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Increasing global supply chains’ resilience after the COVID-19 pandemic: Empirical results from a Delphi study☆

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A R T I C L E   I N F O

Keywords:
COVID-19 pandemic
Delphi study
Supply chain disruption
Supply chain resilience
Supply chain risk management
Resource dependence theory

A B S T R A C T

COVID-19 has revealed global supply chains’ vulnerability and sparked debate about increasing supply chain resilience (SCRES). Previous SCRES research has primarily focused on near-term responses to large-scale disruptions, neglecting long-term resilience approaches. We address this research gap by presenting empirical evidence from a Delphi study. Based on the resource dependence theory, we developed 10 projections for 2025 on promising supply chain adaptations, which were assessed by 94 international supply chain experts from academia and industry. The results reveal that companies prioritize bridging over buffering approaches as long-term responses for increasing SCRES. Promising measures include increasing risk criteria importance in supplier selection, supply chain collaboration, and supply chain mapping. In contrast, experts ascribe less priority to safety stocks and coopetition. Moreover, we present a stakeholder analysis confirming one of the resource dependence theory’s central propositions for the future of global supply chains: companies differently affected by externalities will choose different countermeasures.

1. Introduction

Over the last decades, companies have established global supply chains (GSCs) by expanding offshoring and outsourcing activities to benefit from higher productivity, lower labor costs, and access to scarce resources abroad (López & Ishizaka, 2019). This development has led to a rise in the complexity and interdependencies of supply chains (SCs) (Gölgeci, Yıldız, & Andersson, 2020). In recent years, an increasing number of disruptions (e.g., natural disasters or political interventions) have struck the complex GSC environment, revealing its vulnerability to externalities (Lechler, Canzaniello, Roßmann, von der Gracht, & Hartmann, 2019). In this context, scholars have explored GSCs’ downsides and pointed out their inferiority regarding flexibility, lead times, and recovery capabilities in case of supply chain disruptions (SCDs) (López & Ishizaka, 2019). Nevertheless, companies had not significantly adapted their GSC setup when the COVID-19 pandemic exposed GSCs’ vulnerabilities more clearly than any previous SCD (Craighead, Ketchen, & Darby, 2020; Gölgeci et al., 2020). The pandemic’s unique characteristics, including its simultaneous disastrous impact on various industries, geographies, and supply and demand markets, led to worldwide SC breakdowns (Carracedo, Puertas, & Martí, 2021; Craighead et al., 2020). Moreover, governmental interventions such as lockdowns or border closures further complicated GSC operations (Ivanov, 2020). The crisis’s severity was incomparable, with 94% of companies reporting COVID-induced SCDs and forecasts predicting a world trade decline of up to 32% (Dib & Ould Azouz, 2020; WTO, 2020).

These experiences put the concept of supply chain resilience (SCRES) – which discusses a company’s ability to prepare for, respond to, and recover from an unexpected SCD (Hohenstein, Feisel, Hartmann, & Giunipero, 2015) – at the center of academic interest (Craighead et al., 2020). Scholars state that SCRES will gain importance and companies will start questioning and modifying their current GSC designs (Dolgui & Ivanov, 2020; Gölgeci et al., 2020; van Hoek, 2020). This includes sourcing and site location decisions as well as networks’ ability to react quickly and flexibly to environmental changes (Säenz & Revilla, 2014). However, there is high uncertainty regarding promising SC design

Abbreviations: CV, convergence rate; D, desirability; EP, expected probability; FCM, fuzzy c-means; GSC, global supply chain; I, impact; IQR, interquartile range; LSP, logistics service provider; P, projection; RDT, resource dependence theory; SC, supply chain; SCD, supply chain disruption; SCM, supply chain management; SCRES, supply chain resilience.

☆ This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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https://doi.org/10.1016/j.jbusres.2022.06.008

Received 1 February 2021; Received in revised form 30 May 2022; Accepted 5 June 2022

Available online 10 June 2022

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strategies and related measures to increase SCRES in a post-COVID-19 world (Queiroz, Ivanov, Dolgui, & Fosso Wamba, 2020; Verma & Gustafsson, 2020). Previous SCRES literature primarily addressed near-term response and recovery measures during SCDSs, neglecting long-term resilience approaches (Hohenstein et al., 2015; Spieske & Birkel, 2021). Moreover, SCRES research lacks contributions regarding large-scale SCDSs such as the COVID-19 pandemic in terms of impact, duration, and volatility, mainly focusing on operational risks or previous regional natural disasters (Ivanov, 2020, 2021). Therefore, various scholars have asked for research on SC design alternatives to reduce vulnerabilities, dependencies, and increase SCRES in GSCs following the pandemic (van Hoek, 2020; Verma & Gustafsson, 2020).

To address this critical research gap, we developed 10 future projections regarding SC design alternatives following the COVID-19 pandemic. Between September and November 2020, 94 supply chain management (SCM) experts from 10 countries evaluated the projections in a Delphi study, a well-suited method for evaluating uncertain future scenarios (Rowe & Wright, 1999; Winkler, Kuklinski, & Moser, 2015). We embedded the projections in the resource dependence theory (RDT) (Pfeffer & Salancik, 1978), a suitable and established frame for studying company interdependencies in SCM (Gligor, Bozkurt, Russo, & Omar, 2019; Pfeffer, 1989; Spieske, Gebhardt, Kopyto, & Birkel, 2022). RDT explicitly refers to situations in which firms depend on an uncertain environment to acquire essential resources for their operations (Bode, Wagner, Petersen, & Ellram, 2011). These characteristics were present during the large-scale COVID-19 SCDS, when complex SC networks, including an indefinite number of cross-company relationships, were impacted directly or through ripple effects (Ivanov, 2020; Li, Chen, Collignon, & Ivanov, 2021). Overall, this approach allows us to address the discussed research gap by answering the following research question (RQ):

RQ: How will companies adapt their GSCs by 2025 to increase SCRES after the COVID-19 pandemic?

Our paper offers several contributions to research on SCRES. We adopt a widely ignored perspective in SCRES research by presenting empirical evidence of measures companies will likely implement to improve SCRES in the aftermath of a large-scale SCDS. In this context, we note contradictions to SCRES measures generally accepted in the literature and present reasons for SCM experts’ diverging preferences. Moreover, we uncover positive and negative interdependencies between the identified measures. Our contributions are backed by RDT, a so-far underrepresented theory in SCRES research. Apart from confirming its suitability to study pandemic-related SCM challenges, this theory serves as a valuable foundation for explaining company reactions to a large-scale SCDS.

This paper’s remainder is organized as follows. First, we review previous research on the intersections of RDT, SCRES, and COVID-19-related literature and introduce the Delphi projections. Second, we describe the research methodology. Third, we present our quantitative and qualitative results and discuss them to answer our RQ and advance theory. Lastly, we derive conclusions and implications for theory and practice, note limitations, and propose future research directions.

2. Theoretical background and projection development

2.1. Supply chain resilience measures following large-scale disruptions

Currently, SCRES research on the aftermath of large-scale disruptions is scarce. Although studies investigating large-scale disruptions have gained momentum in recent years (Hohenstein et al., 2015; Parker & Ameen, 2018), scholars still predominantly address response and recovery measures during disastrous events and neglect long-term adjustments of resilience strategies. For instance, Blome and Schoenherr (2011) and Jüttner and Maklan (2011) conducted case studies to identify suitable SCRES measures during a financial crisis. Although Jüttner and Maklan (2011) assumed that their identified measures might also prove suitable for the future, evidence is missing. Matsuo (2015) analyzed Toyota’s initiatives to restore SCs following the Tohoku earthquake, limiting long-term implications to improved coordination mechanisms. During the COVID-19 pandemic, Gölgeci et al. (2020), Wieland (2021), and Wieland and Durach (2021), among others, indicated the need to comprehensively transform SCs instead of solely identifying measures to manage the present crisis. However, most recent empirical papers focused solely on identifying SCRES measures for the ongoing pandemic (e.g., Belhadi et al. (2021), Nandi, Sarkis, Hervani, and Helms (2020), Sharma, Adhikary, and Borah (2020)), making empirical evidence on initiatives triggered by large-scale disruptions to improve future SCRES a major research gap.

2.2. Resource dependence theory

In today’s globalized world, entire SCs, instead of single firms, compete against each other (Christopher, 2000). This leads to dependencies on other players to successfully operate an SC (Craighead et al., 2020). These conditions became apparent during the COVID-19 pandemic. Due to the SC’s unpredicted scale and simultaneous impacts on various geographies and SC tiers (Ivanov, 2021; Li et al., 2021), managing externalities and maintaining product flows were among the biggest challenges for GSCs (Craighead et al., 2020).

Nandi et al. (2020) reported that effectively managing SC dependencies is more important than internal capabilities when building SCRES. While most existing frameworks approach SCRES from multiple angles – including organizational resources, employee capabilities, and top executive involvement (e.g., Blackhurst, Dunn, and Craighead (2011), Pfeffer & Salancik, 1978) – and without a clear prioritization of measures, RDT offers a well-established perspective to specifically discuss inter-corporate relations and related measures (Gligor, Bozkurt, et al., 2019; Pfeffer, 1989). This theory has been repeatedly applied to analyze complex relationships in SC networks since dependencies in these settings are particularly strong (Al-Balushi & Durugbo, 2020; Nandi et al., 2020). Despite the theory’s suitability for analyzing relationships in complex SC networks, RDT-backed SCRES research is still scarce and, therefore, a highly encouraged research foundation in the context of the COVID-19 pandemic (Ali & Gölgeci, 2019; Craighead et al., 2020).

RDT is based on the idea that companies depend on their environments to acquire scarce resources at favorable conditions to ensure their survival (Bode, Wagner, Petersen, & Ellram, 2011; Pfeffer & Salancik, 1978). In this context, resources refer to any input factor which can support an organization’s success (e.g., materials, labor, and cash) (Craighead et al., 2020). Sources to acquire them are manifold, including suppliers, competitors, customers, and public authorities (Al-Balushi & Durugbo, 2020). To secure these resources in an uncertain environment, firms are advised to reduce or eliminate their dependence on external partners or increase others’ dependence on them (Cai, Yang, & Hu, 2009; Pfeffer & Salancik, 1978).

Two types of resource dependencies are discussed in RDT literature, symbiotic and competitive relationships, which were also affected during the COVID-19 pandemic (Pfeffer, 1989). In symbiotic relationships, dependency originates when one organization’s output is the input for another SC member (Pfeffer, 1989; Pfeffer & Salancik, 2003). When suppliers and logistics infrastructure were forced to cease operations to prevent COVID-19 cases from spreading, many companies experienced supply shortages, leading to worldwide ripple effects (Ivanov, 2020; van Hoek, 2020). In competitive relationships, companies share a customer base, and the market success depends on each firm’s behavior (Pfeffer, 1989; Pfeffer & Salancik, 2003). When competitive conditions suddenly changed because of the COVID-19 pandemic, these dependencies were...
also negatively affected. Border closures favoring local rivals is a prominent example (Assunção, Medeiros, Moreira, & Lopes, 2020).

To cope with difficulties resulting from inter-organizational dependence during SCDs, RDT generally offers two approaches: **buffering** and **bridging** (Bode et al., 2011). While buffering is external to a relationship and reduces a company’s exposure to current exchange partners, bridging is internal to existing relationships and attempts to increase an organization’s power over the opposite party (Al-Balushi & Durugbo, 2020; Mishra, Sharma, Kumar, & Dubey, 2016). Both approaches can be applied simultaneously to manage dependence in a specific relationship (Bode et al., 2011).

### 2.3. Projections’ literature foundation

Based on a comprehensive projection development process further described in Section 3, we developed 10 concrete projections for the year 2025 to discuss SRES opportunities in GSCs with the Delphi expert panel (see Table 1). Aligning with RDT, all projections represent buffering and/or bridging approaches and aim to improve symbiotic and/or competitive relationships between companies. In the following paragraphs, we introduce the RDT and SRES literature serving as a foundation for the projections.

**Safety stocks (P.1).** One of the most prominent buffering measures is increasing safety stocks to hedge against supplier failures and short-term demand increases (Mishra et al., 2016; Park, Min, & Min, 2016). GSCs in particular can benefit from additional inventory, since transport routes and durations are long with a comparably high probability of delays. Particularly can benefit from additional inventory, since transport routes and durations are long with a comparably high probability of delays (Manuj & Mentzer, 2008). Although this measure was widely applied during the COVID-19 pandemic (Sharma et al., 2020; Verma & Gustafsson, 2020), enhancing SRES through safety stocks comes with additional costs (Christopher & Peck, 2004). Therefore, the continued application of this strategy after the pandemic is uncertain.

**Multiple sourcing (P.2).** Another concept to reduce dependency and improve SRES is multiple sourcing (Hohenstein et al., 2015). Scholars have reported that companies applied this measure to buffer supply shortages during the COVID-19 pandemic (Verma & Gustafsson, 2020). Particularly, multiple sourcing for strategic components and geographical sourcing diversification helped to mitigate negative consequences (Sharma et al., 2020; van Hoek, 2020). However, initiatives to onboard additional suppliers may not always be successful, since they require significant time, certification, and coordination efforts (Zsidisin & Wagner, 2010). Moreover, multiple sourcing is associated with higher costs, leading to hesitant application (Costantino & Pellegrino, 2010).

**Backup transportation (P.3).** Sourcing is not limited to physical supply. It also includes transportation capacities, which was another bottleneck during the COVID-19 pandemic (Ivanov, 2020). Therefore, alternative transportation solutions are sometimes required to sustain a GSC’s delivery capability. Potential backup transportation solutions include excess capacities and alternative transport modes, routes, and supply concepts (Albertzeth, Pujawan, Hilletoth, & Tjahjono, 2020). Scholars compared the measure’s usefulness to other risk management approaches ranging from safety stocks to insurance coverage and confirmed its effectiveness in countering transportation disruptions (Albertzeth et al., 2020; Zhen, Li, Cai, & Shi, 2016).

**Standardized components (P.4).** Furthermore, companies can reduce their dependence on certain suppliers by designing their products more resiliently (Mishra et al., 2016). For instance, reducing the number of customized components and specifying alternate components lowers the dependency on specialized suppliers (Matsuo, 2015; Saenz & Revilla, 2014). This offers more procurement options in case of supplier failures and is also associated with cost savings due to easier product development and economies of scale (Matsuo, 2015).

**Flexible network design (P.5).** To implement resilience measures, companies require flexibility in their GSCs, especially in times of SCDs (Manuj & Mentzer, 2008). This includes the speed of exchanging suppliers, finding new distribution channels, and reacting to rivals’ behavior (Hohenstein et al., 2015; Zsidisin & Wagner, 2010). During the COVID-19 pandemic, a lack of flexibility in GSCs became evident (Golgeci et al., 2020), bringing this topic to the top of SC practitioners’ agendas (van Hoek, 2020).

In addition to the five measures predominantly relying on the buffering approach, there are also several measures to bridge resource dependencies.

**Supplier selection (P.6).** Establishing risk management criteria in supplier and logistics service provider (LSP) selection and auditing can reduce information asymmetries between exchange partners and empower buyers to better predict vulnerabilities in times of SCDs (Christopher & Peck, 2004; López & Ishizaka, 2019). In this context, it is crucial to not just receive and assess information on operational and financial performance but to proactively help suppliers to overcome potential weaknesses to better address or avoid SCDs (Zsidisin & Wagner, 2010).

**SC mapping (P.7).** Companies can also invest in network visibility to identify sub-tier suppliers and enhance end-to-end transparency (Hohenstein et al., 2015). Additional SC information can increase power and improve governance mechanisms related to direct suppliers (Gilg,
Gligor, Holcomb, & Bozkurt, 2019; Touboulic, Chicksand, & Walker, 2014). However, scholars report that establishing visibility in GSCs is challenging because of their high complexity and numerous interdependencies (Gölgeci et al., 2020). In this context, mapping techniques can help to lift the fog (Saenz & Revilla, 2014).

Collaboration SC partners (P.8). Intensifying collaboration with SC members and developing SCRES jointly is another promising approach to strengthening symbiotic relationships (Bode et al., 2011). This measure’s foundation is risk information and resource sharing between SC partners (Gölgeci et al., 2020). When holistically deployed, SC collaboration can produce successful collective continuity planning, including node vulnerability assessments, critical component mapping, and joint risk scenario simulations (Saenz & Revilla, 2014). However, previous research demonstrates that companies often delay sharing disruption information, leading to compromised countermeasures (Scholten & Schilder, 2015).

Collaboration competition (P.9). Bridging measures can also target competitive dependencies. To build resilience and secure sustainable competitiveness, companies should consider cooperating with rivals (Gligor, et al., 2019). Coopetition measures can include pooling resources or labor and were partially observed during the COVID-19 pandemic (Beninger & Francis, 2021; Craighead et al., 2020). However, collaborations with both SC members and rivals have not yet been sufficiently explored and require additional research (Ali & Gölgeci, 2019).

Market proximity (P.10). Furthermore, companies started evaluating their current GSC network setups during the pandemic, putting a greater focus on geographical market proximity (van Hoek, 2020). Offshoring activities in recent decades have resulted in complex and fragile GSCs (López & Ishizaka, 2019), which had their vulnerabilities exposed by the COVID-19 pandemic (van Hoek, 2020). Network modifications toward regionality would comprise several benefits, including quick delivery to customers and local sourcing (van Hoek, 2020).

3. Research methodology

3.1. The Delphi method

The Delphi method structures group interactions and elicits and combines expert judgments via multiple rounds of interaction (Rowe & Wright, 2001). We employed the Delphi approach for two main reasons. First, it is well-suited for studying future scenarios with high uncertainty (Winkler et al., 2015). This enables investigation of how GSCs will adapt after the disruptions caused by the COVID-19 pandemic. Second, it offers a tested approach for research areas where expert opinion is the only reliable source of information and the availability of statistical data is limited (Rowe & Wright, 2001). This method is assumed to reach a higher accuracy than individual evaluations and mitigate multiple unwanted group occurrences, such as the bandwagon or halo effect (Hirschinger, Spickermann, Hartmann, von der Gracht, & Darkow, 2015; Linstone & Turoff, 1975). Our Delphi study included two assessment rounds and followed a rigorous process (see Fig. 1), which is described in detail in the following sections.

3.2. Phase 1: Developing the Delphi projections

To ensure reliability and validity, we followed a systematic process to develop the Delphi study’s projections (Warth, von der Gracht, & Darkow, 2013). First, we defined our RQ and selected the Delphi approach as our methodology. Thereafter, we identified relevant antecedents of SCRES for GSCs by conducting (1) an extensive review of academic and practitioner literature, (2) a creative workshop with four researchers, and (3) six expert interviews with experienced SCM practitioners. By leveraging multiple sources, we ensured methodological rigor and established a comprehensive base for further projection development.

Subsequently, 10 future projections were designed in another
workshop. To ensure reliability and validity, we applied generally accepted formulation recommendations regarding projections’ length, clarity, wording, and self-sufficiency and limited their total number to increase the response rate and mitigate sparse completion (Linstone & Turoff, 1975; Rowe & Wright, 2001; Salancik, Wenger, & Helfer, 1971). Moreover, the projections were formulated in a thought-provoking manner to encourage controversial discussions (Kopyto et al., 2020). To ensure completeness and comprehensibility (Warth et al., 2013), we then conducted six additional interviews with practitioners and academics to pre-test the formulated projections.

Projections were formulated for the year 2025. We chose a five-year time horizon for two reasons. Firstly, we selected a mid-term perspective to enable creative ideas and ensure enough temporal distance to short-term and reactive measures addressing the COVID-19 crisis. Secondly, we kept the horizon close enough to the pandemic to investigate which strategic SCM decisions will have been triggered by the COVID-19 disruption. We further validated with the practitioners in our interviews that the formulated projections could – in theory – be realized in a five-year time span.

### 3.3. Phase 2: Selecting the expert panel

Choosing appropriate experts with deep expertise and diverse perspectives ensures the quality, reliability, and accuracy of a Delphi study’s results (Paré, Cameron, Poba-Nzaou, & Templier, 2013; Rowe & Wright, 2011). Similar to previous research projects (e.g., Corte-Real, Ruiz, Oliveira, and Popovic, 2019; Gebhardt, Spieske, and Birkel (2022)), we ensured an unbiased selection process by defining concrete selection criteria (e.g., organization type, function, global work experience, academic status, risk management expertise). Overall, we identified 876 candidates that met the selection criteria by searching for suitable job titles (e.g., “Chief Procurement Officer,” “Head of Supply Chain Management”, “Professor Logistics”) on the online career network LinkedIn. Of this expert pool, 94 individuals from 10 countries and a well-mixed background (see the third column of Fig. 1) participated in both rounds. The number of participants and the response rate of 10.7% are higher than or equal to various recent Delphi studies (Hirschinger et al., 2015; Lechler et al., 2019). Furthermore, only 9.6% of experts that participated in the first round (10 of 104) dropped out of the second round.

### 3.4. Phase 3: Conducting the Delphi study

We conducted the Delphi study for this research in two consecutive rounds between September and November 2020. In the first round, participating experts assessed the 10 projections along three dimensions:

- Expected probability of occurrence (EP) on a scale of 0–100%;
- Impact on SC performance under disruption in case of occurrence (I) on a five-point Likert scale: very low (1), low (2), medium (3), high (4), very high (5); and
- Desirability of occurrence (D) on a five-point Likert scale (see above).

The second dimension, I, is related to SCRES based on Sheffi and Rice (2005) and Hosseini, Ivanov, and Dolgui (2019), who contextualize SCRES within the development of SC performance in the course of a disruptive event. Panelists were provided these explanations for each dimension to ensure a common understanding. Furthermore, panel members could comment on each assessment through written statements. In round two, experts could re-evaluate their assessments and add additional written arguments based on the panel responses in round 1. To do so, experts received feedback on the statistical group opinion (boxplots showing means and interquartile ranges per dimension) and a summary of representative qualitative statements for each projection as additional input.

As a Shapiro-Wilk-Test on normality ($p < 0.05$) indicated a non-normal distribution of the sample for each dimension, we employed a Wilcoxon-Mann-Whitney-Test to evaluate the existence of a non-response bias. Since the test did not reveal any significant differences ($p < 0.05$) between early responders (initial 10) and late responders (last 10) across the two rounds (Corte-Real et al., 2019; Röllmann, Canzaniello, von der Gracht, & Hartmann, 2018), and characteristics of respondents and non-respondents known a priori (e.g., work experience, organization types, industries, countries) did not extensively differ (Wagner & Remmerling, 2010), we rejected the existence of a non-response bias.

### 3.5. Phase 4: Analyzing the results

Results of the Delphi study were analyzed quantitatively and qualitatively. Next to calculating mean values for the assessment dimensions (EP, I, and D) of each projection after round two (Lechler et al., 2019; Warth et al., 2013), two additional indicators were derived for the EP. First, we leveraged the interquartile range (IQR) to evaluate the level of agreement with a projection. The IQR measures the statistical dispersion of expert ratings – either clustered or scattered – on the 0–100% EP scale, with small values indicating high levels of panel agreement. Aligning with other Delphi studies (e.g., Röllmann et al. (2018), Warth et al. (2013)), we set a threshold of IQR $\leq 25$ for consensus, meaning that panel consensus was reached with at least 50% of the expert ratings falling within a range of 25 percentage points on the 0–100% EP scale. Second, we calculated the convergence rate (CV) – defined as the percent difference in standard deviation for EP between both rounds – to investigate changes in assessment.

The stability of results between two rounds is an established measure to decide how many Delphi rounds to conduct (Linstone & Turoff, 2011; von der Gracht, 2012). Scheibe, Skutsch, and Schofer (1975) considered a 15% change or lower between two distributions (i.e., Delphi rounds) a stable situation. The change in mean values for the assessment dimensions (EP, I, and D) across the 10 projections between the rounds was below this threshold, and convergence rates (see Table 2) were equal to or lower than other round-based Delphi studies (Corte-Real et al., 2019; Fritschi & Spinler, 2019). Therefore, a considerable improvement in the results was not expected from further rounds. Due to this and the danger of losing further experts through fatigue, the research team stopped the process after two rounds.

To enable an objective interpretation of the experts’ judgments and a more structured contextualization of the qualitative statements, we used a fuzzy c-means (FCM) algorithm to cluster the 10 projections into three groups according to their EP, I, and D (Hirschinger et al., 2015; Röllmann et al., 2018). To analyze diverging viewpoints of our multi-stakeholder sample, we further investigated differences in judgment among subgroups within the expert panel (Warth et al., 2013). We, therefore, calculated the mean values, IQRs, and CVs for each subgroup and identified significant deviations by conducting a Wilcoxon-Mann-Whitney-Test.

For qualitative analysis, following a coding procedure based on Corbin and Strauss (2015), we classified each of the written statements. The statements were labeled as supportive (in favor of a high value), negative (in favor of a low value), balanced/neutral (providing both positive and negative arguments or more general statements), or non-applicable (the comment was incomprehensible) in the context of the projection. Two researchers conducted the coding independently, reaching an initial level of agreement of $\approx 92\%$ (Voss, Tskrikitsis, & Frohlich, 2002). Any differing assessments were discussed and resolved by the research team until consensus was reached. We, thereby, reduced investigator bias and improved inter-rater reliability. The coding exercise enabled a more systematic analysis of the panelists’ qualitative comments, which we leveraged to further interpret the quantitative expert judgments.

The analysis phase concluded with a full-day interpretation...
workshop. Along with the full research team, two additional scholars who had not assisted in any of the study’s previous phases participated. The results are presented and discussed in Section 4.

4. Results and discussion

4.1. Quantitative Delphi results

Quantitative assessment results and statistics from the coding exercise for qualitative comments were summarized after Round 2 (see Table 2). The panel estimated a high impact for six projections (I ≥ 3.5) and assessed five projections as highly desirable (D ≥ 3.5). The estimated probability of occurrence ranged from 24% for P.9 (collaboration competition) to 68% for P.6 (supplier selection). The iterative Delphi process demonstrated an overall decrease in standard deviation of 10.5% across all projections’ EP ratings. This indicates that the Delphi approach functioned as envisioned (Rowe & Wright, 2011). Consensus was achieved for three projections (IQR ≤ 25 for P.4, P.6, and P.9). On the qualitative side, experts provided 677 comments to support their quantitative assessments. On average, a panel member provided 7.2 comments, and over 76% of participants wrote at least one statement, indicating active participation in the format. The distribution of qualitative comments in positive, negative, and balanced/neutral in accordance with the quantitative assessment direction validates our approach of leveraging the panelists’ written statements to interpret the Delphi study results.

| Projection (2025)     | EP [0–100%] | IQR [0–100] | CV [%] | I [1–5] | D [1–5] | Supportive | Negative | Balanced/neutral | n/a | Sum |
|-----------------------|-------------|-------------|--------|---------|---------|------------|----------|------------------|-----|-----|
| P.1 Safety stocks     | 39%         | 30.5        | –17%   | 3.4     | 2.4     | 14         | 25       | 46               | 0   | 85 |
| P.2 Multiple sourcing | 46%         | 50.8        | –8%    | 3.9     | 3.5     | 29         | 35       | 25               | 9   | 98 |
| P.3 Backup transportation | 39%      | 30.0        | –9%    | 2.9     | 2.8     | 16         | 15       | 35               | 2   | 68 |
| P.4 Standardized components | 32%   | 25.0        | –8%    | 3.1     | 2.7     | 17         | 33       | 31               | 4   | 85 |
| P.5 Flexible network design | 53% | 38.0        | –9%    | 3.8     | 3.8     | 25         | 7        | 19               | 2   | 53 |
| P.6 Supplier selection | 68%         | 24.0        | –17%   | 3.6     | 3.9     | 43         | 4        | 14               | 3   | 64 |
| P.7 SC mapping        | 65%         | 29.5        | –8%    | 3.7     | 3.9     | 34         | 3        | 24               | 2   | 63 |
| P.8 Collaboration SC partners | 57%   | 37.5        | –8%    | 4.0     | 4.1     | 29         | 9        | 17               | 1   | 56 |
| P.9 Collaboration competition | 24% | 20.0        | –9%    | 3.0     | 2.6     | 11         | 26       | 16               | 1   | 54 |
| P.10 Market proximity | 50%         | 38.8        | –13%   | 3.5     | 3.3     | 15         | 5        | 28               | 3   | 51 |
| Total                 | 233         | 162         | 255    | 27      | 677     |            |          |                  |     |     |

Note: EP: Expected probability, I: Impact, D: Desirability, CV: Convergence (i.e., change in standard deviation), IQR: Interquartile range, IQR ≤ 25 equals panel consensus, highlighted in italics

4.2. Discussion of projection clusters

Three clusters were determined by leveraging the FCM approach (see Fig. 2).

4.2.1. Cluster 1 – Priority measures

With an average EP rating between 57% and 68% and high ratings for impact (I ≥ 3.6) and desirability (D ≥ 3.9), Cluster 1 bundles three projections that show a tendency toward realization in 2025 and will have a considerable and desirable impact.

Supplier selection (P.6). Experts consider this measure a “quick win” compared to other projections, as its implementation requires relatively little investment. Experts further note that, even if supplier risk assessments might not specifically investigate resilience in the case of disruptions such as a pandemic, the practice of individual supplier assessments for operational risks will eventually translate into better preparedness for SCDs. The projection’s high relevance aligns with many recent papers which discuss opportunities to reduce SC risks through technology-enhanced supplier selection (Birkel & Hartmann, 2022).
Panellists also highlighted several focus topics that an intensified risk assessment should entail to increase its impact. First, experts consider it crucial that companies demand their suppliers demonstrate viable risk management processes as part of their own governance. Second, a supplier’s mid- and long-term financial stability was deemed a risk assessment criterion with increasing importance in future selection processes. Overall, panel members stress that risk evaluations should go beyond Tier 1 suppliers, as risks often lie deeper within GSCs, hinting at indirect dependencies from sub-suppliers.

Despite these arguments, many experts predict that cost efficiency will continue to be the dominating criterion for supplier selection. However, they expect this dominance to decrease and argue that companies will take a more holistic perspective. Additionally, various experts noted that risk criteria are often already present in selection processes but lack a corresponding action plan. Thus, potential impact can only be realized if a clear link to operational measures is established.

Collaboration SC partners (P.8). P.8 is deemed the most impactful and desirable among the projections. According to many panel members, COVID-19 has shown that increased risk and resource sharing with SC partners can be a mutually beneficial effort for involved SC stakeholders. Moreover, as possibilities to buffer (e.g., by sourcing from different suppliers) decrease in an SCD such as COVID-19, experts consider it more promising for future risk mitigation to strengthen and intensify the existing relationships and bind partners. It will enable timelier proactive and reactive risk measures. Members of the panel also argue that continued progress in digital technologies until 2025 (e.g., blockchain solutions that enable trusted and secure information exchange) will make stronger collaboration among SC partners more likely.

Despite the high expected impact and desirability, perceived implementation barriers such as the cautious mindset toward collaboration cause indecisiveness about the projection’s actual realization by 2025. A “central condition is that all supply chain members participate and act ethically. The abuse of trust can heavily damage a supply chain,” as one panelist emphasized.

Our findings are consistent with a substantial body of literature advocating for more SC collaboration to improve SCRES (Botes, Nemmann, & Kotzé, 2017; Hosseini et al., 2019; Scholten & Schilder, 2015). SC actors have shown during the COVID-19 pandemic that overcoming collaboration inhibitors such as a lack of trust or confidentiality reservations can be mutually beneficial (Feanne, Wagner, McDougall, & Loseby, 2021). This should encourage industries to overcome the barriers to realizing the substantial SCRES potential that SC collaboration offers.

SC mapping (P.7). Most experts agreed that SC mapping efforts will fundamentally increase in the future. A deadline of 2025 is deemed a realistic time horizon, as experts consider extensive SC mapping more as a continuation of an already existing trend than a new development. The COVID-19 crisis is considered a significant accelerator of such efforts. Nevertheless, most panelists attribute the expected progress to advancements in digitalization. Furthermore, they argue that third-party providers’ increasing number and effectiveness will overcome prohibitive cost barriers to more extensive mapping efforts. Experts indicate that such extended mapping efforts cohere with intensified information sharing and collaboration with SC partners (P.8). Panelists further note that more holistic and risk-oriented supplier selection (P.6) can function as an important enabler for sophisticated SC mapping. Thus, P.6, P.7, and P.8 are strongly interconnected bridging measures.

Experts cite a lack of willingness to share information and the considerable effort to orchestrate effective mapping exercises as persistent barriers. Some panelists further suggest more targeted instead of holistic, end-to-end approaches. They note that “each additional tier increases complexity; marginal benefit could be low.” This more nuanced view on SC visibility contrasts recent studies advocating for holistic, end-to-end approaches, while neglecting this effort/benefit consideration (Ivanov & Dolgui, 2021). It remains blurry how far SC mapping efforts should be driven while ensuring sensible benefits and acceptance within organizations. Therefore, experts argue for focusing the potentially limited resources for such visibility efforts on the most critical components, suppliers, and network nodes first before targeting a more holistic, end-to-end perspective.

From an RDT perspective, all projections of Cluster 1 concern bridging strategies, concerting measures aimed at increasing the organizations’ power within dependencies.

4.2.2. Cluster 2 – Promising measures

The three projections allocated to Cluster 2 have been rated with an EP around 50%, indicating that the expert panel is indecisive. However, all projections’ impact in case of occurrence is expected to be high (I \( \geq \) 3.5). Therefore, it is essential to analyze the barriers that make the realization of these measures less likely in 2025 than the projections with similar impacts but higher EP in Cluster 1.

Flexible network design (P.5). Experts agree that higher flexibility and, therefore, lower dependency on partners is desirable and can have a high impact on SC performance during a disruption. One participant concluded that “agility has become the new norm for supply chains to survive.” Nevertheless, several panelists favor enhancing ties with existing partners and transforming arms-length into long-term, strategic partnerships. They argue that, especially during an SCD such as COVID-19, switching costs become higher, and suitable partners are increasingly hard to find. The experts’ rationale, therefore, indicates a negative relationship between P.5 (flexible network design) and P.8 (collaboration SC partners), an insight consistent with previous studies (Gölgeci et al., 2020).

Further, several panel members consider a five-year horizon challenging for building the required flexibility capabilities for such structural network changes. The panelists generally think that other projections (e.g., P.6 and P.7) will face less significant investment and, thus, lower realization barriers, which explains the relatively low EP compared to the other evaluation dimensions. This assessment resonates with Cluster 1, further indicating that bridging strategies might be prioritized to build SCRES after the COVID-19 pandemic.

Nevertheless, illustrating the relatively high dissensus, several experts argue that quick, flexible network adaption will be a core capability to manage SCDs and reduce resource dependencies in an increasingly uncertain environment. “The fast will win the race,” one panelist stated. Experts stress the increasing importance of agility and responsiveness. These can enable companies to secure scarce resources in a crisis faster. Furthermore, more rapid channel switches can put organizations on top of the competition in the aftermath of a disruption. The experts further argued that emerging platform economies and improving digital technologies for quick supplier identification and assessment will make network adaption easier in the future.

Market proximity (P.10). The panel did not conclude with a clear prediction on whether companies will reduce their geographical distance between production sites and sales markets. Experts welcomed such developments to reduce environmental risks and enable shorter lead- and reaction-times in local markets. However, panelists noted that complex resource dependencies with existing suppliers would, in many cases, prevent companies from establishing a more local network presence. Suppliers would often need to follow suit and develop local production, which might not provide a net economic benefit. Some experts also mentioned that commercial reasons would continue to outweigh risk considerations when deciding geographical setup. Like the panel’s assessment for P.5 (flexible network design), a considerable number of experts deem 2025 too short-term to realize such a structural shift. Overall, experts assessed the topic of market proximity more critically than the findings of other recent studies, such as Belhadi et al. (2021), who presented localization as one of the top three initiatives for manufacturing SCs after the pandemic.

Multiple sourcing (P.2). This projection yielded the highest IQR among the experts, indicating controversy. A comparatively low CV further reveals relatively high confidence among participants about
their estimations. Several panelists appreciate a broader sourcing strategy in the future but expect and endorse a more focused approach on select key components. They predict that additional sources will specifically be built up for suppliers that showed lower performance and less reliability than others throughout the COVID-19 crisis.

Critics insist that cost and coordination efforts for a holistic multiple sourcing strategy will remain prohibitively high in 2025. They believe that emergency reactions to mitigate the risks of a single sourcing strategy will, typically, be more efficient than a broad, proactive multi-source approach. However, literary support for this view is currently lacking. Although Fearne et al. (2021) showed that parallel SCs with new suppliers were successfully established during the COVID-19 crisis (effectiveness), they did not investigate the required investments (efficiency). How the costs for reactively onboarding additional suppliers during an SCD compare to proactive investments into multiple sourcing requires further research. Experts further note that many geographies are equally affected in an SCD such as a pandemic and multiple sourcing will only have a limited effect. From an RDT perspective, dependence might shift from one supplier to another but not improve overall. Besides that, strong dependence on suppliers with unique products and value propositions might exclude a multi-sourcing option.

Overall, the panelists perceive high impact potential for the projections of Cluster 2. Nevertheless, common barriers, such as prohibitively high switching/investment costs and strong dependencies on existing suppliers with unique offerings, make the realization of these SCRES measures by 2025 uncertain. Addressing these common barriers in a targeted manner can unlock another set of promising SCRES levers next to those discussed in Cluster 1.

4.2.3. Cluster 3 – Limited measures

The third cluster contains four projections. The low EP rates (EP ≤ 39%) indicate that these projections will most likely not be realized until 2025; although, if they occur, they are predicted to have a considerable effect on SCRES (I ≥ 2.9). Furthermore, all four projections show a low average desirability rating (D < 2.9), indicating that experts perceive them as threats (Keller & von der Gracht, 2014).

Safety stocks (P.1). Scoring the lowest desirability among all projections, panel members revealed that systematically increased safety stocks for all materials and components will not be a preferred measure in 2025. They acknowledge that the bullwhip effect induced by COVID-19 has led to higher stock levels in the SC. However, they consider a safety stock increase a temporary and targeted countermeasure for once disruptions occur or a safeguarding mechanism restricted to critical components. For improving the availability of materials and components, panelists pointed to alternative measures such as P.2 (multiple sourcing) and P.10 (market proximity), which many prefer over increased safety stocks. Besides that, experts argue that digital technologies such as advanced analytics, machine learning, and digital twins will vastly improve supply–demand balancing visibility and, thereby, allow for inventory optimization in the long run. Consequently, systematically increasing safety stocks will be a measure employed by organizations that failed to adopt such advanced solutions. Due to the high working capital involved and the fact that the measure does, as one panelist noted, “only cover the real problems deeper in the supply chain,” such companies will ultimately lose competitiveness. The anticipatios continuous use of safety stocks as a temporary countermeasure – sometimes without alternatives and highly cost-intensive – explains these low desirability ratings while this projection simultaneously scores moderate on expected probability.

Backup transportation (P.3). Compared to acquiring backup suppliers for materials and components, panelists assessed backup transportation capacities lower across all dimensions. One of the most prominent arguments is that during the COVID-19 pandemic and other SCDs, transportation capacities, compared to shortages in goods supply, tend not to be severely bottlenecked. The experts further claimed that holding idle capacities (both internally and externally) will be prohibitively expensive. They consider it more likely that firms will bundle capacities with SC partners to reduce costs and improve environmental performance. Moreover, panel members stressed the importance of forming more strategic partnerships with existing LSPs to prioritize capacities before and during an SCD and receive preferential treatment in crisis. Another argument made is that the platformization of the transportation market will increase transparency and ease access to capacities. This trend might lead to a more efficient allocation and make it easier for companies to search for alternative LSPs. From an RDT perspective, such a development will decrease companies’ average dependency on their LSPs and, thereby, act as a buffering mechanism.

Standardized components (P.4). Panelists agreed on an overall non-favorable assessment of less customized components for better procurement risk mitigation. There are two main reasons for this view. First, experts argue that companies’ current dependency on suppliers with unique components for specific products will make higher levels of standardization difficult. Second, the increasing trend towards consumer individualism will prohibit most organizations from abandoning their customization strategy. According to the Delphi participants, customization has become the new normal in many industries and will remain essential for competitive advantage. As one panelist puts it, “Customer happiness beats procurement risk reduction.”

Few experts indicated reasons for more standardization. Most prominently, they argued that such a measure would (compared to most other strategies) increase the resilience of an SC while creating economic benefit. The enabled supply network flexibilization would create redundancies without increasing inventory levels, and in theory, dependencies on specialized suppliers could be reduced. Moreover, some experts see a higher degree of standardization as a way to ease the implementation of P.2 (multiple sourcing).

Collaboration competition (P.9). Across all projections, panelists assessed increased collaboration with competitors as the most unlikely to be implemented by 2025. They also reached the strongest consensus for this projection. The COVID-19 pandemic might have shown that cooperation can have its benefits. Additionally, in some industries, a “we are all in this together”-mentality has emerged, as one expert commented. Furthermore, digitally-enabled platforms that ensure trust and confidentiality might enable more information exchange.

However, in the grander scheme of things, panelists predict that companies will still avoid collaborating with their competition. According to the experts’ assessment, information protection will remain the key barrier and tightening antitrust regulations represent an additional obstacle. Referring to P.8 (collaboration SC partners), panelists argued that companies that are already hesitant to share information with their SC partners will avoid doing so with their competition even more. Another fact mentioned by the experts is that they consider their companies’ robust risk management capabilities as a competitive advantage and a means to emerge from a crisis ahead of their competition. Stronger cooperation would undermine this competitive edge. Interestingly, some experts find it more likely that organizations across different, non-competing SCs will pool resources (e.g., for transportation capacities or the procurement of common materials) in the future. Hence, rather than exploring collaboration with competing SC actors, as suggested in recent literature (Ali & Gölgeç, 2019; Beniger & Francis, 2021), experts see more SCRES potential in examining partnerships beyond industry boundaries.

From an RDT perspective, three of four projections in Cluster 3 can be allocated to buffering strategies. With the observations in clusters 1 and 2, a prioritization to build on existing dependencies rather than buffering against them can be expected in coming years. Nevertheless, considering the partially high impact and desirability ratings for buffering projections, we must stress that some buffering mechanisms can still be considered effective in an SCRES context. However, they might not be realized until 2025.
4.3. Discussion of stakeholder group particularities

During the COVID-19 pandemic, companies faced various challenges (Donthu & Gustafsson, 2020). For instance, some sectors experienced increased demand and severe supply shortages, while others were affected by demand declines (Gölgeci et al., 2020; Nandi et al., 2020). These differing market conditions also applied to our diverse Delphi panel as publicly available information (e.g., news and company reports) and data provided by the participants revealed. Of the 71 industry participants, 20 worked for companies with stable/increasing demand (mainly healthcare and consumer goods firms), while 51 experts experienced downturns (mainly automotive, machinery, and logistics firms).

To account for these peculiarities, we analyzed the projection assessments according to the experts’ backgrounds: industry (demand stable/increase), industry (demand decrease), and academia. This more granular analysis based on Wilcoxon-Mann-Whitney-Tests enabled more profound insights and provided empirical evidence for one of RDT’s central propositions: companies differently constrained by exchange partners may show distinct reactions (Pfeffer, 1989).

First, we tested the three stakeholder groups’ average EP, I, and D ratings across projections. While the academic group did not reveal peculiarities, both industry groups’ EP and D assessments differed significantly from the total panel (p < 0.05). The statistical tests hint that the projections’ impact was assessed independently from the companies’ challenges during the COVID-19 pandemic. Both industry expert groups expect similar SCRES benefits when implementing the proposed measures. However, the projections’ probability and desirability assessments were significantly higher (lower) among the stable/increasing (decreasing) demand group. This indicates that the ratings depend on the externalities experienced by the companies, which is a clear indication of different reactions to individual external resource challenges.

With most projections focusing on maintaining the product flow and sustaining SC performance, their future implementation is particularly attractive for companies with stable or rising demand. In contrast, the comments from the expert group experiencing demand downturns revealed that they anticipate more pressing priorities than restoring the product flow, including coordinated GSC shutdowns, manufacturing flexibility, and cash management. This finding questions several SCRES definitions (e.g., Christopher and Peck (2004), Hohenstein et al. (2015)), which solely focus on quickly restoring operations but miss emergency measures to ensure SCs’ short-term survival.

Second, we applied the same statistical test on a more granular, individual projection level to identify differences between the industry expert groups and the overall panel assessments (see Table 3). Four projections’ EPs, including three buffering measures, were rated significantly higher (p < 0.05) by the stable/increasing demand group. This accounts for the firms’ inability to fulfill demand in times of COVID-19 supply shortages and makes future initiatives to increase redundancy in selected GSCs likely. Simultaneously, this finding unveils weaknesses in current redundancy literature, which does not consider company peculiarities such as previous SCD experiences or industry characteristics when discussing redundancy measures’ future role (e.g., Ivanov (2021)). With the comparatively high probability for P.7 (SC mapping), the stable/increasing demand group addresses visibility issues impeding customer order fulfillment during the pandemic. Furthermore, the Wilcoxon-Mann-Whitney-Tests unveiled significantly lower (p < 0.05) values for two D ratings, one EP rating, and one I rating of the decreasing demand industry expert group. Considering the industries in this group...
and their efficiency-driven history, the desire for additional safety stocks is unsurprisingly low. Moreover, this industry expert group sees a significantly lower probability for more local SCs, justifying this assessment with high investment costs. Finally, they rated the desirability and impact dimensions of P.8 (Collaboration SC partners) more pessimistically than the overall panel. With SCRES research holistically promoting SC collaboration and its numerous advantages (e.g., Scholten and Schilder, 2015), this finding underlines that this lever still requires research (Ali & Gölgeci, 2019), for instance, regarding industry or disruption peculiarities.

Third, we compared the individual projection assessments from academic participants to the total panel. Overall, academia showed more consensus than the overall panel, with six projections reaching IQR ≤ 25. This reveals scholars’ generally lower level of specialization and their attitude of analyzing trends from several perspectives. Apart from projection P.2 (multiple sourcing), industry and academia assessments did not show significant deviations. This implies a strong alignment between both stakeholder groups regarding GSCs’ future development. Concerning multiple sourcing’s expected probability, scholars must perform more research to better understand the measure’s attractiveness for increasing SCRES.

### 4.4. Considerations for supply chain disruption literature

Relating the resulting prioritization of long-term measures to earlier SCRES studies reveals considerable differences from near-term response strategies and other large-scale disruptions. For instance, compared to the adjustments suggested by this study for the aftermath of the COVID-19 crisis, SC stakeholders focus more prominently on buffering measures in immediate response to disruptions like the financial crisis (Blome & Schoenherr, 2011; Jüttner & Maklan, 2011) and the Tohoku earthquake (Matsuo, 2015). Following a dominating principle of hedging against (potentially) failing suppliers and corresponding dependencies, companies increased redundancies in stocks, suppliers, and transportation capacities (Blome & Schoenherr, 2011; Jüttner & Maklan, 2011) and widely considered product standardization (Matsuo, 2015). Jüttner and Maklan (2011) and Blome and Schoenherr (2011) derived these insights primarily from companies facing demand downturns. Conversely, our stakeholder analysis (see Section 4.3) revealed an even greater future focus on bridging for such organizations, making the discrepancy with earlier SCRES studies more striking. While bridging approaches, such as increased SC visibility and more intensive collaboration, were widely applied in earlier crises (Jüttner & Maklan, 2011; Matsuo, 2015), they did not carry the same weight as in the presented Delphi study. Jüttner and Maklan (2011) even argued that hesitancy to collaborate increases in risk scenarios. This contrasts our quantitative and qualitative findings, which suggest that the disruption due to COVID-19 will trigger more intense collaboration and coordination to make SC networks more resilient.

We present two possible reasons for these considerable differences. First, the discussed studies on earlier disruptions primarily investigate reactive responses. While Jüttner and Maklan (2011) and Matsuo (2015) argue that the identified measures are suitable to increase SCRES in the future, evidence is missing. Following this logic and relying on our future-oriented empirical evidence on potential SCRES measures following the COVID-19 pandemic, we propose that bridging measures are more suitable than buffering measures to increase SCRES following a large-scale disruption. Second, the apparent differences in the crisis responses could be explained by the unique characteristics of the COVID-19 crisis. While other large-scale disruptions are usually characterized by a comparatively clear origination point and propagation path and a relatively constrained impact scope, the COVID-19 pandemic affected an unprecedentedly large spread of SC tiers and impacted many geographies and SC steps simultaneously (Craighead et al., 2020; Ivanov, 2021). As potential buffering sources (e.g., alternative suppliers or LSPs) have been similarly affected by the wide disruption scope, SC stakeholders focus on presenting SC links and improving their positioning within existing dependencies. Hence, we deduce that compared to other large-scale disruptions, bridging measures are more suitable to increase SCRES in the aftermath of a pandemic.

### 5. Conclusion

With the COVID-19 pandemic disrupting the vulnerable GSC environment in 2020, SCRES is currently a primary interest in research and industry. However, there is high uncertainty regarding the most promising measures for increasing SCRES in a post-COVID-19 world (Queiroz et al., 2020), leading to calls for foresight research in this area (e.g., van Hoek, 2020; Verma & Gustafsson, 2020). Based on RDT, previous SCM literature, a series of workshops, and interviews with industry experts, we developed 10 future projections for SC network measures companies will potentially establish by 2025 to increase SCRES in GSCs. Overall, 94 international SCM experts assessed and discussed the projections’ probabilities, anticipated performance under disruption impact, and desirability based on a Delphi study approach. Through qualitative and quantitative analyses, including an PCM algorithm, we bring transparency to the panelists’ evaluations and illuminate GSCs’ future setups.

#### 5.1. Theoretical implications

Our study offers distinct advances to SCRES literature. First, the analyses imply that companies will primarily engage in bridging activities to protect their GSCs against SCDs in 2025. This includes expanding collaboration with current SC partners, increasing risk criteria’s importance in supplier and LSP assessments, and enforcing SC mapping activities. In contrast, buffering-related measures were either assessed as less desirable or too sophisticated to be implemented by 2025, largely due to the GSCs’ complexity and interdependencies, which cannot be easily revolved within a few years. Relating the insights to earlier SCRES literature suggests that bridging strategies have a higher capacity than buffering strategies for improving resilience as a long-term crisis response. Moreover, bridging seems to be more effective in response to a pandemic than to other large-scale disruptions due to its unique characteristics. Second, while our paper’s insights align with some indications from previous research, the results imply that several measures advocated for in recent literature face substantial barriers that will inhibit their implementation. For instance, SCM experts attribute only a limited marginal return to holistic, end-to-end SC visibility; do not foresee a definite trend toward market proximity after the pandemic; retain high dissent regarding the cost-benefit of multiple sourcing; and reject coopetition initiatives. Third, our qualitative analysis reveals critical interdependencies between various investigated SCRES approaches. While there are instances of mutually reinforcing measures (e.g., P.6 and P.7), the analyses also suggest negative relationships (e.g., P.5 and P.8). Fourth, this study substantiates central dynamics of RDT for SCRES research in a pandemic context. In line with the theory’s principal propositions (Bode et al., 2011; Pfeffer & Salancik, 1978), the dependency increases caused by a pandemic disruption are considerable and trigger SC organizations to implement substantial long-term measures to decrease dependencies or strengthen actors’ positioning within those dependencies. Moreover, our stakeholder analysis of industries with stable/increasing demand and demand decrease confirms a central RDT proposition for the SCRES context: different constraints from exchange partners cause companies to adopt distinct reactions (Pfeffer, 1989).

#### 5.2. Managerial implications

Our research also has important implications for practice. First, our study results confirm that GSCs will experience important adaptations following the COVID-19 pandemic. Practitioners must recognize the trends for further implementing SCRES measures to stay competitive in
future SCD scenarios. Considering the ever-existing resource constraints against building resilience (Zsidisin & Wagner, 2010), managers can leverage the study results to evaluate their measure prioritization for future adaptation. Our dedicated stakeholder analysis will permit such an assessment and prioritization exercise on a more granular level specific to the individual practitioner’s sector. Second, our qualitative analysis outlines specific implementation barriers organizations must overcome to increase SCRES in the future. In this context, several SCRES-improving strategies face similar challenges, such as high investment costs, strong dependence on existing exchange partners, and a lack of willingness to collaborate. Practitioners, therefore, should plan their long-term crisis responses holistically by addressing common barriers together. Third, the indicated effectiveness differences between bridging and buffering measures in the context of different large-scale disruptions, and when comparing near-term and long-term crisis responses, can prompt managers to re-evaluate their long-term SCRES strategy. Knowledge derived from the immediate management of earlier disruptions, such as the financial crisis, might not be applicable for increasing SCRES in the aftermath of COVID-19.

5.3. Policy implications

The COVID-19 crisis and a general rise in the frequency and severity of SCDs in recent decades (Lechler et al. 2019) have triggered calls for more substantial policy interventions to create the right regulatory environment for increasing SCRES (Queiroz et al., 2020; Verma & Gustafsson, 2020). The presented Delphi study offers implications for how such efforts could be designed. First, our results provide a prioritized list of future measures, empirically derived from industry and academia experts, that can support the formulation of targeted policy interventions for post-COVID-19 recovery. Specifically for strategies in the “promising measures” cluster (see Section 4.2.2), policy action can play an essential role. These approaches demonstrate similar SCRES potential to the “priority measures” (cluster 1, see Section 4.2.1) but are vastly subject to prohibitive implementation costs. Targeted regulatory incentives, such as tax breaks for localization or simplified requirements for onboarding additional suppliers, could particularly address these barriers. Second, it is essential to differentiate regulatory interventions by industry, as our stakeholder analysis shows. Different challenges of a pandemic, especially regarding demand development, have different effects on the prioritization of SCRES measures.

5.4. Limitations and future research

The study’s limitations offer opportunities for future research. First, our study empirically confirms many projections’ attractiveness for increasing SCRES following the COVID-19 pandemic. However, it lacks insights on the measures’ implementation in a complex GSC setting. Therefore, we call for further research to empirically investigate realization approaches (e.g., through case study analyses). Second, our research project focused on measures applicable to increasing SCRES in a mid-term time horizon. This led to the finding that impactful buffering approaches might require more time to be realized. Research on the necessary time horizon and implementation barriers can enable a quicker realization of these promising measures. Third, the study’s qualitative analysis revealed interesting interdependencies between various buffering and bridging measures, though it did not examine them quantitatively. Future studies can leverage methods such as factors analyses or DEMATEL approaches to investigate this direction. Fourth, we consciously limited the number of projections in our Delphi study to increase participation and reduce dropout rates. However, other promising buffering and bridging approaches exist (e.g., vertical SC integration and cross-sector collaboration) which should also be investigated in the future.

CRediT authorship contribution statement

Maximilian Gebhardt: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Alexander Spieske: Writing – review & editing, Writing – original draft, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Matthias Kopyto: Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Hendrik Birkel: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Job titles of contributing experts.

| ID | Job title | ID | Job title |
|----|-----------|----|-----------|
| 1  | Head of Procurement | 2 | Global Head of SC |
| 3  | Proc. Strategy & SCM | 5 | CPO |
| 7  | Operations Director | 8 | Head of Procurement |
| 9  | Logistics Manager | 10 | SCM Director |
| 11 | Research Ass. SCM | 12 | VP SCM |
| 13 | Procurement Specialist | 14 | Manager SC Planning |
| 15 | SCM Research Lead | 16 | Procurement Manager |
| 17 | Manager SCM Risk | 18 | Purchasing Manager |
| 19 | VP Procurement | 20 | Research Ass. SCM |
| 21 | Head of SC Planning | 22 | Ass. Prof. SCM |
| 23 | Procurement Manager | 24 | Consultant SCM |
| 25 | SCM Analyst | 26 | SCM Director |
| 27 | Head of Materials | 28 | Head of Logistics |
| 29 | Global Head of SCM | 30 | Manager Procurement |
| 31 | SCM Excellence | 32 | Manager Supplier Dev. |
| 33 | GM SC & Procurement | 43 | SCM Manager |
| 34 | VP Global SCM | 44 | SCM Strategy |
| 35 | Procurement Manager | 45 | Manager Log. & SCM |
| 36 | Prof. Logistics & SCM | 46 | Head of SCM |
| 37 | Research Ass. Logistics | 47 | Global Head of SCM |
| 38 | Prof. Logistics | 48 | Ass. SCM |
| 39 | Consultant SCM | 49 | SCM Risk Manager |
| 50 | Purchasing Manager | 51 | Manager Procurement |
| 52 | Research Ass. SCM | 53 | Head of SCM |
| 54 | SCM Analyst | 55 | SCM Strategy |
| 56 | SCM Director | 57 | SCM Strategy |
| 58 | Ass. Prof. SCM | 59 | SCM Strategy |
| 60 | SCM Strategy | 61 | SCM Strategy |
| 62 | SCM Strategy | 63 | SCM Strategy |
| 64 | Head of SC Excellence | 65 | SCM Strategy |
| 66 | SCM Strategy | 67 | SCM Strategy |
| 68 | SCM Strategy | 69 | SCM Strategy |
| 70 | SCM Strategy | 71 | SCM Strategy |
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