POSSIBILITIES AND LIMITS OF DIGITALIZATION TO INCREASE SUPPLY CHAIN RESILIENCE

TEDARİK ZİNCİRİ DİRENCİLİĞİNİ ARTIRMAK İÇİN DİJİTALLEŞME OLASILIKLARI VE SINIRLARI

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Abstract

In case any unexpected circumstances occur, a supply chain may be heavily influenced with a wide range of negative con-sequences such as inability to deliver or large delays in delivery. Therefore, it is important for every supply chain and the companies that are involved in them to reduce these negative outcomes. In this context, the term Supply Chain Resilience (SCR) stands for the level of adaptability of a supply chain to respond to and recover from disruptions. A high SCR is given if re-maintaining operational continuity is quickly possible. As an example of unexpected disruptions, the COVID-19-crisis showed major impacts on the functionality of global supply chains. The upcoming technologies of industrial Digitalization, mainly known as Industry 4.0, provide opportunities to increase SCR. In this paper, first a brief overview of different surveys is given to show the COVID-19-impact on global supply chains and therefore prove the need to generally increase SCR. Second, an insight of how especially Digitalization may help to increase SCR is provided. Especially improving the database for all supply chain partners, faster and more precise decision-making processes, including the use of Artificial Intelligence, are described. Finally, positive chances and major challenges of using Digitalization to increase SCR are addressed.

Özet

Beklenmeyen herhangi bir durumun meydana gelmesi durumunda, bir tedarik zinciri, teslim edilememe veya teslimatta büyük gecikmeler gibi çok çeşitli olumsuz sonuçlarla büyük ölçüde etkilenebilir. Bu nedenle, her tedarik zinciri ve bunlara dahil olan şirketler için bu olumsuz sonuçların azaltılması önemlidir. Bu bağlamda, Tedarik Zinciri Esnekliği (SCR) terimi, bir tedarik zincirinin kesintilere yanıt verme ve kesintilerden kurtulma konusundaki uyarlanabilirlik düzeyini ifade eder. Operasyonel sürekliliğin sürdürülmesi hızlı bir şekilde mümkünse, yüksek bir SCR verilir. Beklenmedik kesintilere bir örnek olarak, COVID-19 krizi, küresel tedarik zincirlerinin işlevselliği üzerinde büyük etkiler gösterdi. Temelde Endüstri 4.0 olarak bilinen endüstriyel Dijitalleşmenin yaklaşan teknolojileri, SCR'yi artırmak için fırsatlar sunuyor. Bu yazıda, öncelikle küresel tedarik zincirleri üzerindeki COVID-19 etkisini göstermek ve bu nedenle genel olarak SCR'yi artırma ihtiyacını kanıtlamak için farklı anketlere kısa bir genel bakış verilmektedir. İkinci olarak, özellikle Dijitalleşmenin SCR'yi artırmaya nasıl yardımcı olabileceğine dair bir fikir verilmektedir. Özellikle tüm tedarik zinciri ortakları için veri tabanının iyileştirilmesi, Yapay Zeka kullanımı da dahil olmak üzere daha hızlı ve daha kesin karar verme süreçleri anlatılmaktadır. Son olarak, SCR'yi artırmak için Dijitalleşmeyi kullanmanın olumlu şansları ve başlıca zorlukları ele alınmaktadır.

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1. INTRODUCTION

The recent COVID-19-crisis proved that unexpected events may cause heavy negative influences on global supply chains. As the beginning of the crisis was only less than three years ago and it is still continuing, a full scientific exploration is not given. However, several surveys prove that the effects on supply chains were globally recognized among all industries, and the "classic" risk management systems have not been able to overcome the obstacles. For example, several surveys from EulerHermes, Capgemini, McKinsey, and others show that more than 50% of the companies examined have been negatively affected by COVID-19 (Capgemini, 2021; McKinsey, 2020; Semmann, 2020; Sherman, 2020; VDMA, 2020).

Therefore, an improvement of the resilience of supply chains is inevitable. This paper addresses this problem and provides selected solutions to the problem based on the use of digitalization.

2. RESILIENCE IN SUPPLY CHAIN MANAGEMENT

The term 'resilience' generally stands for the ability of a system to recover from any disruption (Figure 1). Especially, if it is related to supply chains, the term 'supply chain resilience' (SCR) stands firstly for the ability of a supply chain to prepare for an unexpected event in advance (ideally avert the disruption), secondly for responding to it quickly once it occurs, and thirdly for a fast recovery from the disruption, back to the desired level of service (Belhadi et al., 2021; Black, 2020).
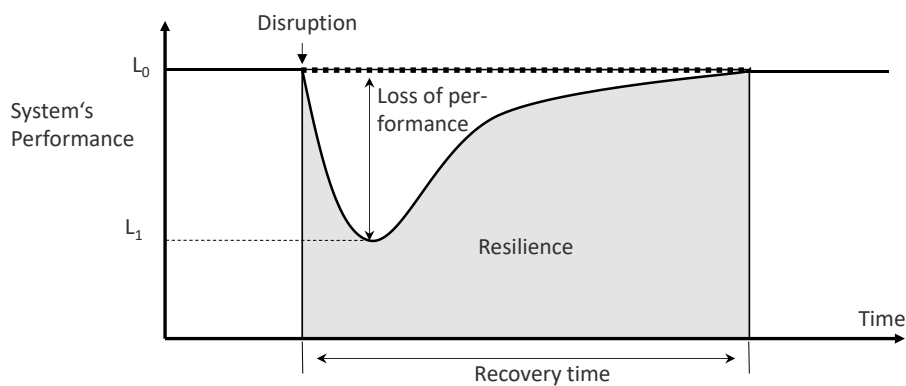
Figure 1: Resilience as a function of recovery time for a system's performance (Belhadi et al. 2021).

Dealing with SCR is generally a part of a company's risk management. Recent research on risk management for supply chains has heavily focused on operational risks (such as currency fluctuations etc.) with mostly short-term impacts. However, dealing with unexpected, disruptive changes that may cause long-term implications on a company's business, especially on a global basis concerning all industries, has not been in scope of the research so far (Black and Glaser-Segura, 2020; Shen and Sun, 2021). Therefore, it is necessary to provide scientifically-based assistance for practitioners in preparing for future disruptions comparable to the COVID-19-crises.

3. DIGITALIZATION'S CONTRIBUTION TO SUPPLY CHAIN RESILIENCE

Several options are given to improve SCR. Generally speaking, first of all the top-management of a company should fulfill its leadership and management role in a proactive, risk-anticipating form. If this is given, a best-as-possible planning for any critical case may take place in form of an identification of potential operational and non-operational risks and the development of basic solutions that establish robust processes (Figure 2). Digital process support within a single company and within a supply chain by using suitable technologies is one of the key aspects, also referred to as Digitalization (or Industry 4.0) (Black and Glaser-Segura, 2020).
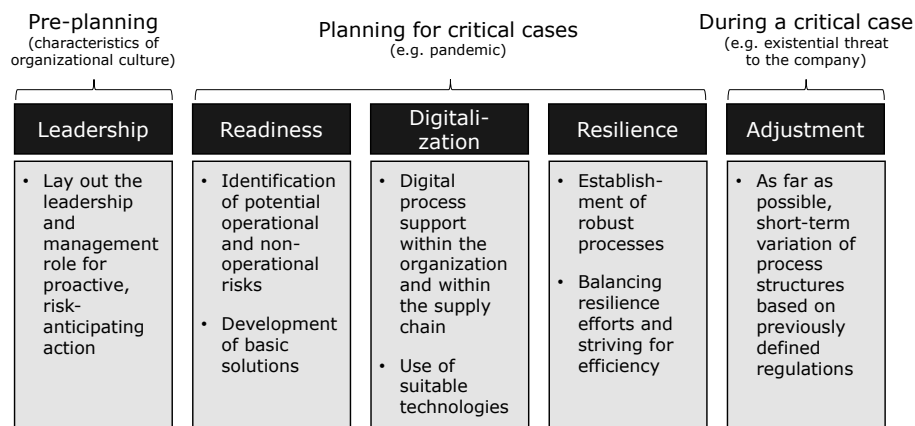
Pre-planning (characteristics of organizational culture)	Planning for critical cases (e.g. pandemic)		During a critical case (e.g. existential threat to the company)
Leadership	**Readiness**	**Digitali-zation**	**Resilience**	**Adjustment**
• Lay out the leadership and management role for proactive, risk-anticipating action	• Identification of potential operational and non-operational risks • Development of basic solutions	• Digital process support within the organization and within the supply chain • Use of suitable technologies	• Establish-ment of robust processes • Balancing resilience efforts and striving for efficiency	• As far as possible, short-term variation of process structures based on previously defined regulations

Figure 2: Stages of overcoming disruptive, negative effects (Black and Glaser-Segura, 2020).

The use of Digitalization includes in a first step measurement technologies for binary status descriptions of processes. Afterwards, in most cases, any technology such as networking transmitters and receivers is used for transferring the data from the point-of-recording to the point-of-processing. The latter is done by automated data processing and information gathering, such as Big Data Analytics. Additionally, the data can optionally be displayed to human workers involved in the processes via digital media. Finally, the processed data is deployed for previously defined tasks and objectives, mostly within a framework of control loops (Weber, 2021). As Digitalization includes a wide range of technologies and approaches, we refer to those that promise to increase SCR in a best-suitable way, based on our literature review.

3.1. Improvement of Supply Chain Overview

If data is available from all partners in a supply chain, and if it is processed simultaneously and shared, the overview of the status-quo within the supply chain is improved. Real-time data transmission of physical activities of all partners in the supply chain allows for calculating different key performance indicators, showing for example current inventory levels, production rates or transports. This mainly allows for establishing alarm-systems if the measured as-is data is compared to pre-defined goals (Das et al., 2021; Deloitte, 2020; Karger and Seewald, n.d.). Having a clearly defined description of the current status of the supply chain is the basis for the second step as described in the next chapter.

3.2. Ease of Scenario Calculation and Decision Making

Any decisions made in supply chains should be based on accurate calculations. Digitalization helps in those calculations by using Big Data Analytics and simulation models based on statistical foundations. First of all, the current status-quo needs to be adequately described based on historical and actual data as described in the previous section. This offers the possibility for ratings based on indicators in the second step. Afterwards, scenarios can be calculated based on assumptions about future development possibilities and their probabilities. Finally, all calculated scenarios are the basis for finding an "optimal" solution, based on the most likely scenario. This serves as the basis for actual decisions (Figure 3) (Belhadi et al., 2021; Ivanov and Das, 2020; Miceli et al., 2021).
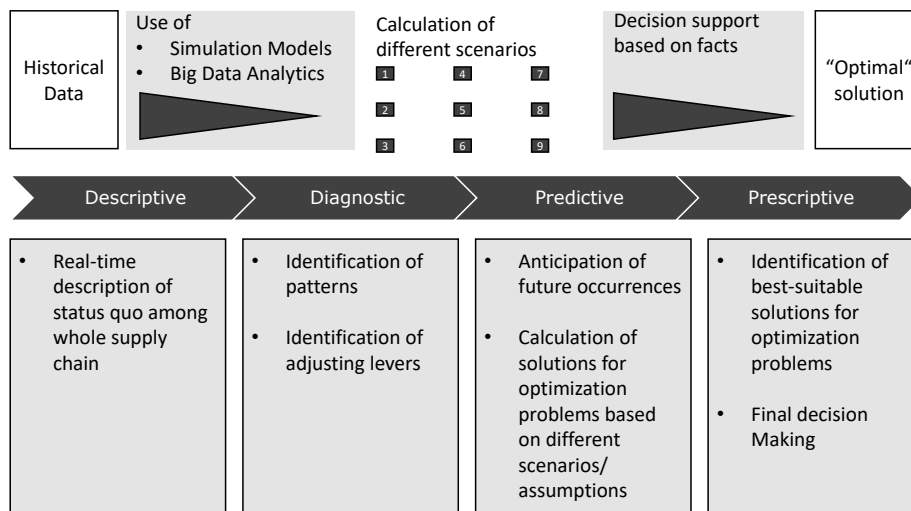

Figure 3: From the status-quo to an "optimal" decision finding.

As all of those calculations need a good database, it might be necessary to improve the given database as described in the next chapter.

3.3. Improvement of Database and Support for Strategic Decision Making

There are two promising technologies within the broad field of Digitalization that can improve the database for decision finding processed. First to mention is the use of Blockchain, which is a technology for decentralized and highly secured data storage with accessibility to all partners within a supply chain. It also allows for data quality verification. Secondly, Artificial Intelligence allows for data completion in case of missing information, and also for a certain simplification of complex decision findings. It can help in anticipating future happenings, in compensating given information asymmetries as well as establishing early warning systems. (Black and Glaser-Segura, 2020; Das et al., 2021; Deloitte, 2020; Hobbs, 2021; Miceli et al., 2021; Shen and Sun, 2021; Tasnim, 2020).

By using these two technologies jointly, fast, transparent, and straight decision finding processes can be established. Furthermore, this allows for supporting strategic decision-making processes, as changes within the supply chain or on markets can be anticipated in a much better way. Especially AI allows for a "view into a distant future" in a much better sense than common technologies.

4. CHANCES AND RISKS

There are several chances as well as risks if Digitalization is used to improve SCR. Regarding the chances and positive effects, a gain of transparency by the use of real-time data as well as faster and more accurate communication along supply chain stages are given. More detailed forecasts can be made, which leads to a reduction of bullwhip and ripple effects. Additionally, a reduction of operational transaction costs based on more efficient use of resources can be a positive outcome. Generally speaking, faster and more precise actions in alignment with supply chain partners are possible.

Regarding the risks and challenges, a harmonization of IT-systems (e.g., the integration of different IT-systems in use) is not easy. Especially, it may result in a challenge to integrate non-long-term partners and/or smaller partners without sufficient digitalized processes. Additionally, the availability of powerful IT resources, especially in remote areas, during transportation etc., is often not given. And, obviously, more cyber-attacks are likely to occur in case more Digitalization is used.

Generally speaking, all Digitalization approaches are not applicable in a short time-span. In some cases, legal frameworks need to be fully adapted to allow the use of Digitalization. Furthermore, Artificial Intelligence and Blockchain themselves are evolving technologies and therefore are currently not usable in a way they ideally should be. Finally, it can be stated that Digitalization may itself cause effects which negatively influence SCR, e.g., if data connections are interrupted, power failures occur, or data exchanges fail (Black and Glaser-Segura, 2020; Deloitte, 2020; Heß and Kleinlein, 2021; Miceli et al., 2021; Nandi et al., 2020; Nandi et al., 2021; Riecke, 2020).

5. CONCLUSION

As stated in this paper, COVID-19 caused major problems in global supply chains, showing that there is a general need for improving supply chain resilience (SCR). Digitalization can be used as one tool to improve it. Real-time data about the current status-quo within a supply chain that is shared among the supply chain partners serves as a basis for all digitalization applications. This can be the basis for decision finding calculations, which are mostly based on scenario calculations. Furthermore, Artificial Intelligence and Blockchain are promising technologies to increase SCR. However, future research is required on SCR strategies for long-term, disruptive, and global changes as well as on digitalization technologies in general.

REFERENCES

Belhadi, A., Kamble, S., Jabbour, C.J.C., Gunasekaran, A., Ndubisi, N.O., & Venkatesh, M. (2021). Manufacturing and service supply chain resilience to the COVID-19 outbreak: Lessons learned from the automobile and airline industries. *Technological Forecasting and Social Change*, *163*, 120447. https://doi.org/10.1016/j.techfore.2020.120447

Black, S., & Glaser-Segura, D. (2020). Supply chain resilience in a pandemic: The need for revised contingency planning. *Management Dynamics in the Knowledge Economy, 8*(4), 325-343. https://doi.org/10.2478/mdke-2020-0021

Capgemini. (2021). *The wake-up call: Building supply chain resilience in consumer products and retail for a post-COVID world*. https://www.capgemini.com/de-de/wp-content/uploads/sites/5/2021/03/Supply-Chain-in-CPR_2021-03-10_Web.pdf

Das, D., Datta, A., Kumar, P., Kazancoglu, Y., & Ram, M. (2021). Building supply chain resilience in the era of COVID-19: An AHP-DEMATEL approach. *Operations Management Research*, 1–19. https://doi.org/10.1007/s12063-021-00200-4

Das, D., Datta, A., Kumar, P., Kazancoglu, Y., & Ram, M. (2022). Building supply chain resilience in the era of COVID-19: An AHP-DEMATEL approach. *Operations Management Research*, *15*(1–2), 249–267. https://doi.org/10.1007/s12063-021-00200-4

Deloitte. (2020). *Building Supply Chain Resilience beyond COVID-19*. file:///C:/Users/marc-/Desktop/deloitte-ch-study-building-supply-chain-resilience-covid-19-2020.pdf

Heß, G., & Kleinlein, A.C. (2021). *Resilienz im Einkauf - Konzept und Praxisleitfaden zum Management unerwarteter Risiken in der Lieferkette*. SpringerGabler.

Hobbs, J.E. (2021). Food supply chain resilience and the COVID-19 pandemic: What have we learned?. *Canadian Journal of Agricultural Economics*, *69*, 189-196. https://doi.org/10.1111/cjag.12279

Ivanov, D., & Das, A. (2020). Coronavirus (COVID-19/SARS-CoV-2) and supply chain resilience: a research note, *International Journal on Integrated Supply Management, 13*(1), 90-102. https://dx.doi.org/10.1504/IJISM.2020.107780

Karger, T., & Seewald, D. (n.d.). *Aufbau einer Supply Chain nach COVID-19*. https://www.efficioconsulting.com/de/publikationen/insights/aufbau-einer-supply-chain-nach-covid-19/

McKinsey. (2020). *Resetting supply chains for the next normal*. https://www.mckinsey.com/business-functions/operations/our-insights/resetting-supply-chains-for-the-next-normal

Miceli, A., Hagen, B., Riccardi, M.P., Sotti, F., & Settembre-Blundo, D. (2021). Thriving, not just surviving in changing times: How sustainability, agility and digitalization intertwine with organizational resilience. *Sustainability*, *13*, 2052. https://doi.org/10.3390/su13042052

Nandi, S., Sarkis, J., Hervani, A., & Helms, M. (2020). Do blockchain and circular economy practices improve post COVID-19 supply chains? A resource-based and resource dependence perspective. *Industrial Management and Data Systems, 121*(2), 333-363. https://doi.org/10.1108/IMDS-09-2020-0560

Nandi, S., Sarkis, J., Hervani, A., & Helms, M. (2021). Redesigning supply chains using blockchain-enabled circular economy and COVID-19 experiences. *Sustainable Production and Consumption*, *27*, 10-22. https://doi.org/10.1016/j.spc.2020.10.019

Riecke, T. (2021, August 16). Trotz dramatischer Engpässe: Deutsche Firmen halten an Ihren Lieferketten fest. *Handelsblatt*. https://www.handelsblatt.com/meinung/kolumnen/globale-trends/globale-trends-trotz-dramatischer-engpaesse-deutsche-firmen-halten-an-ihren-lieferketten-fest/27519328.html?ticket=ST-4715831-9kCEhYf0r6oekygYrYne-cas01.example.org

Semmann, C. (2020, December 16). Lieferketten nach Corona: Was Unternehmen planen. *Deutsche Verkehrszeitung*. https://www.dvz.de/dossiers/zukunft-der-lieferketten/detail/news/lieferketten-auf-dem-pruefstand-1.html

Shen, Z.M., & Sun, Y. (2021). Strengthening supply chain resilience during COVID-19: A case study of JD.com. *Journal of Operations Management*. https://doi.org/10.1002/joom.1161

Sherman, E. (2020). *94% of the Fortune 1000 are seeing coronavirus supply chain disruptions: Report.* https://fortune.com/2020/02/21/fortune-1000-coronavirus-china-supply-chain-impact/

Tasnim, Z. (2020). Disruption in global food supply chain (FSCs) due to Covid-19 pandemic and impact of digitalization through block chain technology in FSCs management. *European Journal of Business and Management, 12*(17), 73-84. https://doi.org/10.7176/EJBM/12-17-08

VDMA, IfW. (2020). *Lieferketten in der Zeit nach Corona. Kurzgutachten im Auftrag der IMPULS Stiftung für den Maschinenbau, den Anlagenbau und die Informationstechnik*. https://www.ifw-kiel.de/fileadmin/Dateiverwaltung/IfW-Publications/-ifw/Policy_Papers/2021/Lieferketten_in_der_Zeit_nach_Corona_Endbericht.pdf.

Weber, M.A. (2021). *Nutzung der Digitalisierung zur Produktivitätsverbesserung in industriellen Prozessen unter Berücksichtigung arbeitswissenschaftlicher Anforderungen*. Springer.