Supply Chain Digital Twins and Resilience Analysis

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Webinar

September 29, 2021
Agenda

• Ripple effect and resilience in supply chains
• Modeling and digital technology
• Ripple effects during the COVID-19 pandemic
• Digital twins, Viable Supply Chain Model, and Reconfigurable Supply Chain
• Example of supply chain resilience modeling in anyLogistix
Increased interest in supply chain risks and resilience is usually born out of a crisis:

- 1999-2001: floods, September 11, factory fires
- 2008-2009: world economic crisis
- 2011: Fukushima
- 2020-?: COVID-19 pandemic

The COVID-19 pandemic has been a stress-test for supply chain resilience unveiling missing preparedness, insufficient recovery capabilities, and multiple ripple effects across different industries and sectors. Businesses and governments recognized an urgent need to review resilience of supply chains and enhance their resilience for future.
Supply Chain Resilience

- **Supply chain resilience** is the firm’s capability to withstand, adapt, and recover from disruptions to meet customer demand and ensure the target performance.

**Disruption**: An event which is not planned or anticipated and may affect the structure or dynamics of systems.

- Economic and political shocks or changes, Terrorist attacks, Natural disasters, Epidemics, Labor strike, Legal disputes

**Risk = Virus**  
**Resilience = Immune System**

**Ripple Effect**

*Ripple effect* describes the disruption propagation in the supply chain network leading to unavailability of components at different echelons and an associated performance degradation.

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**Ripple Effect**

*Ripple effect* describes the impact of a disruption on SC performance, disruption propagation, and disruption-based scope of changes in the SC structures and parameters.


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State-of-the-Art in OR Methods for coping with the Ripple effect

Network and Complexity Theories
- Bayesian Networks
- Complexity Theory
- Reliability Theory
- Petri Nets
- Markov Chains

Mathematical Optimization
- Mixed-Integer Linear Programming
- Robust Optimization
- Stochastic Optimization

Agent-Based Simulation
- Discrete-Event Simulation
- Systems Dynamics

Simulation


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# Managerial Outcomes

**Network Level:**

*Network and Complexity Sciences*

- Identification of disruption propagation scenarios of different severity
- Stress-testing of SC design proneness to disruption risk propagation
- Identification of critical suppliers and facilities for maintaining SC operations
- Adaptation of SC designs according to the environmental changes

**Process Level:**

*Mathematical Optimization*

- Stress-testing of SC production-distribution plans within differently disrupted network designs
- Analysis of contingency / preparedness plans
- Recovery plan selection

**Control Level:**

*Simulation*

- Analysis of disruption propagations in dynamics with considerations of production and inventory control policies
- Simulation of operations policies during the disruption, in transition to recovery, and in the post-recovery periods

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Ripple Effects during the COVID-19 Pandemic

The ripple effect has been one of the strongest stressors on SC resilience during the COVID-19 pandemic.

- Production stops at suppliers in January 2020 → Closing of ports in February 2020 → Production stops at OEMs in March-April 2020

- Silicon production decrease in Fall 2020 → Semiconductor shortage in December 2020 → Production stops at OEMs in January 2021

- Production capacity shutdown during the pandemic in 2020 → Demand increase during pandemic elimination in 2021 → Product deficits and price increases in the markets in 2021-


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# Adaptation Strategies During the COVID-19 Pandemic

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<tr>
<th>Viable Supply Chain Layers</th>
<th>Adaptation Strategies</th>
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<td>Intertwining</td>
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<td>Ecosystem</td>
<td>Intertwining of different supply chains</td>
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<td>Network</td>
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<td>Resources</td>
<td>Product substitution</td>
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Relative stability in demand and supply in some supply chains over decades led to the formation of a crisis-free management mentality, belief in having risks and uncertainty under control, long-term planning, rigid and lean network structures and planning paradigms – it was all turned upside down during the COVID-19 pandemic. The pandemic challenged supply chain management by introducing a novel and distinct context of order and chaos, controllable and uncontrollable, rigid and fluid, fixed and adaptable, and certain and uncertain.

During the COVID-19 pandemic, the management mentality has been characterized by a sense of crisis. The need to continuously prepare for disruptions, and living in anticipation of disruptions and continuous change instead of long-term stability, have led to an ability to adapt becoming a central supply chain management perspective. Adaptability and survivability became a normal, rather than an exceptional, state.
- what is the role of adaptability in resilience and viability of supply chains, and how to implement inherent adaptability while maintaining profitability?
- should we change from long-term planning to situational reaction paradigm or can we control uncontrollable?
- is planning under chaotic conditions helpful or counterproductive?

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End-to-end-Visibility: From offline modelling to online, data-driven Digital Twins

Physical Supply Chain:

- The digital supply chain model
- At each point of time, it represents the physical supply chain with the actual transportation, inventory, demand, and capacity data.
- Can be used for planning and real-time control decisions

anyLogistix: a digital supply chain twin
Online, data-driven Supply Chain Digital Twins: supply chain resilience in real-time

Combination of simulation, optimization and data analytics constitutes a full stack of technologies to create a **digital supply chain twin** to improve resilience – a model that always represents the state of the network in real-time.

Source: [7]

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Stress-test and review supply chain resilience

- Mapping risk data and supply chain locations
- Simulation of disruption and recovery impacts

<table>
<thead>
<tr>
<th>Risk Data</th>
<th>Supply Chain Model</th>
<th>Performance Analysis</th>
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<tr>
<td>Risk analysis, monitoring and alerts</td>
<td>Proactive resilient supply chain design and reactive recovery planning</td>
<td>Performance impact analysis, selection of stabilization and recovery policies</td>
</tr>
</tbody>
</table>
- COVID-19 Pandemic
- Financial Crisis / Recession
- Suez Canal Crisis
- Stress-testing of the SC designs
- Recovery plan selection
- Possible performance impact
- Real performance impact

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Supply Chain Resilience Analytics

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Sources: [5], [6]
Viability is the ability of a supply chain to maintain itself and **survive** in a changing environment through a redesign of structures and replanning of performance with long-term impacts.

Survivability of a supply chain is its ability to continue to exist and secure the provision of society with products and services of vital needs by adapting network designs and functions to radically changed environments.

**Viable Supply Chain** model - adaptable structural SC designs for supply-demand allocations and, most importantly, establishment and control of adaptive mechanisms for transitions between the structural designs.

Viability as an Extended Resilience Perspective

With the COVID-19 pandemic, some novel context has been unveiled which goes beyond an instantaneous event-driven understanding and can be described as a supply chain crisis characterized by long and severe uncertainty of current and future conditions and entailing extensions toward SC viability.

Supply Chain Resilience: bouncing back to an "old normal" after a disruption or the ripple effect to recover a planned performance

Supply Chain Viability: adaptation to a "new normal" to survive in radically changed internal and external conditions

<table>
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<tr>
<th>Profile</th>
<th>Closed System View</th>
<th>Open System View</th>
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<tbody>
<tr>
<td>Assessment</td>
<td>Degree of performance degradation and recovery</td>
<td>Survivability of a SC</td>
</tr>
<tr>
<td>Objective</td>
<td>Maintaining performance of a SC or a firm</td>
<td>Maintaining provision of a society with critical services</td>
</tr>
<tr>
<td>Preparedness</td>
<td>One can prepare a contingency and recovery plan</td>
<td>One cannot plan for super-disruptions; adaptation is the key issue</td>
</tr>
<tr>
<td>Object</td>
<td>Individual SCs</td>
<td>Individual SCs and intertwined supply networks (ISN)</td>
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</tbody>
</table>

Intertwined Supply Networks

• Supply chains are usually intersecting with other supply chains
• Buyers and suppliers at the same time
• Identify mutual synergies and develop ecosystem views

Example: suppliers in the automotive sector are at the same time producers of valves for respirators

Reconfigurable Supply Chain

| Supply chain structures | $S_0$ | $S_1$ | ... | $S_K$ | $S_0$ | $S_1$ | ... | $S_K$ |
|-------------------------|-------|-------|     |       |       |       |     |       |
| Product structure       | ![Diagram](image1) | ![Diagram](image2) | ... | ![Diagram](image3) |
| Process structure       | ![Diagram](image4) | ![Diagram](image5) | ... | ![Diagram](image6) |
| Organizational structure| ![Diagram](image7) | ![Diagram](image8) | ... | ![Diagram](image9) |
| Technological structure | ![Diagram](image10) | ![Diagram](image11) | ... | ![Diagram](image12) |
| Logistics structure     | ![Diagram](image13) | ![Diagram](image14) | ... | ![Diagram](image15) |
| Financial structure     | ![Diagram](image16) | ![Diagram](image17) | ... | ![Diagram](image18) |
| Informational structure | ![Diagram](image19) | ![Diagram](image20) | ... | ![Diagram](image21) |


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anyLogistix Academic Workshop: a Way to Innovate Your Supply Chain Teaching and Learning Experience

**Date:** October 30-31, 2 – 5 pm CEST ([convert to your local time](#))
**Place:** online
**Language:** English

**Attendance fee:** 100 EUR (academia) / 135 EUR (commercial)
* 50 EUR special rate for full-time bachelor and master students

Advanced Level Workshop - Learn more >>

anyLogistix Advanced Academic Workshop: Building Supply Chain Digital Twins and Doing Projects with anyLogistix

**Date:** November 27-28, 2 – 5 pm CEST ([convert to your local time](#))
**Place:** online
**Language:** English

**Attendance fee:** 100 EUR (academia) / 135 EUR (commercial)
* 50 EUR special rate for full-time bachelor and master students
Supply Chain Resilience Course at Berlin School of Economics and Law (Online)

Supply Chain Resilience: Coping with and thinking beyond the COVID-19 pandemic

Go to
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- Certificate

Certificate
- Certificate with optional 2 ECTS
  - Online Seminar
  - 20 academic hours online teaching (synchronous) + 40 hours self-study work (incl. examination option)

Seminar schedule
- 11 / 12 November 2021
- 25 / 26 November 2021
- 9 December 2021
- Running time: each date from 2.00 to 5.15 pm CET

Language of instruction
- English

Tuition fees
- 395 Euro
- 195 Euro (Students and University members)
Thank you!

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Research interests, expert knowledge and methodical expertise:

- Supply chain resilience and risk management
- Simulation and data-driven digital supply chain twins
- Optimal control and scheduling in digital manufacturing
- Supply chain digitalization and Industry 4.0
- Network robustness and resilience


