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Responding to discontinuities in product-based service supply chains in the COVID-19 pandemic: Towards transilience

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ABSTRACT

Purpose: In this study, we identify and characterise how organisations have responded, in ways ranging from restoration to radical change, to discontinuities in their product-based service (PBS) supply chains during the COVID-19 pandemic.

Design/methodology/approach: Following a theoretical approach that integrates transilience and panarchy theory as a response strategy in PBS supply chains, our qualitative study involved collecting data through 19 semi-structured interviews at six manufacturing firms during the first 6 months of the COVID-19 pandemic (i.e., March to August 2020) and triangulating the findings with the secondary data and that from an industry workshop. Following an inductive approach, we performed thematic data analysis in NVivo software package.

Findings: The findings suggest characterising discontinuities in PBS supply chains as unmanageable external supply-side, demand-side or interactional discontinuities or other manageable deliberate or forced organisational discontinuities. Following that characterisation, we developed a conceptual framework combing both resilience and transformation into new service opportunities.

Research limitations/implications: We gained insights into the first-response abilities and ways of coping among manufacturing firms during the COVID-19 pandemic. Though our findings capture a contemporary, eye-of-the-storm perspective on future directions, a longitudinal study on the pandemic could further validate and extend the modes of response that complement mitigation with the ability to accelerate change or innovation of internal process or external service offerings.

Originality/value: Combining current literature with lessons learned from the firms’ immediate responses, this paper’s overview and characterisation of discontinuities following the COVID-19 outbreak in PBS supply chains demonstrate how manufacturing firms can foster transilience. As such, it integrates product-based supply chain discontinuities into the domain of service-based supply chains.

1. Introduction

This paper presents a perspective on how manufacturing firms offering product-based services (PBS) have responded to the disruptive dimensions of the COVID-19 pandemic in their supply chains. PBS can be broadly defined as service offerings “delivered throughout the product’s lifetime” (Ichihira et al., 2008)—for example, repair, maintenance, and refurbishment. We argue that the severity of discontinuities experienced by organisations in PBS supply chains requires transilience instead of resilience only—that is, quickly restoring some processes while simultaneously radically changing others (Craighead et al., 2020).

In supply chains, resilience has traditionally been associated with precededent disruptions (Christopher & Peck, 2004) initiated by shocks with rippling effects, although often limited to a region and/or sector, but that nevertheless affects either supply or demand (Craighead et al., 2020), with spikes in demand exemplifying a demand-side risk and shuttered factories exemplifying a supply-side risk (Christopher & Peck, 2004). In manufacturing supply chains, current resilience strategies often focused on the flows of materials and products, include sharing of information between actors (Lee et al., 1997), use of flexible suppliers (Tang, 2006), ensuring redundant suppliers (Chopra & Sodhi, 2014), mobilising inventory buffers and backup sources (Vanpoucke & Ellis, 2019), and use of multiple sources and sharing risk among all actors (Manuj & Mentzer, 2008).

However, these trends have themselves been disrupted. First,
discontinuities in PBS supply chains exceed the traditional boundaries of demand-side and supply-side risks because PBS offerings include not only parts and components, but also people and products at the in-use stage (Gatenholm et al., 2021), affecting their risk management and resilience (Vilko & Ritala, 2014). Second, despite the increased focus on service-based offerings, which can boost revenue for OEMs by 30–60 percent (McKinsey, 2019), many supply chain disruptions concern product-centric settings. Moreover, despite considerable attention having been paid to supply chain disruptions, such attention has largely concerned manufacturing supply chains, which generally focus on the physical flows of goods and materials. Although the importance of service supply chains has been both highlighted and discussed in the literature (Arbijn et al., 2011; Ellram et al., 2007; Vilko & Ritala, 2014), resilience, risk, and disruptions therein are scarcely mentioned in the literature on services (Belhadi et al., 2021), likely because their risk and resilience are in their infancy and because the management of traditional supply chains has dominated the academic literature (Vilko & Ritala, 2014). By contrast, literature on services and/or servitisation primarily addresses risks associated with transitioning from a product to a service-based company (Zhang & Banerji, 2017), not external risks, which are instead discussed in terms of technological development, digital disruptions, market trends, globalisation and capital management (Benedettini et al., 2015).

Third, the COVID-19 pandemic differs substantially from previous supply chain disruptions in three dimensions: scope, spillover, and shifts. For one, disruptions—natural disasters, strikes or supplier shutdowns, for instance—are normally localised in a region and/or an industrial sector. For another, they are usually catalysed by a shock with rippling effects that eventually dissolve. The COVID-19 pandemic, by contrast, has triggered shocks with aftershock upon aftershock across nearly all regions and sectors worldwide. Fourth, disruptions usually affect either supply or demand. A port strike, for example, generally affects only supply while demand remains intact. The pandemic, however, has relentlessly affected both sides (Craighead et al., 2020).

Finally, calls have been issued for higher-skilled responses, particularly transilience (Craighead et al., 2020). Ali et al. (2017) have argued that current literature on resilience in supply chains emphasises the ability to recover and adapt at the expense of addressing transformability—that is, the capacity to both learn from disruption and prepare for the next one. Considering that trend and the emerging nature of PBS combined with the magnitude of COVID-19’s impact and the dimensions affected, we have embraced Craighead et al.’s (2020) notion that pandemics qualitatively differ from typical disruptions and that developing preparedness and responsiveness has also foster transilience, that can be defined as “the ability to simultaneously restore some processes and change—often radically—others” (Craighead et al., 2020, p. 840, p.840). Some firms have scaled their businesses up and down; others have extended or altered their product-service offerings, and still, others have pivoted along both dimensions. Whether such pivots are a means of survival, or an emergent innovation remains unclear. Furthermore, we argue for adopting panarchy theory to better understand the transformative dimension of transilience (Wieland, 2021; Wieland & Durach, 2021), compared to resilience which mainly focuses on restoring and returning to equilibrium (Christopher & Peck, 2004).

The circumstances created by the COVID-19 pandemic that have impacted PBS supply chains were unprecedented, thus warranting a new understanding of how to manage responses to the pandemic and future comparable disruptions in the supply chain. Against that background, we sought to identify and characterise discontinuities in PBS supply chains and elaborate upon initial responses to restoring while also redirecting organisations towards transilience. Our study’s purpose was thus twofold: to understand discontinuities in manufacturing firms’ PBS supply chains due to the pandemic and to analyse the firms’ initial responses with an eye on transilience and panarchy theory. In this way, this paper contributes to the general literature on service and supply chains by conceptualising transilience as a way of responding to discontinuities.

2. Literature review and framework

The motivation of this paper’s key theoretical components is twofold. First, supply chain risk and resilience literature are highly manufacturing, and hence product-based focused. Literature on supply-side risk predominantly focuses on physical products and material flows, (Flynn et al., 2021; Harland, 2021; Srivastava & Rogers, 2021; Wieland & Durach, 2021). Second, most of the current supply chain risk resilience literature relates to a static supply chain considering a certain set of fixed conditions (Wieland, 2021). The COVID-19 pandemic and its consequences have highlighted the need to look beyond the firm level and its closest connections, emphasising interconnectedness across supply chains (Harland, 2021).

2.1. Product-based service (PBS) supply chains

The PBS supply chain is a network that supports the provision of both products and services, with products provided by certain organisations and services on the products provided by the same and/or several other actors in the supply chain (Cohen et al., 2006; Gatenholm et al., 2021). PBS connects actors into a constellation that provides services during the in-use phase product, for instance, a vehicle or cell phone by ensuring up-time or a function of a product, which takes place after the point of sales (Gatenholm et al., 2021). Such supply chains require the coordination of manufacturing systems, maintenance, the distribution of spare parts, logistics systems, remanufacturing operations, customer support, the sale of accessories, assistance from field technicians and customer care, among other components (Durugbo, 2020). Because supply chains, although often vertically limited, may include several actors horizontally (Wang et al., 2015), dividing and differentiating tasks in the PBS supply chain via close supplier-customer relationships constitutes an important undertaking (Arbijn et al., 2011). Customer engagement is increasingly important in what has become a process of developing the service in conjunction with consumers that enables direct feedback (Brax, 2005). For that reason, service personnel are especially important, because they directly impact customers’ satisfaction with services. On the other side, the customers or buyers of services have become key players in the supply chain (Ellram et al., 2004; Tran & Kummer, 2015). As creators of demand, they significantly impact the flows of information, which, in turn, affects the supplier–customer relations. These characteristics of the PBS supply chain make it differ from the product-based supply chain.

To date, risk management in supply chains has commonly focused on supply chains for manufactured goods, meaning that literature on service supply chains in general and on risk and resilience in service and PBS supply chains, in particular, is scarce and rather underdeveloped (Belhadi et al., 2021). Adjacent, sometimes overlapping literature on risk in PBS supply chains meanwhile primarily explores decisions related to inventory ordering under service constraints (Wang et al., 2015) or establishing relationships between service supplier and end-customer (Åhström & Nordin, 2006). Despite those trends, risk management is crucial to the success of PBS supply chains and, as such, should include the implementation of strategies to manage both daily and exceptional risks along the supply chain (Tran & Kummer, 2015). Mollenkopf et al. (2007) provide a service perspective, yet highlights dimensions concerning the well-being of employees and customers in the service supply chain and encourage researchers to explore the applicability of the transformative service lens to other less developed societies. Seeharaman (2020) suggests that industries that produce and deliver information, products and services have been less impacted than those producing physical products. Rapaccini et al. (2020) present four crisis management models to be better positioned after the pandemic, taking a large perspective on both products and services. However, manufacturing companies providing services based on physical products
are not concerned in the paper.

2.2. Risk and resilience in supply chains

Supply chain resilience concerns the ability of supply chains to cope with unavoidable risk-taking and recover in a timely manner after being disrupted, either to their original state or to a new, more desirable one (Christopher & Peck, 2004). The view on risks that disrupt supply chains has evolved from exclusively considering demand-side risks to also including supply-side and control risks (Christopher & Peck, 2004) and even ever-growing risks arising from the globalisation of supply chains and the increased focus on single sourcing (Pettit et al., 2019). The five types of supply chain risk identified by Ho et al. (2015), including Macro risk, demand risk, manufacturing risk, supply risk, and infrastructural risk (information, transportation, and financial), reflect the rather wide scope of the concept. A common way of responding to these disruptions is designing supply chains that are both responsive to changes in demand (Holweg et al., 2005) or flexible by introducing new products, adjusting volume, managing transactions in production and delivery or tailoring product and service features to meet customers’ needs (Williams et al., 2013). Other established strategies for supply chain resilience entail leveraging and sharing information between actors (Lee et al., 1997), other collaborative measures (Scholten & Schilder, 2015), or inventory buffers and backup sources (Vanpoucke & Ellis, 2019).

Two interpretations of resilience commonly used are resilience engineering and socio-ecological resilience (Wieland, 2021). The former assumes a desirable stable state that a system should revert to. This serves well in short term, where returning to one equilibrium state may stabilize the system for the moment. However, the reason behind the disruption may prevail long-term, thus making such a return to equilibrium not desirable for the system in a long-term perspective (Wieland, 2021). The latter refers to a system continuously adapting and transforming in response to multiscale feedbacks and shocks (Holling, 2001). This perspective allows for the supply chain to continuously adapt to new circumstances while at the same time transforming key structures and processes. This approach seeks to answer the question of how the supply chain will continuously adapt and transform rather than how well does the supply chain revert to equilibrium after a disruption (Novak et al., 2021).

Following the COVID-19 pandemic, a higher degree of resilience has been called for. Azadegan and Dooley (2021) introduce a new level of resilience: meso-level resilience, going beyond buyers–supplier coordination and into multi-organisational collaboration, echoing recent calls by others for viewing the supply chain as a complex adaptive supply network rather than a static simple linear supply chain. (Wieland & Durach, 2021; Wieland, 2021). They argue that the supply chain can be better understood by interpreting it as a complex adaptive supply network rather than a static simple linear supply chain. Two recently published papers provide a further perspective on this adaptive approach to resilience by relating it to panarchy theory (Wieland, 2021; Wieland & Durach, 2021). The panarchical interpretation extends the level of analysis beyond the linear supply chain.

2.3. Key theoretical components: discontinuities, transilience and panarchy theory

Fig. 1 presents the final theoretical framework on which this study is based. We enlisted three key theoretical components for our research, panarchy theory, discontinuities, and transilience. First, we used the idea of panarchy theory to describe how resilience is achieved in the PBS supply chain. The adaptive cycle based on panarchy theory involves four consecutive phases: exploitation, conservation, release, and reorganization (Holling, 2001). Exploitation means that resources (suppliers, assets, workers, capabilities, materials, and technologies) are used to exploit opportunities leading to conservation when capital is accumulated (Holling, 2001; Wieland, 2021). By accumulating resources, the system increases both its connectedness, which relates to the degree to which the system can control its own destiny, and its potential that determines the range of future options (Holling, 2001). As the connectedness increases over time, the system becomes increasingly rigid in its control; hence, fragile toward disruptions (Wieland, 2021). This is hence the optimal state for the current supply chain setup and how the PBS supply chain would be structured at best before any changes in the external market. In that situation, the supply chain may be locked into a situation that overlooks changed consumer preferences or a changing business landscape. Here, we wanted to classify COVID-19-related disruptions to service offerings as supply chain discontinuities, our second theoretical component, defined as situations that introduce unexpected, unplanned, often dramatic variations in a system (Ghezzi, 2013). Considering the severity of discontinuities stemming from the outbreak of the COVID-19 pandemic and the disruption’s potential to forever change markets, we propose that resilience requires an integrated perspective on discontinuities and how organisations respond to them.

The vulnerability from external discontinuities in the conservation phase leads, in turn, to the release of resources. The release phase occurs when the current supply chain no longer fits changing demands; it could be due to changed consumer behaviour or a business climate that no longer supports the current setup (Wieland, 2021). This phase can also occur when the supply chain is disrupted by an external source, such as the COVID-19 pandemic. Here, we introduce the third theoretical component, transilience, in answer to the call for further investigation into responses to COVID-19. Transilience is an analytical construct that combines the dimensions of resilience and transformability and is defined as “the ability to simultaneously restore some processes and change—often radically—others” (Craighead et al., 2020). In that sense, transilience seeks to combine resilience against normal disruptive situations and transformability in becoming part of the new normal (Craighead et al., 2020).

The trajectory from release to reorganization is usually very quick,
and this is the phase in which new combinations can unexpectedly occur and can lead to innovations in the next adaptive cycle (Holling, 2001). Yet, this is not always the case, there could also be a situation in which the potential is not grasped, and the supply chain no longer meets the requirements of the future. Yet, this phase can lead to valuable innovation and permanent changes in the supply chain configuration. According to this logic, after the reorganization has taken place, the supply chain returns to exploitation and conservation state to optimize the current structure.

3. Methods

The emerging nature of the COVID-19 pandemic’s impact and response to the pandemic from the so-called “eye of the storm” in spring 2020 and the aftermath in late 2020 motivated an explorative, qualitative research design. The pandemic’s impact, in its various dimensions, has been distinct from that of other supply chain disruptions (Cortez & Johnston, 2020). At the same time, transience is a recent concept (Craighead et al., 2020), and given the rather limited research on disruptions and resilience in the literature on services, we consider the theme of transience in PBS supply chains to have an emerging nature as well (Edmondson & McManus, 2007). Thus, our research design builds upon an approach to thematic analysis developed by Boyatzis (1998), from which a framework of coding and analysis was developed. Thematic analysis is a way to determine important themes that emerge from the phenomenon studied—in our case, discontinuities, and responses in PBS supply chains during the COVID-19 pandemic—which we analysed in three phases of inquiry: recognising, encoding, and interpreting patterns in the data (Boyatzis, 1998).

3.1. Sampling and data collection

The primary data were collected via semi-structured interviews. The interview guide presented by the data collection sheet in Appendix 1 was developed from the literature review and the logic is outlined in the theoretical framework. The sheet lists 12 categories of questions that act as a priori codes (Miles et al., 2020) ranging from the disruptive event impact and mitigation to short-term and long-term response. Given the emerging nature of the field, the questions were framed in a way that the respondents could elaborate rather openly on the topic. All interviews were transcribed and imported into NVivo package, and a comprehensive process of data coding and identification of themes was undertaken.

The first step entailed determining sampling and the selection of subsamples. To establish some boundaries we investigated COVID-19’s impact exclusively on large manufacturing firms with extensive experience with established PBS offerings (Pettigrew, 1990). In addition, sampling considered heterogeneity (Robinson, 2014), such that each respondent was expected to contribute a different perspective from a particular industry sector and/or about different products and PBS. To ascertain the impact on each firm, we selectively interviewed at least two individuals at each firm in positions of supply chain management, operations management, production, and sales and/or service management. The sample ultimately comprised 19 employees at six large manufacturing firms (Table 1).

To improve the quality of the data of such an under-examined topic and ensure the validity of results, the results were reinforced with secondary data and a discussion of findings from Section 4 below and analysis on three modes of response to senior managers in a workshop that we specifically arranged for this study. The participants were all senior managers with a high level of responsibility and engagement in responding to the COVID-19 pandemic in their organisations. This workshop was conducted three months after the final interview and provided input on how well we had captured the impact and responses of the COVID-19 pandemic. Secondary data from an in-depth analysis of written material from newspaper articles, online news articles, internal company documentation, and annual reports regarding 107 large and midsized firms in Sweden were considered in the raw data sources. These data were deliberately collected and analysed in the same manner as the interviews, to pinpoint discontinuities and evaluate how the firms had responded to them. Overall, that evidence reflects the pattern that emerged from our analysis of the interviews.

3.2. Data analysis

We followed an inductive approach to thematic analysis (Boyatzis, 1998) in which codes were derived from the empirical data, which complemented the research’s purpose by allowing themes to emerge directly from the data. Inductive coding is particularly suited for studying topics with little to no predetermined theory, structure, or framework available. Instead, data supply the structure of analysis. This was considered appropriate as we assumed that some discontinuities, as well as responses, would be unprecedented, and a structured way of guiding the respondents into what has previously been found in theory would hamper this development. The method allowed us to derive four categories of discontinuities experienced during the COVID-19 pandemic. We also grouped ways of coping with the pandemic with data collected directly from the firms that used them and interpreted

| Industry (PBS offering) | # | Role | Interview length | Interview date |
|-------------------------|---|------|------------------|----------------|
| Company 1: Truck manufacturer (Repair, maintenance, uptime, refurbishment, remanufacturing) | 1 | Aftermarket manager for Europe | 38 min | 2020-06-03 |
| Company 1: Truck manufacturer (Repair, maintenance, uptime, refurbishment, remanufacturing) | 2 | Industrial supply chain analytics expert (Ph.D.) | 40 min | 2020-06-26 |
| Company 1: Truck manufacturer (Repair, maintenance, uptime, refurbishment, remanufacturing) | 3 | Inbound operations support manager | 32 min | 2020-06-08 |
| Company 1: Truck manufacturer (Repair, maintenance, uptime, refurbishment, remanufacturing) | 4 | Purchasing indirect products & services manager | 28 min | 2020-07-02 |
| Company 2: Facilities management (Repair) | 5 | Group innovation manager | 27 min | 2020-06-01 |
| Company 2: Facilities management (Repair) | 6 | Sales & service manager | 26 min | 2020-06-01 |
| Company 3: Forklift manufacturer (Repair, maintenance, uptime, refurbishment, remanufacturing) | 7 | Vice president of manufacturing | 30 min | 2020-06-17 |
| Company 3: Forklift manufacturer (Repair, maintenance, uptime, refurbishment, remanufacturing) | 8 | Production director | 31 min | 2020-06-24 |
| Company 3: Forklift manufacturer (Repair, maintenance, uptime, refurbishment, remanufacturing) | 9 | Supply chain director | 31 min | 2020-06-24 |
| Company 3: Forklift manufacturer (Repair, maintenance, uptime, refurbishment, remanufacturing) | 10 | Spare parts sales & service manager | 30 min | 2020-06-25 |
| Company 4: Forklift manufacturer (Repair, maintenance, uptime, refurbishment, remanufacturing) | 11 | Purchasing department manager | 32 min | 2020-06-29 |
| Company 4: Forklift manufacturer (Repair, maintenance, uptime, refurbishment, remanufacturing) | 12 | Professional services manager | 36 min | 2020-06-29 |
| Company 5: Machinery manufacturer (Repair, maintenance, uptime) | 13 | Vice president of sales and services | 25 min | 2020-07-01 |
| Company 5: Machinery manufacturer (Repair, maintenance, uptime) | 14 | Vice president of sourcing | 30 min | 2020-07-10 |
| Company 5: Machinery manufacturer (Repair, maintenance, uptime) | 15 | Demand & supply planning manager | 36 min | 2020-08-04 |
| Company 6: Healthcare equipment manufacturer (Repair, maintenance, uptime) | 16 | President of global operational services and CIO | 26 min | 2020-06-25 |
| Company 6: Healthcare equipment manufacturer (Repair, maintenance, uptime) | 17 | Director of business support & e-business | 36 min | 2020-07-02 |
| Company 6: Healthcare equipment manufacturer (Repair, maintenance, uptime) | 18 | Vice president of global supply chain | 33 min | 2020-07-02 |
| Company 6: Healthcare equipment manufacturer (Repair, maintenance, uptime) | 19 | Vice president of global sourcing | 35 min | 2020-06-29 |
with reference to literature on supply chain resilience and services for clarification on transience in PBS supply chains. As such, our data-driven, two-stage process of code development and analysis was an iterative, reflexive one, with each company as the level of analysis and one sentence as the unit of coding (Boyatzis, 1998).

The first entailed developing themes and codes by reducing the raw information, derived from the semi-structured interviews, identifying themes, comparing them, creating a code, and determining its reliability. The second, by contrast, involved validating codes by applying them to the remaining raw information, determining the validity of the results and interpreting them. The major categories—discontinuities, circumstances and short- and long-term responses—were developed after brief, one-on-one discussions with industry representatives early during the COVID-19 pandemic and outlined as areas of focus in the semi-structured interview guide. Subcategories emerged during a trial coding of the empirical data, and the combined categories and subcategories became the foundation for the coding framework ultimately used in data analysis. Discontinuities were separated into four groups; circumstances were classified as either moderating or amplifying; and short- and long-term responses were categorised as mitigation, resilience, or acceleration. Each code was defined in a structured coding framework following Boyatzis (1998) as presented in Appendix 2, outlining a definition and a description of key categories, inclusion/exclusion criteria, and illustrative quotes from the interview transcripts. NVivo enabled a structured analysis in which each code contributed to the structure of the findings. We preserved the unit (i.e., the firm) at the beginning of data analysis by generating one mind-map per firm to showcase each discontinuity and associated response strategies and the firm’s view on cultivating resilience. That step was taken to preserve a link between the discontinuity and the response. Ultimately, we set aside the individual company as the level of analysis to detect patterns cross-firms in the themes and combine the findings into the themes presented in section 4.

3.3. Research quality

Thematic analysis faces three major threats: mood and style, projection, and sampling (Boyatzis, 1998). Above all, style and mood are subjective from researcher to researcher. By extension, in projection, researchers may attribute personal readings or attitudes to others. In that case, it is necessary to understand one’s own projections and minimise their effect on analysis. Last, appropriate sampling matters when reviewing empirical data because the sample must reflect the phenomenon under study. In our study, we sought to limit mood and style, projection and sampling by ensuring that the data collection and analysis meet four criteria: credibility, transferability, dependability, and confirmability (Table 2, adapted from Halldórsson & Aastrup, 2003; Miles et al., 2020).

4. Findings

Grounded in data from the manufacturing firms, discontinuities in PBS supply chains can be recognised as four distinct types: all-encompassing interactional, organizational, supply-side, and demand-side. All firms experienced each of the four discontinuities, albeit neither to the same extent nor in the same way. After mind-mapping each firm, their distinct discontinuities and responses were ultimately combined. The empirical findings contained different ideas about how to foster resilience and what measures may have diminished or amplified the pandemic’s impact.

4.1. Product-based service supply chain discontinuities during the COVID-19 pandemic

4.1.1. Interactional disruptions

Above all, restrictions on physical interactions between individuals as a form of interactional discontinuity arose in having personnel socially distanced in their professional roles in PBS supply chains. Those restrictions occurred both upstream and downstream in interactions with suppliers and customers. PBS themselves were also constrained due to transportation restrictions that affected customers traveling to workshops with products and dealers and service technicians traveling to customers. Unsurprisingly, the services were also severely affected by restrictions on physical interaction due to restrictions and shutdowns occurring worldwide, as was also true at workplaces and in interactions with suppliers. Such a severe overarching discontinuity warrants initial attention because it influences the other three categories, as detailed in each context below.

4.1.2. Organisational disruptions

Due to the COVID-19 pandemic, all firms experienced internal organisational discontinuities that we organised into nine types and later grouped them into three broad areas: production, internal issues, and personnel.

4.1.2.1. Service delivery.

1. Factory shutdowns: Several firms shuttered their production facilities, thereby leaving orders unfulfilled and customers unattended. Likewise, service offerings received less focus.

| Table 2: Components of research quality. |
|-----------------------------------------|
| Criterion | Explanation | Application in our study | Phase in study |
| Transferrability | Extent to which general claims can be made from findings (generalisability) | Predefined questions in an interview guide | Research design |
| | | Cross-firm analysis | Data analysis |
| | | Thematic analysis for coding | Data analysis |
| | | Comparison of findings with evidence in the literature | Data analysis |
| | | Use of replication logic in interviews | Research design |
| Dependability | Reliability and long-term stability of data (repeatability) | Use of multiple researchers | Data collection |
| | | Predefined questions in the interview guide | Research design |
| | | Recording of data from interviews | Data collection |
| | | Peer review and examination of results | Data analysis |
| Conformability | Whether the findings justify what the data justify, freedom from bias | Participants’ review of findings | Data analysis |
| | | Use of multiple sources of evidence | Data analysis |
| | | Key informants’ review of drafted findings | Data analysis |
| Credibility | Extent to which variables interrelate, with reality determined and validated by the participants | Assurance of internal coherence of findings and concepts | Data analysis |
| | | Triangulation of interviews, secondary data and literature review | Data analysis |
| | | Researchers’ acknowledgment and minimisation of personal biases | Data analysis |
| | | Peer review | Data analysis |
2. Decreased or halted services: Service delivery had to be stopped or reduced due to decreased service demand.

3. Production prioritised over services: One firm mentioned a necessary trade-off in which parts from the aftermarket supply chain had to be used in production, which left customers with unmet service demand and frustrated employees.

4.1.2.2. Internal issues.

4. Delayed projects: All firms reported having to postpone or cancel most projects that were not related to navigating the COVID-19 pandemic, which will have long-term effects on the organisation’s competitive advantage.

5. Lack of processes: Crisis-response processes were unclear, which caused delays and confusion in the organisations. As staff struggled to know their roles, uncertainty took hold, which imbalanced workloads as some employees were overwhelmed and others unoccupied.

4.1.2.3. Personnel.

6. Staff on leave or furlough: Because of reduced and/or altered demand, facility shutdowns, and border closures, many firms were forced to put people on leave or furlough to survive.

7. A high degree of uncertainty: Uncertainty due to the situation’s unprecedented nature and a lack of information bred confusion and distress among employees and customers.

8. Remote work: All firms had to execute an instant conversion to increased remote work, which placed exceptional pressure on existing IT solutions to meet service demand.

9. Increase in sick leave: The pandemic prompted spikes in sick leave.

4.1.3. Supply-side disruptions

Of the various supply-side disruptions reported by all firms, the overarching one was the complete global shutdown. We grouped such discontinuities into four subcategories: shutdown, inventory, communication, and delays and inertia. Initially, the most pressing concern was suppliers in Asia, followed by ones in Italy and the rest of the world as the pandemic spread.

4.1.3.1. Shutdown.

1. Supplier shutdowns: All supply ceased for a time, starting with China and then spreading globally. The firms also recognised the risk that once China reopened its factories, an oversized backlog of orders would prolong lead times because their own supply lines were disrupted as well, and their capacity would remain low until production completely resumed.

2. Transportation shutdowns: Transport services were completely stopped in many countries, which left inventory in transit and delayed new supply.

3. Border closures: Borders were closed, which also left inventory in transit and delayed new supply. Furthermore, trucks had to take longer routes to avoid closed border crossings.

4. Airfreight shutdowns: Unlike in past supply disruptions, when firms could rely upon air freight to cover supply shortages, nearly all flights were cancelled early during the COVID-19 pandemic.

4.1.3.2. Inventory.

5. Low inventory levels: Inventory levels, traditionally kept low in supply chain management to cut costs, quickly emptied without transport services or suppliers available to resupply parts for repairs and similar services.

6. Panic ordering: Several firms reported ordering parts and components in a panic following COVID-19’s outbreak to ensure inventory, which precipitated other long-term inventory-related setbacks. One even mentioned manually altering every item in their demand and supply planning system, because each had been affected by panic orders.

4.1.3.3. Delays and inertia.

7. Port delays: Ports closed when transportation sector employees were forced to stay at home, which left inventory in transit and delayed new supply.

8. General delays: The delivery of goods and materials was generally delayed.

4.1.3.4. Communication.

9. Lack of information sharing: Some suppliers were unpredictably closed one day but opened the next, which left manufacturers and customers unaware of the situation and forced to resolve problems independently.

10. Lack of risk sharing: Contract-related discontinuities heavily affected most firms’ relationships with suppliers. Although manufacturing firms tend to reroute financial pressure to suppliers during crises, doing so was impossible during the pandemic. When once-reliable contracts for manufacturers backfired as suppliers could not afford more financial burden, the manufacturers became dependent on procuring all supplies available.

4.1.4. Demand-side disruptions

Regarding demand, our analysis revealed two affected areas: service demand and product usage.

4.1.4.1. Service demand.

1. Service demand fluctuations: All firms experienced shifting service demand once COVID-19 broke out. For most firms, service demand varied considerably between product categories in the business and depending upon whether they were to businesses or consumers. For instance, in automotive, service demand was sometimes half of the previous year’s.

2. Market shutdowns: Complete market shutdowns in some regions reduced service demand to nearly zero for some industries.

3. Varying service demand by region and sector: Whereas service demand in some regions and sectors plummeted, in others, it skyrocketed. The same firm could have a service decrease of 60% in France while at once experiencing 50% growth for the same product in Sweden. Such disproportion upended balance within organisations as some employees were unoccupied while others faced heavy workloads.
4. Increased demand for critical services: Although product usage generally decreased, essential sectors such as healthcare became even more reliant on the functional quality of service offerings, which increased demand for critical services (e.g., forklift operation at hospitals).

4.1.4.2. Product usage.

5. Decreased product usage among customers: Most firms experienced massive drops in the use of their products among customers, which likewise lowered service demand.

4.1.4.3. Customers.

6. Lack of communication and information: Difficulties arose with keeping customers informed of current situations and gathering information from them to customise service offerings.

7. Limited service performance: Difficulties with performing services also arose due to restrictions on physical interaction.

4.2. Responses to minimise the impact of COVID-19

Organisational responses: Major mitigating responses prominent in all firms were prioritising customers, cash flow, and activities that generated revenue and immediately halting projects with redundant costs that did not contribute to navigating the pandemic. Crisis-response teams and clear channels of communication were established as solutions for remote work were mobilised. Many firms reported a high degree of uncertainty within the workforce and that communication from top management was important as the crisis unfolded. Those effects demonstrate that internal hierarchies and channels of communication must be established pre-crisis so that all employees know the source of their information and instruction. Indeed, firms with crisis-response plans had an advantage during the pandemic. To further lower costs, workforces were trimmed or reorganised, sometimes by terminating consultancy contracts, furloughing personnel, eliminating redundant positions, or relocating employees. Having an organisation flexible enough to accommodate all these changes was also mentioned as fundamental to fostering robustness and, along with appropriate IT solutions, enabling the sort of remote work needed to keep the business afloat.

Supply-side responses: Most firms urgently sought to order all critical parts and components and to increase their inventory levels. However, alternative solutions for either supplier and/or transportation were not always available due to worldwide shortages and lockdowns. Thus, enlarging the inventory buffer beforehand would have reduced supply dependencies, especially for critical parts needed by PBS supply chains. Another measure taken was reducing the range of service offerings to manage demand and to prioritise critical cases. Nevertheless, the pandemic severely undermined supply, sometimes because no clear action plan was in place for handling a crisis with suppliers, while other firms struggled to share risks and costs with suppliers. Time had to be spent on managing risk sharing and cost cost-sharing before solving the more pressing problems, resulting in delays in responses and solutions. Last, the strategy of single sourcing from low-cost suppliers was viewed as having become unacceptable and revealed the need to shift towards multiple local sources to improve resilience.

Demand-side responses: As product usage dropped, so did the need for services, but urgent service operations became essential. Firms supplying critical sectors (e.g., healthcare) could justify keeping dealers, workshops, suppliers, and production open despite lockdowns. Others attempted to keep service operations running by changing opening hours for workshops and dealers as much as possible. For the demand side, the most crucial capability mentioned was the ability to adapt services to new and changing patterns of demand. To do so, firms need to maintain close collaboration with their customers, especially key ones, at all times. Remote services or changed way of interacting was considered the most important tool and is further explained under interactional responses. During the COVID-19 pandemic, firms assumed that their competitors faced similar challenges, which made maintaining customer satisfaction somewhat easier despite shifting circumstances.

Interactional responses: Physical interaction was eliminated by allowing customers to leave products outside service workshops and retrieving them once ready. Another solution was remote servicing, in which service providers interacted with customers remotely. In cases when service operations were simple, that solution was quite effective, and customer satisfaction peaked. Service providers could, if needed, ship the parts required for the service and, upon their arrival, remotely show customers how to perform the service. Nevertheless, only one firm managed to efficiently reroute their services online; although the others recognised the value of doing so, they also acknowledged that internal processes hindered them. Digitalisation and connectivity had been on the agenda of firms for years when COVID-19’s outbreak forced their rapid implementation. Two firms mentioned that new solutions, including contactless contracting, were wholly implemented mere weeks after the outbreak. All firms reported that prior investments in IT solutions had helped them to weather the crisis, thereby indicating that a high level of digitalisation is pivotal during crises with interactional discontinuities.

5. Discussion

Considering that PBS has experienced new, somewhat unfamiliar circumstances during the COVID-19 pandemic, we investigated discontinuities experienced by managers and their organisations’ immediate actions in response. Our findings show that while PBS sustained focus on products in use at the customer end (i.e., an external dimension), a major discontinuity and immediate response identified related to the need to adapt focal organisations to the new circumstances in an inside–out sort of response. Another major finding is that restoring PBS to their original focus was often complemented by extended, sometimes radically altered service delivery and/or offering. From our theoretical framework and analysis of the empirical results, we derived a conceptual framework (Fig. 2) illustrating key components of transilience in a PBS supply chain.

The framework combines panarchy theory with transilience that extends a current situation and/or seeks a new normal one. It is found that discontinuities can be both managed deliberately, either forced or voluntary, or un-managed externally associated. The release phase of panarchy theory has further been developed to include two dimensions of transilience, the transformative dimension, and the traditional resilience dimension. These range from radically changing the service offering and/or delivery or restoring. The traditional resilience dimension can be distributed into the first mode of resilience, to scale up or down current PBS delivery. Mode I refers to restoring and focusing on the current supply chain structure, it does not require a major reorganization, but can directly transform to exploitation and conservation. The transformative dimension of resilience on the other hand can be distributed into the two modes, either to extend the normal by adding or improving the PBS offering or to embrace a new normal by radically changing the PBS offering. Here, the organization takes advantage of the changed consumer behaviour and/or the changed business landscape to release resources and reorganise. These new findings are further discussed hereunder, first in terms of the nature of discontinuities and second, transilience by the three modes of resilience.

5.1. Nature of discontinuities

Traditionally, supply chain disruptions are regarded as events
occurring outside organisations that impact logistics flows and the operationality of key business processes. Literature on the topic has shifted focus from demand-side risks to supply-side risks, control risks (Christopher & Peck, 2004) towards the ever-increasing risk amid globalisation of supply chains combined with single sourcing (Pettit et al., 2014). To capture the unique dimensions or circumstances of the COVID-19 pandemic, our analysis integrates those external, unmanageable disruptions into the conceptualisation of discontinuity with at least four characteristics in the grey box of Fig. 2.

5.1.1. Supplier–customer bidirectionality
PBS supply chains encompass the in-use phase of products and the flow of transformative resources. This complements the current upstream focus and material- or product-centric view on disruptions similar to the shutdowns, low inventory and lack of communication observed in our study (Manuj & Mentzer, 2008; Tang, 2006; Vanpoucke & Ellis, 2019). Adding the customer-related discontinuity of the COVID-19 pandemic, which in our cases ranged from fluctuations in service demand due to changes in product usage to more severe developments that could either increase demand for critical services or complete market shutdowns, seems to confirm what Cortez and Johnston (2020) regard as unique to the situation—that is, severity related to both suppliers and customers, which is even more evident in the PBS supply chain. Furthermore, the PBS supply chain entails an interactional dimension between customer and provider.

The rippling effects of the COVID-19 pandemic’s impact have clearly manifested in the global shutdown. The literature has discussed avoiding risk by excluding suppliers from risky areas (Parida et al., 2014); however, the global shutdown could not have been solved with that strategy. Moreover, the severity of the impact also incited panic ordering, general delays, and a lack of communication with suppliers. Thus, the discontinuities in PBS supply chains reflect key features of service supply chains identified as being bidirectional by Sampson and Spring (2012). As with the supply side, the demand side was affected by shutdowns and international discontinuities. Fluctuating demand, complete market shutdowns, and gaps in critical support were all unprecedented, and that bidirectional attribute also surfaced in new ways of delivering services in PBS supply chains that had to be managed in new ways to avoid physical interaction between individuals.

5.1.2. Organisational suspension
Another trait of discontinuity concerns how organisations adapted to the new situation by suspending some aspects of their structures and routines in three ways. First, production was either halted or adjusted, not only due to lack of demand or shortage of supply but also to meet the requirement of social distancing between individuals. Similarly, although also as a means of managing cash flow by immediately cutting costs, internal projects were either delayed or discarded. Also, for social distancing and cost savings, personnel were placed on leave or asked to work remotely.

Compared with the external orientation of supply chain disruptions that dominates the literature, which presumes that organisations react to disruptions with externally oriented measures (Christopher & Peck, 2004; Vanpoucke & Ellis, 2019), a novel finding in the PBS setting during the COVID-19 pandemic illustrates immediate actions taken not only by but rather on the focal organisation. Another novel insight was that disruptions are not only responded to by restoring aspects of the old order, for the crisis’s severity may also first require a more immediate action—namely, suspending some organisational routines and structures. Although the literature on services in relation to supply chain disruptions remains underdeveloped, it does acknowledge the need to alter internal structures as a means to support business transformations (Fang et al., 2008). Moreover, while the COVID-19 crisis affected organisations in their entirety, service transitions are normally concerned with the specific organisational component of service personnel who directly impact customers’ satisfaction with services (Brax, 2005).

5.1.3. Manageable but either forced or deliberate
Traditionally, the conception of disruptions and response is rather broad, for example, illustrated by avoiding the use of suppliers in certain regions (Jüttner & Maklan, 2011). Moreover, discontinuities are regarded as external in nature and have thus far been conceptualised as such, such that the point of the disruptive event introduces an interval that is unmanageable.

By contrast, the service literature, with its rather narrow conception of disruptions, takes a broader perspective on their ongoing role and need for immediate management in relation to the organisational environment (Benedettini et al., 2015). Combining those two areas of supply chains and services, insights gained from the findings reveal
several actions taken by management that essentially reduced that unmanageable space. On the one hand, the manageable actions can be seen as mandatory or forced, including unavoidable remote work due to concerns for the health and safety of personnel. On the other, management sometimes acted upon a lack of insight into the severity and longevity of the crisis by taking immediate actions that deliberately reprioritised project development or involved more radical shifts in priorities. One such example was the use of components at the plant for new production versus parts used in services to cater to existing customers. In both cases, the management team, guided by immediate attention to cash flow, minimised as rapidly as possible but also paid attention to significant revenue-generating activities on the customer end, including services to maintain some level of incoming cash.

In sum, one step towards transilience as a means to responding to the COVID-19 pandemic has been to explore the dimensions of discontinuities experienced in the PBS supply chain, grouped as either inter-organisational dimensions (e.g., considering both customers and suppliers and the impact’s bidirectionality) or intra-organisational dimensions (e.g., organisational suspension and manageability, whether forced or deliberate).

5.2. Transilience: integrating restoration and radical change into release mode of panarchy theory

The PBS supply chain can respond to discontinuities by either maintaining current operations or transforming into a release mode. A further step towards transilience is exploring the release dimension of the conceptual framework in Fig. 2. The conception of transilience extends the current traditional resilience literature, mainly focusing on restoration as a response, with additional extension and radical change as a means by which industrial organisations can prepare for and respond to major crises and disruptive events in the PBS supply chain. Moreover, taking a firm PBS perspective offers a valuable insight into how organisations adapt by suggesting that managed discontinuities could be either deliberate (e.g., workforce reductions) or forced (e.g., production shutdowns).

First, we propose that the severity of the COVID-19 pandemic relates to suppliers and customers in tandem. This resonates well with the supply-chain nature of products-based service offerings, and more specifically with the key features of supply service chains as being bidirectional; as with the supply side, the demand side is similarly affected by shutdowns and discontinuities. The bidirectional dimensions place additional emphasis on new types of the service offer in which physical interactions of individuals (e.g., service visits) must be avoided.

Second, whereas much impact and response related to factors outside the boundaries of the firm, getting own organisation into shape appears as a distinct measure in the findings. We have introduced the interval of manageability and measures taken to reduce the unmanaged interval during the crisis—for instance, by enabling remote services or contactless ones. Added to that, we argue that managed discontinuities could be either deliberate (e.g., workforce reductions) or forced (e.g., production shutdowns).

Third, to analyse the response in more depth, the study draws upon transilience and panarchy theory as means to respond to those discontinuities investigated. The analysis suggests three modes by which firms can strive for transilience in the release phase, both in terms of preparedness prior to crises and in actions during them: Mode I (extending the normal and scaling PBS delivery up or down), Mode II (extending the normal and adding or improving PBS offerings) and Mode III (embracing a new normal, with radical changes in new PBS offerings).

6. Conclusion

The COVID-19 pandemic has rapidly transformed the world as we know it and provided a unique setting to investigate how firms respond to discontinuities. By investigating a PBS setting, concerning the in-use phase of products by the customer or end user, the study identifies and categorizes a set of discontinuities and responses to these. To capture the new order as an interesting dimension that firms in PBS supply chains experience, we have developed a conceptual framework for transilience that builds on not only the combination of characteristics of discontinuities that can be managed or unmanaged but also three modes or responses, ranging from restoring to radical change. In that way, we have extended the traditional view of disruptions in supply chains to PBS supply chains by using COVID-19 as a context.

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6.1. Theoretical implications

The first contribution is integrating product-based service supply chain discontinuities into the domain of service-based supply chains. The literature on services is less developed with respect to risk and disruptions than the literature on supply chains. More specifically, servitisation and PBS primarily concern risks associated with the company’s transition from product-based to service-based (i.e., PBS) customer offerings. Our study introduces the ideas of risk and disruptions in supply chains into the service context and highlights three distinct dimensions. First, the service aspect of PBS puts emphasis on the customer-end as regards what disruptions companies need to adapt to, allowing for a firmer integration between the upstream and downstream resilience. By this, resilience is not only associated with supply or cost-related performance but also ties into the revenue and the service offering as stipulated by the business model of the organisation. Second, the study seeks a position in the ‘adaptive supply chain’ branch of extant literature. The study extends how organisations adapt by suggesting that
the organisation may need to deliberately suspend some of their current routines and practice. Hereby, transilience allows for a more fundamental question to be asked about the nature of how to respond to discontinuities; disruptions are not external, unmanageable phenomena, but must also entail actions on rather than only by the focal organisation. To achieve this end, the study introduced the notions of manageable and unmanageable discontinuities: the former being either deliberate or forced, the latter referring to external discontinuities on the supply and demand sides. Third, this underpins further the extension of the dominant view of mitigation as a response strategy toward responding by accelerating change or innovation of current practice or customer offerings (see Modes II and III above).

6.2. Managerial implications

Providers of PBS offerings need to adapt their supply chains to future events like COVID-19. With this paper, we have offered practitioners a conceptual framework of transilience in PBS supply chains, for we believe that current literature does not fully grasp the severity of discontinuities in PBS or the dimensions of response. In that sense, we have responded to the call for more research on transience by presenting ways in which manufacturing firms have managed their responses to the COVID-19 pandemic and lessons learned that may apply to PBS supply chains in comparable future events.

6.3. Limitations and future research

Our study involved examining six manufacturing firms engaged in PBS that were severely impacted by the COVID-19 pandemic. Data were collected from an eye-of-the-storm perspective in Sweden during the first 6 months of the COVID-19 pandemic. Investigating manufacturing firms in a PBS supply chain experiencing major disruptions and lockdown of own operations as well as in their supply chains during a fixed period enabled us to monitor and learn from the current, intense situation and context. Beyond that, our study reflects a situation in which managers have limited or incomplete information about future events as the basis for rational or evidence-based decision-making. To especially complement the dimension of radical change in transilience, longitudinal research with a broader scope could further validate and extend our findings, but perhaps more importantly, investigate the inter-relationship between resilience and sustainable development. This is in line with the shift Industry 5.0 is pursuing. For example, future studies could examine circularity in PBS supply chains and its importance, given its clear value during the spread of the virus amid additional shutdowns. This dimension has become even more important in the light of the aftermath of the lockdown – the abrupt re-start of operations in many sectors has resulted in the scarcity of raw materials and a steep increase in prices of raw materials. This, in turn, fuels discussions on segmenting global supply chains into regions, which favours shorter transport distances. On reflection, Covid-19 resulted in severe discontinuity of service offerings as consequence of lockdown and limited mobility of people resources critical to a service context. The after-effects were increased trade demand and shortage of critical components and serious congestions in the freight transport system. Compared to the discontinuous character of these disruptions, the first weeks of the Ukraine conflict and the following humanitarian crisis have revealed other forms of disruptions, namely geopolitical, image risk and market risk, to name a few. The immediate responses to this have been extremely fast and large-scale shifts at the political as well as company levels, which will affect not only the short-term efficiency of PBS but also their long-term design. One such shift is the rise in energy prices and dependency on sources of energy supply. Further research must consider how this can create favourable conditions for local or regional PBS that offer advanced circular services that keep valuable materials in a geography-specific closed-loop.

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Appendix 1. Interview guide
## Appendix 2. Coding framework following Boyatzis (1998)

| Discontinuity | Supply | Description | Inclusion and exclusion criteria | Illustrative quotes from the interviews |
|---------------|--------|-------------|----------------------------------|----------------------------------------|
| Event (now)   | Mitigation and recovery (immediate response) | Passages where supply interruptions due to COVID-19 are discussed | In: Supply disruptions linked to COVID-19 e.g., all other disruptions | “Lack of materials supply from basically all our suppliers” |
| Topic 1       | Organization | Passages where organizational interruptions due to COVID-19 are discussed | In: Organizational disruptions linked to COVID-19 e.g., all other disruptions | “It was unclear from our processes who would do what during the crisis” |
|               | Demand    | Passages where demand disruptions linked to COVID-19 are discussed | In: Demand disruptions linked to COVID-19 e.g., all other disruptions | “Decreased customer demand throughout all our businesses” |
|               | Interaction | Passages where interaction disruptions linked to COVID-19 are discussed | In: Interaction disruptions linked to COVID-19 e.g., all other disruptions | “Complete lock-down and closed borders, we could not meet the customer” |
|               | Circumstances | Passages where these amplifying factors are discussed | In: Amplifying circumstances to discontinuities e.g., all other circumstances | “We had an unclear risk-sharing setup in the contract agreement, it took time to agree on risk allocation.” |
|               | Mediating | Passages where these mediating factors are discussed | In: Mediating circumstances to discontinuities e.g., all other circumstances | “We could claim that we supported critical industries, and hence continue operations during lockdown” |
|               | Short/Long term response | Passages where initial mitigation actions are discussed | In: Mitigation actions taken as a consequence of COVID-19 e.g., all other initiatives | “Initially looked over costs and what we immediately could cut” |
|               | Accelerating change/innovation | Passages where new markets and/or opportunities with a corresponding change and/or innovation arise as a consequence of COVID-19 | In: All new business initiatives linked to COVID-19 e.g., business as usual and initial mitigation and recovery actions that have not led to any changes | “In general, digital solutions are more important and projects related to that are prioritized (for example contract management are now digitized)” |
|               | Resilience | Passages where actions to respond to future disruptions are | In: All actions that contribute to a more resilient business in the | |

(continued on next page)
