International Journal of Logistics Management
Available online 10 April 2024
DOI: 10.1108/IJLM-02-2023-0077

From exploitation and exploration to exaptation? A logistics service provider (LSP) perspective on building supply chain resilience capabilities during disruptions

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Abstract

Purpose: During the supply chain disruptions caused by Covid-19, logistics service providers (LSPs) have invested heavily in innovations to enhance their supply chain resilience capabilities. However, only little attention has been given so far to the nature of these innovative capabilities, in particular to what extent LSPs were able to repurpose capabilities to build supply chain resilience. In response, using the concept of exaptation, this study identifies to what extent LSPs have discovered and utilised latent functions to build supply chain resilience capabilities during a disruptive event of high impact and low probability.

Design/methodology/approach: This conceptual paper uses a theory building approach to advance the literature on supply chain resilience by delineating the relationship between exaptation and supply chain resilience capabilities in the context of Covid-19. To do so, we propose two frameworks (1) to clarify the role of exaptation for supply chain resilience capabilities, and (2) to depict four different exaptation dimensions for supply chain resilience capabilities of LSPs.

Findings: We illustrate how LSPs have repurposed original functions into new products or services to build their supply chain resilience capabilities and combine the two critical concepts of exploitation and exploration capabilities to identify four exaptation dimensions in the context of LSPs, namely *impeded exaptation, configurative exaptation, transformative exaptation* and *ambidextrous exaptation*.

Originality: As one of the first studies linking exaptation and supply chain resilience, the framework and the subsequent categorization advance the understanding on how LSPs can build exapt-driven supply chain resilience capabilities and synthesize the current literature to offer conceptual clarity regarding the varied implications and outcomes linked to the repurposing of capabilities.

1. Introduction

The Covid-19 pandemic in 2020 caused an unprecedented disruption of supply chains, demonstrating the vulnerability of global trade systems which are characterised by complex material flows and just-in-time deliveries (Shen and Sun, 2023; Zighan, 2022). As supply chains can be regarded as networks cooperating to manage the material and information flow from suppliers to the end consumer (Bhatnagar and Teo, 2009), it needs to be stressed that the material flow of global supply chain networks primarily rely on logistics infrastructure provided by logistics service providers (LSPs). Scholars also highlight the increasingly critical role of LSPs in supply chains, as organizations focus on their core competencies and outsource logistics activities for more efficiency and flexibility in warehousing and transport (Herold *et al.*, 2021; König and Spinler, 2016; Liu and Lee, 2018).

During Covid-19, LSPs were among the first the first to feel the impact of the global disruptions as material flows declined, were delayed or stopped, leading to uncertainty on several levels (Özcan and Yumurtacı Hüseyinoğlu, 2023). In particular, it led to unprecedented volatility demands for logistics infrastructure, requiring LSPs to adapt rapidly to the changing operational capacity requirements (Gultekin *et al.*, 2022). However, the LSPs' core competencies of on-demand capacity supported by their flexible asset and logistics infrastructure placed them in the strategically critical position to alleviate the negative effects on supply chains caused by disruptions (Herold *et al.*, 2021; Liu and Lee, 2018). In other words, the operational adaptability and flexibility of LSPs not only to manage and coordinate material flows, but also to limit or even eliminate operational risks had a significant impact on the overall resilience of global supply chains (König and Spinler, 2016).

As a result, logistics and supply chain academics have started an extensive discourse about the role of LSPs in supply chain resilience (Dovbischuk, 2022; Herold *et al.*, 2021; Hohenstein, 2022) and have presented empirical evidence and theoretical constructs on how LSPs can build relevant dynamic capabilities (Teece, 2007) to respond to the supply chain disruptions caused by an external shock of high impact and low probability. However, the majority of the studies focus on how resilience capabilities were or can be built to recover from the disruption, thereby neglecting the nature of these innovative capabilities, in particular, i.e. to what extent LSPs can use exploitation and exploration to repurpose their capabilities to build supply chain resilience.

From a theoretical point of view, the repurposing of acquired capabilities during a crisis or disruption can be linked to the concept of *exaptation*. Originally used in the field of biology to illustrate features that originally have been developed for one function, but were later used for an alternative function (Gould and Vrba, 1982), the concept of exaptation has recently found its way into the business and management literature, investigating the role of exaptation in digital innovation ecosystems (Beltagui *et al.*, 2020), redesigning manufacturing (Liu *et al.*, 2021) or business model innovation (Codini *et al.*, 2023). Exaptation in a business context can be regarded as an innovative process that enables a transformation of existing offerings by increasing its efficiency or extending its range of uses (Andriani *et al.*, 2017). Exaptation can be defined as "the repurposing of artifacts, technologies, processes, skills, organizations, and resources for emergent uses that they were not (initially) designed for" (see Gould and Vrba, 1982; Liu *et al.*, 2021). It needs to be emphasized that exaptation usually leads to innovation *without* starting a innovation project from the start as the original work has been completed and needs 'only' redirection to new domains (Savino *et al.*, 2017). As such, exaptation allows to generate capabilities and knowledge in existing product or processes, but favors novel applications of an existing patterns (De Sordi *et al.*, 2019).

Studies about the exaptation of capabilities are rather limited, in particular in the logistics and supply chain sphere. As a response, this article attempts shed light on how LSPs can capture innovation from the exaptive-driven supply chain resilience capabilities after a disruptive event of high impact and low probability. To examine the resilience capabilities, this study takes the LSP's point of view, as these companies were at the logistics forefront during the Covid-19 pandemic and were subsequently not only heavily affected, but also needed to react quickly to the change and build new capabilities (Herold *et al.*, 2021).

In line with existing literature, we argue not only that the LSPs' capabilities play a critical part for supply chain resilience as their flexible logistics infrastructure and the associated assets put them in advantageous strategic position to react to even volatile capacity requirements (Gebhardt *et al.*, 2022), but also that the exaptation of supply chain resilience capabilities

depends on both *exploitative* and *exploratory* capabilities of LSPs (Wei *et al.*, 2021). Exploitation capabilities rely on *existing* knowledge and on an existing customer base and represents a firm's ability to "improve quality and lower cost continuously, improve the reliability of products and services, increase the levels of automation, constantly survey existing customers' satisfaction [and] fine-tune what is offered" (Gayed and El Ebrashi, 2022, p. 92), while exploration capabilities build and *new* knowledge and target new markets and represents the ability to "look for novel technological ideas, create innovative products or services, look for creative ways to satisfy customers' needs, aggressively […] target new customer groups" (Gayed and El Ebrashi, 2022, p. 92).

Given the scarcity of literature regarding the exaptation of capabilities, in particular in a logistics and supply chain resilience context, an examination of determinants and a clarification of its implications is warranted. More specifically, the interplay between exploitation and exploration capabilities and its implications on exaptation of supply chain resilience for LSPs are unclear, leading to the following two research questions:

> RQ1: *How do exploitation and exploration influence the exaptation of supply chain resilience capabilities?*
>
> RQ2: *How did LSPs shape the exaptation of supply chain resilience capabilities during Covid-19?*

In this conceptual paper, we theorize about the supply chain resilience capabilities of LSPs based on the concepts of exploitation and exploration capabilities and their implications on exaptation. Using conceptual research for theory building is well establish among researchers (Meredith, 1993; Wacker, 1998). Corley and Gioia (2011) argue that conceptual research and its associated frameworks provide useful tools for theory building and better understand relationships among constructs and concepts. Following Naim and Gosling (2023), we adopt a qualitative approach seeking for topics and themes from existing literature for a "discursive alignment of interpretation" (Seuring and Gold, 2012, p. 547) that are in line with the above mentioned research questions. As such, this paper not only takes "a novel perspective on something that has already been identified" (MacInnis, 2011, p. 143), but also represents what Yadav (2010) calls a 'conceptual development'.

The contribution of this paper is twofold. First, we use the concepts of exploitation and exploration capabilities to integrate them into a framework which presents the relationships between (dynamic) capabilities, supply chain resilience and exaptation. We argue that this framework can help illustrate how capabilities during a crisis are utilised or repurposed and provides a theoretical foundation to identify exaptation capabilities for supply chain resilience. Second, we use the main concepts in the framework to build an integrative model that depicts four different exaptation dimensions for supply chain resilience capabilities of LSPs. We then subsequently propose specific implications of each exaptation dimension, thereby offering conceptual clarity regarding the varied implications and outcomes linked to the exaptation of resilience capabilities in a LSP context.

The remainder of this article is structured as follows: the next section discusses the role of LSPs in and for supply chain resilience and links it to the dynamic capabilities concept. The section also presents a framework illustrating and clarifying the relationships between capabilities, exaptation and supply chain resilience. Next, we present the two critical concepts of exploitation and exploration capabilities to categorize the multiple exaptation dimensions for supply chain resilience. A combination of these two concepts is illustrated in the next chapter,

where four exaptation dimensions are described and presented in a model. Finally, the conclusion highlights the contributions of this paper and discusses future research.

2. Literature Review

2.1 Exploitation and exploration of supply chain resilience capabilities

Supply chain resilience has been widely discussed as the capability of a system to adapt and regain a new stable position after perturbations (Beer *et al.*, 2022; Herold and Marzantowicz, 2024). Previous scholars broadly acknowledged its importance as companies increasingly need to anticipate, adapt, respond to, and recover promptly from unpredictable events (Ponomarov and Holcomb, 2009). As the pandemic introduced huge uncertainties in both supply and demand, it highlighted the importance for companies to properly design and manage logistics systems to cope with supply chains risk and emphasized the key role of LSPs (Dovbischuk, 2022; Prataviera *et al.*, 2022). LSPs and their integration of logistics activities are increasingly seen as a key factor to build resilience along global supply chains (König and Spinler, 2016). As companies turn their focus to build their core competencies, the outsourcing to LSPs is seen an opportunity to tailor the shippers needs to the exact carrier capacity that is required and which leads in turn to leads to an increase of the shipper's supply chain flexibility (Prataviera *et al.*, 2021b). As such, LSPs are ideally strategically positioned because their core competencies comprise the adaptation and utilization of their assets to respond to potential volatile demands from customers. In other words, the flexibility of their logistics infrastructure and operations provides LSPs with what can be regarded as resilient supply chain and thus a strategic advantage to fulfil customer requirements (Christopher, 2011). For example, in former crises such as the Icelandic volcano eruption, the LSP DHL were able to reroute flights to Southern Europe and immediately shifted shipments onto trucks and trains to minimize their customers' losses (König and Spinler, 2016).

During the Covid-19 related supply chain disruptions, LSP were forced to enhance the resilience of their supply chains in order secure the continuity of their operations, thereby building up and utilizing their intra-organizational *dynamic capabilities* to address e.g. mismatches between supply and demand, labour shortages and lack of transport capacities (Dovbischuk, 2022; Hohenstein, 2022). Dynamic capabilities, which are defined as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece *et al.*, 1997, p. 516), can be seen as the result of experience accumulation, knowledge articulation, knowledge codifications and knowledge sharing (Sabahi and Parast, 2020) as means to achieve strategic change in a patterned, repeatable and reliable way (Helfat and Raubitschek, 2018; Winter, 2003). As the actions during the pandemic were rather reactive than proactive (Belhadi *et al.*, 2021), dynamic capabilities theory can help address how firms respond to changing business environments and specifically how these newly acquired capabilities are or can be repurposed (Napoleone and Prataviera, 2020).

Previous research has indicated that the concept of dynamic capabilities is linked to *exploiting* existing technologies and resources to safeguard efficiency as well as the creation of product and service variations through *exploration* (Yalcinkaya *et al.*, 2007). In an innovation context, exploitation and exploration capabilities are considered dynamic capabilities, as both capabilities are utilised to transform a company's current resources into different competencies for the new environment (Nayak *et al.*, 2020). According to March (1991), exploitation can be defined as "the refinement and extension of existing competencies, technologies, and paradigms

exhibiting returns that are positive, proximate, and predictable", thus it corresponds in dynamic capabilities context with what Teece (2007) calls 'seizing', i.e., the "mobilization of resources to address needs and opportunities, and to capture value from doing so" (p. 332). Exploration, however, can be defined as "experimentation with new alternatives having returns that are uncertain, distant, and often negative" (March, 1991, p. 85) and in a dynamic capabilities content, corresponds with the Teece's (2007) definition to attempt to 'transform', that is, the "continued renewal" (p. 332) of the firm as its resources are reconfigured to strategically seize opportunities and respond to threats.

During Covid-19, LSPs exploited their capabilities to build supply chain resilience. In the beginning, LSPs were confronted with volatile transport demands when global production halted and trucks were grounded, leading to a drastic cut of transport capacity (Herold *et al.*, 2021). During the recovery phase, however, LSPs were confronted with a both a lack of aircraft belly capacity when customers, governments and other related stakeholders put in urgent requests for PPE equipment and asked for transport capacity which was not available on the market. As a response, some LSPs were able to exploit their resources to provide additional capacity. For example, the LSPs FedEx Express and UPS were able to make reroute adjustments in their air network and recalibrate their cold-chain shipping capabilities for the roll-out of vaccines in 2020 in order to rapidly deliver vaccines throughout the United States (Hajibabai *et al.*, 2022; Simunaci, 2021).

LSPs were also exploring new capabilities during the pandemic, in particular the development of new IT solutions and the digitalisation of certain processes in order to maintain business critical functions (Herold *et al.*, 2021). Studies show that pre-Covid-19, LSP operations were characterised by limited innovation capabilities and a low level of digitalization (Busse and Wallenburg, 2011; Herold *et al.*, 2023). Due to the pandemic restrictions, LSPs had to innovate and drive digitalization to tackle the challenges stemming from the disruptions. For example, LSPs quickly developed solutions for digital freight documents for cross-border checks and also transformed the handwritten POD [Proof of Delivery] to a digital POD (Wilson, 2020).

However, scholars examining how to build resilience capabilities in logistics and supply chains after Covid-19 have mainly focused on adaptive and contemporary practices (Kähkönen *et al.*, 2023; Nikookar and Yanadori, 2022), IT capabilities (Zhou *et al.*, 2022), data analytics (Bag *et al.*, 2023; Munir *et al.*, 2022), mapping capabilities (Pimenta *et al.*, 2022), institutional responses (Herold and Marzantowicz, 2023) or artificial intelligence (Modgil *et al.*, 2021), thereby neglecting the role of exaptation during Covid-19. In other words, existing literature lacks still frameworks that help to illustrate the interaction between these concepts of exploitation and exploration for supply chain resilience in a Covid-19 context and how these capabilities are or can be utilised or repurposed. In the next section, we will expand on the concept of exaptation and clarify the link between supply chain resilience capabilities and exaptation.

2.2 Exaptation of supply chain resilience capabilities

Exaptation is an emerging and relatively new term which is often used rather ambiguously (Aaltonen, 2020). Originally rooted in evolutionary biology, exaptation refers to a shift in or a repurposing of a function of a trait (Gould and Vrba, 1982). Examples of exaptation in biology include the development of wings on dinosaurs or swim bladders exapted from floating to breathing (Andriani *et al.*, 2017). Early management literature used the concept to illustrate and

explain serendipitous business inventions and events such as the Post-It notes (Villani *et al.*, 2007), while recent academic management studies used exaptation to better understand service or product innovations or even to investigate organizational and radical change (Ardito *et al.*, 2021; Cao *et al.*, 2023; Garud *et al.*, 2018; Yu *et al.*, 2023). Andriani and Carignani (2014) see exaptation as on discontinuous evolutionary process that include specific characteristics: a) an unpredictable association or emergence of a new function within a process ecosystem or artifact, b) the transformation of internal capabilities or components of existing services or products to extent the functionalities without developing new services or products.

Studies show that exaptation in a management context usually happens when there is a need for flexibility, e.g. during a disruption (Liu *et al.*, 2021) or a gradual industry shift (Marquis and Huang, 2010). Thus, due to the exaptation's characteristics and the concept's potential benefits from a dynamic capabilities viewpoint, we posit that exaptation is related to supply chain resilience capabilities during Covid-19 for two key reasons: First, according to Mastrogiorgio and Gilsing (2016), exaptation-driven innovation is strongly related to the exploitation of a latent function in new contexts, which involves – in contrast to deliberate strategies – discovery-driven search processes or serendipitous discoveries, often also outside of the ecosystem (Garud *et al.*, 2018; Swierczek, 2024). Therefore, exaptation as a discovery-driven process for a new function of an existing trait is aligned with the LSPs' rapid reaction to build supply chain resilience during the Covid-19 disruption. In the beginning of the pandemic, LSPs had often neither the time nor the resources for and systematic analysis and relied more on an experimental approach (Herold *et al.*, 2021).

Second, exaptation represents a mechanism that can lead to less-time consuming and more efficient innovations (Bonifati, 2013). That is, because exaptive processes can enable a transformation of existing services or products and extending its use without creating a new service or product, often only by spotting or identifying opportunities in the changing environment (Aaltonen, 2020). The exaptive transformation of products through identifying opportunities in a changing environment could be observed during Covid-19. For example, exaptation played a critical role to address the shortage of ventilators during Covid-19 by the "repurposing of design, manufacturing, 3D printing, AI, VI, supply chain coordination, and mass-production technologies from […] logistics industries" (Liu *et al.*, 2022, p. 86). They also found that the success of technology exaptation depends on the agility of people and their openness to novel ideas, unfamiliar technologies, and unorthodox processes.

To illustrate the links between dynamic capabilities, supply chain resilience and their influence on exaptation, Fig. 1 presents our first framework explicating the relationships and answering research question 1 (*"How do exploitation and exploration influence the exaptation of supply chain resilience capabilities?"*). While we developed this framework with LSPs in mind, the relationships between these concepts also exist outside of the logistics sphere and can be applied in a broader business sense. Research has shown that building dynamic capabilities is linked to the exploitation and exploration of capabilities (Blome *et al.*, 2013; Sandberg, 2021) and building resilience capabilities is crucial to respond to the disruptions caused by external shocks such as the Covid-19 pandemic (Boh *et al.*, 2023; Hohenstein, 2022). However, given the competition for limited organizational resources, the literature points to tensions between exploitation and exploration and the need for trade-offs, i.e. companies often choose to focus on either exploiting their existing capabilities or focus on exploring new capabilities (Li *et al.*, 2008; Luger *et al.*, 2018). Studies show that this interplay between exploitation and exploration defines the degree of resilience capabilities in the supply chain (Eltantawy, 2016; Gu *et al.*,

2021). In line with recent literature (see e.g. Beltagui *et al.*, 2020; Codini *et al.*, 2023), we also argue that the exploitation and exploration of capabilities has a direct impact on exaptation processes, i.e. the various degrees of resilience capabilities in the supply chain lead to multiple exaptation dimensions.

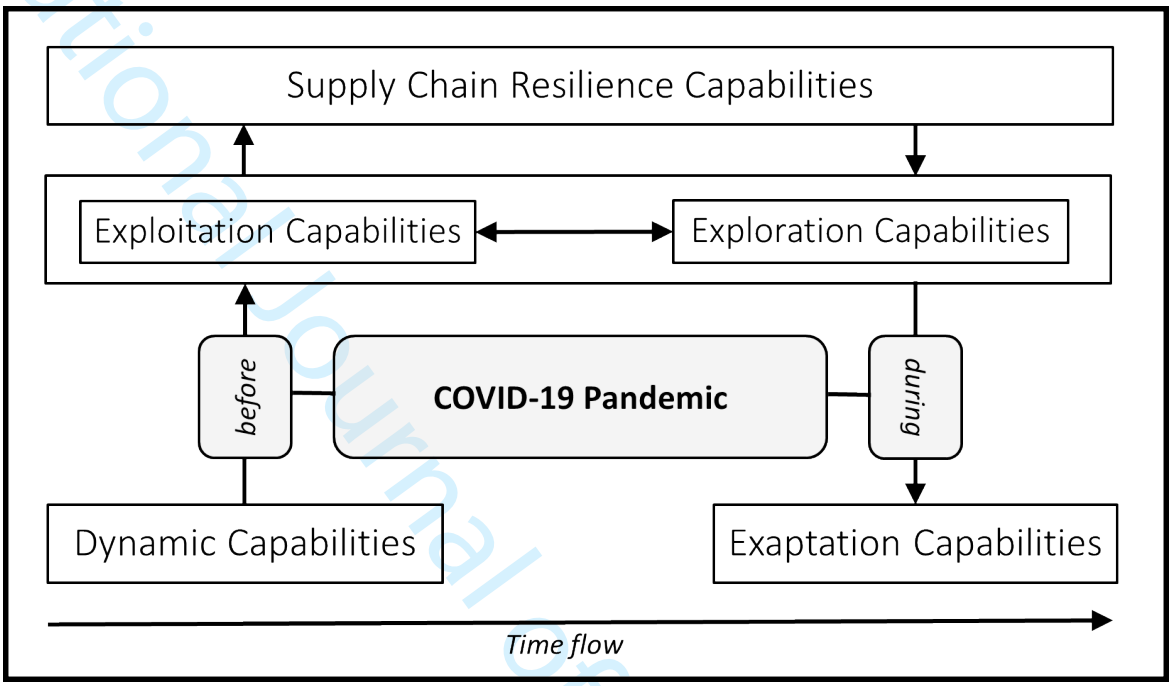

Figure 1: The link between capabilities, supply chain resilience and exaptation

In a supply chain management context, exaptation offers a route to innovation by allowing capabilities to be co-opted for a new function or a new context and thus can help us to better understand how newly acquired capabilities during Covid-19 may be utilised or repurposed to produce novel reconfiguration. For the purpose of this study and in the context of Covid-19, we define exaptation "*as an organization's ability to exploit and explore its capabilities during an external shock of high impact and low probability to discover latent functions or repurpose existing capabilities for a more resilient supply chain."* By using the concepts of exploitation and exploration capabilities and integrating them into a framework (Fig. 1), the illustration of the relationships between (dynamic) capabilities, supply chain resilience and exaptation provides a conceptual foundation to identify exaptation capabilities for supply chain resilience. In the next section, we propose four exaptation dimensions stemming from the interplay between exploitation and exploration of supply chain resilience capabilities.

3. Exaptation dimensions of supply chain resilience capabilities

Taken together, both concepts of exploitation and exploration provide a theoretical foundation to build an integrative model which allows us to categorize exaptation dimensions for supply chain resilience capabilities and answer research question 2 ("*How did LSPs shape the exaptation of supply chain resilience capabilities during Covid-19?*"). From a theoretical point of view, the degree of exploitation capabilities depend on the LSP's ability to continuously improve their operations through its existing set of resources and processes (March, 1991; Prataviera *et al.*, 2021a). In other words, the degree of exploitation capabilities is linked to how

LSP managers are able to improve, select or maintain relationships with existing suppliers and finding solutions for a more using efficient implementation and execution of existing supply chain resources technologies to drive resilience (Wang *et al.*, 2021). As such, the greater the degree of exploitation capabilities, the higher the harvesting and the incorporation of existing operational knowledge that drives resilience. The lesser the degree of exploitation capabilities, the lower the processing capabilities for developing supply chain resilience, thus there is a lack to turn knowledge into action (Roh *et al.*, 2022). Building on these findings, we define the exploitation capabilities as "the LSP's ability to continuously improve their operations through its existing set of resources and processes."

In contrast, the degree of exploration capabilities depend on the LSP's ability to seek, discover and adopt new products, service and process that are unique from those used in the past (March, 1991). In other words, the degree of exploration capabilities is linked to the LSP exploratory activities that involve creative and unique solutions based on new approaches and seeking to meet customers' various needs (Roh *et al.*, 2022). As such, the greater the degree of exploration capabilities, the higher the LSP's engagement with novel technological ideas, create innovative products or services and aggressive ventures into new market segments to actively target new customer groups (Gayed and El Ebrashi, 2022). As such, exploration capabilities can be defined as "the LSP's ability to seek, discover and adopt new products, service and process that are unique from those used in the past."

In the context of our study, we argue that exploitation reflect the degree of an LSP's ability to continuously improve their operations through its existing set of resources and processes, while exploration reflect the degree of an LSP's ability to seek, discover and adopt new products, service and process that are unique from those used in the past. LSPs', however, are confronted with the inherent trade-off between exploration and exploitation activities and thus the allocation of the company's resources, leading to varied dimensions between "serving existing work versus searching for new work" (Rogan and Mors, 2014, p. 1864). In this section, we combine the concepts of exploitation and exploration to propose four exaptation dimensions: *Impeded, Configurative, Transformative, and Ambidextrous Exaptation*. Figure 2 depicts the four exaptation dimensions, and each dimension is described below. We used dashed rather than solid lines between the types to emphasize that exploitation and exploration are continuous aspects and that exaptation can therefore vary between the types. By building an integrative model that depicts four different exaptation dimensions, this framework offers conceptual clarity regarding the varied implications and outcomes linked to the exaptation of resilience capabilities in a LSP context.

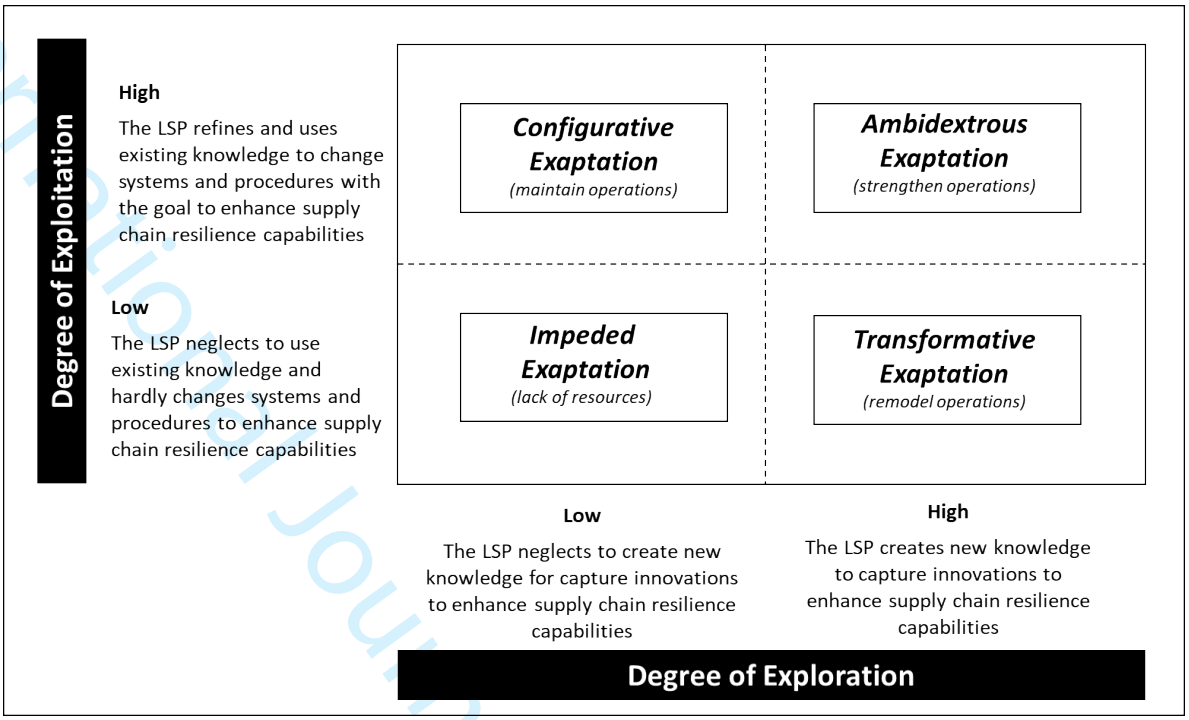

Figure 2: LSPs' exaptation dimensions for supply chain resilience capabilities

3.1 Impeded Exaptation

In the first exaptation dimension, LSPs are characterised by a low degree of exploitation capabilities and a low degree of exploration capabilities. These LSPs do not invest time to seek new markets and new innovations, doing little to repurpose their exploration capabilities for a future resilient supply chain (Bode *et al.*, 2011). However, a low degree of exploitation capabilities indicates that existing knowledge to configure the LSPs supply chain network and resources is utilised to a lesser extent, leading to little or no changes being made to confront the disruption of supply chains (Gupta *et al.*, 2022). As a result, these LSPs are neither implementing any structural changes nor engaging with external parties or new technologies to enhance the resilience along the supply chain. We therefore label this dimension as *impeded exaptation*.

An impeded exaptation approach is the outcome when LSPs, according to Bode *et al.* (2011), are "exposed to disruptions that impede their supply chain relationships and associated operations" (p. 833). Mainly due to lack of resources, the LSPs in this quadrant are neither able to effectively react to disruptive, nor can they accommodate latent problems or adjust operations, thereby posing a threat to both competitiveness and its long-term success (Lengnick-Hall, 1992). Because these LSPs have a low degree of exploitation capabilities, the flexibility to adapt or redesign the supply chain as well the plan demand or to adjust inventory as a response to the rapidly changing environment stemming from the disruption is rather limited (Rajesh, 2017). For instance, some LSPs increased the use of parcel lockers for deliveries during Covid-19. In order to keep human contact during the delivery process to a minimum, LSPs exploited the function of parcel lockers to optimize internal resources, thereby attempting to elevate a rather peripheral service offering to a core business concept (Wang *et al.*, 2023). However, while these practices may have reduced customer contacts and increased delivery levels, it does not represent a repurposing of existing function, but rather a pure exploitation approach.

Moreover, a low degree of exploration capabilities indicates that these LSPs fail to collaborate with their supply chain partners (Fawcett and Waller, 2014), thereby not only fail in *buffering* activities to enhance residence by implementing safeguards in partnership, but also fail in *bridging* activities to manage disruption through actions with partners outside of the supply chain ecosystem (Bode *et al.*, 2011; Magliocca *et al.*, 2023). Ultimately, the lack of resources or management skills to leads to low exploitation and a low exploration capabilities, thereby not only increasing the chance for organizational inertia (Moradi *et al.*, 2021), but also limiting the exaptation potential to build resilience for short- and long-term success.

Proposition 1: In situations of impeded exaptation, LSPs may opt for recalibrating their organizational structures to focus either on the generation of capabilities from existing processes or the development of novel applications in existing patterns to capture the shift of a function to build supply chain resilience.

3.2 Configurative Exaptation

The second dimension of exaptation exhibits a high degree of exploitation capabilities and a low degree of exploration capabilities. In these LSPs, the high degree of exploitation capabilities indicates that internal existing knowledge is used to significantly adapt resources and the network to build a more resilient supply chain and guarantee operations during a disruption (Dolgui *et al.*, 2020). A low degree of exploration capabilities, however, means that the LSP mainly relies only on existing knowledge, thereby neglecting to seek new knowledge for a long-term transition of the supply chain. As a result, these LSPs restructure and reorganize their supply chain network and its associated processes, which results in a supply chain configuration that involves the coordination of logistics decisions to appease customers during a disruptive event. We therefore label this dimension as *configurative exaptation*.

A configurative exaptation approach reflect the LSP's focus to configure the integrated supply chain network of "key supply units, operating throughout the length of the supply chain, be they predominantly internal to a firm where there is a degree of vertical integration, or largely external supply partners where there is significant outsourcing of components, parts, technology or general supply" (Singh Srai and Gregory, 2008, p. 392). Because these LSP have a high degree of exploitation capabilities, they are in a position to collaborate strategically with their supply chain partners and adapt intra- and inter-organizational processes to maximize the effectiveness and efficiency of material, service and information flows (Carissimi *et al.*, 2023; Flynn *et al.*, 2010). An example of configurative exaptation was the LSPs' process development of contactless and signatureless deliveries (Garola *et al.*, 2023). The new process ensured both service quality and safety and included both a delivery without getting in touch with customers as well as a new digital proof of delivery, with e.g. taking pictures with a mobile phone of the delivered package as visual evidence (Banker, 2020). By repurposing the function of the delivery and the mobile phone, the new function can not only be regarded as a "jump" to a new strategic state (Fischer *et al.*, 2010), but also to exploit, experiment and test existing technologies for a resilient operations (Ponomarov and Holcomb, 2009). However, the high degree of exploitation capabilities in combination with a low degree of exploration capabilities indicates that these LSPs mainly focus on 'surviving' the disruption, i.e., they use their capabilities mainly for short-time adjustment of the network structure or time-limited arrangements with subcontractors to bridge the time until the disruption is over.

As such, LSPs in these quadrant are threatened by what Gayed and El Ebrashi (2022) call "success traps" (p. 6682). Studies found that combination of a high degree of exploitation capabilities with a low degree of exploration capabilities prevent companies from further exploring new resources in a dynamic environment (Gupta *et al.*, 2006; Tian *et al.*, 2021). In addition, Shi *et al.* (2020) found that companies in these quadrant can usually rely on sufficient resources, which allows them to "focus more on the benefits of exploiting existing markets, products, technologies, customers and processes rather than exploring new markets, products, technologies, customers and processes" (p. 98). This claim is backed up by Singh and Lumsden (1990) who argue that when companies "enjoy current resources", LSPs are more reluctant to explore to avoid putting their current resources in jeopardy. Ultimately, using existing knowledge to configure the current network and processes to maintain the operations during a crisis leads to short-term resilience activities, thereby neglecting the exaptation potential to build long-term resilience building blocks for the supply chain.

Proposition 2: In situations of configurative exaptation, LSPs may opt for the exploitation of latent functions by using existing sets of capabilities to turn an original functionality into a new function within a process or into a new product/service to build supply chain resilience.

3.3 Transformative Exaptation

The transformative exaptation dimension in LSPs embodies a low degree of exploitation capabilities and a high degree of exploration capabilities. These companies neglect the use of existing knowledge to respond to the immediate needs to counter the supply disruption. Unlike the impeded dimension, however, these LSPs have a high degree of exploration capabilities to expand their view outside of the current market, structures, and technologies. As a result, and in contrast to the configurative exaptation dimension, these LSPs invest in long-term solutions that can transform the supply chain network and its associated market, structures, and resource allocation. We therefore label this dimension as *transformative exaptation.*

LSPs with a transformative exaptation are using the exploration capabilities to expand their existing supply chain scope and to position themselves for the future disruption challenges (Mollenkopf *et al.*, 2021). One key aspect of the transformational approach is the focus on IT solutions and the digitalization of supply chains (Hribernik *et al.*, 2020; Weisz *et al.*, 2023). Herold *et al.* (2021) found LSPs were under pressure during Covid-19 to digitize critical processes, thereby raising awareness and accelerating the digital transformation. LSPs in this quadrant, for example, see investments in digitalization for (big) data management not to be an "if" anymore, but increasingly a "when" question (Cichosz *et al.*, 2020; Mikl *et al.*, 2021). Transformative exaptation could be observed in the rapid adoption of technologies throughout the pandemic to help enforce social distancing in warehouses. For example, the implementation of robotic goods-to-person (G2P) systems that helped not only to move goods from one person to another, but also led to better warehouse efficiency by increased productivity improved storage density (Dhaliwal, 2021). Here, the LSPs transformed the emergent functionality into a new service function, thereby not only replacing a manual process with a digitized one, but also controlling the adaptive trajectory of the technology (Codini *et al.*, 2023). Overall, an operational level, these LSPs implement data management to further consolidate shipments and better plan last-mile deliveries (Dobrovnik *et al.*, 2018; Kummer *et al.*, 2020; Mikl *et al.*, 2020). On a strategic level, these LSPs use data for accurate tracking processes that can help to adapt shipping transportation speed (e.g. slow steaming), so that the 'floating storage' arrives in warehouses when needed (Lee, 2017).

However, LSPs in these quadrant are threatened by so-called "failure traps" (Gayed and El Ebrashi, 2022, p. 6682). LSPs combing a low degree of exploitation capabilities with a high degree of exploration capabilities may be confronted with uncertain results of experiments with novel and untested structures and technologies, leading to 'failure' and a reduction of efficiency levels (Kafetzopoulos, 2021). Moreover, Nohria and Gulati (1996) argue that the LSPs in these quadrants usually face a lack of resources, driving the LSP to more risk-taking and innovations, and consequently, a focus on their exploration capabilities for adaption. On the one hand, LSPs with a focus on exploration capabilities drive the transformation of the supply chain for more resilience by investing in lasting structural and network changes mainly through digitalization. On the other hand, the neglect of exploitation capabilities may reduce the response time to an immediate disruptive event, thereby applying or repurposing the capabilities to build resilience during a crisis.

Proposition 3: In situations of transformative exaptation, LSPs may opt for the exploration of novel technologies and practices to extend and repurpose their range of existing functionalities in new contexts to build supply chain resilience, both inside and outside of the ecosystem.

3.4 Ambidextrous Exaptation

The fourth dimension of exaptation exhibits a high degree of exploitation capabilities and a high degree of exploration capabilities. These LSPs have both the ability to continuously improve their operations through their existing set of resources and processes as well as the ability to seek, discover and adopt new products, service and process that are unique from those used in the past (Lee and Rha, 2016). As a results, these LSP managers are able to allocate the company's resources evenly between exploration and exploitation, which according to O'Reilly and Tushman (2004) can be described as "ambidextrous managers" (p. 81). We therefore label this dimension as *ambidextrous exaptation.*

LSPs with an ambidextrous exaptation have the capability to exploit existing competences and explore new opportunities with equal dexterity (Lubatkin *et al.*, 2006). Scholars argue that an ambidextrous ability leads to enhanced efficiency, flexibility, alignment and adaptability in an organization (Gibson and Birkinshaw, 2004). Because the LSPs in this dimension have a high degree of exploitation capabilities, they focus on maintaining a relationship with current suppliers, search for supply chain solutions using existing resources and leverage current supply chain technologies, which increase the LSPs flexibility to solve problems quickly and efficiently during e.g. new service or product development as a response to a disruption (Kristal *et al.*, 2010; Sheremata, 2000). But due to the high degree of exploration capabilities, LSPs in this quadrant are also seeking for supply chain solutions based on novel approaches and creative ways to provide a better customer experience, which can lead to market and technological leadership in the long term because LSPs are able to utilize their capabilities to deal with environmental shift stemming from the disruption. Ultimately, the combination of the high degree of both concepts indicate that the LSP managers have the "ability to orchestrate the complex trade-offs that the simultaneous pursuit of exploration and exploitation requires" (O'Reilly and Tushman, 2004, p. 6).

A striking example of ambidextrous exaptation is the case of the LSP DB Schenker which used passenger airlines to increase their transport capacity and removed the seats from three Iceland Air 767s for regular cargo shipments from Asia to Europe and the US (DVZ, 2020). Such a process is markedly different to the usual innovation adoption processes, where innovation is

adapted over time to suit a particular purpose. The rapid remodelling of passenger airplanes to increase transport capacity is represents an ideal case of ambidextrous exaptation as it is both a result of the discovery-driven or experimental process of exploitation of the existing capabilities to carry cargo as well as that exaptation took place by exploring a co-development with key partners (passenger airlines) that operate in businesses other than the DB Schenker core business. In other words, by using an existing set of capabilities, the original functionality of the passenger airline was turned into a new product/service to create cargo capacity that contributed to resilience of the operations (Codini *et al.*, 2023).

Proposition 4: In situations of ambidextrous exaptation, LSPs may opt to further invest in discovery-driven processes to capture new or serendipitous functions both from existing knowledge and technological advances to build supply chain resilience.

4. Implications for theory and practice

By expanding insight into the concepts and implications of exaptation dimensions of supply chain resilience capabilities during Covid-19, this paper has important theoretical and managerial implications. From a theoretical view, the integration of exaptation opens a new chapter on how supply chain resilience capabilities can be utilised after a disruptive event. Research regarding exaptation in a business context seems to be in its infancy, with only recent literature using the concept to examine management issues (Codini *et al.*, 2023; De Sordi *et al.*, 2019) or Covid-19 related themes (Ardito *et al.*, 2021; Liu *et al.*, 2022). By presenting a conceptual model based on exploitation and exploration capabilities, we provide a theoretical foundation to identify multiple exaptation dimensions of supply chain resilience. We thereby contribute to the existing supply chain literature by focusing on resilience as an important phenomenon that requires further investigations and conceptualizations. To the authors' knowledge, this is the first study integrating the concept of exaptation for supply chain resilience in a Covid-19 context. While exaptation in biology is referred to as an can be seen as an 'occasional novelty' (Aaltonen, 2020), research points out that exaptation is far more common in a business or economics context (De Sordi *et al.*, 2019). For example, Andriani *et al.* (2017) found that approx. 40 per cent of the drugs in the pharmaceutical industry were exaptive in nature. Given the significance of exaptation for businesses, it is surprising that this concept seems to be under-researched in a management and innovation context. As such, our paper sheds light on how organizations might innovate within their supply chains through exaptation and proposes a framework that describes the role of resilience capabilities and its implications on exaptation.

By categorizing supply chain resilience capabilities in terms exploitation and exploration capabilities, our model proposes four exaptation dimensions for LSPs, thus providing an understanding of the interaction between capability and innovation building during a disruptive event. While academic literature has established a clear link between capabilities and supply chain resilience (Han *et al.*, 2020; Yu *et al.*, 2019), existing research has been relatively silent on the relationship between supply chain resilience capabilities and specific exaptation outcomes. Existing literature often regards exaptation as a non-linear and disruptive event (Aaltonen, 2020; Gould and Vrba, 1982), however, our framework rather illustrates that exaptation represents a complementary function together with exploitative and explorative capabilities. In this study, the combination and the interplay between concepts allow the identification and categorization of the varied exaptation dimensions employed by LSPs. In this

regard, the framework advances the rather neglected body of knowledge on the implications of supply chain resilience capabilities, which to date has been limited in providing an explanation about the exaptation of supply chain resilience capabilities and clarity about the exaptation outcomes. In fact, exaptation may support LSPs in exploring various initiatives to create, deliver and capture innovation based on their respective degree of exploitation and exploration capabilities. For example, LSPs in the 'configurative exaptation' quadrant with a focus on exploiting existing knowledge are more likely to exapt their supply chain resilience capabilities within the organization's structures and processes, while LSPs in the 'transformative exaptation' quadrant with a focus on exploring new knowledge are more likely to exapt their supply chain resilience capabilities by transform their organization's structures and processes for the long-term.

From a managerial standpoint, by categorizing exaptation dimensions for supply chain resilience, our framework points to practices through which management can exert influence innovation capture. As LSPs and their managers are constantly facing difficulties and challenges to build resilience capabilities, LSPs may adopt an exaptation strategy that can facilitate the exploitation of available resources in original and ways. For example, to respond to falling package volumes, Özcan and Yumurtacı Hüseyinoğlu (2023) found that LSPs switched to micro-hub distribution, thereby not only managing the reduced demand, but also testing new innovative last-mile concepts for the future. For managers, this may result in an exaptation strategy that complements existing patterns or may stimulate exploring prior unnoticed opportunities. For example, LSPs implemented digital systems between them and their partners to access and exchange information (Creazza *et al.*, 2023). As such, the categorization of the four exaptation dimensions identifies four specific ways how LSPs can contribute to supply chain resilience capabilities, i.e. each exaptation quadrant shows a different mechanism to build capabilities for supply chain resilience.

Overall, managers need to adapt to changes in the environment by exploitative processes, but also be able to transform their capabilities via explorative processes at the same time. In other words, managers who focus only on one of the two processes are unlikely to capture all innovation and develop full exaptation potential. As such, one implication for managers is to allocate resources to focus on both exploitative and explorative processes and capabilities, thus utilizing internal competencies and engage with the external ecosystem to further drive supply chain resilience. In this respect, we provide important insights into how exploitation and exploration capabilities need to be balanced for an ambidextrous exaptation potential to further develop supply chain resilience.

5. Conclusion

If exploitation and exploration capabilities impact the exaptation of supply chain resilience, then frameworks that describe these impacts expand insight into the concepts and implications, and thus advance supply chain management research. So far, the link between supply chain resilience capabilities and exaptation has only attracted limited attention, in particular from an LSP perspective. Although scholars acknowledge the link between dynamic capabilities and supply chain resilience, the exaptive-driven implications remain unanswered. This paper's intention is to close this gap and build frameworks that clarify and help to describe the relationships between capabilities, supply chain resilience and exaptation in a LSP context. To do so, we developed two frameworks which make several contributions to the extant literature

about supply chain resilience by deepening the exaptation of dynamic capabilities in a Covid-19 context.

This first framework presents the relationships between (dynamic) capabilities, supply chain resilience and exaptation during and after Covid-19. We argue that our framework can help us to illustrate how newly acquired capabilities during a crisis are or can be repurposed and provides a theoretical foundation to better understand the exaptation dimensions for supply chain resilience capabilities. For the second framework, we combined two critical management concepts in the context of dynamic capabilities to categorize exaptation dimensions for LSPs. The first concept represents the 'exploitation capabilities', which in our study represent the degree of the LSP's ability to continuously improve their operations through its existing set of resources and processes. The second concept represents the 'exploration capabilities', which is defined in the context of our study as the degree of the LSP's ability to seek, discover and adopt new products, service and process that are unique from those used in the past. We used these concepts to build an integrative model that depicts four different exaptation dimensions and to formulate four related propositions on how LSPs can build exapt-driven supply chain resilience capabilities.

However, the study's findings and implications must be viewed in the light of the research limitations. Although our frameworks and the associated exaptation of supply chain resilience capabilities may be applied beyond the LSP domain and thus in a greater technological innovation context, the case of LSPs reflects a specific case as this sector was hit particularly hard during the pandemic. Moreover, we restricted our dynamic capabilities view to exploitation and exploration capabilities, but other concepts that influence both exaptation and supply chain resilience exist in practice. We encourage future researchers to extend our framework by integrating other concepts, beyond the concept of ambidexterity. Overall, it seems that research dealing with exaptation in the supply chain resilience domain is still in its infancy. Future research will help to better understand how exaptation impact supply chain resilience and how organizations can capture innovation from the newly acquired capabilities when confronted with a disruptive event.

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