

Supply chain resilience in societal vital sectors and functions

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Abstract

Purpose – Severe disruptions in supply chains caused by events such as pandemics, energy crises and geopolitical tensions place significant pressure on supply chains related to societal vital sectors and functions. The purpose of this paper is to enhance the understanding of the complexity of building resilience in the supply chains that support societal vital sectors and functions.

Design/methodology/approach – This paper presents a process model grounded in current research, incorporating insights gained through engagement with resources from the former Danish Critical Supply Agency (now Danish Resilience Agency) and representatives from various critically important societal vital sectors.

Findings – Based on process theory, this paper presents a four-phase process model to ensure supply chain resilience (SCRES) in societal vital sectors and functions: map the supply chains for societal vital functions under the societal vital sectors, assess the probability and consequences of incidents for societal vital functions, identify vulnerabilities for societal vital functions and conduct risk assessments and develop action plans for risk mitigation and capability building.

Research limitations/implications – This paper is based on societal vital sectors in Denmark, which may have a different structure and legislation compared with other countries.

Practical implications – This paper proposes a pragmatically structured approach to ensuring SCRES in societal vital sectors and functions, which involves significant complexity.

Social implications – By mapping supply chains, assessing risks and identifying vulnerabilities, the model helps societies better prepare for potential disruptions.

Originality/value – This paper introduces segmentation theory to segment societal vital sectors and functions to guide employees to focus their work on what is most critical. Furthermore, a supply chain perspective is applied in the analysis of societal vital sectors and functions.

Keywords Critical infrastructure, Supply chain resilience, Segmentation, Process theory

Paper type Research paper



Introduction

Supply chain management (SCM) focuses on the flow of materials, information and finances from raw material extraction to the point of consumption (Cooper *et al.*, 1997;

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[Mentzer et al., 2001](#)). Along the way, there are numerous actors, such as logistics companies, retailers, wholesalers, manufacturers and public organizations. A key element of SCM is business processes that span functions within organizations ([Lambert and Enz, 2017](#)). This focus is essential to avoid a so-called silo mentality, which can lead to suboptimization within functions such as sales, production and procurement ([Lambert and Enz, 2017](#)). This article applies a supply chain perspective to public and private actors working with critical infrastructure. Critical infrastructure refers to an asset, facility, equipment, network, system or any part thereof, essential for delivering a vital service (The CER Directive, EU Directive 2022/2557).

The focus on and awareness of the efficiency of global supply chains have increased significantly due to disruptions caused by events such as the COVID-19 pandemic, the grounding of the Ever Given in the Suez Canal, Houthi disruptions of shipping traffic in the Red Sea through attacks on cargo ships, Russia's invasion of Ukraine, the war in Gaza, cyberattacks, climate changes and rising geopolitical tensions. The COVID-19 pandemic, in particular, had a substantial impact on global supply chains, leading to country, port and factory shutdowns, as well as panic buying of finished goods, semifinished products and raw materials due to shortages and hoarding. These disruptions also placed significant pressure on critical infrastructure ([Ahlqvist et al., 2020](#); [Pujawan and Bah, 2022](#)). Concepts closely related to critical infrastructure in the Danish context include societal vital sectors and societal vital functions ([DCSA, 2023](#)). Societal vital sectors, societal vital functions and critical infrastructure constitute three closely interconnected levels within the Danish approach to societal security and emergency preparedness. Societal vital sectors encompass broad areas of society, such as energy, health and transportation. Within these sectors are societal vital functions, which comprise the specific services and activities necessary to maintain societal functioning and ensure the operational capability of the sectors. These functions are supported by critical infrastructure, consisting of the physical and digital facilities, systems and networks that enable their delivery. Consequently, the failure of critical infrastructure can disrupt societal vital functions, potentially causing significant consequences for both individual sectors and society as a whole.

Disruptions in supply chains have heightened the focus on supply chain resilience (SCRES), which has developed significantly as a research field over the past decade ([Ali and Gölgeci, 2019](#); [Hohenstein et al., 2015](#); [Kochan and Nowicki, 2018](#)). However, existing research on critical infrastructure in the context of SCRES appears limited, despite being identified as an essential area for further exploration ([Ahlqvist et al., 2020](#); [Gabler et al., 2017](#); [Pettit et al., 2019](#)). According to [Stewart et al. \(2009\)](#), there is a need for new research focusing on resilience across societal levels, such as federal, state and local levels. [Scholten et al. \(2020\)](#) also call for research on SCRES at the sectoral, national and supranational levels.

Critical infrastructure and supply chains are closely intertwined, as many resources and activities vital to supply chain functionality are integral to critical infrastructure itself ([Roman et al., 2023](#)). Critical infrastructure forms a complex web of interdependencies, where disruptions in one sector can cascade and have far-reaching effects across others ([OECD, 2019](#), p. 22; [Oliver et al., 2022](#); [Rinaldi et al., 2001](#); [Månefjord and Johansson, 2024](#)). Supermarkets and food producers, for example, depend on electricity for everything from warehouse refrigeration to payment systems. At the same time, the power grid relies on supply chains that provide fuel, spare parts and maintenance. If the power goes out for an extended period, it can disrupt the food supply, and if supply chains fail, it can impact the operation of the power grid. The EU's Network and Information Security

Directive (NIS2) has been approved by the European Parliament and the European Council and will be implemented into Danish law by 2025. NIS2 imposes strict requirements to enhance cybersecurity among companies and authorities, impacting critical infrastructure as well. In 2024, NIS2 was supplemented by the Directive on the Resilience of Critical Entities (CER), which introduces additional requirements to strengthen critical infrastructure's resilience to threats such as terrorist attacks, sabotage or natural disasters.

The field of SCRES is rapidly evolving, driven by events such as the COVID-19 pandemic, rising geopolitical tensions and climate change. However, in the supply chain literature, critical infrastructure has received less attention. Existing contributions have primarily focused on building SCRES through public-private partnerships (Schwellnus *et al.*, 2023; Stewart *et al.*, 2009; Yang and Xu, 2015) and a multilayered framework for risk management in public and private organizations (Ahlqvist *et al.*, 2020). Thakur-Weigold and Miroudot (2024) suggested that businesses and governments should focus on enhancing the resilience of supply chains by managing both regular disruptions and extreme, unforeseen events. Resilience is not only about ensuring supply security but also about improving the overall system's performance through effective risk management practices and strategic collaboration where governments are encouraged to play a facilitating role during extreme crises by reducing logistical barriers, promoting regulatory cooperation and strengthening industrial communities for preparedness. There is a lack of contributions that take a state perspective on how to support critical sectors in strengthening their SCRES (Scholten *et al.*, 2020). In addition, research in a public and especially state-level context is sparse. Scholars have emphasized the need for more normative contributions on *how* to create SCRES (Narasimhan, 2018) with practical relevance (Arlbjørn *et al.*, 2008), as opposed to theoretical discussions of *what* and *why* (Samson and Kalchschmidt, 2019; Van Hoek, 2020). Stentoft and Mikkelsen (2024) have specifically addressed the *how* question with a process model for creating SCRES in small and medium-sized manufacturing enterprises (SMEs).

The issue of ensuring SCRES in societal vital sectors has gained further relevance with the establishment of the new Ministry for Societal Resilience and Contingency (MSRC) on August 29, 2024, in Denmark. The ministry aims to strengthen Denmark's ability to prevent, withstand and manage incidents that challenge the nation's fundamental functions. A total of eight ministries have contributed to varying degrees, by transferring responsibilities to the new ministry: the Ministry of Defense; the Ministry of Justice; the Ministry of Finance; the Ministry of Industry, Business and Financial Affairs; the Ministry of the Environment; the Ministry of Digitalization and Equality; the Ministry of Education and Research; and the Ministry of Climate, Energy and Utilities. Thus, this paper focuses on SCRES at a societal level and seeks to answer the following research question:

RQ1. How can supply chain resilience be achieved in societal vital sectors and functions through a structured process?

The article contributes to new perspectives in at least three areas. First, it proposes a process model for creating SCRES in societal vital sectors and functions. Second, it advocates for MSRC to take on the overarching coordinating role in prioritizing resources across Denmark's 15 societal vital sectors during crises, recognizing that each sector holds its own sectoral responsibility. Third, the process model emphasizes the importance of broad interdisciplinary involvement in the efforts within individual sectors, supported by MSRC. The paper is further structured into five sections. The next section presents the theoretical foundation which is followed by a section describing the applied method. Then follows two

sections that first present a segmentation model of societal vital sectors and then a process model for enhancing SCRES in societal vital sectors and functions. Finally, a discussion and conclusion are provided.

Theoretical underpinning

Supply chain resilience

SCRES as a field has undergone significant development in recent decades. Extensive research in the area has resulted in a wide range of definitions. A study by [Ali and Gölgeci \(2019\)](#) highlights various definitions of SCRES, addressing it from organizational, network and system perspectives. Because this article focuses on public authorities, it adopts a system-based definition of SCRES by [Christopher and Peck \(2004, p. 4\)](#), who define it as “the ability of a system to return to its original state or move to a new, more desirable state after being disturbed.”

Within SCRES, a distinction can be made between proactive and reactive strategies. Proactive strategies involve actions and activities taken before a disruption occurs, whereas reactive strategies focus on recovery after a disruption ([Hohenstein et al., 2015](#)). Proactive strategies aim to maintain operational stability, while reactive strategies emphasize response, recovery and growth. One approach to SCRES is identifying vulnerabilities in the supply chains and determining the capabilities needed to address them. Vulnerabilities are the fundamental factors that make a company susceptible to disruptions, while capabilities are the attributes that enable a company to anticipate and overcome such disruptions ([Petit et al., 2010](#)). [Stentoft and Mikkelsen \(2024\)](#) developed a process model to guide companies in fostering greater cross-functional awareness of SCRES. The model consists of four phases:

- (1) mapping the supply chain;
- (2) identifying vulnerabilities and capabilities;
- (3) prioritizing issues and establishing cross-organizational consensus; and
- (4) developing action plans.

The process incorporates risk management by supporting decisions on whether risks should be eliminated, mitigated or accepted. SCRES has therefore become a highly relevant discipline for preparing organizations to respond to disruptions before, during and after they occur.

Critical infrastructure

Critical infrastructure plays a crucial role in ensuring the functioning of society by providing goods and services such as supply, transport, electricity and communication ([Rehak et al., 2019](#)). Critical infrastructure constitutes a complex network of interdependencies, where disruptions in one sector can spread and have far-reaching consequences for other sectors ([OECD, 2019, p. 22](#); [Oliver et al., 2022](#)). This interconnection and mutual dependency are a well-known reality ([Rinaldi et al., 2001](#)). Ongoing changes in and around critical infrastructure include rapid technological and institutional shifts (e.g. from public to private), increased system complexity, growing cross-border dependencies, heightened tensions between market interests and long-term sustainability demands, as well as rising service quality requirements ([Herder and Thissen, 2003](#)). Over time, critical infrastructure has evolved from local systems to complex, interconnected, international and integrated systems involving both public and private actors ([Ahlqvist et al., 2020](#)). The importance of focusing on critical infrastructure increases when natural disasters, pandemics or cyberattacks occur ([Oliver et al., 2022](#)), while attention tends to be lower when systems are functioning

normally. In 2022, the European Parliament approved new legislation aimed at more effectively protecting the EU's critical infrastructure (European Parliament, 2022). The EU directive covers 11 critical entities (CER): energy, transport, banking, financial market infrastructure, health, drinking water, wastewater, digital infrastructure, public administration, food and space.

The state may choose to outsource tasks to private companies, but not the responsibility for solving the task (Dunn-Cavelty and Suter, 2009). The shift of responsibilities of critical infrastructures may also require transformation processes from engineering-dominated toward more management-oriented organizations (Worch *et al.*, 2012). Stewart *et al.* (2009) emphasized the importance of collaborative management of critical infrastructure by the public and private sectors to build resilience, with supply chains playing a central role in this effort. Normann and Ahre (2024) focused on supply chain risk governance argue for a need for tailored approaches that consider the distinct features of different critical infrastructure. It underscores the importance of integrating both public and private actors into the governance process to enhance resilience and ensure the continuity of vital services. Ponomarov and Holcomb (2009) likewise emphasized the importance of collaboration with government actors in strengthening sustainability and improving effectiveness in responding to future disasters. Today, a large part of critical infrastructure and essential services in Denmark is outsourced to companies not owned by national entities (Jensen, 2018). These companies may also be foreign-owned and use a network of subcontractors outside national control. Society has evolved from being complicated to being complex, which means that the task of collecting and processing relevant information in response to a crisis can be overwhelming if a central authority is to handle it (Jensen, 2018). In Denmark, national legislation, such as the "Emergency Management Act," operates under the principle of sector responsibility, where it is up to each minister within their area of responsibility to plan and maintain societal functions in the event of accidents or disasters. According to DCSA (2023, p. 13), Denmark works with 15 societal vital sectors:

- (1) energy;
- (2) information and communication technology;
- (3) transportation;
- (4) emergency services, police and civil protection;
- (5) health;
- (6) social affairs;
- (7) drinking water and food;
- (8) wastewater and waste management;
- (9) finance and economy;
- (10) education and research;
- (11) meteorology;
- (12) defense, intelligence and security services;
- (13) foreign service;
- (14) general law enforcement; and
- (15) cross-sector crisis management.

Within these 15 sectors, 112 societal vital functions have been identified (DCSA, 2023, pp. 34–38). Societal vital functions are, for example, data and voice transmission via

telecommunications networks, including mobile networks; data processing or data storage and satellite, radio and TV transmission under information and communications technology as a societal vital sector.

Segmentation theory

Segmentation and portfolio theory are well-established today across a range of academic disciplines. The fundamental idea is to segment a set of objects such as markets, customers and projects into various management categories based on a set of variables that depend on the purpose of the segmentation (Freytag and Mols, 2001). In this way, segmentation becomes a method for considering a portfolio, allocating resources and adjusting management attention according to the different segments in the portfolio (Mahajan and Jain, 1978). Since the 1950s, segmentation and portfolio theory have been applied in many different areas. Segmentation models are used, for example, to categorize suppliers, products or services into different groups based on specific criteria such as value, risk, costs, or market dynamics. These models help organizations, for instance, tailor their purchasing strategies to each segment, which should ensure effective resource allocation, risk management and value maximization. For example, suppliers can be segmented into categories such as strategic, bottleneck, leverage, or non-critical (Kraljic, 1983), allowing procurement teams to prioritize efforts and establish targeted collaboration strategies. Similarly, products or services can be segmented based on complexity or criticality to optimize purchasing decisions and supplier relationships. Segmentation models are used across many different fields such as marketing (Cortez *et al.*, 2021), sales (Bucklin *et al.*, 1998), buyers' and sellers' international strategies (Andersson and Servais, 2010), healthcare (Lynn *et al.*, 2007) and coopetition (cooperative competition) in a public context (Stentoft *et al.*, 2018).

Segmentation models have received several criticisms. Although they are easy to understand, they have been criticized for being too simplistic (Dubois and Pedersen, 2002), too normative (Gelderman and Van Weele, 2005) and too static (Hesping and Schiele, 2015). To address these criticisms, it is important that the segmentation work be repeated at regular intervals to account for dynamic societal developments and incorporate further analyses as a supplement to the segmentation.

Process theory

This article is based on process theory, which examines how specific outcomes are achieved through a sequence of actions and events, taking into account specific inputs (Van de Ven and Huber, 1990). Process data includes narratives that describe what happened, who was involved and when, including events, activities and decisions over time (Langley, 1999). Process research is crucial for addressing questions related to "how" (Bizzi and Langley, 2012). According to Van de Ven and Huber (1990), the fundamental components of process theory are input, actions and events and consequences.

Input is associated with the assumptions that initiate the process. In this context, it may involve pandemics like COVID-19, climatic changes and increasing geopolitical tensions with threat levels and segmentation of society-critical functions. Such inputs can create awareness of the need to strengthen supply security for societal vital functions. Actions and events represent the specific initiatives that sectors of critical infrastructure must undertake. Who is involved, what tasks are performed, when and in what order? Examples of such activities include mapping supply chains for society-critical functions, assessing vulnerabilities for these functions, including risk assessments and creating action plans for risk mitigation and strengthening capabilities. Consequences are the final outcomes of the theorized process. These may include prioritized action plans consisting of activities and

projects necessary to ensure SCRES for specific society-critical sectors and critical infrastructures.

Method

This paper is based on both primary and secondary data. The primary data is developed by qualitative interviews with a Head of Department at the Danish Resiliency Agency in December 2024. Two interviews were conducted. The first interview was based on the interview guide in [Appendix](#). The purpose with the interview was to further develop a segmentation model of societal vital sectors developed by [Stentoft and Mikkelsen \(2023\)](#) that included eight societal critical sectors in Denmark, so the segmentation covers all 15 societal critical sectors. Furthermore, the interviews were concerned about the application of a four phased supply chain resilience process model developed by [Stentoft and Mikkelsen \(2024\)](#) in societal vital sectors. The four phases in the process model are:

- (1) supply chain mapping of the societal vital sector;
- (2) assessment of probability and consequences for incident types;
- (3) identifying vulnerabilities for the societal vital functions and conducting risk management; and
- (4) developing actions plans for risk mitigation.

The second interview was a verification interview with a focus on getting feedback (member check cf. [Maxwell, 1996](#), p. 94) on the revised segmentation model of societal vital sectors and the SCRES model for societal vital sectors. The two interviews were recorded and transcribed. To ensure inter-rater reliability, the authors collaborated during the data validation and interpretation process ([DeCuir-Gunby et al., 2011](#)). In addition, the research team jointly reviewed and discussed the validation and interpretation of the interview findings after the completion of the data analysis.

The secondary data consists of the data analysis included in [Stentoft and Mikkelsen \(2023\)](#) based on eight interviews carried out in January and the beginning of March 2023. These interviews have formed the grounding structure of the segmentation model with its two axes that is presented in the next section. Three interviews were carried out with employees from the former Danish Critical Supply Agency (DCSA) [now Danish Resilience Agency (DRA)]. Five interviews were carried out with five representatives from societal vital sectors (drinking water and food, energy, transportation and health). Two interviews were conducted with different informants regarding drinking water and food, as responsibility for these areas lay with two different ministries. Finally, one interview was carried out with a chief consultant from DCSA concerning the critical societal sectors of emergency services, police and civil protection, defense and intelligence and security agencies, information and communication technology and wastewater and waste management.

Segmentation of societal vital sectors

Major supply chain disruptions caused by, e.g. pandemics, energy crises and geopolitical tensions, put much pressure on public sector supply chains. To advance the understanding of the complexities to build SCRES in societal vital sectors [Stentoft and Mikkelsen \(2023\)](#) introduced a segmentation model of societal vital sectors. Their paper identified challenges to ensure SCRES due to a public system based on significant differences across societal vital sectors in terms of degree of privatization (number of private actors) and degree of central state governance. The segmentation model is based on two dimensions:

- (1) the degree of central government control of the sector; and
- (2) the degree of privatization of the sector.

The degree of central government control refers to the extent to which governance responsibility and authority are centralized or decentralized at the national, regional or municipal level (or a combination thereof). This dimension indicates the government's decision-making power to allocate resources to the sectors in times of crisis. Denmark has three levels of public governance: the national level with the government and parliament, the regional level with regional councils and the municipal level with city councils. The more levels involved, the more complex the task. Similarly, different sectors have varying compliance cultures concerning, for example, regulations and directives.

The degree of privatization refers to the extent to which activities are carried out within the boundaries of the public sector or whether the activities are outsourced to private actors. It concerns how much of the value chain is managed within the public sector's boundaries and thus the degree of intervention power that local or central public authorities have over the sector. This dimension indicates the complexity of ensuring resilience and supply security among sectors. In sectors with a high degree of privatization, it is more challenging for public authorities to intervene in crisis situations and allocate resources in the sectors.

Figure 1 illustrates a proposed segmentation model of the 15 Danish societal vital sectors described in DCSA (2023), which is an adaptation of Stentoft and Mikkelsen (2023) that originally only included 9 of the 15 sectors. The new segmentation model is developed based on an interview with a Head of Department, Danish Resilience Agency (December 2024). As shown in Figure 1, Health is placed in both low and high degrees of privatization. This indicates that segmentation solely at the sector level will be too coarse for some sectors, which is why it may be recommended to segment the societal vital functions identified within each societal vital sector. In resilience planning, e.g. health, it is not sufficient to simply categorize sectors as "public" or "private." Instead, there should be a more nuanced approach that segments each sector based on the societal vital functions they perform. For instance, within the health sector, some functions (like emergency medical services) may be predominantly public, while others (like private hospitals or pharmaceutical supply chains) may be largely private. By segmenting societal vital sectors into their specific critical functions, policymakers and organizations can design more targeted resilience measures, ensuring that both public and private aspects of these sectors are adequately protected and supported during disruptions.

Cell 1 (low/low): In this quadrant, both the degree of central control and privatization are low. Tasks and activities in this quadrant are therefore carried out within the public sector framework. At the same time, governance competence is delegated to regional and/or local authorities, meaning that the degree of direct intervention from the central government is low.

Cell 2 (high/low): In this quadrant, the degree of central control is high, reflecting that activities are centrally managed and monitored at the state level with a high degree of direct intervention. Conversely, the degree of privatization is low, as activities are carried out within the public hierarchical framework.

Cell 3 (low/high): In this quadrant, the degree of central government control is low, while the degree of privatization is high. The sector is regulated through legislation and directives. However, governance competence is delegated to regional and/or local authorities, meaning that the degree of direct state intervention is low, while most activities in the supply chain are carried out outside the public framework by private companies.

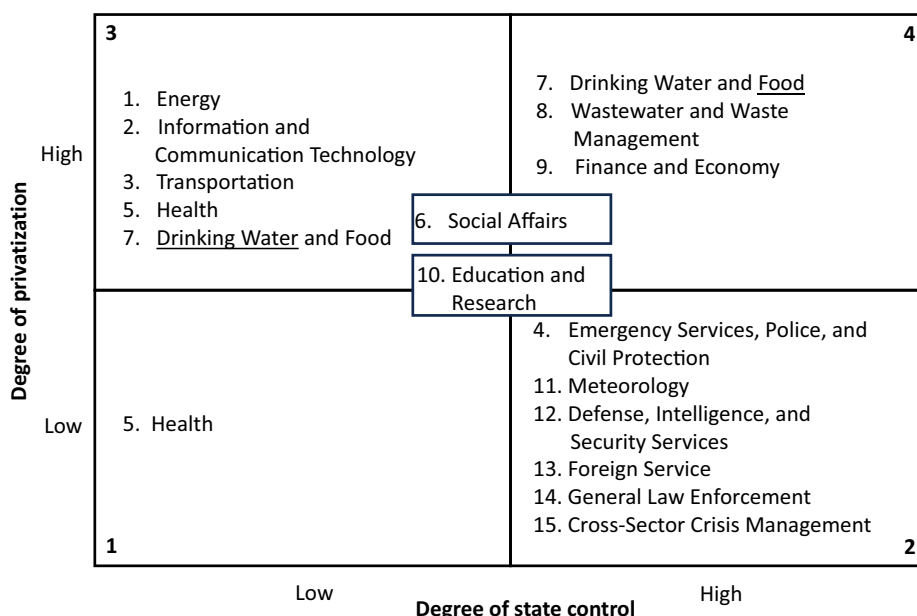


Figure 1. A segmentation of societal vital sectors

Note: Figure 1 includes all 15 Danish societal vital sectors, of which the following seven sectors have been added compared with the first version presented by [Stentoft and Mikkelsen \(2023\)](#): Social Affairs, Finance and Economy, Education and Research, Meteorology, Foreign Service, General Law Enforcement and Cross-Sector Crisis Management

Source: Further development of [Stentoft and Mikkelsen \(2023\)](#)

Cell 4 (high/high): In this quadrant, both the degree of central government control and privatization are high. The majority of activities in this cell are carried out by private companies outside the public framework. The state's governance and control in this quadrant are high but are not executed through direct intervention; instead, they occur through directives, legislation and central state institutions.

As shown in [Figure 1](#), health is positioned in both low and high degrees of privatization. This indicates that segmentation solely at the sector level may be too coarse for some sectors. Therefore, it is recommended to further segment the individual societal vital functions identified within each societal vital sector. Similarly, social affairs are positioned with both low and high degrees of privatization, while education and research appear in all four cells. In other words, some sectors do not clearly fall into a single quadrant.

The process of segmenting sectors should help highlight that tasks related to ensuring SCRES across sectors differ and therefore require different approaches. When applying [Figure 1](#) specifically to the societal vital functions within a societal vital sector, one could find that the individual functions could be placed at different points in the matrix. This can, for example, occur in societal vital functions such as “maintaining daycare services,” “after-school programs,” “care and support for the elderly, people with disabilities, the chronically ill, vulnerable, and marginalized individuals,” as well as in “spiritual support and funeral services” under the societal vital sector of social affairs. A given placement would require

EBR dialogue among participants, which, in addition to staff from MSRC, could benefit from involving employees within the specific sector.

A process model for achieving supply chain resilience in societal vital sectors and functions
Inspired by the process model for SCRES in production SMEs by [Stentoft and Mikkelsen \(2024\)](#), a process model is proposed to create SCRES for societal vital sectors, as shown in [Figure 2](#). The figure incorporates elements from the applied process theory, such as input, actions and events and consequences. Compared to [Stentoft and Mikkelsen \(2024\)](#), the level of analysis differs, but the main steps are the same, shifting from a company perspective to a societal vital sector perspective. The input to the process model is the segmentation of societal vital sectors and functions, facilitated by, for example, MSRC ([DCSA, 2023, p. 20](#)) or, for MSRC, by entities such as DCSA. Based on an interview with a Head of Department, Danish Resilience Agency (see [Appendix](#)), the process model by [Stentoft and Mikkelsen \(2024\)](#) was discussed regarding its implication at a societal level. This interview stressed the importance of a clear starting point from the segmentation analysis, and then the importance of acknowledging the importance of the 112 societal vital functions among the 15 societal vital sectors. The prior segmentation serves to improve the consciousness of the different complexities of the 15 societal vital sections and their functions before the activities in the process model are initiated. The importance of the segmentation is justified as follows:

It is important to understand that we are working with different societal vital sectors. We need to treat the sectors differently to treat them equally in terms of supply security. It is crucial that the responsible authorities behind the sectors understand this. – Head of Department, Danish Resilience Agency

The actions and events can be carried out by each societal vital sector with continuous support from MSRC and include: Phase 1: Mapping the supply chains for societal vital

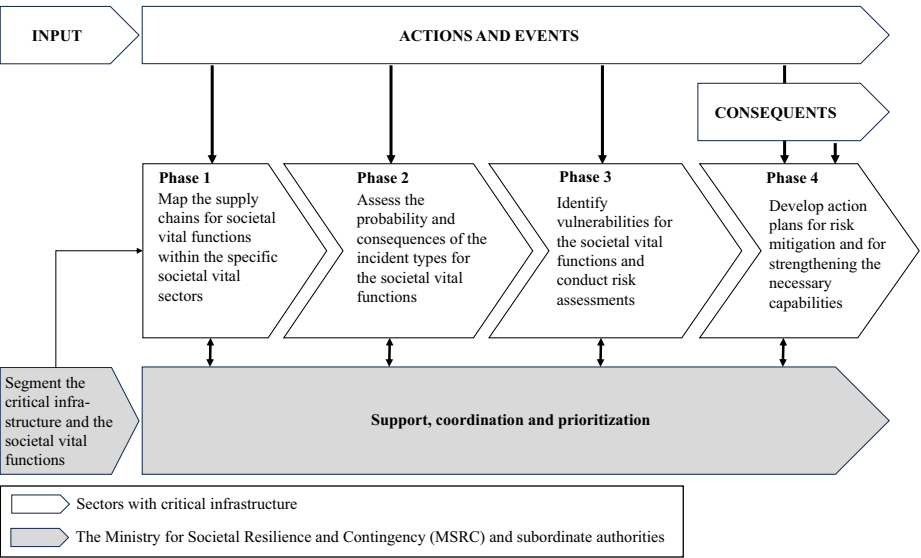


Figure 2. A process model to achieve supply chain resilience in societal vital sectors
Source: [Stentoft \(2025, p. 79\)](#)

functions within the specific societal vital sector; Phase 2: Assessing the probability and consequences of incidents for the societal vital functions; Phase 3: Identifying vulnerabilities in the societal vital functions and conducting a risk assessment; and Phase 4: Developing action plans for risk mitigation and strengthening the necessary capabilities. The consequences also include the development of action plans, which must subsequently be monitored for implementation.

Mapping the supply chains for societal vital sectors and their vital functions

The first phase of the process model involves mapping the supply chains for the societal vital functions within the specific societal vital sector. The input to this phase is the segmentation work of the critical infrastructure and its functions, which are being actively worked on. According to [Wood \(1992\)](#), mapping the supply chain can provide deep insights into reality, leading to new understandings. By visualizing material flows between different actors, it is possible to gain an understanding of the complexity ([Craighead et al., 2007](#); [Iftikhar et al., 2022](#)). Concerning Phase 1 in the process model, the Head of Department commented:

If we take your model with the four phases, we first need to outline how our structures are set up. There are some societal vital sectors, some societal vital functions, and some critical infrastructure. We need this to understand which playing field we want to focus on and conduct our analysis. We need to look at these elements in the first phase. – Head of Department, Danish Resilience Agency

Mapping the supply chain is a comprehensive task, so it is recommended to start with the most critical parts of the supply chain based on the initial segmentation and then map suppliers and their suppliers as far back in the chain as possible ([DCSA, 2024](#), p. 7). For example, the societal vital function of “Law enforcement and crime prevention, including prevention and investigation” under the societal vital sector Emergency Preparedness, Police and Civil Protection can quickly become complex when mapping the actors involved. A core task here is patrolling, which depends on a number of critical resources such as personnel, vehicles, fuel, radios, phones, GPS devices, weapons, ammunition, police signs and uniforms. The output of this phase is the mapping of supply chains for the prioritized functions within the analyzed sector.

Assessing the probability and consequences of incidents for the societal vital functions

Phase 2 of the process model focuses on assessing the probability and consequences of incidents for the societal vital functions as described by the DRA ([DRA Danish Resilience Agency, 2025](#)) in the national risk profile. Regarding Phase 2, the interviewee further highlighted the importance of referring to common concepts in the public sector to avoid introducing a new set of concepts and terminologies that could make an already complex area even more complicated:

When you reach Phase 2, you will gain much support if you integrate a national risk and vulnerability analysis into the evaluation part of Phase 2 (ed. [DRA Danish Resilience Agency, 2025](#)). All the valuable parameters identified in phase one should now be measured against the vulnerabilities related to them, and to do this, one must understand the threat landscape. Therefore, the national threat landscape should be included as part of Phase 2. – Head of Department, Danish Resilience Agency

The prioritized societal vital functions from Phase 1 are evaluated individually in relation to types of incidents, including an assessment of the probability of these incidents (ranging from 1 = very low probability to 5 = very high probability) (see assessment scheme in [Table 1](#)). This activity is included to assess what level of security there should be prepared for. Different security levels have different price tags, which is important to acknowledge

Table 1. Assessment matrix for different types of incidents, their likelihood and consequences

Types of incidents	Probability (1–5)	Level of consequence			
		Insignificant	Noticeable	Serious	Very serious
Cyber incidents					
Shortage of energy					
Nuclear incidents					
Maritime incidents					
Transportation incidents					
Chemical incidents					
Water and foodborne risks					
Animal diseases					
Infectious diseases					
Heat waves					
Drought					
Coastal flooding					
Extreme rain					
Storms and hurricanes					
Terrorist acts					
Space incidents					

Source(s): Based [DRA Danish Resilience Agency \(2025\)](#) and [DEMA Danish Emergency Management Agency \(2022, p. 20\)](#)

when financial resources are scarce. The risk tolerances by [DEMA Danish Emergency Management Agency \(2022\)](#) can be used which essentially express the thresholds for which consequences are acceptable, and which are not. In addition, an assessment is made of the consequences for the societal vital functions if these incidents occur, where the classification from Insignificant to Very Serious is borrowed from [DEMA Danish Emergency Management Agency \(2022, p. 20\)](#). The output is a concrete assessment of the types of incidents and a consequence evaluation of these incidents for the societal vital functions.

Identify vulnerabilities in societal vital functions and conduct risk assessment

In the third phase, the prioritized and most societal vital functions are analyzed in greater depth to uncover the vulnerabilities that the current setup entails. For each of the societal vital functions, a risk assessment should be conducted, evaluating the likelihood that the functions will be disrupted and the impact this will have on operations. Phase 3 in the SCRES process model for societal vital sectors seems to be similar to the process model developed by [Stentoft and Mikkelsen \(2024\)](#):

In Phase 3, it gives sense to identify the specific vulnerabilities of the societal vital functions based on Phase 2, along with a concrete risk assessment (likelihood and impact). – Head of Department, Danish Resilience Agency

The output of this phase is specific vulnerability and risk assessments of the societal vital functions. The identified vulnerabilities in each societal vital sector could beneficially be shared across sectors, which could be a task for the MSRC or a subordinate authority.

Develop action plans for risk mitigation and for strengthening capabilities

In Phase 4, action plans are developed to mitigate the identified vulnerabilities. Which capabilities should be prioritized, and to what threat level should these capabilities be developed? The output may result in a concrete list of areas that need to be strengthened

within the specific societal vital sector. Again, it is important that this work is done in collaboration between employees from the specific societal vital sector and MSRC, or an underlying authority, to ensure coordination across sectors and to provide a foundation for making overarching cross-sector priorities in a crisis situation. The interviewee again found a similarity of the Phase 4 with the similar phase in the process model by [Stentoft and Mikkelsen \(2024\)](#):

The first three phases identify areas where resources should be prioritized to mitigate identified risks by strengthening specific capabilities. I see no difference in these activities within the context of societal vital sectors compared to what happens in manufacturing companies. – Head of Department, Danish Resilience Agency

Discussion

The discussion surrounding SCRES, particularly in the context of critical infrastructure, has gained significant traction in recent years, especially in light of the disruptions caused by the COVID-19 pandemic. The pandemic exemplified the vulnerabilities inherent in global supply chains, leading to widespread shutdowns and panic buying, which in turn placed immense pressure on critical infrastructure systems. This situation has underscored the necessity for a comprehensive understanding of how supply chains operate within the framework of critical infrastructure, which is characterized by a complex web of interdependencies ([OECD, 2019](#), p. 22; [Oliver et al., 2022](#); [Roman et al., 2023](#)). Disruptions in one sector can have cascading effects across others, highlighting the interconnectedness of supply chains and critical infrastructure.

The application of process theory provides a valuable lens through which to analyze these dynamics. Process theory emphasizes the sequence of actions and events that lead to specific outcomes, allowing researchers to dissect the intricate relationships between inputs, actions and consequences in SCRES ([Stentoft and Mikkelsen, 2024](#); [Van de Ven and Huber, 1990](#)). By leveraging this theoretical framework, scholars can gain a deeper understanding of how resilience can be built within supply chains, especially in high-stakes societal vital sectors. For instance, identifying vulnerabilities within supply chains and determining the necessary capabilities to address these vulnerabilities is a crucial step toward enhancing resilience ([Pettit et al., 2019](#); [Stentoft and Mikkelsen, 2024](#)). This approach not only aids in anticipating disruptions but also equips organizations with the tools needed to mitigate their impact effectively.

Moreover, the segmentation of societal vital sectors and functions based on their complexity or criticality is an essential element in the process of ensuring SCRES. Furthermore, the collaborative management of critical infrastructure between public and private sectors is paramount for building resilience ([Normann and Ahre, 2024](#); [Stewart et al., 2009](#)). As many essential services are outsourced to private entities, often with foreign ownership, the need for effective collaboration with governments becomes increasingly important. This partnership can facilitate the sharing of resources and information, ultimately leading to more sustainable and effective responses during crises.

The interplay between SCRES and critical infrastructure is multifaceted and requires a nuanced understanding of both theoretical frameworks and practical applications. By leveraging process theory and adopting strategic segmentation, public authorities can enhance their resilience against disruptions. In addition, fostering collaboration between public and private sectors will be essential in navigating the complexities of globalized supply chains, ensuring that critical infrastructure remains robust in the face of future challenges. The paper is in line with the thoughts of the OECD paper by [Thakur-Weigold](#)

and Miroudot (2024) by emphasizing the interconnected nature of supply chains and critical infrastructure, highlighting how disruptions can have cascading effects across sectors. This aligns with the OECD report's focus on resilience as more than just securing supply chains; it is about improving the entire system's performance through strategic collaboration and risk management. Both businesses and governments must enhance resilience through comprehensive risk management and strategic partnerships their call for governments to play a facilitating role during extreme crises. The presented process model is step toward such a facilitation.

Conclusion

This article aims to analyze how to work toward ensuring SCRES in the 15 Danish societal vital sectors with their 112 associated societal vital functions. In 2024, MSRC was established with the purpose of thinking about preparedness across sectors by preventing, resisting and managing threats and crises that challenge the fundamental functions and security of Danish society, while ensuring continued stability and supply security. In Denmark, individual sectors operate under a sector responsibility principle, which means that the authority responsible for a task on a daily basis retains responsibility for the task during a major disaster or crisis. During the COVID-19 pandemic, we witnessed the Prime Minister's Office taking on both strategic and operational tasks with the overall coordination and allocation of resources, developing and implementing restrictions across sectors and ministries, ongoing communication and planning for reopening. At that time, there was no corrective ministry like MSRC, and the heightened threat scenarios now make the government proactively work through MSRC to strengthen, among other things, supply security. However, the mandate for MSRC still seems unclear, with roles, responsibilities and resources overlapping multiple areas of government responsibility.

A segmentation model has been proposed based on the dimensions of the degree of governmental control and the degree of privatization. By segmenting the societal vital sectors and the vital functions, it becomes clear that the tasks related to securing supply security vary in scope and complexity, which points to a differentiated approach to advising the sectors. As described earlier, segmentation models face criticism (too simple, normative and static), which it is important to be aware of. While reality is more complex than a simple 2 x 2 matrix, these frameworks offer a practical approach to navigating intricate areas like societal vital sector supply chains. This segmentation can be further enriched with complementary analyses and should be revisited regularly to account for ongoing changes and developments. Based on process theory, a four-phase process model is proposed to help the sectors create SCRES with assistance from MSRC and underlying authorities. Experience from Stentoft and Mikkelsen's (2024) process model is, among other things, that cross-organizational involvement is important and should be based on the same assumptions, which the four phases of the process model can contribute to. The application of the process model to societal vital sectors should also acknowledge the interconnection of these sectors and how this can lead to domino effects between them. Here, MSRC plays a crucial role with the overall overview.

Implications for theory and practice

This study has several implications for theory as well as practice. First, for theory the definition of critical infrastructure may help to refine theoretical frameworks in fields like risk management and resilience theory. Understanding which assets, networks and

systems are essential for societal function requires scholars to categorize and prioritize components in a broader theoretical context. Second, the growing importance of critical infrastructure invites interdisciplinary research that integrates fields like engineering, social sciences, economics and cybersecurity. This requires the development of new theories to bridge gaps between technical, social and policy perspectives. Third, critical infrastructure challenges the way we view systems as isolated entities. It underscores the interdependence between different sectors (e.g. energy, transport and health) and highlights an untapped potential to develop theories that consider such connections and their vulnerabilities and capabilities needed. For practice, the paper also points to some implications. First, understanding the role of critical infrastructure may drive policy decisions on national security, public safety and economic stability. Governments must design regulations, protective measures and contingency plans to safeguard infrastructure from both natural and human-made threats. Second, identifying critical infrastructure informs where resources and investments should be allocated. This could influence decisions about upgrading or securing aging infrastructure or developing new practices to ensure continued services during emergencies or disruptions. Third, critical infrastructure often spans both public and private sectors. The process approach outlined in this paper may be relevant for private actors that are supplying goods and services to societal vital infrastructures and functions. This calls for collaboration between governments, businesses and civil society. This might include sharing data, joint planning and coordinated response strategies to ensure the robustness of critical systems.

Limitations and suggestions for future research

The paper has several noteworthy limitations. First, it is a general review that relies on secondary data and a reflective approach. As a result, the proposed process and approach may require further investigation, particularly in engaging employees from various critical infrastructures and the MSRC. Second, the study focuses on critical infrastructure in Denmark, which may differ significantly from that in other European countries. Future research could examine practices across European countries to provide a broader basis for comparison and learning. Third, critical infrastructure in Denmark is owned by both private and public entities. Despite existing legislation, this ownership structure poses challenges for state management – specifically, the extent to which the new MSRC has the authority to prioritize resources across critical infrastructures during major societal incidents. Therefore, future research should explore these governance principles from a dynamic perspective. Fourth, the process model emphasizes societally vital sectors and functions from a state perspective. The supply chains supporting these sectors and functions may be part of broader global value chains that influence their performance. Although the present paper does not focus directly on a global value chain perspective, addressing this aspect is considered highly relevant for future research.

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Appendix. Interview guide

- (1) Which societal vital sectors and functions exist in Denmark?
- (2) How are the societal vital sectors placed in the segmentation model?
- (3) To what extent do you think the phase model for supply chain resilience developed for manufacturing SMEs can be applied to societal vital sectors and functions?
 - Are the four phases appropriate?
 - Is the description of the content accurate?
- (4) What is the interaction between the 15 societal vital sectors and the Ministry of Societal Resilience and Contingency in the process?

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