" (Brazilian CEO, during the interview). Over time, to be able to align employees from the most diverse levels using a common language. We also observed that top management is close to workers on the shop-floor, knows the employees in the unit, and seeks to visit them and follow their processes in different shifts. From the employees' perspective, this attitude inspires confidence. It demonstrates the president's interest in familiarising himself with the problems and participating in the solution in a more agile way.

In the perception of other levels of management, the maximum efficiency and speed constraints when developing the company's operational capabilities result from the region in which the plant is located; Mogi das Cruzes, a city with a limited labour force. Many newly graduated students and professionals prefer to work in São Paulo in their search for better salaries. The factory is also located far from the Industrial District.

These facts meant that the company recruited professionals with little experience and then had them undergo intensive training in Brazil and abroad. The company also created knowledge-sharing initiatives among employees, thus motivating them to train their colleagues outside the plant and retain talents.

> "[…] And the interesting thing is that some people have already changed. If there is an issue, then it's one of competence and learning. […] and I'd say: 'It's no good for you to assimilate this knowledge and for it to remain with you; if you want to grow, you have to pass this knowledge on to others …'" (excerpt from the interview with the operations manager of the Brazilian unit)

All units manufacture very similar products, which mean the processes are mostly the same. So, most of them are standardised globally. Existing process differences are directly related to the level of technology and the equipment available at each site. The company's current focus is on improving operational performance and sharing best practices from the HQ with the units. The most important operational priorities are continuous improvement and cost optimisation while focusing on production efficiency, better materials management, waste reduction, and employee training for problem-solving.

Along with the other subsidiaries, the Brazilian unit is a knowledge-receiving unit, according to Vereecke et al. (2006). Knowledge is absorbed from a unit considered to be a technological reference point for the manufacturing network. The company has sent its employees to other plants for training and short immersion courses. After two years of international training, with several foreign trips and meetings, the result was still not satisfactory. The CEO understood that this was due to little experience in sharing practices and, consequently, absorption capacity is limited. Also, from his perspective, employees still find it challenging to analyse and compare the processes critically and to decide on the best practices to be applied locally.

4.1.3 Case C

Company C is a German auto parts manufacturer; it is present in 38 countries and has approximately 30,000 employees distributed among its 170 units worldwide. The three main business divisions are tubes and rolling stocks; engineering services, and the development of projects in various sectors, such as the automobile, infrastructure, industrial, and public transport industries; and the automotive division (the object of this study), with the development and production of structural parts, chassis, modules and engines. The automotive division has 70 plants in 29 countries and about 21,000 employees. There are five manufacturing units in Brazil.

The competitive priority of this corporation is product quality. Consequently, they care greatly about the processes, and the HQ vigorously seeks standardisation. According to its website, the company emphasises "the highest quality requirements and a production that saves resources and minimizes the environment are the two objectives that complement each other and that we are constantly pursuing." This strategic orientation is perceived in the behaviour of both the executive staff and workers on the shop floor.

Company C is highly interested in the continuous development of its employees and in improving its techniques, processes and operational efficiency. On various hierarchical levels, employees are urged to undergo frequent training. It is not unusual for them to travel abroad for periods of immersion in other manufacturing units as a way of quickly

absorbing new knowledge. As in Case B, Company C has three benchmarking units known as knowledge and training centres, which receive employees from other units (Vereecke et al., 2006). However, Company C's network differs somewhat from that in Case B because all units are highly linked to the HQ, which defines the rules, standards, and methodologies adopted in all plants. This strong emphasis on global standardisation, however, has important local implications. Due to insufficient knowledge of the local context (Arellano et al., 2020), it is not rare for plants to be asked to undertake unnecessary work in the local context since the HQ cannot support the plants properly. The HQ is rarely willing to accept plant initiatives for solving problems:

> "[…] there is local diversity of solutions, providers, and alternatives for attending our needs and those of our customers. However, when we try to develop this supplier and product, the HQ urges us to follow international requirements (which, in some cases, do not apply in Brazil). For example, a specific product needs to be resistant to shallow temperatures, which makes sense in Europe and the USA. But it makes no sense in the Brazilian environment, which is tropical. In Germany, they don't even care. They (HQ) don't take a single step towards delegating a degree of autonomy to us. In some cases, it's embarrassing, and sometimes it's frustrating." (Project manager)

On the other hand, these highly standardised global processes lead to positive outcomes. The existence of a common language; and similar equipment, procedures and employee requirements, and profiles has made it possible to exchange experiences for problem-solving continuously. Because the HQ establishes practices and routines unilaterally, it influences new capabilities in its subsidiaries. Company C, therefore, has an exact way of implementing its operations strategy. This initiative aims to ensure the governance of its processes and provide a common language for problem-solving among units.

Case C provides clear evidence of the importance of operational capabilities as a source of competitive advantage. A company's capability is its operational responsiveness (Wu et al., 2010). The basis of any company is its firm-specific knowledge, processes and routines, which are developed from an operations management system that is regularly used for problem-solving. Since this auto parts manufacturer develops exclusive procedures for automakers and does not operate in the aftermarket, it has developed a whole technical framework for the customer. This focus can be either for a low-cost, mass-produced automobile or a high-end model produced on a smaller-scale. As a result, its operational capability allows it to operate with several different batch sizes. This capability is embedded in the company's engineering and technological expertise.

On the other hand, because Company C has a high degree of specialisation, it is not open to new practices and technologies from other units. Consequently, they lack to absorb the cumulative positive outcomes from others to improving and reconfiguring their processes. On the contrary, the company establishes a business strategy for translation into competitive priorities for each unit. Procedures and routines are defined in Germany and replicated at all plants without exception. No adjustments or changes to these procedures are allowed without the agreement of the HQ. It is a possible evidence of the 'rooted' model proposed by Ferdows (2006). According to the author, these are networks of companies whose units are rooted in a particular environment, culture, or product, with significant mobility barriers. The established models are generally managed

from the centre of the manufacturing network (top-down) and passed on to the units. These characteristics are regularly present in the strategy adopted by Company C.

The HQ monitors the macro-environment to identify and decide the projects to invest in, based on risk analysis and medium and long-term business opportunities. Due to the specificity of the developed projects (practically all are developed jointly with the automakers), the strategies are defined by the HQ.

Practices are shared among the units following the establishment of competitive priorities. In theory, the best practices adopted in the European units are followed closely in the other units. The local context is little considered, and the company rarely allows significant operational changes. Despite the procedures being highly disseminated throughout the manufacturing network, the respondents argue that the operational results of the units are different (information based only on the interviews). It may reflect a homogeneous level in the transfer of practices. Still, the units do not necessarily have the same level of operational performance or the same capabilities. The HQ always finds it difficult to understand these divergences, and there are cultural conflicts with the units. As each unit is located in a different place, local aspects may impact the development of other processes.

An example of this was reported by one of the plant managers: “We have a serious problem with skilled labor in Brazil. We have not yet been able to achieve the same levels of operational excellence as in Germany with the same number of people. And they (HQ) insist on the understanding that it is not unwillingness. It is a characteristic of Brazil itself, unfortunately.”

4.1.4 Case D

Company D is a Swedish bearings manufacturer. The company is renowned for being the market leader in technology, quality and innovation. Its products and services are applied in several different industries (domestic appliance, automotive, aerospace and energy), which have provided the company with a diversified view of market demands and expectations. The company has also been a global player for more than 50 years, which brings the expertise required for operating in very different cultural, economic and political environments. Employees recognise this worldwide experience as necessary to create the company’s current values and mission. The company has maintained an innovation tradition, with 16 research and technology centres. It has made the brand a synonym for innovative, quality products, but with higher costs. However, due to the aggressive entry of very cheap Chinese products into the global market in the late 1990s, the customer quality requirements of the products manufactured by Company D became ‘commoditised’. The market was no longer willing to pay a premium price for the innovation and quality of its products. In this context, Company D was obliged to reformulate its corporate strategy and, consequently, its operations strategy.

The company changed some product lines and business models and introduced the ‘servitisation’ of its products. In other words, instead of just producing and selling products, it began to offer service solutions to its customers to keep quality assurance. The company has shared its responsibility towards the supply chain, thus benefiting financially when there are total improvements in the processes.

This same proposal was adopted in the factory in Brazil in the mid-2000s. The strategy comprised both in the operations reorientation and in relationships with its distributors and suppliers. Currently focused on “developing technologies to reduce the

environmental impact of assets during their life cycle, both in our operations and in our customers", the company has invested significantly in moving the units to be "highly involved in the manufacturing network to speed up improvements and avoid risks based on the failures and (lack of) experience of other units" (quality manager statement). This process is complicated, but investments have substantially affected its results and competitiveness over the years. There are technology and reference centres, but the company has motivated the operations executives to share their experiences concerning operational skills. This learning process has helped establish best practices in several units geographically distant from each other and have apparent cultural differences but operate in competitive environments with similar characteristics. In this sense, the company's capabilities are related to two orientations: operational innovation and operational improvement. Evidence of this was identified in the executives' responses and during visits to the plants.

Operational innovation has been part of the operational strategy for years. Still, not all units have the same level of expertise. This knowledge needs to be shared rapidly among the actors because they are multinationals and demand the same evolutionary speed from all the plants. The same is true of operational improvements. Even with the same practices, the same equipment, and the same resources, units perform differently operationally. As with Company C, it refers to different maturity levels of capabilities and to institutional environments among the units that are also diversified. In the case of Company D, however, all the units are permitted to make process improvements without the need for previous corporate approval. The units are highly motivated by innovation and continuous improvement. This approach seems to be quite close to a 'cultural' willingness to share and assimilate experiences (Vereecke et al., 2006).

All the group's units have the same production management model and a common language since they produce similar products with similar equipment. Therefore, process standardisation is high, ranging from the products and processes developed to the planning and purchasing processes. The company uses the same ERP, and the units share the same databases and technology. Best maintenance practices and production processes are standardised. All areas have frameworks and a matrix for information sharing. Employees often attend global meetings specific to their particular expertise.

The headquarter initially defines the competitive priorities for each unit based on their characteristics instead of deploying the same competitive priority to all of them. This approach is aligned with the corporate strategy and the strategic objectives of each division (automotive, industrial and services). At the same time, each manufacturing unit participates in strategic and operational decisions. They contribute to the analysis of demand, manufacturing performance expectations, key critical points, investment needs, idle capacity, capacity, technological trends and other aspects. This alignment is followed up monthly between the commercial, operations, and financial areas through sales, financial and operations (SF&OP) meetings. The company included the 'F' of financial to boost the participation of finance executives in corporate and operations strategies. The units monitor the macroeconomic aspects that directly impact their business and the relationship with the manufacturing network. This monitoring reflects the overhaul of plant unit priorities, which can potentially have an impact in leading to a reformulation of practices.

Manufacturing plants and the HQ interact continuously. Firstly, significant efforts are made for sharing and reinforcing the organisation's competitive priorities, followed by

lessons learned from other units, the action plan for continuous improvement, and the reshaping of operational practices. It is a constant, cyclical process and over time, these routines drive and accelerate the evolution of operational capabilities. The company also tracks the macro and meso-environment. It seeks to actively and continuously observe potential changes that may have an impact on future business. The HQ encourages the replication of this dynamic in all units in the manufacturing network.

It is noteworthy that, over time, the reformulation and maturation of capabilities have an impact on the market: suppliers adopt new levels of service, quality, and responsiveness as a standard in the market, and this leads to new improvements and quality standards and requirements being changed. Cyclically, the company is again impacted by continuous improvement. The dynamics start over and over again, denoting the coevolutionary characteristic of the institutions.

4.2 Cross-case analysis

Each case presented different aspects concerning the dissemination of operational capabilities. The differences relate to their operations strategies, levels of coevolution, and interactions within the network and with the external environment.

Our analysis starts from the attributes of the coevolutionary theory. As Company A is at an initial stage in its manufacturing management, the ontological object is not present in the three units. Despite being heterogeneous, the three manufacturing plants' managers and the operations director have a different understanding of each unit's competitive priorities. Consequently, they have distinct routines, do not share a standard management orientation, and have no management system for decision-making and problem-solving. Their heterogeneity is apparent. Despite the lack of a clear connection between the units, the actors' problems are practically the same. In aiming for immediate solutions, each unit seeks to solve its issues individually. In the other companies (B, C and D), the ontological object is perceived. We perceive the presence of variation-selection, but this is not shared with any sister plant.

Company B had two attributes that are still unclear. The first is the multilevel approach. The company does not recognise the impact of market changes on its operations. It is still at an early stage of development because its functions are at a point that precedes capability creation, which is reconfiguring its operational practices. The company's capabilities have been weakened. Historically, these were directly related to the expertise of employees and not duly rooted in the company. With changes in the external environment, the company was not sufficiently agile to exploit any possible operational changes. It lost employees in the cyclical crisis and could not develop new capabilities and resources (exploitation). After analysing the cases, the main attributes in the coevolutionary process are summarised in Table 4.

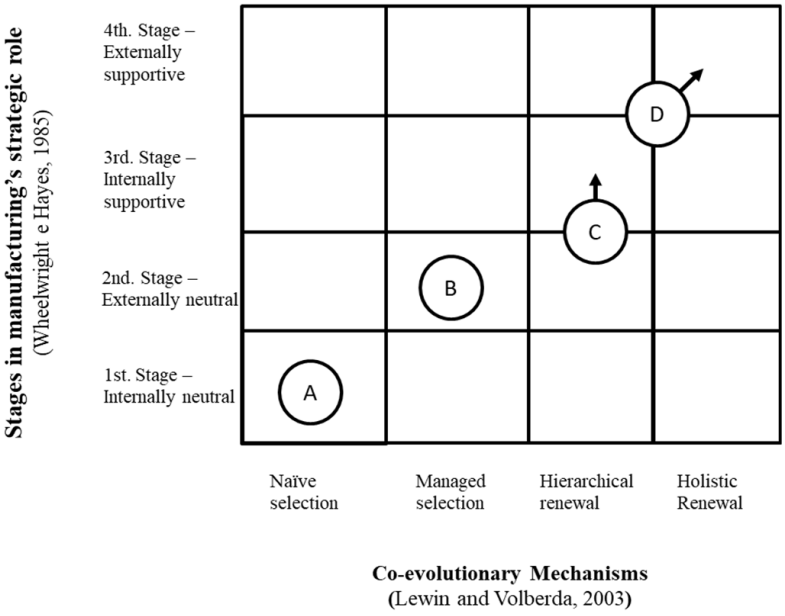
The four companies are also at different stages as far as concerns their manufacturing networks. It suggests that a relationship exists between the stages proposed by Wheelwright and Hayes (1985) and the coevolutionary theory. More specifically, operational capability emerges from established practices and develops over time. Thus, it is possible to identify that each case is at a different stage in its manufacturing development. Some companies at more advanced stages today than others strengthen the argument that "these stages are a continuum" [Wheelwright and Hayes, (1985), p.103].

Table 4 Attributes of the coevolutionary theory identified in the cases

Coevolution attributes	*Case A*	*Case B*	*Case C*	*Case D*	*Authors*
Ontology object		X	X	X	Winder et al. (2005)
Variation and diversity	X	X	X	X	Norgaard (1994), Winder et al. (2005), Kallis (2007)
Selection	X	X	X	X	Norgaard (1994), Kallis (2007)
Emergence or generation of new variations	X	X	X	X	Norgaard (1994), Kallis (2007), McGlade and Garnsey (2006), Kay et al. (2018)
Multilevel perspective			X	X	Norgaard (1994), McKelvey (1997), Winder et al. (2005)
Feedback			X	X	Lewin and Volberda (1999), McGlade and Garnsey (2006)
Multidirectional causality			X	X	Kauffman (1993), Murmann (2012)
Unpredictability	X	X	X	X	McKelvey (1997)
Absorption capacity		X	X	X	Cohen and Levinthal (1990)
Trajectory		X	X	X	Lewin and Volberda (1999), McGlade and Garnsey (2006)
Heterogeneity	X	X	X	X	Dooley and Van de Ven (1999), Volberda and Lewin (2003), McKelvey (2002)

Source: Prepared by the authors

Figure 2 The positioning of each case in the coevolutionary manufacturing matrix



Source: Developed by the authors

Figure 2 shows Company A at the first stage proposed by Wheelwright and Hayes (1985). It is still incipient in the coevolutionary process, which is called a naïve coevolutionary mechanism. The plants are not integrated, and they have different operational strategies, procedures and routines. There are few established connections between the plant managers. We found no effort by top management to change this aspect. We highlight quality management among the regular links, which seeks to share successful practices and routines among the manufacturing units, thereby disseminating similar quality standards. The company is at the level of 'naïve selection' coevolution because there are few relationships between the units. Those that exist are limited to just a few practices. Top management is distant from the operational routines and focuses on some specific issues and on problem-solving. The company is bound to a low level of improvement because little is invested in assets or HR development.

Company B is somewhat more advanced than Company A. The company has already perceived opportunities for improving its operations and implementing standardised practices in its units. Established connections can build best practices, and these practices are shared with employees from other units through training and development. What differentiates Case A from Case B is the role of top management. In the latter, top management is directly involved in the operations and seeks to understand the constraints. It consequently invests time and financial resources in developing alternatives to foster continuous improvements. Evidence for this was the CEO's initiative to take over the industrial management role on an interim basis. Company B has characteristics from the second stage of Wheelwright and Hayes (1985) and the coevolutionary mechanism called 'managed selection' (Volberda and Lewin, 2003). The company seeks to increase sales by way of strategic reorientation and new customers. The goal is to maximise the use of its manufacturing capacity and improve scale-related gains.

Company C's characteristics fall between the second and third stages of Wheelwright and Hayes (1985). The company seeks to align communication in its manufacturing network, albeit using a top-down approach. Its operations strategy is deployed from the German corporate strategy. Case C is not entirely in the third stage for specific reasons. Firstly, the HQ finds it challenging to understand the differences in the local culture and the constraints of each unit (Arellano et al., 2020). They look for common standards rather than adapting them to suit different needs and market characteristics. At the same time, the company's units are trying to boost the trust of the HQ. Local investments are consistent with the corporate strategy, which is a characteristic of the third stage. More precisely, any new investment must be justified and aligned with ongoing projects. A definite return on investment is mandatory, including the life-cycle of equipment used after the project. The strategy process has a top-down orientation. Thus, the company's units have little autonomy and must strictly follow corporate rules and procedures. This aspect is an apparent characteristic of the coevolutionary mechanism called 'hierarchical renewal'. Therefore, Company C is positioned between the second coevolutionary mechanism and the third.

Finally, Case D is at the third stage, with some evidence being close to the fourth stage of Wheelwright and Hayes' (1985) proposal. We found apparent efforts to sustain a manufacturing-based competitive advantage. In the last 15 years, the company has developed many process innovations, with constant interactions between units and the external environment. It means that the units are highly motivated to share experiences between themselves. However, the managers stated that the implementation of techniques

and processes had already been exhausted. There was a need to discuss new ways of enhancing this process. This orientation shows a transition position from the coevolutionary mechanism of 'hierarchical renewal' to 'holistic renewal'.

The company has sought to increase the units' autonomy. However, the HQ still has a significant influence on the operations strategy, which is revealed by a close monitoring process. This aspect reflects a clear relationship with the coevolutionary mechanism of 'hierarchical renewal'. The company competes in a highly competitive market. It has a low turnover of personnel due to the internal recognition of success and achievements. Managers are forced to change by market pressures resulting from cyclical crises in the auto industry and the rapid rise in quality and low-cost products from China and Eastern European countries.

5 Implications for theory and practice

Scholars have been presenting several perspectives on capability development dynamics and their implications to strategy and operations management. However, from a practical point of view, it is challenging to translate such findings into a practical oriented-material. Our study provides elements that practitioners can use to recognise their current situation and discuss the paths to move forward. Our results suggest four stages blending manufactory maturity and the level of interaction between manufacturing units. It also reveals how one organisation can evolve from one stage to the other.

The implementation can start by discussing with executives, in similar positions of the respondents selected in this research, to what extent the organisation is open to sharing operational capabilities. Even though such roles can be easily identified in the field, there is not a standard tool for mapping them. Conversely, the practitioners can adopt the research framework (Figure 1) as a preliminary driver to the discussion. The elements investigated in our study can be replicated and adapted for any industry.

In brief, we can identify a set of key elements for the dissemination of capabilities in manufacturing networks. Firstly, companies need to develop formal channels to allow the communication among the units. Secondly, the units should develop an increasing standardisation in their routines and operational processes. Thirdly, top management should be closer of the decisions related to manufacturing. Finally, companies need to understand local constraints (Arellano et al., 2020) in order to align their units' strategies to capability development.

Therefore, this study helps develop an integrative theoretical approach between operations strategy and coevolutionary theory. In the context of our research, it encompasses the elements and dynamics involved in disseminating capabilities within a manufacturing network through the coevolutive lens. From the theoretical coevolutionary viewpoint, it was possible to observe the complexity of the relationships between manufacturing units and how the developed capabilities impact the external environment. The relationships formed between the units seek to minimise inefficiencies. Based on past experiences, the actors interact and adapt their routines and competing priorities. In this context, it offers a unique integration of theories that ought to provide a meaningful analysis of the theme.

6 Conclusions

The coevolution of manufacturing units based on the dissemination of capabilities is a gradual process. This process is related to the level of centralisation vs. the autonomy of the units and motivational factors. It involves several actors with different absorption speeds.

Operational capability is sometimes being created at the manufacturing network level. While this finding may not be very significant, it portrays the relationship between operational competence and corporate strategy. The former is a source of competitive advantage.

Our analysis, therefore, helps explain how complex relationships between manufacturing units can support the dissemination of operational capabilities. Despite the peculiarities of the context being a key aspect, this is an initial effort to understand a concept that companies usually perceive as a 'black box'. Even though the plants belong to the same corporation, and it should be easier to promote the dissemination of operational capabilities internally, the parental relationship between units can be a constraint when there is competition between units (Pla-Barber et al., 2018). Another restriction could be the geographical distance and different environmental contexts (Almeida and Phene, 2004; Tene et al., 2021).

One of the limitations of this study was the decision to adopt a purposeful selection of cases. We considered three critical conditions to mitigate possible bias. We sought polar cases (Eisenhardt, 1989) with distinct operational strategies and performances. There is no other way to do so but by purposeful selection. Another condition for case selection is the managers' willingness to participate in a case study. This aspect could be a significant challenge because many executives are uncomfortable about receiving a researcher in their plants, discussing their strategies and current shortcomings. Finally, the selection of the industries was initially based on the literature.

As suggestions for future research, we highlight the development of an ethnographic study to follow the dissemination process of capabilities between manufacturing units. Despite being a lengthy study, ethnography could provide valuable information when observing how the phenomenon develops over time and its micro, meso and macro-perspectives and dynamics.

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