

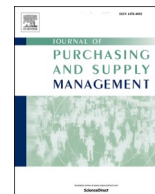


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## Journal of Purchasing and Supply Management

journal homepage: [www.elsevier.com/locate/pursup](http://www.elsevier.com/locate/pursup)

# Getting back into the swing of things: The adaptive path of purchasing and supply management in enhancing supply chain resilience

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## ARTICLE INFO

## Keywords:

Purchasing and supply management  
 COVID-19  
 Supply chain resilience  
 Resource-dependency theory  
 Adaptive cycle

## ABSTRACT

The COVID-19 crisis posed significant challenges to global supply chains (SCs) and exposed their vulnerability to disruption. As SCs have evolved into complex structures comprising a multitude of globally dispersed companies that collaborate closely with one another, purchasing and supply management (PSM) have played a key role in addressing the crisis. The existing PSM measures for increasing supply chain resilience (SCRES) were stress tested and it became evident that these methods are applicable only to a limited extent due to their static perspective and their lack of a network character. Thus, this paper examines the role of PSM by identifying implemented response measures. By conducting 40 semi-structured interviews with experts from original equipment manufacturers and first-tier suppliers in the German automotive industry, a comprehensive overview of the industry was obtained. To reflect the network nature of the industry and the adaptive path of PSM, the data analysis is framed by resource dependence theory and the adaptive cycle approach. The results of the study are 25 response measures of PSM to enhance SCRES, categorized into three waves of measures: initial measures upon the occurrence of the disruption, temporary measures during the disruption, and post-disruption measures. In this way, the study contributes to the existing literature by demonstrating that PSM takes on a major role in increasing resilience by implementing diverse response measures. In addition, the study shows that PSM follows the path of an adaptive cycle, and that after the disruption and the initial and temporary measures, PSM adapts, which is reflected in the post-disruption measures. For practitioners, the study provides a list of response measures to increase resilience that can be used to review existing measures or implement new ones.

## 1. Introduction

In recent years, due to various developments such as offshoring, lean practices, outsourcing of non-core competencies and the focus on continuous cost reduction, supply chains (SCs) have evolved into complex constructs whose actors operate in mutual dependency (Free and Hecimovic, 2021). This increasing complexity, in turn, enhances the vulnerability of SCs (Wagner and Bode, 2006), which was highlighted by the COVID-19 pandemic that posed devastating challenges to SCs worldwide (Swanson and Santamaria, 2021). The impact was particularly drastic, as the pandemic disrupted SCs across multiple industries (Haren and Simchi-Levi, 2020) while companies faced shocks on both the demand and supply sides (van Hoek et al., 2020) and also struggled to comply with medical and regulatory requirements (Handfield et al., 2020).

The automotive industry in particular has experienced strong

disruptions resulting from its industry-specific characteristics and the predominant global sourcing structure (Ishida, 2020). The significant impact of COVID-19 results from two interconnected trends that have been influencing the automotive industry since the 1980s: outsourcing and regional production patterns (Sturgeon et al., 2009). On the one hand, automotive manufacturers have increasingly outsourced production steps to suppliers due to the continuous striving for efficiency (Humphrey and Memedovic, 2003). Outsourcing these activities to specialized suppliers led to a decrease in value added at manufacturers to approximately 25% and complex supply relationships across multiple geographies (Ishida, 2020). On the other hand, the automotive industry is establishing regional production systems in several countries as a result of political, strategic, technical, or economic factors (e.g., import tariffs, regulations on local content, and lean production) (Sturgeon et al., 2009). Outsourcing and regionalization have led to enormous global integration in the automotive industry in recent decades (Ivanov,

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<https://doi.org/10.1016/j.pursup.2022.100802>

Received 31 July 2021; Received in revised form 5 September 2022; Accepted 16 September 2022

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2020), resulting in complex networks with multiple tiers (Belhadi et al., 2021) and visibility constraints (Xu et al., 2020). For instance, Toyota has more than 2,100 first-, second-, and third-tier suppliers serving its over 50 worldwide factories (Kito et al., 2014).

In industries such as the automotive industry, purchasing and supply management (PSM) has moved into the spotlight due to the pandemic (Craighead et al., 2020; van Hoek, 2021), as PSM is responsible for sourcing items from suppliers and determining the strategy and design of the supply network (Patrucco and Kähkönen, 2021). In this context, PSM is defined as the “business management function that ensures identification, sourcing, access, and management of the external resources that an organization needs or may need to fulfill its strategic objectives” (CIPS, 2020). Thus, PSM is the function of a firm responsible for determining the design and strategy of the supply network and for sourcing items from suppliers, providing the focal point for increasing the supply-side responsiveness of companies and their SCs (Patrucco and Kähkönen, 2021). As a result, numerous studies in the past have focused on how the PSM can increase supply chain resilience (SCRES) (e.g., Pereira et al., 2020; Dabhilkar et al., 2016; Vanpoucke and Ellis, 2020).

However, COVID-19 has demonstrated that since the risks caused by the pandemic are different from typical SC disruptions (Swanson and Santamaria, 2021), previous PSM strategies have only limited applicability in this context (Glas et al., 2021; Patrucco and Kähkönen, 2021), forcing PSM to employ novel SCRES measures to address the disruption, such as the in sourcing of production processes (Ishida, 2020), measures to secure material supplies (Münch and Hartmann, 2022), or unusual forms of collaboration (Spieske et al., 2022b). This leads to the conclusion that previous research approaches may need to be reconsidered due to the current business environment, as two important aspects have been neglected: First, many studies ignore the network nature of today’s SCs and the resulting interdependencies among actors (Chowdhury et al., 2021; Vespignani, 2010). In a highly interdependent system, a relatively localized disruption in one firm could lead to disruptions in another firm; this is also referred to as fragility of interdependence (Vespignani, 2010). This is particularly the case with COVID-19, as the pandemic both impacted many tiers of the SC simultaneously (e.g., original equipment manufacturers [OEMs] due to a demand shock, third-party logistics providers due to closed borders, or suppliers due to the lack of material) and had a delayed impact on the overall system with recurring disruptions (e.g., postponed shutdowns in Asia and Europe) (Craighead et al., 2020; Haren and Simchi-Levi, 2020). Second, studies often adopt a static perspective and see SCs as closed systems (Nilsson and Gammelgaard, 2012; Wieland, 2021). However, this approach fails to consider the dynamic and open nature of SCs and the notion of different time horizons in responding to pandemic-related risks (van Hoek, 2021). Given this temporal perspective, deterministic approaches are only minimally suitable to deal with the diverse challenges and rapid changes of our world (Wieland, 2021). These more static narratives need to be replaced with approaches that take into account the fact that SCs change over time (Biggs et al., 2010), and SCRES is not a ‘being’, but rather a ‘becoming’ (Wieland, 2021). This ‘becoming’ ultimately suggests that SCs change over time, and that a mere return to the previous state is not sufficient, but that disruptions lead to transformation and a new state (Carpenter et al., 2001; Glas et al., 2021), which makes it necessary to understand how the different responses over time are interconnected (Harland, 2021; van Hoek, 2021).

Motivated by these shortcomings in existing research, this study aimed to investigate what measures PSM has applied to increase resilience over time and how this response will lead to an adaptation of PSM. By examining the automotive industry with a focus on the mutual interdependence between manufacturers, first-tier suppliers, and n-tier suppliers, the following research question should be answered:

What measures is PSM implementing over time to increase SCRES in the face of a major disruption?

To investigate the research question, a qualitative study using expert

interviews was applied. Overall, 40 semi-structured interviews with 18 companies (six car manufacturers and 12 first-tier suppliers) were conducted. To evaluate the results and provide a suitable basis for analysis, as well as to address the identified research gaps, the research is grounded in two theoretical assumptions: resource dependence theory (RDT) (Pfeffer, 1989; Pfeffer and Salancik, 1978) and the adaptive cycle approach (Holling, 1986, 2001). Therefore, the study contributes to research in three ways: First, the study complements existing research in PSM with response measures applied by PSM to increase SCRES (Pereira et al., 2020; Vanpoucke and Ellis, 2020). It not only confirms existing measures and identifies new ones, but also shows that companies are applying these measures over the time horizons (van Hoek, 2021), which in this study is reflected in three ‘waves of measures’. Second, this study takes into account the fact that companies in the automotive industry face a high degree of interdependence and shows the collaborative nature of the identified response measures, which may be divided into buffering and bridging strategies (Pfeffer and Salancik, 1978). While the initial and temporary measures both use strategies to improve existing relationships with suppliers (bridging) and to compensate for damaged relationships (buffering), the post-disruption measures show a strong tendency toward the buffering strategy. Third, the study illustrates the dynamic nature of SCs and shows that PSM adapt to experiencing a disruption by going through an adaptive cycle (Wieland, 2021). The relationship among the measures in the three implementation waves suggests that those in the initial and temporary phases may provide information about which adaptations the PSM could make in the post-disruption phase. In addition, to the further development and targeted implementation of many initial and temporary measures, it was also possible to identify a restructuring of the SC and supplier base, which is described in this study as ‘natural selection’ in the context of the adaptive cycle.

This paper is further organized as follows. In Section 2, a literature review on SCRES in general, as well as in the context of PSM and the theoretical underpinning of this paper is provided. The applied methodology is presented in Section 3, including the data sampling, collection, coding, and analysis. Subsequently, the results are described in Section 4. Finally, in Section 5, the study is summarized, theoretical contributions are discussed, practical implications are derived, and limitations, as well as future research paths, are presented.

## 2. Literature review and theoretical background

### 2.1. Supply chain resilience

Debates about SCRES began more than one decade ago, but have gained new momentum since COVID-19 began (Craighead et al., 2020; van Hoek, 2020). One reason for this is that the recent series of major disruptions have made organizations increasingly aware that existing measures to minimize and treat SC risks are reaching their limits. These measures are often based on a simple transformation from organizational risk management to SCs. In particular, in industries such as automotive which consist of countless involved organizations, establishing sufficient approaches to reduce and deal with complex threats is difficult (Wieland and Durach, 2021).

For Sheffi and Rice (2005), major disruptions that cause harm to companies occur in seven typical disruption stages. This perspective is relevant as it describes the behavior of decision-makers, such as PSM managers, from a time horizon. The first stage is preparation, when a company may anticipate and, consequently, prepare for a disruption before the disruptive event occurs. According to Sheffi and Rice (2005), this is followed by the first response to the disruption, which is the attempt to get the situation under control. This response is followed by the initial and full impact. In this stage, performance usually starts to decrease until it drops dramatically at the full impact stage. Recovery preparations is the next stage; this includes, for example, qualifying alternative suppliers or finding alternative transport options. The

seventh stage is recovery, in which companies try to compensate for the losses by increasing their workload. The last stage includes long-term impacts of the disruption that are difficult to solve or may even be permanent.

Consequently, combining these disruption stages with the common SCRES understanding, which states that resilient SCs can recover operational performance within a short period of time (Christopher and Peck, 2004; Jüttner and Maklan, 2011), it is necessary to apply measures to reduce the time horizon of the various disruption stages. These measures are important fundamentals of existing SCRES research.

Christopher and Peck (2004) were among the first to investigate SCRES and identified key requirements for developing resilient SCs. Their SCRES framework identifies SC (re-)engineering, collaboration, agility, and a risk-aware organizational culture as crucial. In SC (re-)engineering, they consider the use of design principles that deal with the trade-off between redundancy and efficiency in establishing the SC network (Christopher and Peck, 2004). In particular, this also requires a structural understanding of SCs to determine potential bottlenecks and critical paths at an early stage (Wichmann et al., 2020). By SC collaboration in the context of SCRES, Christopher and Peck (2004) understand that SC entities combine their resources and mitigate risks together. Agility is generally understood to be a combination of speed and visibility and a risk-aware organizational culture is based on appropriate management of threats (Hohenstein et al., 2015; Rajesh and Ravi, 2015).

Sheffi and Rice (2005), in another commonly used SCRES perspective, also identify measures for strengthening the resilience of companies. They see important levers in building up flexibility or redundancies in order to be able to react quickly to disruptions. For these researchers, this is particularly relevant in highly competitive markets to gain market share or strengthen the market position.

One subsequent stream of research on SCRES has focused on preparing for and anticipating risks through the use of robust and agile elements (Wieland and Wallenburg, 2012). Robustness is the ability of an SC to maintain its function despite a disruption (Brandon-Jones et al., 2014; Wieland and Wallenburg, 2013). In this regard, redundancy, collaboration within SCs, a SCRES-aware organizational culture, and information-sharing support are core elements of SCRES (Brandon-Jones et al., 2014; Hohenstein et al., 2015). In contrast, agile SCs are characterized by their ability to quickly adapt processes in response to unforeseen changes (Jüttner and Maklan, 2011; Pettit et al., 2019).

A more recent stream understands SCRES in the context of environmental influences, as current and recent disruptions have shown that processes and structures of SCs are fluidly intertwined with planetary and political-economic phenomena (Wieland, 2021). Traditionally, SCs have been strongly understood and described as static, reductionist systems (Nilsson and Gammelgaard, 2012), which is also evident in the SCRES understanding that exists to date. As in engineering, it would be necessary to make adjustments 'only' to build resilience, which is why Wieland and Durach (2021) summarize previous SCRES research as engineering resilience. Wieland and Durach (2021) provide a newer understanding of SCRES, summarizing it as follows: "Supply chain resilience is the capacity of a supply chain to persist, adapt, or transform in the face of change" (Wieland and Durach, 2021: 316). Here, greater consideration is given to the fact that SCs must change over time to remain meaningful. This means that organizations need to strive for transformational and adaptive capabilities in order to better anticipate and influence developments that occur outside of SCs (Wieland, 2021).

## 2.2. Supply chain resilience and purchasing and supply management

The mitigation of SC disruptions is a pressing concern of today's PSM managers that has also been tested during the COVID-19 pandemic (van Hoek, 2021; Vanpoucke and Ellis, 2020). Mitigating SC disruptions is an important responsibility of PSM, especially in industries in which extensive SC networks are prevalent, such as in the automotive industry

(Glas et al., 2021). PSM can be crucial in improving resilience due to its cross-boundary nature, which is characterized by bundles of proactive and reactive measures within internal and external activities (Pereira et al., 2020). Dabhilkar et al. (2016) present a summary of PSM practices that have been explicitly mentioned in literature for improving resilience. Proactive practices range from internal training of employees and the setting up of recovery processes to the external activities of seeking additional sourcing bases and expanding collaborations. Within the reactive practices, the focus within PSM on the internal activities is on setting up the task forces, coordination both inside and outside the company boundaries, and sharing relevant information as external activities. Regarding external activities, Zsidisin (2003) recommends additionally buffer and process-oriented strategies. The former strategy includes approaches focused on generating redundant resources, such as increasing inventories or expanding suppliers, which supports robustness if a disruption occurs and, thus, increases SCRES (Brandon-Jones et al., 2014). The second strategy supports process-oriented mitigations through relationship activities by improving processes and transparency with suppliers. This increases agility and, thereby, enables the enhancement of SCRES (Bode et al., 2011).

Hohenstein et al. (2015) and Tukamuhabwa et al. (2017) identify redundancy, collaboration, visibility, and flexibility as important antecedents to SCRES, which may also be enabled by PSM through various procurement practices. For example, these factors were used by Spieske et al. (2022a) to describe the PSM role in the SCRES context within the healthcare industry. In the automotive industry, redundancy may be created by having backup suppliers and breaking up single-sourcing strategies to increase the robustness of SCs (Belhadi et al., 2021). Collaboration may be strengthened by sharing information within the industry (Agarwal and Seth, 2021). Visibility may be improved through the use of advanced digital technologies, such as supplier platforms (Balakrishnan and Ramanathan, 2021). Creating more flexibility through optimized processes may also be facilitated through PSM in the automotive sector (Spieske et al., 2022b).

## 2.3. Theoretical underpinning

To address the research gaps identified in the introduction section (i. e., the network character and the time horizon of measures), the present research study is grounded in two theoretical approaches: the RDT and the adaptive cycle approach.

First, RDT is used to describe the network character and resulting interdependencies of the companies. This theory is based on the notion that organizations cannot operate autonomously and, therefore, must establish inter-organizational relationships to gain access to important resources (Drees and Heugens, 2013). These relationships create dependency on external actors, lead to an imbalance of power, and represent potentially harmful sources of business (Touboulie et al., 2014). Actors within an SC try to minimize their reliance on others or to maximize other organizations' reliance on them to mitigate uncertainty (Pfeffer, 1989). RDT postulates two types of interdependencies: symbiotic relationships and competitive relationships. While the symbiotic relationship describes the dependence of actors due to an output-input relationship, the competitive relationship describes the dependence due to access to equal resources (Pfeffer and Salancik, 1978). Interdependencies between different actors can be competitive and symbiotic in parallel, for example, when two organizations compete for a resource (competitive) and at the same time have a relationship due to a resource (symbiotic) (Pfeffer and Salancik, 2009). The management of interdependencies is critical for limiting adversity and reducing the harmful effects of disruptions (Bode et al., 2011). In general, two types of RDT strategies may be distinguished: buffering and bridging (Bode et al., 2011). To decrease a company's dependency on an existing supplier and thus mitigate potential disruptions that a dependency on this supplier could bring, buffering strategies are applied (Bode et al., 2011). Contrary to this, bridging strategies protect a company from the

consequences of disruptions by establishing closer links with a supplier and extending the firm's influence over it (Bode et al., 2011). In doing so, bridging—as opposed to buffering, which occurs outside of a supplier relationship—aims to mitigate uncertainty through cross-border measures such as sharing of information, joining an alliance, or further strategies that enhance the power of a buyer in a relationship (Bode et al., 2011). Both strategies can be used in parallel to manage dependencies in one relationship (Al-Balushi and Durugbo, 2020).

Second, to account for the dynamic and open nature of SCs (Nilsson and Gammelgaard, 2012), as well as the understanding of 'becoming' resilient (Wieland, 2021), the so-called adaptive cycle approach is chosen as the present paper's second theoretical foundation (Holling, 1973). Originating in ecosystem research (Biggs et al., 2010), the adaptive cycle is a framework for understanding and describing the change and resulting resilience of complex systems (Gunderson and Holling, 2002). The basic assumption in an adaptive cycle is that it often does not evolve toward a stable position (Carpenter et al., 2001), instead passing through the four phases (Gunderson and Holling, 2002): exploitation ( $r$ ), conservation ( $K$ ), release ( $\Omega$ ), and reorganization ( $\alpha$ ). The movement of the system through these four phases occurs within a three-dimensional state space defined by resilience, connectedness, and system potential (Holling, 1986). Thereby, resilience describes the degree of disruption that a system can absorb without transitioning to a new configuration (Holling, 2001). Connectedness relates to the relationships between elements and processes of the system (Holling, 2001). System potential is connected to the range of options available for future system responses (Holling, 2001). In the two phases of the front loop, exploitation and conservation, there is an aggregation of resources and relationships that is relatively rapid at first but slows down as the conservation phase is reached (Gunderson and Holling, 2002). Systems spend most of their time in these phases, with the conservation phase also understood as a quasi-equilibrium in which system features are stabilized (Holling, 2001). When moving from the exploitation phase into the conservation phase, the potential and connectedness increase, but resilience decrease because as interconnectivity grows, the system becomes rigid and vulnerable to failure (Holling et al., 2002). In the two phases of the back-loop, release, and reorganization, the dynamics are fast because the system is moving into a new phase of exploitation (Gunderson and Holling, 2002). The release phase describes a collapse of the rigid system and is characterized by the rapid loss of system properties, destruction of patterns, and accumulated resources (Simmie and Martin, 2010). This is quickly followed by a period of reorganization (Gunderson and Holling, 2002), during which some novelty arises. The movement in direction of reorganization is characterized by an increase in resilience because the system allows experimentation and innovation in this phase (Holling et al., 2002). Subsequently, the  $r$ -phase, in which the system settles on a new trajectory in a precisely defined area of attraction, begins a second time (Carpenter et al., 2001).

### 3. Methodology

To address the research question, semi-structured expert interviews were conducted to collect empirical data. This decision was based on a multitude of reasons. First, using an exploratory approach is ideal for investigating relatively new and unexplored subjects (Miles et al., 2020). This is of particular benefit in nascent research fields such as COVID-19, given that research on the pandemic's impact on PSM is still at an exploratory stage, and existing knowledge is scarce (Chowdhury et al., 2021; van Hoek, 2020; Yin, 2014). Second, the research design allowed in-depth interactions with informants to observe actual practices and to collect detailed empirical data (Eisenhardt and Graebner, 2007). Conducting semi-structured expert interviews provided a level of openness to unexpected and new facts while also enabling a structured data collection process (Alvesson, 2003; Döringer, 2021). Third, previous research has proven that this approach is a reliable method within

supply chain management and PSM research (e.g., Bals et al., 2019; Benz et al., 2021; Guida et al., 2021; and Juha and Pentti, 2008).

#### 3.1. Sampling and data collection

The experts consulted for this research were identified through a stakeholder analysis conducted by the members of the research team. To avoid bias in the survey data, the experts were selected according to certain criteria (Eisenhardt and Graebner, 2007). The study differentiates between two entities of the automotive SC: OEMs and first-tier suppliers. OEMs were part of the target group, as their PSM measures are of great importance, given that SC disruption risks can have a major impact on their performance (Tang and Musa, 2011). First-tier suppliers have been selected as manufacturing and logistics processes in the automotive sector are highly interdependent and require joint planning, because approximately 75% of a car's value creation is generated by the global supplier network (OICA, 2018). Therefore, to investigate the impact of COVID-19 on PSM, the two SC entities were studied and experts were selected according to this criterion. To increase generalizability and enable comparability, the research focused further on the largest German OEMs and first-tier suppliers that rely on global supply networks. The headquarters and production of all participating companies had to be located primarily in Germany, as this constraint guaranteed that all companies were exposed to similar influences, such as governmental interventions like lockdowns. In addition, the population of the sample was restricted by the criterion that the first-tier suppliers' core business must be in the automotive sector, as this ensured similar dependencies upon the global crisis's influence on the business with automotive OEMs.

In qualitative research, it is important to determine an optimal number of samples instead of aiming for a particular number of participants (Eisenhardt, 1989). To determine an appropriate number of expert interviews, Corbin and Strauss (1990) suggest that it is more important to collect and analyze data until saturation is reached and further interview data only provide marginal new insights. With 40 expert interviews within six automotive OEMs and 12 first-tier suppliers, sufficient saturation was achieved to answer the research question. To reach saturation, data analysis began before all interviews were conducted in order to continue sampling until theoretical saturation was achieved and no additional relevant insights were obtained from the interviews (Guest et al., 2006; Saunders et al., 2018). Based on the anonymization guidelines, the revenues and numbers of employees are presented through incremental ranges, and the competence areas of the experts and their experience are summarized in Table 1. The interviewees' details show a high degree of experience in the sample.

The development of the interview questionnaire was guided by an extensive review of relevant literature and preliminary PSM expert discussions, which validated the relevance, accuracy, and suitability of the defined questions. The final questionnaire featured a semi-structured design. This design was chosen because of its beneficial flexibility that allowed for interacting with each interviewee differently while still addressing the defined areas of data collection (Yin, 2014). A pilot test with two informants from a local first-tier supplier was conducted. The pilot test provided valuable lessons regarding the questionnaire design and interview duration.

All interviews were conducted in the period between mid-2020 and the beginning of 2021. Only experts with a high level of experience and with direct responsibility for COVID-19-related PSM topics were carefully selected as part of the sample. A few relatively smaller companies named a single expert who, due to the nature of the company and role, was able to cover all areas of the survey.

#### 3.2. Coding and data analysis

All interviews were conducted via video conferencing or phone, lasted between 45 and 65 min, and were recorded to enable re-listening

**Table 1**  
Overview of interviewed experts.

Experts	Function of respondents	Experience in years	Number of employees <sup>a</sup>	Revenue in Euros <sup>b</sup>
OEM_A1	Head of Supplier Management	16	>50,000	>50 billion
OEM_A2	Head of Procurement Components	21		
OEM_B1	Head of Procurement	7	>50,000	>50 billion
OEM_B2	Head of Serial Purchasing	16		
OEM_B3	Strategic Procurement	8		
OEM_B4	Senior Buyer	10		
OEM_C1	Head of Procurement	17	25,000–50,000	10-50 billion
OEM_D1	Purchasing Commodity Manager	13	>50,000	>50 billion
OEM_D2	Head of Procurement Components	11		
OEM_D3	Team Lead Semiconductor Management	10		
OEM_D4	Supplier Quality Specialist	6		
OEM_D4	Purchasing Manager	10		
OEM_D5	Vice President Purchasing	21		
OEM_E1	Manager Material Procurement Pre-Series	9	25,000–50,000	10-50 billion
OEM_F1	Head of Procurement Raw Materials	18	>50,000	>50 billion
FT_A1	Head of Purchasing and Supplier Management	34	>50,000	10-50 billion
FT_A2	Director Purchasing Strategy & Processes	19		
FT_A3	Head of Purchasing Raw Materials	21		
FT_A4	Vice President SCM	20		
FT_B1	Head of Supplier Management	16	>50,000	10-50 billion
FT_B2	Director Materials Manager	17		
FT_B3	Director Commodity Purchasing	20		
FT_C1	Head of Lead Buying Electronics	10	>50,000	10-50 billion
FT_C2	Head of Strategic Purchasing	6		
FT_D1	Head of Procurement	15	<25,000	<10 billion
FT_E1	Purchasing Manager	10	>50,000	10-50 billion
FT_F1	Head of Global Cluster Chemicals	15	>50,000	10-50 billion
FT_F2	Head of Reinforcements Purchasing	20		
FT_F3	Head of SCM Execution Planning	19		
FT_G1	Head of Purchasing Mechatronics	11	<25,000	<10 billion
FT_G2	Head of Series Purchasing	25		
FT_H1	Head of Purchasing Raw Materials	21	25,000–50,000	<10 billion
FT_H2	Global Head of Series Purchasing	15		
FT_H3	Global Head of Corporate SCRM	15		
FT_I1	Head of Purchasing	18	25,000–50,000	<10 billion
FT_I2	Head of Purchasing Electronics	20		
FT_J1	Vice President Corporate Purchasing	22	>50,000	>50 billion
FT_J2	Director of Purchasing	20		
FT_K1	Head of Purchasing	22	<25,000	<10 billion
FT_L1	Senior Director Supply Chain & Production	18	25,000–50,000	<10 billion

**Notes:** <sup>a</sup> Range of number of employees: <25,000; 25,000–50,000; >50,000; <sup>b</sup> Range for revenue: <10 billion Euro; 10–50 billion Euros; >50 billion Euro.

and transcription (Riege, 2003). All participants received a copy of the transcript to reassure its correctness, prevent misunderstandings, and validate the transcripts. The revised protocols and relevant additional information from secondary sources were used to verify the results of the interviews (Gibbert et al., 2008). Following a systematic qualitative content analysis procedure, the data were analyzed regarding common phrases, expressions, and words (Mayring and Fenzl, 2014; Schreier, 2014). Thus, a first group of codes was developed, and different sub-codes within these codes were identified to analytically cluster and connect the unstructured qualitative data within each interview. The aggregation of data such as interview quotes to superior categories enabled the identification of patterns, structures, and relationships (Corbin and Strauss, 1990). Therefore, relevant statements from the interviews were paraphrased and assigned to the different thematic codes (Blumberg et al., 2014). As advised by Yin (2014), software for clustering the qualitative data was deployed to support the data volumes' handling and coding. To prevent investigator bias, the coding was performed independently by two members of the research team. Divergences in the results regarding interpreting the interview statements, wording, and allocation to categories were gradually approximated in detailed discussions within the research team until a consensus was achieved. This iterative research approach ensured reliability and a high quality of analysis (Pagell and Krause, 2005).

## 4. Results

The analysis of the expert interviews resulted in a total of 25 different responses of the companies to the pandemic (classified into five measure categories), which were implemented by PSM to enhance the resilience of automotive SCs. These measures are classified depending on whether they are internal (bridging) or external (buffering) to a current relationship with a supplier. The measures identified can be categorized into three waves of measures: initial measures (upon the occurrence of the disruption), temporary measures (during the disruption), and post-disruption measures. An overview of these response measures and their classification into measure category, implementation waves, and categorization into bridging and buffering strategies is provided in the Appendix.

### 4.1. Initial measures upon occurrence of the disruption

The measures initially taken to counteract the disruption with immediate effect can be divided into three categories: communication and coordination, relationship with suppliers, and business operations. Thereby, it can be stated that measures, which have been applied in the short term, serve to control the situation and to prevent further damage. According to the experts, an important aspect that COVID-19 has shown is the increased need for measures to improve internal and external communication and coordination. Uncertainties resulting from the

supply side and production side, or customer side were identified as drivers of complexity for effective SC coordination and planning. Based on the survey participants' comments, the lack of information from the downstream stages to the customers was the primary problem, along with the lack of information about the delivery situation and production capacities on the supplier side. COVID-19 has shown that the internal exchange, as well as the external exchange with SC partners, played key roles in the management of the pandemic.

*"In this topic, we have set up supplier calls to get in touch with people on a regular basis. This was in addition to the bilateral discussions that people have who are then in direct contact with their suppliers."* – Interviewee FT\_A2

To establish relevant information sharing, various measures were taken during the crisis. For example, five OEMs and nine first-tier suppliers conducted digital audits to request the impact of COVID-19 from key suppliers. In addition, specific dashboards containing relevant key figures on delivery capabilities and corporate health were set up on short notice for the most important suppliers and were used for decision-making during crisis meetings. The short-term development of these dashboards indicates that the crisis has created a demand for information processing that had not been made available in advance to deal with SC risks such as a pandemic. All experts mentioned that relevant details were discussed in specific COVID-19 crisis task forces in which PSM had a leading role. In contrast to previous smaller crises, top management was fully informed and actively involved at an early stage, which proved to be an important factor in accelerating decision-making.

*"Suddenly, we had to ensure in the task force that granules were flown from Europe to North America, and, of course, they had to be distributed in such a way that the suppliers most likely to cause a shutdown at our customer were the first to be supplied. This is not just a 1:1 relationship, but a 1:n relationship when a material is affected for n suppliers, which you then have to manage successfully."* – Interviewee FT\_H2

In addition, according to all PSM experts, cross-company coordination took place at several organizational levels involving the PSM functions. The warning indicators from the dashboards, in combination with the close exchange, were important instruments to identify emerging risks and to prepare countermeasures. The selected countermeasures were diverse to enable target-oriented support to suppliers. According to the experts, without insights into SC activities outside the focal company, it would not have been possible to manage the SC in a targeted manner.

In addition to improved communication and coordination, the initial measures also include approaches to intensify the relationship with suppliers. In particular, the support of suppliers was an important measure taken to ensure delivery capability and to avoid a collapse of the SCs. The suppliers, which are often only small and medium-sized companies, especially from lower tiers, were affected by personnel and financial losses during the pandemic. According to almost all experts, the existing suppliers were supported in a targeted manner with personnel, knowledge or financial resources, which led to an improvement in the supplier relationship. Several OEMs used their market power and offered financial support to first-tier suppliers or provided support in terms of crisis management if this was needed. The latter included, as an example, the assistance of steering n-tier suppliers when critical situations occurred. In the case of first-tier suppliers, the support was rather operational. For example, according to one first-tier expert, his company offered the allocation of experienced employees, while another offered to relocate machinery and production equipment, and others extended payment terms for their suppliers. Moreover, experts reported the need to generate SC visibility for early detection of risks beyond direct SC partners. Transparency within the SC was considered as an important factor in identifying risks at an early stage, beyond the direct SC partners. Based on the expert interviews, three OEMs and six first-tier suppliers particularly reported that due to the complexity of

automotive SCs and the costs of permanent monitoring, the active management of partners before the pandemic had been limited to companies directly upstream or downstream and not to the entire value chain. This lack of transparency resulted in limited or absent sharing of relevant information with n-tier suppliers, which led to a sub-optimal alignment of, for example, the production capabilities. As several experts mentioned, the material shortages faced by the automotive industry during the pandemic may also be attributed to the missing visibility along the overall SC.

*"In the ramp-up, you have to have the whole supply chain under control. And in the COVID-19 case, the availability of resources and people actually became critical because of the lack of transparency."* – Interviewee OEM\_D4

Another short-term measure that was implemented and is assigned to the measures that contribute to maintaining the business operations was the restructuring of the production capacities of suppliers to ensure the trouble-free supply of materials. For this reason, many of the first-tier suppliers examined whether it was possible to change the production location of the existing suppliers to a less-COVID-19-affected country and assisted them concerning the relocation. As an example, one first-tier supplier temporarily switched to production facilities in Latin America, as China was impacted by a lockdown. However, the experts highlighted that the short-term feasibility of these measures was limited to the use of existing structures and existing suppliers due to the high qualification and planning requirements associated with the change of a supplier.

#### 4.2. Temporary measures during the disruption

Once the initial measures have created a certain degree of control and transparency in the SC, the temporary measures serve, in particular, to strengthen the relationship with the suppliers to guarantee the supply of necessary materials and maintain the company's business operations. All PSM experts from OEMs and first-tier suppliers agreed that overcoming the challenges of the pandemic also resulted from well-established supplier management approaches and good relationships. While experts from this study stated that the pandemic was different from previous crises, collaboration and existing relationships with suppliers enabled the companies to manage the COVID-19-related risks in a better way. This research shows that suppliers prefer good relationships and reward SC partners who strive for a collaborative relationship with intensive communication and openness. Several participants in the study also stated that in times of crisis, good and trust-based partnerships could also lead to the achievement of competitive advantage, as expressed by OEM\_B3:

*"I think in a crisis, we always talk about limited capabilities, and the question as a supplier is always, which customers do I allocate my limited capacities? One is, of course, the strategically most important customer, then perhaps also the one who pays the best. However, in any case, in the third instance, it is the kind of relationship you have with a supplier."* – Interviewee OEM\_B3

As derived from the different experts' statements, the benefits of a good supplier relationship in a crisis are expressed in various forms of collaboration. It was emphasized by several participants that open communication about the status quo during crisis management—for example, regarding delivery planning, inventory stocks, and production obstacles—is highly relevant. Thus, the experts' statements revealed that companies share information more openly with their direct partners and actively address uncertainties in the company's environment. The experts emphasized that only if the right information is available in appropriate quality and exchanged between the partners at the earliest stage is it possible to steer the SC in such a way that the best outcome may be achieved for the involved parties. These research findings demonstrate that sharing relevant information and improving data

quality in the presence of uncertainty leads to better outcomes.

*“In all purchasing areas where strategic suppliers play an essential role and operate in a critical market, I believe it is essential to have a good, long-term supplier relationship to be adequately supplied, especially in times of crisis.”* – Interviewee FT\_I2

Good relationships with suppliers are seen in this research by OEMs and first-tier suppliers as an opportunity to improve communication, accelerate reactions, exchange accurate information about, for example, the financial health of an SC partner, and simplify and improve monitoring. Strong, opportunistic behavior was not identified by any of the experts interviewed, suggesting that the focus on common goals succeeded. This is also reflected in the fact that many experts referred to a change in mentality to cope with the crisis. Study participants emphasized that in many situations, employees in PSM departments had to or should deviate from contractual agreements to ensure delivery capability. Practical solutions were developed with suppliers, such as deviating from specified quantities or postponing payment targets.

Another measure that was classified as temporary is the anticipation of the wave patterns of global infections. From early 2020 onward, COVID-19 has proven that the world must go through different waves of preventive actions during a global pandemic, such as lockdowns or shutdowns. Thus, according to different PSM experts from OEMs and first-tier suppliers, geographic and seasonal infection patterns during COVID-19 needed to be considered. Concerning geographic differences, crisis teams had to focus on the infection situation not only in the home country but also in the countries of key suppliers. According to the experts, the global SC structures and widespread supplier contacts predominant in the automotive industry have a direct impact on the need for information to be able to identify regional changes with a global impact and to remain capable of taking action. The following expert's statement can prove this finding:

*“On the one hand, we have Asia and China, which are growing strongly and pushing prices up, and, on the other hand, Europe and America are again affected by the pandemic. Some suppliers are not able to deliver because they have a high percentage of sick people or because they are not able to deliver the material for the agreed prices.”* – Interviewee FT\_F2

In addition, it became apparent that the challenges caused by a high infection rate do not occur similarly in all waves and that companies are affected differently. For instance, different experts noted that the second wave was much more crucial because countries were affected differently.

*“The second lockdown is much more critical, as it has affected the economy unequally.”* – Interviewee FT\_F3

The third category of measures, which were applied in the medium term, are measures to guarantee business operations. Multiple experts reported that they had to adjust regular operations and processes in the face of the crisis to ensure production performance. These adjustments included modifying the supply strategies, especially for critical parts, by expanding the supplier base or sourcing from additional suppliers to diversify the supplier base. Additionally, such process adjustments included changing to other transportation options. For example, transport alternatives were explored, and, according to the experts, many companies switched to the expensive—but more flexible and quicker—option of air freight to remain capable of producing when regular transportation options such as sea freight were limited due to capacity bottlenecks or reduced port capacities.

In addition, almost all PSM experts from OEMs and first-tier suppliers reported direct contact with n-tier suppliers, despite the lack of a contractual basis for such interactions during the pandemic. The necessity of this approach may be attributed to the fact that smaller suppliers experienced difficulties in enforcing their demands. For this reason and to deal with these challenges, PSM experts from different companies worked together to represent their demands to n-tier

suppliers jointly. Hereby, the usual company boundaries were dissolved during COVID-19, and PSM's interests were much more jointly represented within the SCs.

The medium-term identification and preparation of alternative suppliers or the assessment of the potential change of supplier facilities was an essential part of the PSM and thus formed the basis for long-term adjustments beyond the pandemic. Thus, defining measures to ensure supply at an early stage of the pandemic enabled companies to cope with occurring disruptions without serious production downtimes.

#### 4.3. Post-disruption measures

The long-term measures applied (or planned) after the disruption are based on the previously implemented short- and medium-term measures and deal both with the intensification of relationships with suppliers, but also with measures to improve supply capabilities and the reconfiguration of SCs. Expanding the relationship with suppliers is intended to be successful through the sustainable creation of transparency. In addition to direct suppliers, n-tier suppliers must also be included to create end-to-end transparency. This is to ensure and maintain cross-company data exchange via standardized interfaces. To this end, the indicators must be defined and possible data harmonized to enable evaluation. One proposed solution to achieve better transparency and maintain data management is using digital supplier platforms that integrate more companies of an SC. Different OEMs and first-tier suppliers of this study reported that they already have such systems in place, but these are accessible only to contracted SC members.

*“We should [...] create a platform, where we share the SC-relevant data so that we know where we stand and what we can do at all times because we are just navigating blindly through this more complex supply chain.”* – Interviewee FT\_H3

As noted, digital solutions such as supplier platforms can help to identify SC risks at an early stage and to start countermeasures to avoid bottlenecks.

To create increased supply security for crucial materials in the future, the establishment of agreements with important n-tier suppliers is being considered by many survey participants as a means of ensuring continuity of supply in the event of future crises. As a result, experts from OEMs stated that the companies tend to negotiate agreements directly with raw materials suppliers. In this respect, the high market power of OEMs may be used to leverage their influence to the advantage of SC partners.

*“Subcontractor management is also an increasingly important topic for us because often the problems of the first-tiers are often not caused by the first-tiers or cannot be solved by their improvements and measures.”* – Interviewee OEM\_D4

This statement was supported by almost all experts working for OEMs, as most of their first-tier suppliers are considered to be established and financially stable companies and SC partners with robust processes. According to the experts, most of the risks occur among n-tier suppliers, which are often characterized by smaller company size and greater vulnerability to disruptions caused by more limited financial stability and, in some cases, high dependencies on individual customers. For this reason, PSM needs to evolve into a more holistic approach focusing on selected n-tier suppliers. In this context, initial findings on the vulnerability of relevant n-tier suppliers may be analyzed in a risk assessment based on the pandemic. Such an expansion of the PSM approach so that n-tier suppliers will be given greater consideration in the future also needs to be embedded in the PSM strategy of the individual companies. The experts also indicate that the monitoring of business partners will become much more important in the future. As a result, companies are increasingly focusing on long-term support for suppliers. Examples of this support include improving productivity, increasing efficiency, and helping with digitization.



According to the experts, many of the investigated companies have already put their existing supplier network under review as a result of the emerging challenges and disruptions that have occurred. In the automotive industry, PSM is often based on a single-sourcing approach. This has been identified as leading to high dependencies and, thus, SC risks. As part of the conducted study, experts from 16 of the total 18 interviewed companies indicated that COVID-19 would lead to a change in PSM strategies. Concerning the long-term changes in PSM activities and SC structures, various changes were mentioned by the experts, including re-shoring and near-shoring, establishing alternative suppliers, and implementing a multiple sourcing strategy. Solely the experts from two OEM companies indicated that an assessment of the long-term changes would be possible only upon surviving the pandemic and being able to assess the long-term changes reliably. Some PSM experts mentioned that they have already been assigned to assess the risks of existing sourcing setups, including the evaluation of re-shoring activities. According to the research participants, this approach is also driven by increasing sustainability efforts. For the experts, changes in currently favored markets may result in new opportunities to change the existing SC setup and switch to more regional concepts, which would shorten SCs and, consequently, make them less vulnerable to global crises. According to the experts, these re-shoring and near-shoring activities would enable more flexible coordination and the reduction of SC disruptions due to transport issues. Global transport issues, as well as intensified local virus outbreaks or production closures during the COVID-19 pandemic, demonstrated the need to develop a strategy to reduce dependencies upon partners. Alternative suppliers, different procurement regions, and suppliers close to the production site are seen as opportunities to reduce dependencies in the long-term. However, such changes are complex due to the high standards of the automotive industry and the low number of alternative suppliers, making this procedure a long-term management decision.

5. Discussion and contribution

5.1. Summary

By using the example of the automotive industry with a focus on the interdependence between OEMs and first-tier suppliers, this study investigated what measures PSM has implemented over time to increase SCRES and how this response will lead to PSM adaptation. The results are depicted in Fig. 1.

This research study identified various measures based on the buffering and bridging strategy that PSM has implemented to enhance SCRES. These measures are applied in different time horizons, which is reflected in three 'waves of measures' in this study: initial measures upon the occurrence of the disruption (e.g., establishing internal task forces involving top management, intensified communication, evaluating the performance of suppliers); temporary measures during the disruption (e.g., changing the means of transport, establishing joint procurement); and post-disruption measures (e.g., using supplier platforms to digitalize collaboration, establish agreements with additional n-tier suppliers to ensure supply of critical materials, monitoring of bottlenecks). It appears that PSM initially applied first-response measures to control the situation and to prevent further damage. This includes, for example, the establishment of task forces for rapid analysis and communication or the evaluation of the performance of suppliers to ensure the supply of materials. After these initial measures, PSM implemented temporary measures to cope with the situation at that time and to secure further operations. For example, the companies changed the means of transport or expanded the supplier base to prevent the failure of material deliveries or production stops. The final time horizon describes measures to be implemented after the disruption, such as utilizing a supplier platform or establishing agreements with n-tier suppliers. Furthermore, the results indicate that there is an interrelationship among initial,

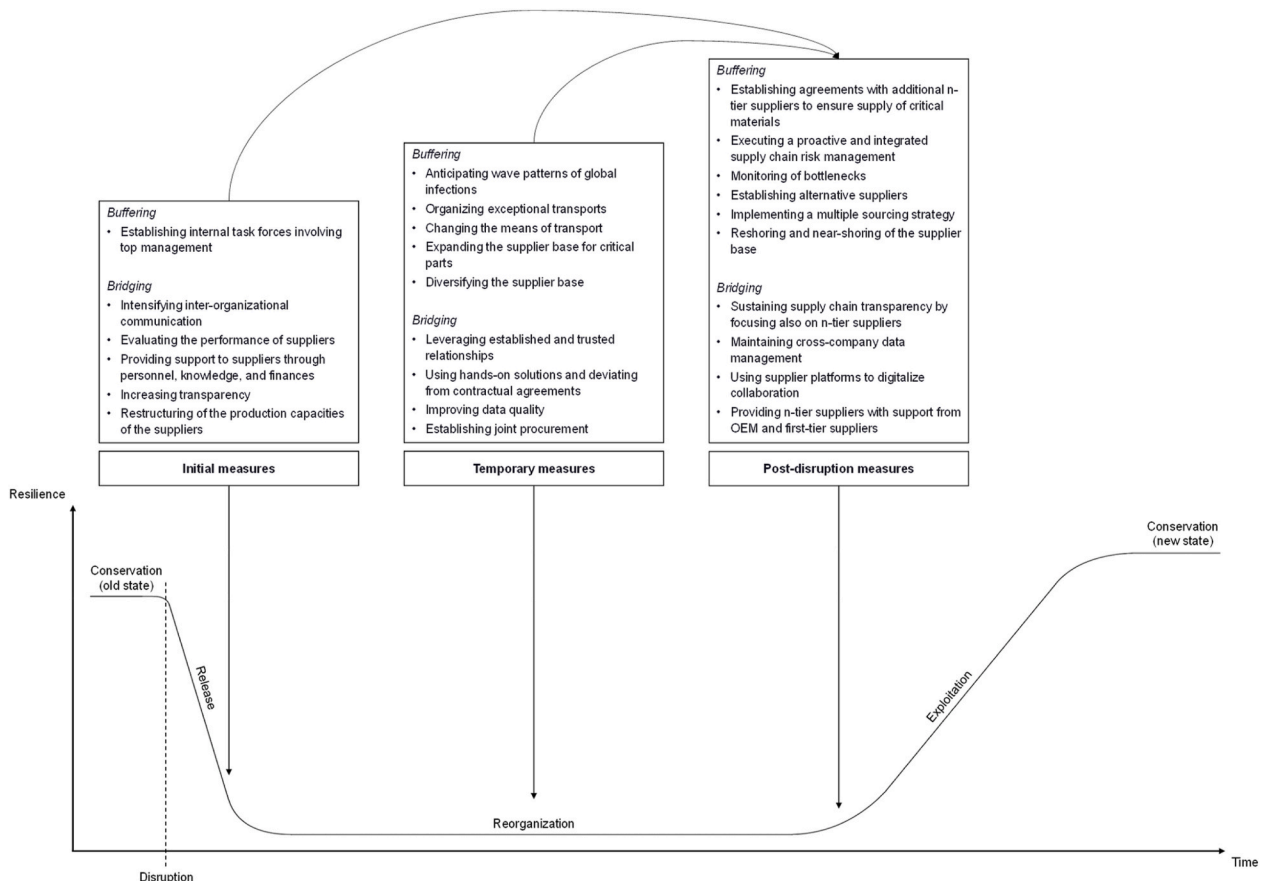


Fig. 1. The adaptive path of purchasing and supply management in enhancing supply chain resilience.

temporary, and post-disruption measures. From the initial and temporary measures, indicators can be derived of what post-disruption measures will result. For example, the supplier evaluation and intensified communication measures indicate that supplier platforms may become established. One particular phenomenon highlighted by this study is the so-called ‘*natural selection*’ of the supplier base. While in the initial and temporary response phase adaptations are made to maintain or improve existing relationships through collaborative measures, the measures in the post-disruption phase show a tendency of rebuilding the supplier base.

## 5.2. Theoretical contributions

From a theoretical perspective, this study contributes in three ways: First, the study highlights the importance of PSM in coping with COVID-19 disruptions by identifying relevant measures that PSM has applied to enhance SCRES. Compared to the existing literature, three categories of measures were identified: 1) measures that have already been identified in other disruptions, for example intensification of inter-organizational communication (e.g., Pereira et al., 2020); 2) measures that became relevant only due to COVID-19 and have been supported by other studies, for example deviating from contractual agreements (e.g., Münch and Hartmann, 2022); and 3) measures that became relevant only with COVID-19 and have not yet received attention in the literature, for example the anticipation of the wave patterns). Furthermore, the findings of the study confirm that different time horizons exist for the application of measures in response to a disruption (van Hoek, 2021). While the existence of time horizons was previously only theoretical (Craighead et al., 2020), this study confirms such waves of measures and shows that measures may be divided into three time horizons.

The second contribution relates to the theoretical grounding of the study within the RDT in order to better comprehend the strong factor of interdependence within the industry and the related behaviors of the actors involved (Pfeffer and Salancik, 1978). The results indicate that due to the high dependency of companies in the automotive industry and the resulting network character, a large number of the implemented measures to increase resilience are collaborative in nature, which was also confirmed by van Hoek (2021). This not only affects collaboration with direct suppliers, which has been strengthened through various measures (e.g., intensification of inter-organizational communication), but also collaboration with n-tier suppliers, which was introduced both as part of the initial measures (e.g., establishing joint procurement) and as a long-term measure (e.g., sustaining SC transparency by focusing also on n-tier suppliers). The study shows that the bridging strategy (nine measures) slightly outweighs the buffering strategy (six measures) during the initial and temporary response phases. In this way, companies aim both to improve their existing relationships with suppliers and to supplement existing partnerships with new suppliers. Thus, companies have sought to use their resources in the form of buyers and knowledge to support their suppliers in the purchasing process (e.g., bridging). Material availability reduced competitive dependencies, and supplier support reduced symbiotic dependencies while strengthening the bargaining position. The symbiotic dependencies were additionally reduced by further buffering procurement measures to increase material availability, such as expanding the supplier base for critical parts or establishing alternative suppliers. In the post-disruption phase, companies continue to rely on buffering and bridging measures, but buffering measures strongly predominate. Thus, the results support recent studies showing that while bridging strategies are a good choice for coping with disruption in the long-term (Gebhardt et al., 2022), buffering strategies continue to be more widely used in the post-interruption phase (Chowdhury et al., 2021).

The third contribution arises from taking a dynamic perspective (Wieland, 2021) and connecting the measures of each response phase (Harland, 2021). Thus, this study provides empirical evidence that SCs are adapting and that resilience should be viewed as ‘*becoming*’ rather

than ‘*being*’ (Wieland, 2021). This existing relationship among the measures confirms that PSM do not return to their original state but rather move to a new state through an adaptive path (Carpenter et al., 2001). This new state represents an improved version and is based on the experiences that occurred during the disruption which confirms that PSM move along an adaptive cycle (Wieland, 2021). Accordingly, before the pandemic, the automotive industry was in the conservation phase, which is characterized by less information about lower-tier suppliers, strong contractual agreements, long transportation routes, and a globalized supplier base. Due to these rigid structures, the industry was not able to react satisfactorily to COVID-19, which led to the release of the construct (e.g., through production stops, the bankruptcy of suppliers) and to the reorganization of parts of the industry. With the results, this study provides insights into how companies in the industry moved from the release to the reorganization phase. In making this metaphorical comparison, this study drew on previous resilience research in addition to the parallels that reorganization corresponds to the first response and preparation for recovery that were proposed by Sheffi and Rice (2005). Continuing the adaptive cycle, after the reorganization, the automotive industry enters the exploitation phase. In this phase, new structures were formed and new measures were implemented to increase resilience. The study shows that the initial-response measures may be used to determine which post-pandemic measures are implemented in the adaptive cycle.

## 5.3. Managerial implications

The paper provides valuable insights into the role of PSM in managing major disruptions and increasing SCRES. In general, the study shows that PSM, especially in industries with a high dependence on other companies, is very crucial in managing global crises. For practitioners, the study provides an overview of what response measures can be implemented through PSM to increase SCRES. Additionally, the study highlights that response measures are applied in different implementation waves. Managers can use the study to compare existing response measures and develop a strategy for how the PSM responds to major disruptions. The study indicates that the focus of the initial and temporary measures is both on maintaining and improving existing supplier relationships and on bridging disrupted relationships. The post-disruption measures, on the other hand, indicate that companies must position themselves more independently and selectively reduce their supplier base based on performance during the disruption and develop new suppliers.

## 5.4. Limitations and opportunities for further research

Like other research, this study is subject to limitations, which provide the foundation for further research. One concerns the sampling frame, as the study results are based on the perspectives of German automotive companies. Country-specific political decisions such as social distancing, border closures, or state support differ across economies, which may lead to different results. Therefore, an extension of the survey could analyze the research model in other countries or geographical regions. Furthermore, the data was collected during the COVID-19 pandemic. Even though the experts had already mentioned the first post-disruption measures at that time, a further study is needed to determine which of these measures were actually implemented and whether other measures only became evident later in the course of the COVID-19 pandemic. Additionally, the data are exclusively from automotive OEMs and first-tier suppliers. It would be beneficial to transfer the study to other industries to investigate whether the same results are also found beyond the automotive industry. To achieve a more holistic perspective of the industry, further investigations should, therefore, also include small and medium-sized n-tier suppliers. Further, it would be interesting if researchers put more attention to the wave patterns of a pandemic and their impacts on SCs. Here, future research could deliver

beneficial scientific and practical insights through a comprehensive analysis of the root causes and the derivation of avoidance strategies.

**Author statement**

Christoph Küffner: Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Validation, Writing - original draft, Writing - review & editing, Project administration. Dr. Christopher Münch: Conceptualization, Methodology, Data curation, Validation, Writing – review & editing, Visualization, Supervision. Sven Hähner: Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Validation, Writing - original draft, Writing - review & editing. Prof. Evi Hartmann: Conceptualization, Methodology, Writing – review & editing, Supervision.

**Declaration of competing interest**

All authors confirm that there is no conflict of interest. We confirm that this manuscript has not been published elsewhere and is not under consideration by another journal. All authors have approved the manuscript and agree with submission to the Journal of Purchasing and Supply Management. We have read and have abided by the journal’s statement of ethical standards.

**Data availability**

Data will be made available on request.

**Appendix. Initial measures, temporary measures, and post-disruption measures that form the adaptive path of PSM**

Measure category	Response measure	Wave of measures			Strategy	
		Initial measures	Temporary measures	Post-disruption measures	Bridging	Buffering
Measures related to communication and coordination	Establishing internal task forces involving top management	x				x
	Intensifying inter-organizational communication	x			x	
Measures related to the relationship with suppliers	Evaluating the performance of suppliers	x			x	
	Leveraging established and trusted relationships		x		x	
	Providing support to suppliers through personnel, knowledge, and finances	x			x	
	Using hands-on solutions and deviating from contractual agreements		x		x	
	Improving data quality		x		x	
	Increasing transparency	x			x	
	Sustaining supply chain transparency by focusing also on n-tier suppliers			x	x	
Measures related to the pandemic-specific characteristics	Maintaining cross-company data management			x	x	
	Using supplier platforms to digitalize collaboration			x	x	
Measures related to the business operations	Anticipating wave patterns of global infections		x			x
	Organizing exceptional transports		x			x
Measures related to the supply capability	Changing the means of transport		x			x
	Restructuring of the production capacities of the suppliers	x			x	
	Expanding the supplier base for critical parts		x			x
	Establishing joint procurement		x		x	
	Diversifying the supplier base		x			x
Measures related to the supply chain configuration	Establishing agreements with additional n-tier suppliers to ensure supply of critical materials			x		x
	Providing n-tier suppliers with support from OEM and first-tier suppliers			x	x	
	Executing a proactive and integrated supply chain risk management			x		x
	Monitoring of bottlenecks			x		x
Measures related to the supply chain configuration	Establishing alternative suppliers			x		x
	Implementing a multiple sourcing strategy			x		x
	Reshoring and near-shoring of the supplier base			x		x

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