DASHBOARD USE CASE FOR SUPPLY CHAIN RESILIENCE MANAGEMENT AND FUTURE RESEARCH DIRECTION

Angela Sekulovska, Frank Morelli, and Frank Schätter
Business School, Pforzheim University, 75175 Pforzheim, Germany, sekulovs@hs-pforzheim.de, frank.morelli@hs-pforzheim.de, frank.schaetter@hs-pforzheim.de

KEYWORDS

Supply Chain Resilience Management, Process Mining, Supply Chain Disruptions, SCOR Model, Key Resilience Areas, Future Research Directions

ABSTRACT

This paper builds upon the foundation of Key Resilience Areas to present a practical use case and to conceptualize a supply chain resilience dashboard. Expert evaluation from process mining and supply chain operations raised concerns regarding the usability and feasibility of such a dashboard. Additionally, future research directions, encompassing platform-based dashboards, resilience-sustainability fusion, and stress testing, are also explored.

DISSEMINATION/ HISTORY OF THE KRAs

The paper by Schätter et al (2022) “Supply Chain Resilience Management Using Process Mining” aimed at identifying relevant data needed for strategic monitoring of the resilience status of the supply chain (SC). The result is eight distinguished Key Resilience Areas (KRAs), which help to have an initial understanding of the state of the SC and are easier to apply than more complicated analytical methods. Below you can find a short description for each of the KRAs (Schätter et al. 2022):

- *KRA1 - Geographic Distribution*: Provides visibility into the locations and distribution of entities, for example assessing the risk of disruptions due to supplier concentration in one specific region.
- *KRA2 - Sourcing Strategy*: Evaluates the impact of supply disruptions by analyzing material sourcing strategies, with a focus on single-sourcing vs multi-sourcing approaches.
- *KRA3 - Warehouse Materials*: Enhances resilience through buffer stocks of critical materials (e.g. due to their value) in warehouses, ensuring SC continuity.
- *KRA4 - Average Storage Time*: Measures the average time materials are stored in warehouses to identify critical materials and assess buffer effectiveness.
- *KRA5 - Transport Delays*: Identifies vulnerable transport relations by analyzing delivery durations and assessing delay-prone materials.
- *KRA6 - Consolidation of Deliveries*: Promotes cost-effective and resilient SC practices by consolidating (combining) material deliveries.
- *KRA7 - Transport Distance*: Analyzes transport distances and regional deliveries to reduce the risk of large-scale disruptions.
- *KRA8 - Intra-Logistics Processes*: Offers transparency into internal SC processes, assessing dependencies on critical materials and revealing potential weaknesses.

KRAs can serve as a strategic evaluation of the existing SC structure, providing a crucial initial insight into its susceptibility. This assessment is a key starting point for comprehending the overall resilience of SCs (Inbound Supply Chain Resilience Analysis Based on Key Resilience Areas, see Schätter et al. 2023). The authors argue that KRAs can be analysed with transactional and master data, which are readily available within the data warehouse of companies. Therefore, the KRAs can be applied on to process links that are in the immediate control of the company. They propose that the initial step when relying on this concept is to select an area (inbound or outbound logistics) or a process link and understand which KRAs apply to it. Consequently, each selected KRA should be evaluated independently, and once vulnerabilities are revealed, the subsequent step would be combining the at least two KRAs together to have a clear distinction between the effects and causes. The overall analysis involving the KRAs can be understood as a filter for vulnerable deliveries and their associated suppliers and materials (Schätter et al, 2023).

STATE OF THE ART FINDINGS

Literature Review

Because of the growing frequency and size of SC disruptions, companies are facing significant challenges due to continuous changes in consumer behaviors, markets, and SCs, leading to an imbalance in their operations. Consequently, the concept of Supply Chain Resilience Management (SCRM) has garnered considerable attention in recent times. Global SC have been made public by events like the COVID-19 pandemic, emphasizing the urgent need for enterprises to proactively manage SC risks (Bret et al, 2021). These destabilizing effects have highlighted how crucial it is to establish robust supply networks that can take shocks, quickly adapt to changing conditions, and recover effectively. The speed and magnitude of these changes necessitate swift responses from leaders who must embrace agile methodologies and accelerate the transformation of their chains. Enhancing the resilience of processes involves applying new insights and abilities while adopting alternative measurements for process-focused performance (Schätter et al, 2022). Additionally, robust data and analytics capabilities are crucial for comprehending complications, anticipating potential disruptions, and rapidly formulating effective strategies in response. Resilience is both defined as a capacity that is developed in response to a shock or disruption and as being more pro-active in helping the company get ready for a disruption (Melnyk et al, 2014). The capability to learn from past disruptions to be able to predict and overcome future disruptions, by reducing the level of risk and being aware of the SC's vulnerabilities (Aman & Seuring, 2021). Therefore, being aware of SC vulnerabilities and possible risks can increase the effectiveness of the response to future disruption, mitigate its damage and restore the state of the SC.

On the other hand, over the past two decades process mining (PM) has emerged as a particularly promising contender and as a relatively new field of study that falls somewhere between process modeling and analysis, computational intelligence, and data mining (van der Aalst et al., 2012). PM aims to identify, monitor, and improve business processes by extracting data from the event logs that are easily accessible in today's information systems. Event data has drastically increased in the past decades, and subsequently many PM techniques have also advanced significantly. Thus, PM has become highly important in management trends that are concerned with process improvement (van der Aalst, 2012; van der Aalst, 2016).

The foundation of PM is an event log, which contains events that relate to a specific process instance aka *a case* and refers to a clearly defined step in a process aka *an activity*. In other words, a case is a specific identifier, like an item from a purchase order, an invoice, or an order number, while an activity is a description of what took place, such as when a purchase order was created or when goods were received. It is necessary to chronologically order and consider all the events that were connected to one case as "one run" of a process. Nevertheless, event logs can hold further information related to the events, such as *a timestamp* that indicates when an event has occurred, details about the resource i.e., device or person that is initiating or performing the activity, or *data elements* recorded along with the event (van der Aalst, 2012).

The information gathered from event logs is usually presented on dashboards, so that the person responsible can quickly identify issues and take corrective actions to help the organization perform better (Rasmussen et al., 2009, p.3). Pauwels et al. (2009) define a dashboard as a reasonably compact group of linked key performance indicators and fundamental performance drivers that represents both immediate and long-term objectives and can be viewed by all members of the organization. A dashboard is a visual representation of the most crucial data required to accomplish one or more goals, collected, and organized on a single screen for easy monitoring (Few, 2006, p.26). Managers frequently use dashboards to monitor a company's performance, and since the COVID-19 pandemic, their use has increased (Reibstein et al., 2023). Dashboards can be categorized based on their level of detail and timeframe into strategic, tactical, and operational tiers (Few, 2006, p.33).

For the purpose of creating resilient SCs, Ivanov et al. (2019) recommended making extensive use of digital technologies, such as data analytics, to create a decision support system for SC risk analytics. Orenstein (2023) has identified several information dimensions to include SC dashboards to get a meaningful understanding of the operations of the SC, namely structural, geographic, and financial layer. Additionally, the author suggests that further layers can be applied depending on the goals of the analyst using the dashboard.

Designing a Use Case for SCR Based on PM

We envisioned and designed an industry-neutral SCR dashboard for in-house consultants at the mid-level of the hierarchical management. The design and development of such conceptual dashboard required relying on framework that was globally recognized; therefore, the newest version of the Supply Chain Operations Reference (SCOR) 14.0 model played a pivotal role in our research. This recent version of the model has redefined performance attributes in three categories: Resilience, Sustainability, and Economic performance with our focus being on the resilience-only performance categories (ASCM, 2022). The model provides three sub-attributes under "Resilience", these are Reliability (RL), Responsiveness (RS), and Agility (AG). Below you can find the description of each resilience attribute:

Reliability (RL): Deals with the ability to execute tasks in accordance with established expectations. It concerns ensuring the predictability of process outcomes. Key metrics associated with Reliability encompass the timely delivery of products or services, meeting the prescribed quantity, and providing accurate documentation.

Responsiveness (RS): Focuses on how quickly tasks related to customer orders are completed. It looks at how fast businesses can respond and satisfy customer needs.

Agility (AG): Describes the ability to respond to unplanned external influences, disruptions and/or events.

The design of the conceptual dashboard prominently featured tabs dedicated to each SCOR resilience performance category, seamlessly integrating metrics from each of these crucial aspects. Nonetheless, it is crucial to recognize that these discrete sub-dimensions of resilience play a pivotal role in conceptualizing and comprehending SCR within varying contexts and across diverse types of companies.

Notably, Accenture's SCR application significantly contributed to the conceptual development of the SCR mockup dashboard. This application was developed in collaboration with Celonis, a leading process mining vendor, and aims to assist companies in enhancing their SCR by leveraging real-time data on disruptive events, conducting SC operational risk, assessment, and providing intelligent solutions to mitigate disruptions. Since we were unable to cover a SC from end-to-end, the focus of Accenture's SCR application on the inbound logistics side, narrowed the scope of the research and eased the selection of an appropriate process on which to center the design around. Purchase-to-Pay (P2P) was chosen as the primary process around which the conceptual dashboard was designed. Then from the SCOR model the S2 Direct Procure process was selected as a surrogate for the P2P process which allowed for an adequate selection and representation of performance metrics that fell under the resilience category. In addition, while designing the layout for the dashboard the following KRAs were considered KRA1: Geographic Distribution of Entities, KRA2: Sourcing Strategy of Materials, and KRA5: Transport Delay. The reason behind the choice of these KRAs is to showcase how different elements of dashboard could help in practically using the KRA framework. Later, after developing a use case for the envisioned dashboard, an evaluation from experts was conducted to uncover potential improvements and ideas regarding our research. (Sekulovska et al., 2023)

SCR Use Case and Designed Dashboard

The Use Case is essentially a demonstration walkthrough of the intended dashboard functionality, offering a comprehensive understanding of how the dashboard achieves its core goals. To enhance reader comprehension, figures (Figures 1 to 3) have been included. These figures offer visual cues that correspond to the steps a potential in-house consultant would take while utilizing the dashboard.

As a hypothetical scenario, the in-house consultant initiates access to the dashboard within the Celonis EMS. Upon entry, their initial view is directed to the "Resilience Overview P2P" tab. Subsequently, they are provided the option to investigate a specific aspect, such as "Reliability," which encompasses two distinct sections. Within the first section, a vital metric—termed "Perfect Supplier Order"—is showcased. In this instance, the metric registers at 77.37%. This metric serves as a comprehensive indicator of collective supplier performance in fulfilling their orders. Notably, the maximum attainable value is 100%, signifying optimal efficiency in meeting the company's order delivery requirements. In the present case, the metric reveals certain suppliers demonstrating inefficiency in fulfilling orders. Transitioning to the second focal point, as depicted in Figure 1, the in-house consultant encounters three pivotal information metrics. These metrics reveal that a quarter (25%) of the suppliers are in a precarious state of risk. Of this subset, 209 suppliers are categorized as "endangered," while 92 are flagged as "high risk." The identification of such risk-laden suppliers raises a preliminary flag, indicating potential concerns warranting a more profound exploration. Consequently, the in-house consultant possesses the option to delve deeper by engaging the "Deep Dive" button—an action depicted as numeral 3 in Figure 1. (Sekulovska et al., 2023)

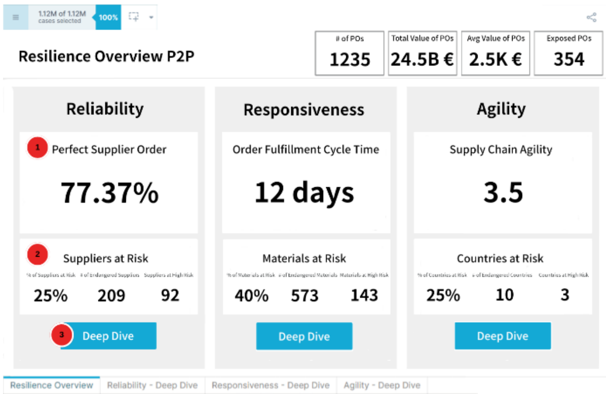

Figure 1: Resilience Overview P2P Demonstration

If the consultant opts to conduct a more in-depth exploration of the emerging issues, they can initiate this process by clicking the "Deep Dive" button, which leads them to the dedicated "Reliability Deep Dive" tab (Figure 2). Here, the in-house consultant gains the opportunity to observe the comprehensive list of suppliers, irrespective of their risk classification—indicated as point number 1 in Figure 2. To proceed, the consultant might choose to refine their focus by utilizing the filtering option to isolate suppliers categorized as "high risk." This action, illustrated as point number 2 in Figure 2, results in the display exclusively of those suppliers that have been identified as being exposed to elevated risk levels.

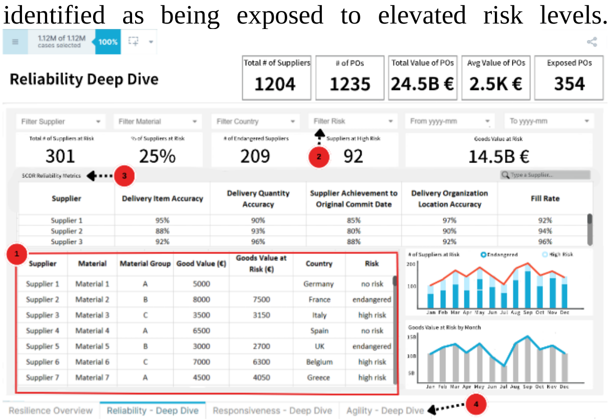

Figure 2: Reliability Deep Dive Demonstration

Subsequently, the in-house consultant can elect to delve deeper into the performance of these specific high-risk suppliers based on the SCOR Reliability metrics. This entails leveraging the search functionality to scrutinize the historical performance of these suppliers. Should the consultant's concerns extend to comprehending the external factors influencing the heightened risk for these suppliers, they can navigate to the "Agility Deep Dive" section. This option is accessible via the tab menu situated at the lower part of the page, as denoted by point number 4 in Figure 2. (Sekulovska et al., 2023).

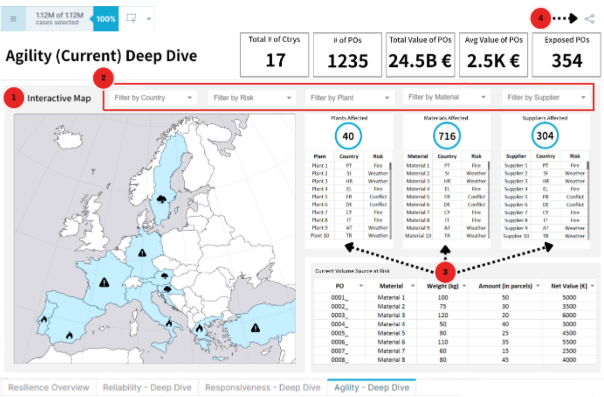

Figure 3: Agility Deep Dive Demonstration

Upon accessing the "Agility Deep Dive" tab, the in-house consultant is presented with an interactive map showcasing countries influenced by risks. This interactive map encompasses multiple functionalities, although in this mockup representation, it primarily serves as a visual depiction of countries impacted by risks—indicated as the primary function (point number 1 in Figure 3). To refine the analysis's scope, the consultant possesses the capability to implement various filters. These filters hold the potential to induce dynamic changes both within the interactive map and across the three associated tables (point number 3 in Figure 3). These tables correspond to plants, materials, and suppliers, and their content adapts according to the selected filters. Upon achieving a satisfactory level of insight, should the in-house consultant consolidate their findings and share them with organizational executives, an option for data extraction is available. This functionality is readily accessible through a button situated in the top-right corner of the interface, which can be found also in all the tabs (point number 4 in Figure 3). (Sekulovska et al., 2023)

Moreover, the design of the mockup dashboard facilitates an exploration of the KRAs to evaluate SCR. Specifically, the previously mentioned KRAs—KRA1: Geographic Distribution of Entities, KRA2: Sourcing Strategy of Materials, and KRA5: Transport Delay—can be assessed using various components within the mockup dashboard. For instance, KRA1 can be hypothetically evaluated through interactive map functionality or by employing filtering options within the "Reliability Deep Dive" tab (Figure 1). These features would provide insights into the number of suppliers originating from specific countries. Likewise, the assessment of KRA2 can be accomplished by using filters within the "Responsiveness Deep Dive" tab (Figure 4), shedding light on sourcing strategies for materials. Addressing KRA5, the mockup dashboard incorporates dedicated metrics to offer an overview of transport delay metrics, encompassing the time taken to procure materials and any associated delays (Figure 4).

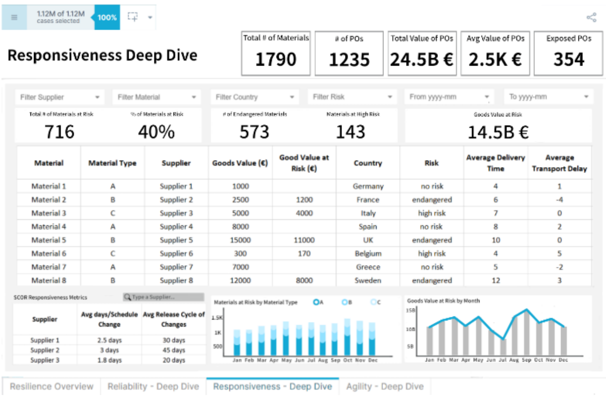

Figure 4: Responsiveness Deep Dive

Expert Evaluation

The evaluation of the mockup dashboard was conducted with two experts from the field of SCM and PM. The evaluation process commenced by introducing the use case for the SCR mockup dashboard to each expert separately. A presentation outlined the dashboard's functionalities, the use case it addresses, and its intended impact on SCR. Following the presentation, in-depth discussions ensued, delving into various aspects of the dashboard's design. The themes of the discussions held with the experts resulted in possible improvements of the concept as well as future directions. Namely, the experts raised concern about the lack of color-coding as well as time-related graphs that would potentially enhance the user experience and readers information comprehension. Other ideas were raised concerning the development of a Supply Chain Centric Data Model and the efforts and challenges that such a model would pose. (Sekulovska et al., 2023)

DERIVATION OF RESEARCH QUESTIONS

Since this is a work-in-progress paper and thus we want to highlight the future research directions we decided to do it in a structured manner. Building upon our previous work, we aim to explore additional research directions closely connected to our current investigations. Given that SCR remains a highly discussed topic in the literature, it provides an opportunity to expand our research in several directions. To achieve this, we conducted an unsystematic literature review to gain insights and information into the recent and current academic discussions related to the themes explored in our work thus far. This approach was selected to address time constraints and the need to cover a wide subject area. The primary themes of focus include platforms, combining resilience and sustainability in SCs, and SCR stress tests. In future research, upon determining the specific subject area to investigate, we plan to transition to a systematic literature review.

Platform-based Dashboard

Challenges that are faced by modern SCs can be addressed through innovative solutions for digitalizing the SC, even though the process "digitalization" itself might present some additional difficulties. However, by adequately implementing digital concepts, processes, and business models, companies are able to enhance their efficiency and effectiveness in the domain of logistics and SC (Binsfeld & Gerlach, 2022). Digitalization can result into a digital twin of the SC which would be a data-driven model that provides real-time visibility of the state of the SC (Ivanov & Dolgui, 2020). Having a digital twin of the SC can be seen as the first step towards a cloud SC which integrates digital technology and advanced SCM concepts into a digital collaboration platform and ecosystem (Ivanov et al., 2022). SC collaboration can help SC partners to work closely to provide accurate data in real time, react rapidly to changes and subsequently increase SCR (Scholten & Schilder, 2015). In addition, SCR could benefit from the concurrent use of information technology and SC collaboration (Zhou et al., 2022). Apart from this, collaboration can have a positive influence on SC visibility, stakeholder trust, economic and environmental performance (Baah et al., 2021).

Nevertheless, establishing a platform and ecosystem that fosters collaboration and trust among SC partners, while simultaneously ensuring the safety and privacy of data is challenging. Such an initiative is GAIA-X ecosystem architecture that was launched in 2021 by the EU with the goal to ensure data sovereignty for all participants (Braud et al., 2021). Unfortunately, Gaia-X aimed at providing an infrastructure that would connect all companies and citizens from the whole EU, thus it got entangled between national interests and bureaucracy. At this time Gaia-X is still collecting use cases to prove that such a digital infrastructure can help the EU in the continuity of its plans and activities.

On the other hand, based on the principles of Gaia-X in 2020 the initiative for the Catena-X project was launched with the aim of enabling the collaborative construction and use of end-to-end data chains for the whole automotive value chain (Schöppenthau et al., 2023). The Catena-X digital ecosystem provides a diverse range of solutions to its members in five application areas, namely sustainability, logistics, maintenance, quality management, and SCM.

Combining Resilience and Sustainability

Sustainability and resilience in SCs are topics that have been widely researched and discussed in the academic sphere, however more than often independently of each other (Fahimnia et al., 2019). The absence of overlap of simultaneous research of these concepts poses a challenge, as studying SC sustainability practices in isolation from SCR practices, or vice versa, may lead to the oversight of the interrelation between the two sets of practices (Cotta et al., 2022). In addition, governments and businesses have come to recognize that examining these aspects independently is insufficient for maintaining global competitiveness (Taleizadeh et al., 2022), and there is an increasing need to develop "resiliently sustainable" SCs (Fahimnia & Jabbarzadeh, 2016; Priyadarshini et al., 2023).

Cotta et al. (2022) found out that there is no prevailing consensus on the nature of the connection between resilience and sustainability. Certain SC managers perceive the relationship as essentially conflicting; others see it as fundamentally synergistic, and a third group does not recognize any relationship whatsoever. Some sustainability practices directly conflict SCR e.g. cost-effective measures and practices to minimize waste require reduced inventory, while at the same time they could potentially compromise SCR by limiting the availability of inventory for mitigating risks during disruptions (Ivanov, 2017). On the contrary, sustainability practices that require supplier selection based on environmental and social performance could in advance prevent disruptions that would otherwise appear if the company would be working with an uncompliant and unlawful partner (Cotta et al., 2022). Experts believe that investing in collaborative technologies, collaboration between SC partners and reshoring strategies are the best resorts to minimizing disruption impact and improving both resilience and sustainability (Singh et al., 2023).

Supply Chain Resilience Stress Test

The term SC stress test was initially introduced by Simchi-Levi & Simchi-Levi (2020). Urging the need behind designing a stress test focused on the resilience of SCs, they developed an initial methodology closely based on the bank stress test which was put in motion after the 2008 financial crisis. Their proposed approach involved two key components: Time to Recover (TTR), representing the duration required for a specific node (such as a supplier facility, distribution centre, or a transportation hub) to fully recover after a disruption, and Time to Survive (TTS), indicating the maximum duration the SC can sustain matching supply and demand following disruption. Using this approach businesses can create plans for mitigating disruptions and calculating the financial impact on the SC in a variety of potential scenarios (Simchi-Levi & Simchi-Levi, 2020).

However, testing the whole SCs can be difficult and requires having a high level of visibility into the structure. Leveraging digital SC twins and applying resilience analytics proactively to simulate how SCs respond to disruptions and recovery strategies will enhance the likelihood of society enduring prolonged crises (Ivanov & Dolgui, 2021). Ivanov (2023) categorized scenarios for SC stress testing into four distinct groups: identifiable disruptions in material flows, identifiable disruptions in non-material flows, unpredictable disruption causes, and extended SC crises. In 2020, Accenture and the MIT Team collaborated to develop a SCR stress test, aiming to establish a global industry standard for data-driven assessments of SCs.

The initial step involves creating a digital twin of the SC and testing various scenarios to identify vulnerabilities, evaluate mitigation plans and assess the exposure to risk. The overall results are summarized as a single resilience score. Subsequently, companies can experiment and refine new resilience capabilities, with the objective of enhancing these capabilities and integrating "intelligent" technologies, data, analytics, and SC expertise (Veeraraghavan, 2022).

DISCUSSION AND OUTLOOK

In the exploration of platform ecosystems and SCR stress tests, companies are recognizing the importance of establishing digital twins of their SCs. Literature on digital twins in combination or developed with PM is scarce and represents a future research opportunity. PM through its adoption can potentially contribute to the development of digital twins. Taking this idea one step further with data ecosystems where companies can safely share data with their SC partners, PM could be implemented to only streamline and optimize processes within one company, but also to help companies optimize their processes with other SC partners and motivate further collaboration between them and promote resilience.

Another important aspect to consider is importance of both SCR and sustainability. There seems to be a relationship that requires further research to gain a clearer understanding of how these two aspects can complement and contradict each other. The SCOR model includes a performance category for sustainability with two sub-categories under it related to environmental and social sustainability. Therefore, it could be interesting to research of the views that SC managers have on both resilient and sustainable SCOR metrics.

Lastly, regarding SCR stress tests incorporating PM in the equation could bring interesting possibilities. The question here would revolve around if PM should play an active role in the stress test itself or is better suited as a technology deployed post-test to enhance resilience. The decision for which research path to take will require a more systematic literature review approach that will help us gain a more precise and clear view of what has been happening in the literature and where the research gaps lie.

ACKNOWLEDGEMENT

We extend our sincere appreciation to Artur Siurdyban and Accenture for their invaluable collaboration and generous provision of access to their SCR application, which greatly influenced and enhanced the scope and quality of this paper.

REFERENCES

Aman, S., & Seuring, S. (2021). Analysing developing countries approaches of supply chain resilience to COVID-19. *The International Journal of Logistics Management*, *34*(4), 909–934. https://doi.org/10.1108/ijlm-07-2021-0362

ASCM. (2022). *ASCM Supply Chain Operations Reference Model SCOR Digital Standard*. https://scor.ascm.org/performance/introduction

Baah, C., Acquah, I. S. K., & Ofori, D. (2021, April). Exploring the influence of supply chain collaboration on supply chain visibility, stakeholder trust, environmental and financial performances: a partial least square approach. *Benchmarking: An International Journal*, *29*(1), 172–193. https://doi.org/10.1108/bij-10-2020-0519

Binsfeld, T., & Gerlach, B. (2022, July 8). Quantifying the Benefits of Digital Supply Chain Twins—A Simulation Study in Organic Food Supply Chains. *Logistics*, *6*(3), 46. https://doi.org/10.3390/logistics6030046

Braud, A., Fromentoux, G., Radier, B., & Le Grand, O. (2021, March). The Road to European Digital Sovereignty with Gaia-X and IDSA. *IEEE Network*, *35*(2), 4–5. https://doi.org/10.1109/mnet.2021.9387709

Bret, L., Dussud, M., Metral, L., Ladier, A. L., & Trilling, L. (2021). Towards a model assessing supply chain resilience strategies. *Procedia CIRP*, *103*, 14–19. https://doi.org/10.1016/j.procir.2021.10.001

Cotta, D., Klink, L., Alten, T., & Al Madhoon, B. (2022, December). How do supply chain managers perceive the relationship between resilience and sustainability practices? An exploratory study. *Business Strategy and the Environment*, *32*(6), 3737–3751. https://doi.org/10.1002/bse.3325

Fahimnia, B., & Jabbarzadeh, A. (2016, July). Marrying supply chain sustainability and resilience: A match made in heaven. *Transportation Research Part E: Logistics and Transportation Review*, *91*, 306–324. https://doi.org/10.1016/j.tre.2016.02.007

Fahimnia, B., Sarkis, J., & Talluri, S. (2019, February). Editorial Design and Management of Sustainable and Resilient Supply Chains. *IEEE Transactions on Engineering Management*, *66*(1), 2–7. https://doi.org/10.1109/tem.2018.2870924

Few, S. (2006). *Information Dashboard Design*. http://books.google.ie/books?id=7-FrPwAACAAJ&dq=Information+Dashboard+Design.&hl=&cd=1&source=gbs_api

Ivanov, D. (2017, June). Revealing interfaces of supply chain resilience and sustainability: a simulation study. *International Journal of Production Research*, *56*(10), 3507–3523. https://doi.org/10.1080/00207543.2017.1343507

Ivanov, D. (2023, September). Intelligent digital twin (iDT) for supply chain stress-testing, resilience, and viability. *International Journal of Production Economics*, *263*, 108938. https://doi.org/10.1016/j.ijpe.2023.108938

Ivanov, D., & Dolgui, A. (2021, May). Stress testing supply chains and creating viable ecosystems. *Operations Management Research*, *15*(1–2), 475–486. https://doi.org/10.1007/s12063-021-00194-z

Ivanov, D., Dolgui, A., & Sokolov, B. (2018, June 28). The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. International Journal of Production Research, 57(3), 829–846. https://doi.org/10.1080/00207543.2018.1488086

Ivanov, D., Dolgui, A., & Sokolov, B. (2022, April). Cloud supply chain: Integrating Industry 4.0 and digital platforms in the “Supply Chain-as-a-Service.” *Transportation Research Part E: Logistics and Transportation Review*, *160*, 102676. https://doi.org/10.1016/j.tre.2022.102676

Ivanov, D., & Dolgui, A. (2020, May). A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. *Production Planning & Control*, *32*(9), 775–788. https://doi.org/10.1080/09537287.2020.1768450

Melnyk, Steven & Closs, D.J. & Griffis, Stanley & Zobel, Christopher & Macdonald, John. (2014). Understanding

supply chain resilience. Supply Chain Management Review. 18. 34-41.
Orenstein, P. (2023, September 6). From Wireframe to Dashboard – Creating Transparency in Supply Chain Networks. Operations and Supply Chain Management: An International Journal, 389–398. https://doi.org/10.31387/oscm0540398
Pauwels, K., Ambler, T., Clark, B. H., LaPointe, P., Reibstein, D., Skiera, B., Wierenga, B., & Wiesel, T. (2009). Dashboards as a Service. *Journal of Service Research*, *12*(2), 175–189. https://doi.org/10.1177/1094670509344213
Priyadarshini, J., Singh, R. K., Mishra, R., Chaudhuri, A., & Kamble, S. (2023, October). Supply chain resilience and improving sustainability through additive manufacturing implementation: a systematic literature review and framework. *Production Planning & Control*, 1–24. https://doi.org/10.1080/09537287.2023.2267507
Rasmussen, N. H., Bansal, M., & Chen, C. Y. (2009). *Business Dashboards*. John Wiley & Sons. http://books.google.ie/books?id=23A5oPOQ7pYC&printsec=frontcover&dq=978-0-470-41347-0&hl=&cd=1&source=gbs_api
Reibstein, D., Hoyne, N., & Pauwels, K. (2023). Dashboards: From Performance Art to Decision Support. *NIM Marketing Intelligence Review*, *15*(1), 60–63. https://doi.org/10.2478/nimmir-2023-0009
Schätter, F., Morelli, F., & Haas, F. (2022). SUPPLY CHAIN RESILIENCE MANAGEMENT USING PROCESS MINING. In 36th International ECMS Conference on Modelling and Simulation, ECMS 2022 (pp. 121-127).
Schätter, F., Morelli, F., & Haas, F. (2023). Inbound Supply Chain Resilience Analysis Based on Key Resilience Areas. In 37th International ECMS Conference on Modelling and Simulation, ECMS 2023 (pp. 277-283).
Scholten, K., & Schilder, S. (2015, June). The role of collaboration in supply chain resilience. *Supply Chain Management: An International Journal*, *20*(4), 471–484. https://doi.org/10.1108/scm-11-2014-0386
Schöppenthau, F., Patzer, F., Schnebel, B., Watson, K., Baryschnikov, N., Obst, B., Chauhan, Y., Kaever, D., Usländer, T., & Kulkarni, P. (2023, August). Building a Digital Manufacturing as a Service Ecosystem for Catena-X. *Sensors*, *23*(17), 7396. https://doi.org/10.3390/s23177396
Sekulovska, A., Morelli, F., Siurdyban. A., Manfreda, A., Schätter, F. (2023, December). Designing a Use Case for Supply Chain Resilience Based on Process Mining. Anwendungen und Konzepte der Wirtschaftsinformatik AKWI (18), 103-116.
Simchi-Levi, D., & Simchi-Levi. (2020, April). We Need a Stress Test for Critical Supply Chains. Harvard Business Review. https://hbr.org/2020/04/we-need-a-stress-test-for-critical-supply-chains
Singh, J., Hamid, A. B. A., & Garza-Reyes, J. A. (2023, January). Supply chain resilience strategies and their impact on sustainability: an investigation from the automobile sector. *Supply Chain Management: An International Journal*, *28*(4), 787–802. https://doi.org/10.1108/scm-06-2022-0225
Taleizadeh, A. A., Ahmadzadeh, K., Sarker, B. R., & Ghavamifar, A. (2022, January). Designing an optimal sustainable supply chain system considering pricing decisions and resilience factors. *Journal of Cleaner Production*, *332*, 129895. https://doi.org/10.1016/j.jclepro.2021.129895
van der Aalst, W. (2012, July). Process Mining. *ACM Transactions on Management Information Systems*, *3*(2), 1–17. https://doi.org/10.1145/2229156.2229157
van Der Aalst, W. M. P. (2016). *Process Mining*. Springer. http://books.google.ie/books?id=hUEGDAAAQBAJ&pg=PR6&dq=978-3-662-49850-7&hl=&cd=2&source=gbs_api
van der Aalst, W., Adriansyah, A., de Medeiros, A. K. A., Arcieri, F., Baier, T., Blickle, T., Bose, J. C., van den Brand, P., Brandtjen, R., Buijs, J., Burattin, A., Carmona, J., Castellanos, M., Claes, J., Cook, J., Costantini, N., Curbera, F., Damiani, E., de Leoni, M., . . . Wynn, M. (2012). Process Mining Manifesto. *Business Process Management Workshops*, 169–194. https://doi.org/10.1007/978-3-642-28108-2_19
Veeraraghavan. (2022, September). *A more resilient supply chain? You no longer have a choice*. Accenture. https://www.accenture.com/us-en/blogs/business-functions-blog/resilient-supply-chain
Zhou, J., Hu, L., Yu, Y., Zhang, J. Z., & Zheng, L. J. (2022, August). Impacts of IT capability and supply chain collaboration on supply chain resilience: empirical evidence from China in COVID-19 pandemic. *Journal of Enterprise Information Management*. https://doi.org/10.1108/jeim-03-2022-0091

AUTHOR BIOGRAPHIES

Angela Sekulovska finished her bachelor studies in Marketing at School of Business and Economics, University of Ljubljana. In 2023 she earned her double degree in Business Informatics at School of Business and Economics, University of Ljubljana, and Information Systems at Pforzheim University of Applied Sciences.

Frank Morelli is Professor of Information Systems - Management & IT at Pforzheim University. In addition to his teaching activities, he is involved in practical and research projects from the fields of business process management, business intelligence, SAP ERP, project management and IT organization. A close cooperation also exists with the Celonis Academic Alliance on the topic of "Process Mining Education". He is one of the contact persons for the Celonis Academic Center of Excellence, with which Pforzheim University was awarded for the second time.

Frank Schätter is a Professor of Supply Chain Processes Management at Pforzheim University. He earned his doctoral degree in 2016 at the Institute for Industrial Production (IIP) at the Karlsruhe Institute of Technology (KIT) in the field of supply chain risk management. His teaching and research focus is on modeling, analysis, and optimization of supply chain processes.