Alternatives for securing critical supply
Emergency supply of manufactured parts in crises

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ABSTRACT

Purpose
When faced with severe crises or war, Swedish authorities need to adaptively secure supply of critical components for their operations. They are in this dependent on industry's production system and supply chain (SC) network. When critical shortages occur, alternatives need to be investigated and developed quickly. This paper aims to present a methodology and way of work to review SC alternatives and developing solutions when an acute shortage is at hand.

Design/methodology/approach
The paper presents action-research based work, performed within a project developing resilient SC-management. An iterative scenario workshop approach was applied to develop and test the methodology. The workshops were performed in a simulated crisis-situation setting. Participating authorities oversaw infrastructural functions and a simulated component shortage, while a cross functional team of researchers and experts applied the methods to find solutions to the situation. The workshop goal was to find and develop several parallel solutions to each shortage situation. Between workshops, literature search, discussion and trials with practitioners, and cross functional process development was done.

Findings
The findings resulted in a guideline for the process from identifying a need to initiating parallel solutions to resolve a shortage. Available materials, production techniques, and critical product-specific characteristics were identified and investigated within the workshops. The solutions were based on four main redesign concepts:

- *Re-sourcing/Sourcing of equivalent product(s)*
- *Reuse via washing/repair/recycling*
- *Reverse engineering - copying existing product*
- *Product development - developing a new product*

Research limitations
The conducted workshops were designed with predefined specific conditions, such as national localization for solution application, logistical challenges, and import restrictions.

Practical, managerial and societal implications

The research was part of a larger research project where the aim was to support Swedish authorities in their development of resilience and security of supply. Both practical results and methodological development of how to perform supply chain scenario workshop simulations will be used by authorities.

Original/value

There exist several studies on how to proactively redesign supply chains to be more resilient, but less papers focus on how to redesign the supply when shortage occurs in crisis situations. This paper contributes with empirical research on such situations.

Keywords: Emergency supply, Scenario workshop simulation, Action research, Supply chain resiliens

1. INTRODUCTION

In recent years, global events and the resulting disruptions in supply chains have highlighted the vulnerability of access to products essential for societal functioning. The significantly deteriorated security situation in Sweden's immediate vicinity has also accelerated the country's total defence planning. Consequently, there is a clear and urgent need to develop and strengthen preparedness capabilities, particularly concerning protective equipment and their components. In their challenges of re-building a total defence strategy for severe crises or war, Swedish authorities need to develop methods/approaches to secure supply of critical components for their operations (Stenerus and Ingemarsdotter 2021). They are in this dependent on industry's production system and supply chain (SC) network and thus need to work in an adaptive way with industry capabilities. When critical shortages have occurred (or is about to occur) in the present supply chain, alternatives need to be investigated and developed quickly.

Numerous strategies to increase resilience of the SC (Christopher and Peck 2004; Durugbo and Al-Balushi 2023; Ho et al., 2015) have been published for different settings. Many papers focus on design of resilient SCs and SC-management. Less papers are published that regards re-design of the SC when a crisis shortage has already occurred or started. Here, a need exists to explore the sociotechnical problem of performing structured analysis and development while having lack of resources such as time, information, and/or materials. If applying a resource-based view the redesign of the SC occurs from a situation where the products have low value but a crisis turns the availability around and products become more valuable.

This paper presents an action research-based development of a methodology for supply chain redesign during crises, with the aim of facilitating collaboration between the public sector and industry to enable effective utilization of alternative industrial production capacity. The research introduces and tests a scenario-based approach for developing solutions to supply shortages under conditions of constrained information, illustrated through a case study that demonstrates how alternative strategies can be systematically reviewed and implemented in crisis contexts.

2. BACKGROUND

2.1. Supply chain resilience

Literature describes how to increase resilience of SCs (Christopher and Peck 2004; Durugbo and Al-Balushi 2023; Ho et al., 2015). Resilience of an operation such as supply chain operation can be seen as the ability to manage a crisis situation in a time and level of performance, which is bearable. Here response, recovery and adaptation to the new situation are important when hit by a crisis situation not planned for (Ekström 2025) When in a crisis situation, supply chain agility consisting of supply chain visibility and supply chain velocity is important for building resilience in the supply chain (Christopher and Peck, 2004). Numerous supply chain strategies exist to cope with disturbed supply. Simangunsong et al., (2012) categorise 10 strategies to reduce and 11 strategies to cope with supply chain disturbances. Some of these, like postponement or delivery flexibility cannot be used for critical supply, but especially process flexibility, customer flexibility, multiple suppliers and collaboration can be considered when a crisis situation has developed and there is a lack of critical materials.

2.2. Production strategy and development

Production strategy is the strategic matching of market demands with the production organizations resources and capabilities (Mats Winroth, 2004) or how to meet market needs with available resources in terms of equipment, labour, capital and supply chains (see Figure 1). In this study, the production strategy is comparable with the production strategy of a company, but with the distinction that it needs to be aligned with the whole production system's resources and capabilities. It is imperative to understand the limitations of the production system, it cannot produce "everything" (at least not at once) (Acur and Bitici, 2004). Changing production processes takes time so it is necessary to consider what choices of existing supply chains are available for different choices of products that can fulfil the desired function within the bearable time. Here balancing product change and process change is needed, that can allow the resources and capabilities of the production system to meet the needs and requirements of the products. In a crisis this needs to be done fast and often with limited available information.

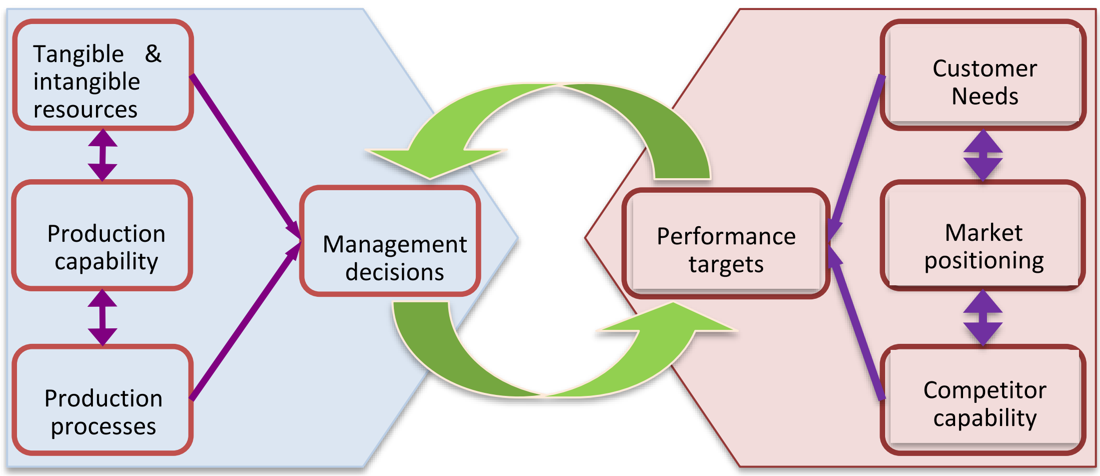

Figure 1. Production strategy redrawn from Winroth 2004).

Normally, in production strategy, one wants to know the volume and design requirements of the product which translates into one or more choices of processes with a certain capability and capacity. In the simplest case, there is a given process with a certain capacity and capability required to make the product. If such a process exists within the existing production system, staff is available and there is a business-wise sound supply of raw materials, then this process is assigned to the production of the desired product. If a sub-process is missing, a decision of make-or-buy the subprocess/subcomponent may be done. Either the subprocess capacity is bought from a subcontractor (subcontracting) or it is developed (built, rebuilt or renovated) internally from own capacity for the sub-process. A special case is 'Greenfield' when no previous processes are in place and a completely new production system is built. The latter may be risky with regards to economical and time frames.

2.3. Emergency production and supply

Emergency production can be said to be a production line that is run in case of emergency and is usually not in continuous use or has to be increased beyond regular supply production capacity (Yang et al., 2024). *Emergency* is defined as "an exceptional event that exceeds the capacity of normal resources and organizations to cope with it" (Alexander2014, section 1.1.1 The nature of disaster). An emergency production can then be interpreted as a production line that is run in case of emergency and is usually not in continuous use (Mattsson et al 2023). When entering a crisis and either the needs of society increase or the overall capacity of the production system decreases, a shortage of products may occur. As in the normal production situation, a make-or-buy decision needs then to be made. Is it possible to purchase the component or process and does the logistics work? If not, is it possible to build up own capability/capacity for the sub-process (by buying a new or second-hand machine) in a proximity where logistics is functioning? In the case of long-term needs, to acquire the missing machine/process to avoid the logistics may still be wanted. It can be a second-hand or a new machine. All sub-options may be available here (e.g. rebuilding or renovating an old machine). The same applies to components, what components can be bought on the market and from whom? Can they be manufactured in own factory instead? Is there a supply of used or discarded components that can be repaired? Even in an emergency, a mass-produced standard component is usually easier to get right than a specially designed custom-made component (whether in-house or a subcontracted process). Paul and Chowdhury (2021) meant that it is important to both develop higher production capacity and employ emergency sourcing and SC collaboration in a crisis.

3. RESEARCH DESIGN AND METHODOLOGY

This action research based empirical work was performed as part of a project developing resilience in authorities SC-management. One part of the project concerned how to find alternatives and develop these when an acute shortage is at hand.

In order to achieve an action learning setting (Bradfield, 2015; Coghlan, 2015), several scenario-based workshops were set up. Here, the axioms defined by Suh (1990), DSM according to Eppinger et al. (1990) and Pugh's complexity number (Pugh, 1991) can be used. These provide insights into the suitability of the various concepts and can be used in a relative ranking of different solution alternatives as depicted in figure 2.

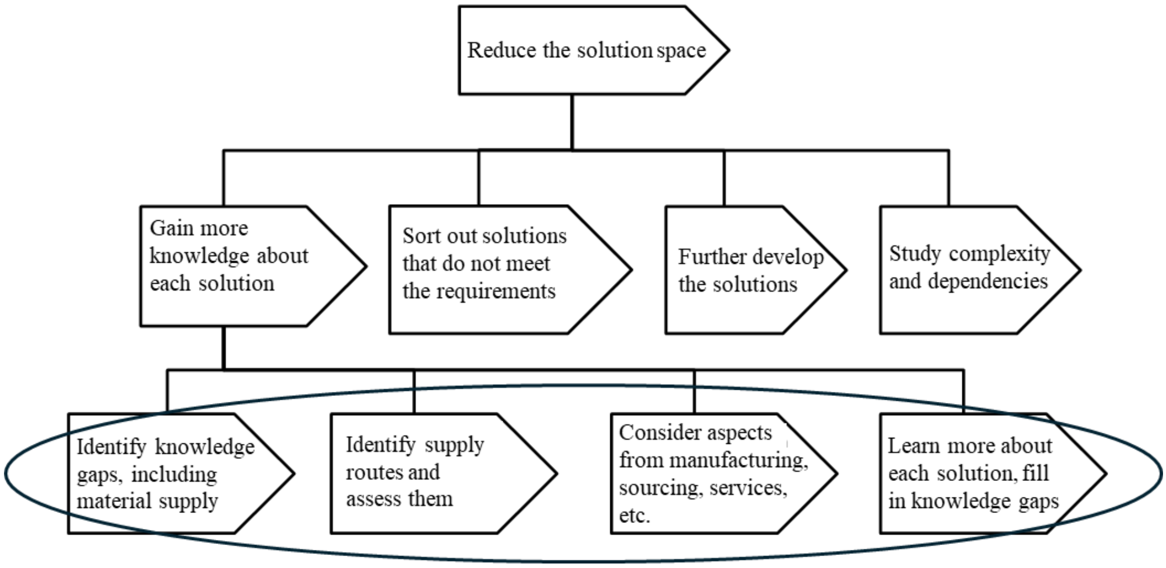

Figure 2. Reduction of solution space

The axioms defined above can be used here. These provide insights into the suitability of the various concepts and can be used in a relative ranking of different solution alternatives.

An iterative scenario workshop simulations approach was applied to develop the methodology. The workshops were performed in a simulated crisis-situation setting. The authorities participating oversaw certain infrastructural functions and a simulated shortage of components, while the participating cross functional team of researchers and experts applied the methods to find solutions to the situation. During the workshops the participants were divided in teams targeting each shortage situation with the aim to find and develop several parallel solutions for acute and large-scale production solutions respectively. The teams were supported on-site by both the stakeholder as well as experts in material substitution and locating available resources. Between workshops literature search, discussion and trials with practitioners, and cross functional development of processes were performed.

4. RESULTS/FINDINGS

The insights and experiences gathered during the conducted workshops served as the basis for the development and evaluation of a structured methodology for emergency production. This methodology was designed to be activated in situations where a shortage of critical products arises or is anticipated in near -time. The results presented in this section reflect the iterative refinement of this approach, based on practical input from stakeholders and scenarios explored during the workshops.

4.1. Emergency production methodology

The proposed methodology for emergency production:

1. Defining the Target Vision and Governance
2. Compiling Product Information
3. Supply Strategies
4. Evaluation and Prioritization of Concept Solutions

5. Initiating Concept Solutions
6. Manufacturing Prototype/Product, Including Packaging
7. Product Verification, Validation, and Certification
8. Documentation

The later phases of the methodology, manufacturing, product verification and documentation, was not conducted during the workshops themselves but completed in between sessions and subsequently presented and discussed within the project group.

4.1.1. Defining the Target Vision and Governance

Before a sourcing strategy could be established, it was necessary to define task governance and structure, as well as to estimate societal needs. A project manager was appointed to oversee communication and ensure progress throughout the process. The project manager was responsible for clearly defining the need—specifying what was to be delivered, in what quantity, and by when. In the absence of this information, the production system development experts appeared uncertain. In some cases, rough estimates were sufficient when exact figures were unavailable. The project manager was also expected to manage evolving conditions, such as changes in requirements, resource availability, or infrastructure, as well as to prioritize among these factors.

4.1.2. Compiling Product Information

This step involved compiling all known information about the product, including its end users, intended purpose, usage and functional descriptions, as well as more detailed aspects such as its construction, materials, manufacturing process, and value chain. The aim was to gather all available documentation and data to serve as a base for informed decision-making in subsequent steps.

Information was gathered through direct dialogue with stakeholders and end users, complemented by a thorough review of available documentation and other relevant sources. These included materials from the responsible authority, as well as applicable certification, classification, and regulatory frameworks. Additional insights were obtained from design documentation, requirements specifications, and user instructions. Technical standards and guidelines issued by standards organizations and technical committees were also reviewed when available. Furthermore, data from testing and verification bodies, risk analyses, and procurement documentation were identified as potential sources of specification of product details. Suppliers, manufacturers, and competitors were recognized as valuable contributors for contextualizing market practices and technical benchmarks.

Based on the compiled product description, the functional and product-specific characteristics critical to fulfilling the product's intended purpose were identified. At this stage, it was recommended to describe requirements based on the desired functions rather than prescribing detailed technical specifications.

To support this process and minimize the risk of overlooking critical requirements and considerations, a checklist was developed. This checklist ensured sufficient product understanding, which formed the basis for continued work. It also helped identify unknown factors whose relevance to the product needed to be assessed.

Product Knowledge Checklist:

- End User — Target group and required expertise
- Purpose & Function — Use context, key and optional feature description
- Construction — Components and materials
- Aesthetics — Colour, texture, transparency, purpose
- Environmental Resistance — Chemical, thermal, humidity, flame
- Geometry & Design — Fit, size, tolerances
- Ergonomics — Interface, light, sound, safety
- Cleanliness — Cleaning and sterilization methods
- Mechanical Strength — Loads, wear, elasticity, stiffness
- Safety Factor — Design margins
- Tribology — Friction and lubrication
- Insulation — Thermal, acoustic, electrical, magnetic
- Functionality — Pressure, absorption, sealing, disinfection
- Assembly — Joining methods
- Use & Storage Environment — Conditions during use, transport, storage
- Durability — Shelf life and stability
- Compatibility — Integration with other systems
- Packaging — Quantity, cleanliness, usability
- Labelling — Standards, clarity, durability
- Environmental Impact — Recycling, separability, hazards, toxicity etc.
- Regulatory Compliance — Standards, classification, certification
- Manufacturers — Existing suppliers
- Partners — Subcontractors, related products
- Value Chain — Lifecycle and stakeholder overview

The development of a requirements specification was carried out as a collaborative effort. To streamline handling and documentation, and thereby optimize the overall process, it was practiced basing the work on established international standards and legal requirements. This approach not only ensured regulatory compliance but also facilitated coordination among stakeholders. Some general aspects that emerged as important considerations when drafting product requirements included both technical and contextual factors. These aspects were identified as important to ensure that proposed solutions would be feasible, effective, and aligned with crisis-related constraints. Key considerations included:

- Use standard materials if available
- Avoid making it a technical specification
- Freedom of choice for different technical solutions

4.1.3. Supply strategies

The scenario exercises, in which scenario leaders used a specific product as a ‘critical shortage item’ revealed several key questions that had to be answered promptly:

- What materials are available?
- What production methods are available?

- Which actors are able to assist?
- Which authority is responsible for the product’s requirements?

To address these questions effectively, it was proposed to assemble a multidisciplinary team with expertise aligned to various solution strategies. This team should include professionals in sourcing (subject-specific), logistics, design, testing/verification/regulatory compliance, production, and automation. The team can be structured and accustomed to adaptive project management practices, with the ability to streamline processes and clearly define the essential product characteristics to be met. Moreover, team members maintain a holistic perspective, understanding the complete process from initial requirements to end objectives, including the verification and validation processes. Equally important is an ability to identify and apply lessons learned from previous experiences, ensuring continuous improvement and increased resilience in future crisis responses.

The two full workshops resulted in the following main concept solutions, see figure 3, which were then developed in parallel to have redundancy and to mitigate delays. Based on the product information and requirements specification compiled, it was determined whether production could be realized through several different concept solution groups:

1. Sourcing of equivalent product(s)
2. Reuse via washing/repair/recycling
3. Reverse engineering — copying existing product(s)
4. Product development — developing a new product

Concept solutions 1 and 2, via alternative suppliers or via reuse/repair, can be initiated immediately with the support of purchasing expertise/supply management and process and workshop expertise respectively.

Concept solution 2, reuse via recycling, is a solution with a slightly longer time perspective and a more extensive process development that requires expertise in recycling process.

Concept solution 3 aims to copy existing product/function based on the assumption that the design basis is available or can be created relatively easily and that the current product material is available.

Concept solution 4 deals with the scenario where material and/or design basis is not available, and a new product has to be developed by replacing the material and/or modifying its design.

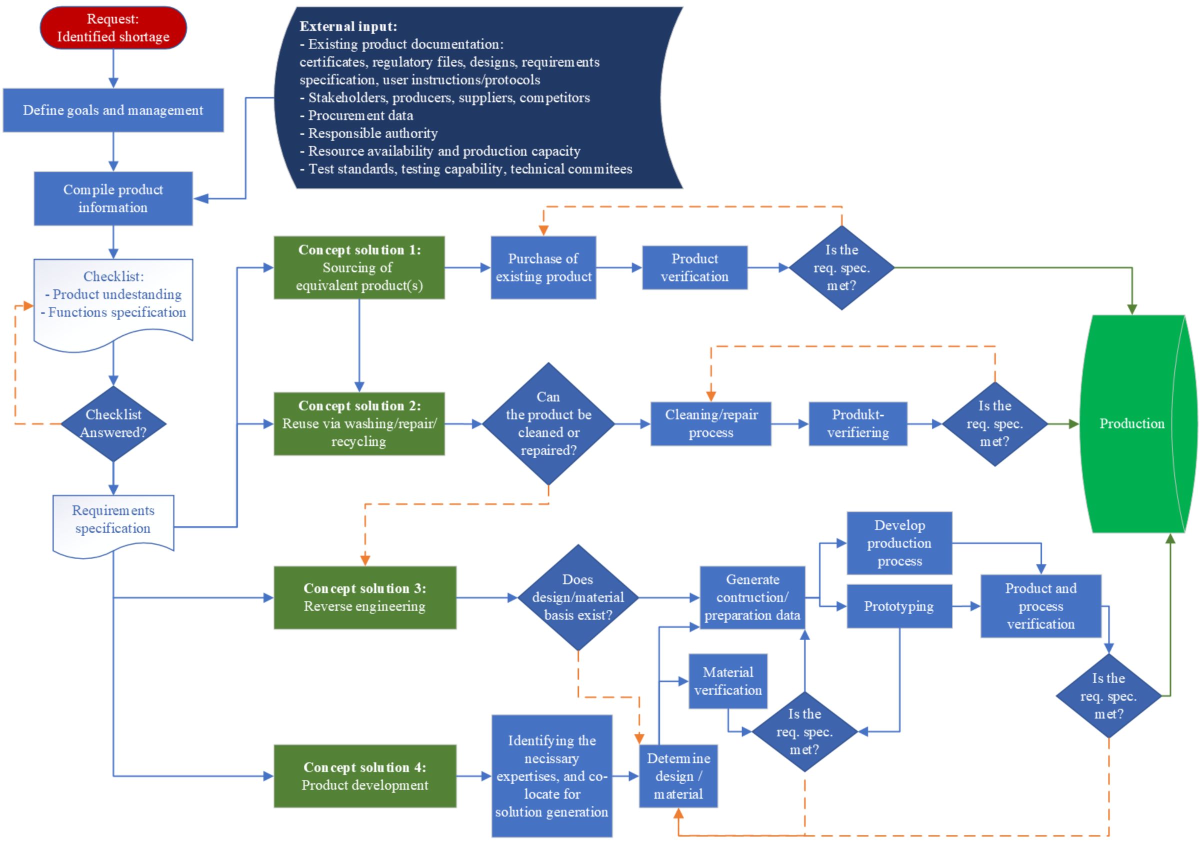

Figure 3. The resulting process model flow chart.

Depending on the prevailing conditions of the crisis, the needs-driven question and the complexity of the product, i.e. the level of uncertainty, it may be necessary to convene a group representing expertise in areas deemed critical from a product or manufacturing perspective. Based on the availability of materials and production technologies, this expert group reflects on various strategies and conceptual solutions. The group is expected to generate several realistic concept proposals, which may involve alternative material selections, design modifications, or new production techniques. These concepts form the base for further investigation and evaluation, supporting the development of feasible and adaptable solutions under crisis conditions.

4.1.4. Evaluation and prioritization of concept solutions

Based on the availability of different materials/production technologies, the strategies and conceptual solutions developed were reflected upon. The suitability of the proposed solutions was assessed, where the capacity of specific production technologies, both in terms of volume and lead time, considered together with other appropriate requirements. An important aspect was whether actors possessed the necessary competences and structures, regarded as a measure of supplier quality. the proposed solutions were summarised and graded in relation to the original production method in a Pugh matrix, see Table 1. The summary then formed the basis for decisions on which to proceed with.

Table 1. Example of a Pugh-matrix, scale -2 to +2 with a reference value of 0.

	Weight	Reference	Concept 1	Concept 2
Criteria 1	1	0	+1	+2
Criteria 2	2	0	-2	+1
Net score		0	-1	3
Weighted score		0	-3	4

It was assessed as more effective to utilise known solutions or new combinations of known solutions rather than relying on new developments in the production process. Relying on simpler and less technologically advanced solutions provided greater flexibility. In addition, avoidance of manufacturing decisions with high technological risk, were preferred. Examples of risks include schedule delays, budget overruns and overestimation of performance (efficiency, production volume). Process design checklists and Failure Mode and Effects Analysis (FMEA), were tools suggested to use for the new process design solutions still needed. With lack of probability and severity data for an FMEA, a qualitative process vulnerability analysis (Kurdve et al., 2024), could still be performed to reduce the potential failure.

Simultaneously, testing protocols in line with the available standards had to be developed to assure that the products produced by each concept fits the product requirements. In the workshops the requirements and test standards were identified but not further developed. Similarly, the last steps of the methodology, concept solution initiation was developed on the basis of previous experience.

4.1.5. Concept Solution Initiation

The different concept solutions should be initiated in parallel, in close collaboration with industry and if needed supported by the established teams of professionals with the relevant expertise. Depending on the specific needs and resource availability, actors located as close to the point of demand as possible are involved. To ensure efficient progress, existing industrial collaborations within each actor’s network are utilized, as establishing new partnerships typically risks delaying the process. For example, companies specializing in product development may already have a network of manufacturers covering all components of a given product, enabling rapid mobilization and streamlined coordination.

Conceptual Solution 1: Sourcing of Equivalent Product

This solution begins by identifying one or more equivalent products from an alternative manufacturer, importer, supplier, or distributor. These actors typically possess extensive knowledge of the market and of comparable products, for which stock is likely available. Identifying such actors, if they exist, is a central part of the process. The selected product may be either similar or, where applicable, significantly different, as long as it meets the established functional requirements. If domestic production of an equivalent product or similar production capacity exists, the process includes assessing the feasibility of supporting production scale-up or modifying the production process to meet the specification requirements. The solution may also involve sourcing an equivalent component or subsystem as a partial solution for a composite product.

Conceptual Solution 2: Reuse via Washing, Repair, or Recycling

This solution focuses on reintroducing products to the market through reuse, washing, repair, or recycling. The approach leverages existing domestic expertise, resources, and infrastructure to develop a refinement process for discarded products, enabling them to be used again. Depending on the product type, the process may involve expertise in materials, cleaning, assembly, and recycling. The work consists of several steps that vary depending on the product value chain. These may include developing protocols for washing or cleaning, disassembly, and troubleshooting to identify and verify functional components. In the remanufacturing of composite products, discarded or defective items often serve as donors of still-functional components. Typically, it is possible to assemble two to three functional products from three to four defective ones. In some cases, worn parts, seals, or protective elements need to be replaced with new components. The repair process may also involve additive manufacturing techniques to restore the product's original shape and function.

Conceptual Solution 3: Reverse Engineering

This solution outlines a product development process that begins with access to design and/or material documentation for the product or components in shortage. Understanding the interaction between multi-component products or systems, as well as how they are assembled, is essential. In cases where documentation is unavailable, the process includes complementary analyses such as dimensional measurement, 3D scanning of geometries, or material analysis to establish the necessary data. The methodology requires information on available production technologies, unit processes, and overall process capabilities, as well as the availability and location of production capacity for the product. In dialogue with identified stakeholders, the party responsible or parties for driving the design process are determined. Based on the defined functional and technical specifications, and considering the availability of materials and manufacturing technologies, industrial actors initiate a preliminary design study. The product design is modified iteratively as needed, i.e., when substituting materials or manufacturing methods. To streamline the optimization process and potentially improve the final product outcome, simulations are used to predict performance. A technical specification for the product and/or tooling is then developed and compiled.

Conceptual Solution 4: Product Development

This solution outlines a product development process initiated in the absence of both design and material documentation for the product intended for production. Similar to Conceptual Solution 3, one or more parallel preliminary design studies are launched based on the defined functional and technical specifications, as well as the availability of materials, production technologies, and production capacity. A new product design is generated in alignment with the available production capabilities. Where necessary, the process considers modifications to existing production processes and capacity-enhancing measures. To streamline the development process and potentially improve the final product outcome, simulations are used to predict performance. A technical specification for the product and/or tooling is then developed and compiled.

4.1.6. Manufacturing Prototype/Product, Including Packaging

While the approach varies by conceptual solution, all aim to produce or release products. This step functions as a feasibility study, where prototypes are iteratively developed and evaluated to identify issues and improvement opportunities. Early-stage tooling for untested designs can be costly and time-consuming. Therefore, alternative methods, such as additive manufacturing (3D printing), are often used to create prototypes that allow for evaluation of key product characteristics. However, 3D printing is limited by material types and may introduce variations in finish and strength, which can constrain what properties are assessed. Once the process is agreed on, design documentation and process protocols are finalized. A production strategy is then defined, along with the necessary tools, equipment, and processes. Packaging solutions are also developed, guided by the product's intended use and specification requirements.

4.1.7. Product Verification, Validation, and Certification

In crisis situations, not all product requirements may be met due to irrelevant specifications, time constraints, or lack of infrastructure. To enable rapid response, established procedures for managing deviations are essential. This requires coordination among stakeholders to assess whether deviations compromise product functionality. During crises, focus shifts to critical functions and safety, often within a narrower scope and timeframe. New methods must be validated for reliability. Verification of product performance and validation of methods should follow existing or adapted standards. Where no testing infrastructure exists, necessary equipment, expertise, and quality systems must be secured.

In the simulations, the product verification and validation were left to the user authority who performed tests in order to verify and validate that the products would work. … Deviations of product performance and understanding where in the production system such deviation stems from becomes more important than in regular production. At the same time is critical.

4.1.8. Documentation

Since the products produced are seen as critical for the societal functions they will support, it is crucial to have a sufficient documentation of what changes has been done compared to the regular process in order to quickly find root cause of deviations of product performance.

Documentation includes several components, such as safety-related materials like risk assessments and CE certificates, as well as safety instructions and user manuals. For products composed of multiple components or involving more complex equipment, it may also be appropriate to include guidance for various operating conditions, settings, and maintenance procedures.

5. DISCUSSION

The conducted workshops were designed with predefined conditions to simulate realistic constraints encountered during national crises. These conditions included the requirement for localised solutions, logistical limitations, and restrictions on import. Within this framework, participants systematically identified and examined available materials, applicable production techniques, and critical product-specific characteristics. The workshops served as a structured environment for exploring how supply challenges could be addressed under constrained circumstances, emphasizing practical feasibility, adaptability, and alignment with national preparedness objectives.

In peacetime crises, heightened states of preparedness, or in the extreme case of war, it is reasonable to anticipate situations where needs escalate rapidly and/or the overall capacity of the production system is reduced—leading to shortages of specific products. In such crisis scenarios, the primary focus often shifts to the functionality and safety of the product, with lead time prioritized over factors such as cost. This shift in priorities underscores the need for flexible and responsive supply strategies that can adapt to urgent and evolving demands.

A key insight from the study was the critical importance of timely access to accurate information and decision-making among the actors involved in crisis response. The ability of stakeholders to collaborate effectively hinges on the availability of relevant data at the right time. Reducing the time from identifying a need to delivering a finished product depends heavily on how quickly and easily certain fundamental questions can be answered, such as:

- What materials are available?
- What production methods can be utilized?
- Which actors have the capacity to contribute?
- Which authority is responsible for the product?

These questions highlight the need for structured information-sharing mechanisms and clearly defined roles and responsibilities. Without such clarity, delays and inefficiencies are likely to arise, undermining the overall effectiveness of the response. The findings suggest that establishing a shared framework for information access and coordination is essential for building a resilient and responsive supply system during crises. The findings are in line with Paul and Chowdhury (2021), with regards to that simultaneously investigating sourcing, production capabilities and collaborative options is essential. The study also confirms that several coping strategies suggested by Simangunsong et al. (2012) such as flexible production processes, use of multiple suppliers and collaboration etcetera are useful in crisis situations.

This research is part of a larger research project where the aim is to support Swedish authorities in their development of resilience and security of supply. Both practical results and methodological development of how to perform supply chain scenario workshop simulations will be used by authorities.

The study is grounded in that a clear and shared process is essential to enable smooth cooperation among various stakeholders, ultimately aiming to reduce the time required to deliver necessary products and services during crises. There exist several studies on how to proactively redesign supply chains to be more resilient, but less papers focus on how to redesign the supply when shortage occurs in crisis situations. This paper contributes with empirical research on such situations. To support this process, we have developed checklists designed to facilitate the rapid collection of the information needed for production.

6. CONCLUSION

This study explored how the supply of products can be effectively managed during crises. The preliminary findings led to the development of a process guideline that spans from identifying a need to initiating parallel solutions aimed at resolving shortages and ensuring the availability of products critical to societal functions. The proposed solutions are based on four main redesign concepts:

- *Re-sourcing/Sourcing of equivalent product(s)*
- *Reuse via washing/repair/recycling*
- *Reverse engineering - copying existing product(s)*
- *Product development - developing a new product*

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REFERENCES

- Acur, N., & Bititci, U. (2004). A balanced approach to strategy process. *International Journal of Operations & Production Management*, *24*(4), 388-408.
- Alexander, D.: Principles of Emergency Planning and Management. Dunedin Academic Press Ltd: e-book (2014). Accessed 03 Apr 2024 https://books.google.se/books?id=c1xwDwAAQBAJ&hl=sv&source=gbs_navlinks_s.
- Beitz, W., Pahl, G., & Grote, K. (1996). Engineering design: a systematic approach. *Mrs Bulletin*, *71*, 30.
- Bradfield, R., Cairns, G., & Wright, G. (2015). Teaching scenario analysis—An action learning pedagogy. *Technological Forecasting and Social Change*, *100*, 44-52.
- Christopher, M., & Peck, H. (2004). Building the resilient supply chain.
- Coghlan, A. (2015). Using scenario-based learning to teach tourism management at the master’s level. *Journal of Hospitality & Tourism Education*, *27*(1), 1-9.
- Durugbo, C. M., & Al-Balushi, Z. (2023). Supply chain management in times of crisis: a systematic review. *Management Review Quarterly*, *73*(3), 1179-1235.
- Ekström, T. (2025). Supply Chain Resilience–An Empirical Exploration of Barriers and Enablers in Military Settings. *Scandinavian Journal of Military Studies*, *8*(1).
- Eppinger, S. D., Whitney, D. E., Smith, R. P., & Gebala, D. A. (1990, September). Organizing the tasks in complex design projects. In *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (Vol. 5251, pp. 39-46). American Society of Mechanical Engineers.
- Ho, W., Zheng, T., Yildiz, H., & Talluri, S. (2015). Supply chain risk management: a literature review. *International journal of production research*, *53*(16), 5031-5069.

- Kurdve, M., Mattsson, S., Thuresson, U., Stenlund, P., Ström, M., & Wäppling-Raaholt, B. (2024). Vulnerability analysis method for manufacturing Case study of emergency production of masks. In *36th Nofoma Conference 2024, Stockholm*.
- Mattsson, S., Kurdve, M., Almström, P., & Skagert, K. (2023). Framework for universal design of digital support and workplace design in industry. *International Journal of Manufacturing Research*, *18*(4), 392-414.
- Paul, S. K., & Chowdhury, P. (2021). A production recovery plan in manufacturing supply chains for a high-demand item during COVID-19. *International Journal of Physical Distribution & Logistics Management*, *51*(2), 104-125.
- Pugh, S., (1991), *Total design*, Addison-Wesley, New York, USA.
- Simangunsong, E., Hendry, L. C., & Stevenson, M. (2012). Supply-chain uncertainty: a review and theoretical foundation for future research. *International journal of production research*, *50*(16), 4493-4523.
- Stenérus Dover, A. & Ingemarsdotter, J. (2021) Nationell försörjningsberedskap. (FOI-R--5174--SE). Totalförsvarets forskningsinstitut. https://www.foi.se/rest-api/report/FOI-R--5174--SE
- Suh (1990) Suh, N. (1990), *The Principles of Design*, New York, NY, USA, Oxford University Press.
- Winroth, M. (2004). *On manufacturing strategies: competing through inter-organizational collaboration* (Doctoral dissertation, Linköpings Universitet).
- Yang, H., Huang, Y., Chen, J., Chen, B., & Shen, Y. (2024). Subsidy strategy for reserving flexible capacity of emergency supply production. *International Transactions in Operational Research*, *31*(1), 316-345.