Digital Supply Chain Twins to Improve Resilience

Prof. Dr. Dr. habil. Dmitry Ivanov
Professor of Supply Chain Management
Berlin School of Economics and Law, Germany

Blog.hwr-berlin.de/ivanov
Where we are located
HWR Berlin Overview

- >11,000 students
- 2,500 graduates annually
- Teaching staff: 200 professors and 800 part-time lecturers
- Close cooperation with 700 companies in Germany and abroad
- Master (M.A.) in Global Supply Chain and Operations Management (in English)
- Organiser of 9th International Conference on Manufacturing Modeling, Management and Control MIM 2019, August 28-30, 2019
Outline

• Practical principles to manage Supply Chain Resilience and Disruption Ripple Effects
• Decision-making support in designing the Resilient Supply Chain by simulation and optimization
• From offline modelling to online, data-driven Supply Chain Digital Twins: computerized supply chain models in real-time
• Current technologies and future vision of using Digital Supply Chain Twins to improve resilience

Prof. Dr. Dr. habil. Dmitry Ivanov
Supply Chain Resilience: Definition

• **Supply chain resilience** is the operational 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

![Diagram showing supply chain resilience during and after disruptions](image-url-1)

- **Performance**
- **Time**

**Disruption**

- **Performance**
- **Time for recovery**
- **Recovered performance**
Supply Chain Resilience: Practical Tools

Supply Chain Resilience

Robustness

- Inventory: using risk mitigation inventory
- Capacity: using capacity flexibility
- Structure: using backup suppliers

Recovery

- Parametric recovery
- Process recovery
- Structural recovery

Prof. Dr. Dr. habil. Dmitry Ivanov
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.
Supply Chain Resilience and the 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.

Simulation and Optimization to Improve Supply Chain Resilience

Supply Chain Model

<table>
<thead>
<tr>
<th>Analytical Methods (CPLEX)</th>
<th>Dynamic Simulation Methods (AnyLogic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear Programming</td>
<td>Agent-Based</td>
</tr>
<tr>
<td>Heuristics</td>
<td>Discrete-event</td>
</tr>
<tr>
<td>Mixed Integer Programming</td>
<td>System Dynamics</td>
</tr>
</tbody>
</table>

- **Resilient Supply Chain Design Optimization** – how to protect the SC against disruptions at lower costs?
- **Stress-testing** of the existing and alternative SC designs
- Computing of **alternative supply network topologies** and back-up routes with performance assessment
- **Simulation** of SC dynamic behavior in the event of possible disruptions with performance assessment
- Real-time analysis of the disrupted **SC performance** and alternative SC designs that contain non-disrupted networks

Prof. Dr. Dr. habil. Dmitry Ivanov
Simulation and Optimization to Improve Supply Chain Resilience

1 DC

Back-up DC

Prof. Dr. Dr. habil. Dmitry Ivanov
From offline modelling to online, data-driven Digital Twins

**Supply Chain Digital Twin:**
computerized supply chain models in real-time

- 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

Product Digital Twin

Prof. Dr. Dr. habil. Dmitry Ivanov
From offline modelling to online, data-driven Supply Chain Digital Twins: computerized supply chain models in real-time

Combination of simulation and optimization constitutes a full stack of technologies to create a supply chain digital twin – a model that always represents the state of the network in the present.
Online, data-driven Supply Chain Digital Twins: supply chain models in real-time

Prof. Dr. Dr. habil. Dmitry Ivanov
Improving Supply Chain Resilience with the help of Digital Twins

Prof. Dr. Dr. habil. Dmitry Ivanov
Current Technologies and Future Vision

Prof. Dr. Dr. habil. Dmitry Ivanov
**Supply Chain Digital Twin**

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

**Managing Supply Chain Risks and Resilience by Simulation, Optimization, and Digital Twins**

- **Resilient Supply Chain Design Optimization** – how to protect the SC against disruptions at lower costs?
- **Stress-testing** of the existing and alternative SC designs
- Computing of **alternative supply network topologies** and back-up routes with performance assessment
- **Simulation** of SC dynamic behavior in the event of possible disruptions with performance assessment
- Real-time analysis of the disrupted **SC performance** and alternative, non-disrupted SC designs
What is coming next?

• Is the Supply Chain as resilient as the digital technology behind it?
• If yes, who will compete in future: the physical supply chains or their digital twins?
• Will SC resilience be managed by Human or Artificial Intelligence, or any hybrids?
• What is the role of future Supply Chain Risk Managers?
Thank you.

Prof. Dr. Dr. habil.
Dmitry Ivanov
Berlin School of
Economics and Law, Ger

Blog.hwr-berlin.de/ivanov
Structural Dynamics and Resilience in Supply Chain Risk Management

Global Supply Chain and Operations Management
A Decision-Oriented Introduction to the Creation of Value
Second Edition