Lecture 3: Supply Chain Risk Management

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Supply Chain Trends and Consequences

- **The trend towards reducing costs:** has resulted in the **globalization** of supply chains, making supply chains more **vulnerable** and **complex**.
- **The trend towards outsourcing non-core business activities:** has resulted in **loss of control** when it is most needed).
- **The trend towards just-in-time and lean practices:** has resulted in **efficiency** rather than **effectiveness**.
- **The trend towards the consolidation of suppliers:** has resulted in the increased potential for **supplier failure**.

Examples of Supply Chain Failures

There are many vivid examples of supplier failures, due to natural disasters, or even quality failures, and associated supply chain disruptions.

• A classic example is the **Royal Philips Electronics** cell phone chip manufacturing plant fire, due to a lightning strike on March 17, 2000, and subsequent water and smoke damage, which adversely affected **Ericsson**, which, unlike **Nokia**, did not have a backup, and suffered a second quarter operating loss in 2000 of $200 million in its mobile phone division.

• The **Fukushima triple disaster** on March 11, 2011 in Japan resulted in shortages of memory chips, automotive sensors, silicon wafers, and even certain colors of automotive paints, because of the affected suppliers.

Examples of Supply Chain Failures

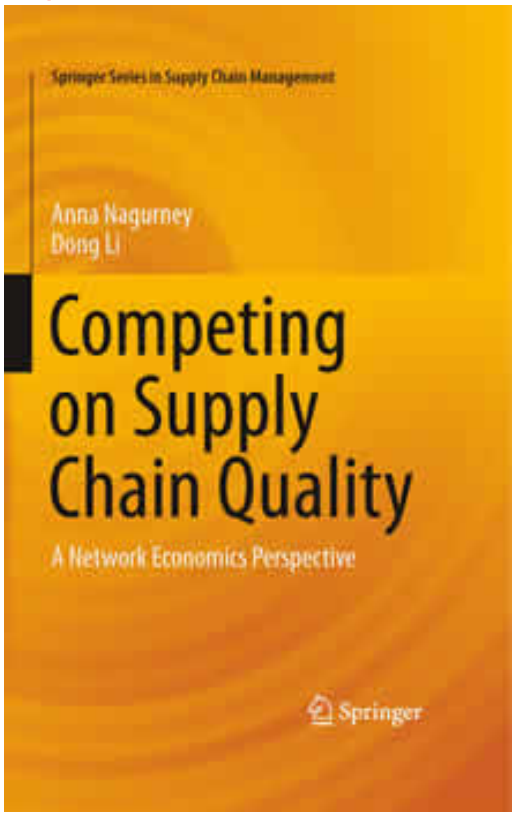
• The worst floods in 50 years that followed in October 2011 in Thailand impacted both **Apple** and **Toyota** supply chains, since Thailand is the world's largest producer of computer hard disk drives and also a big automotive manufacturing hub. However, not all supplier shortcomings need be due to disasters.

• **Boeing**, facing challenges with its 787 Dreamliner supply chain design and numerous delays, ended up having to buy two suppliers for $2.4 billion because the units were underperforming in the chain.

Other Examples of Supply Chain Failures Due to Quality Issues

Examples of recent product quality failures have included:

- adulterated infant formula,
- inferior pharmaceuticals,
- defective airbags,
- defective ignition switches,
- bacteria-laden food,
- exploding smartphones, etc.



Which Suppliers Matter the Most?

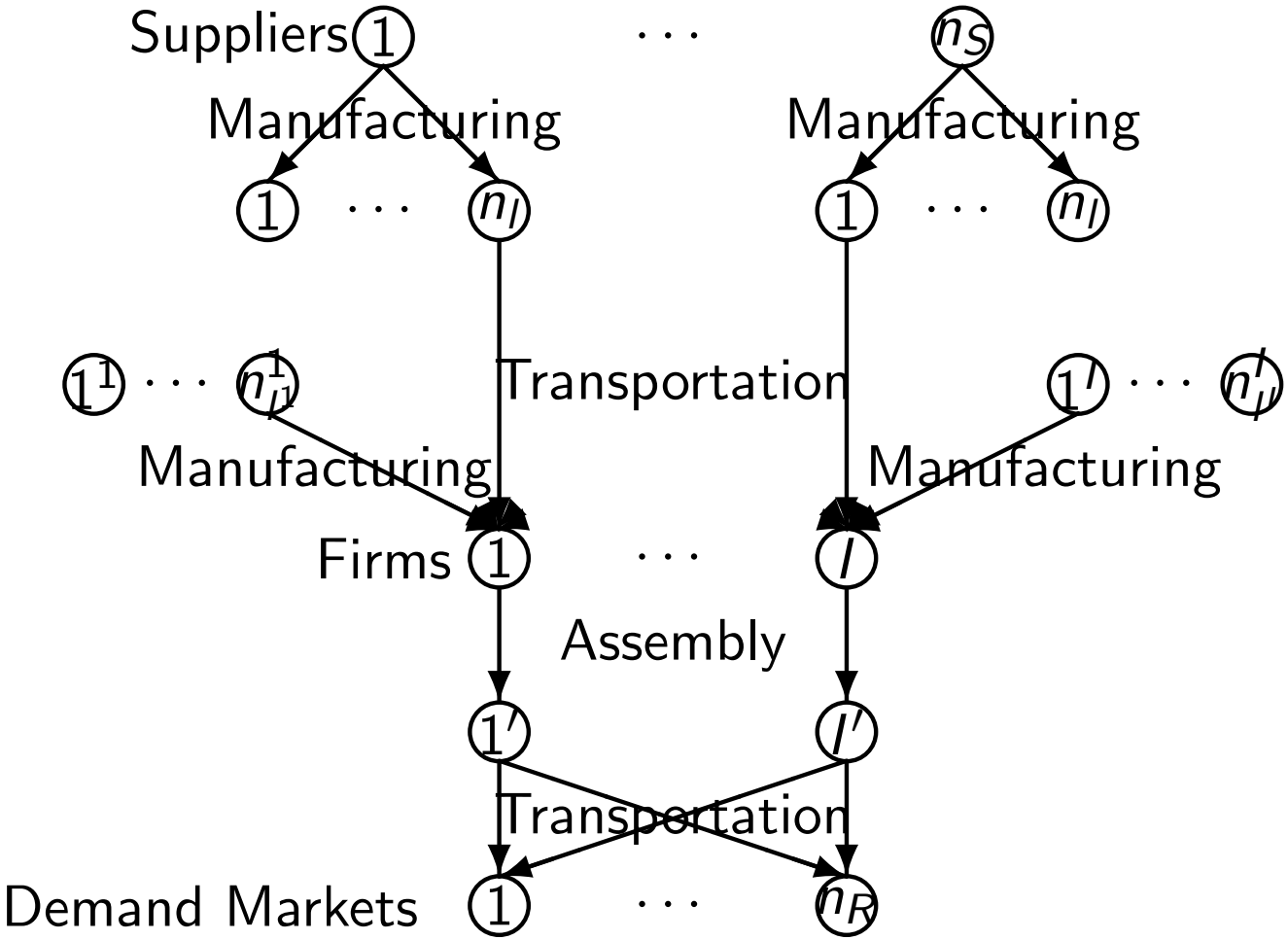


Figure: The Multitiered Supply Chain Network Topology

How to Define Risk

Risk is often defined as

$$\text{RISK} = f(\text{Probability, Consequences}).$$

Hence, risk is the combination of the probability of an event and its consequences/impacts.

Supply Chain Risk Management

Risk in the context of supply chains may be associated with the production/procurement processes, the transportation/shipment of the goods, and/or the demand markets.

Supply Chain Risk Management

Such supply chain risks are directly reflected in firms' financial performances, and priced in the financial market. For example, it has been estimated that the average stock price reaction to supply-demand mismatch announcements was approximately -6.8%. In addition, supply chain disruptions can cause firms' equity risks to increase by 13.50% on average after the disruption announcements.

Supply chain risk management is the intersection of supply chain management and risk management.

Some Research Articles on Risk Modeling and Supply Chains

- Z. Liu and A. Nagurney, 2013. Supply Chain Networks with Global Outsourcing and Quick-Response Production Under Demand and Cost Uncertainty, *Annals of Operations Research* **208(1)**, 251-289.
- Z. Liu and A. Nagurney, 2011. Supply Chain Outsourcing Under Exchange Rate Risk and Competition, *Omega* **39**, 539-549.
- Z. Liu and A. Nagurney, 2011. Risk Reduction and Cost Synergy in Mergers and Acquisitions via Supply Chain Network Integration, *Journal of Financial Decision Making* **7(2)**, 1-18.
- Q. Qiang, A. Nagurney, and J. Dong, 2009. Modeling of Supply Chain Risk Under Disruptions with Performance Measurement and Robustness Analysis, in *Managing Supply Chain Risk and Vulnerability: Tools and Methods for Supply Chain Decision Makers*, T. Wu and J. Blackhurst, Editors, Springer, Berlin, Germany, pp 91-111.

See the Virtual Center for Supernetwork website; http://supernet.isenberg.umass.edu for other articles.

Supply Chain Risk Management

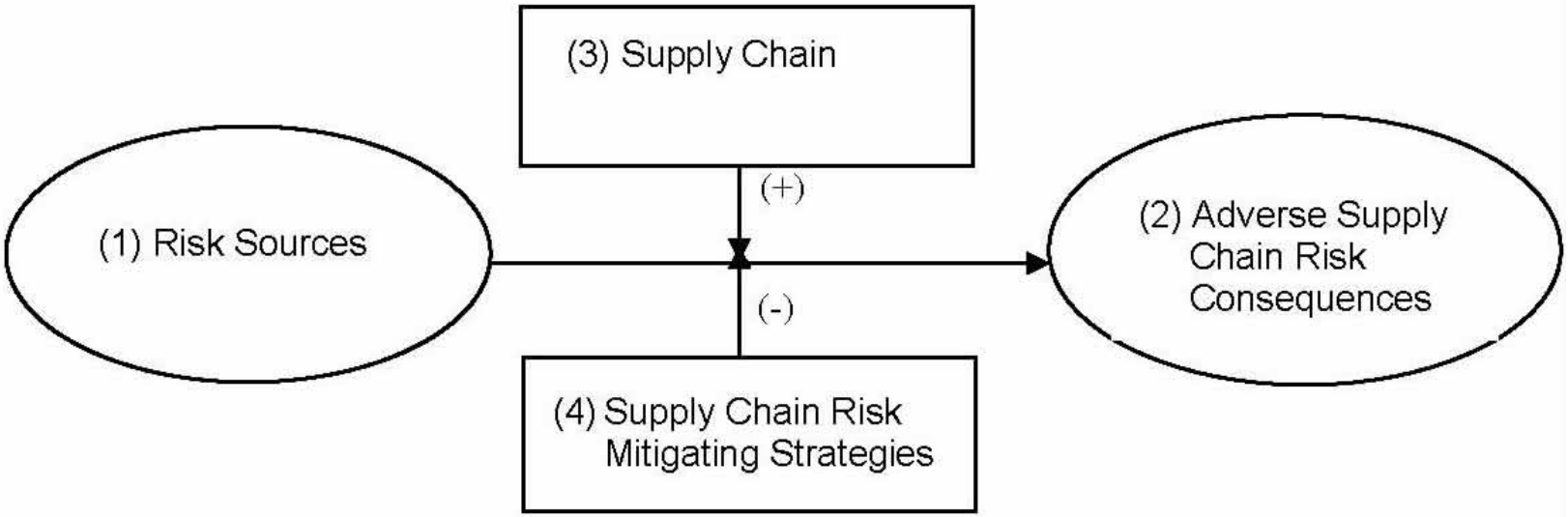


Figure: The Basic Constructs of Supply Chain Risk Management

Source: U. Juttner, H. Peck, M. Christopher, 2003. *International Journal of Logistics* **6**, 197-210.

Categorization of Risk

There have been different ways proposed of categorizing risk:

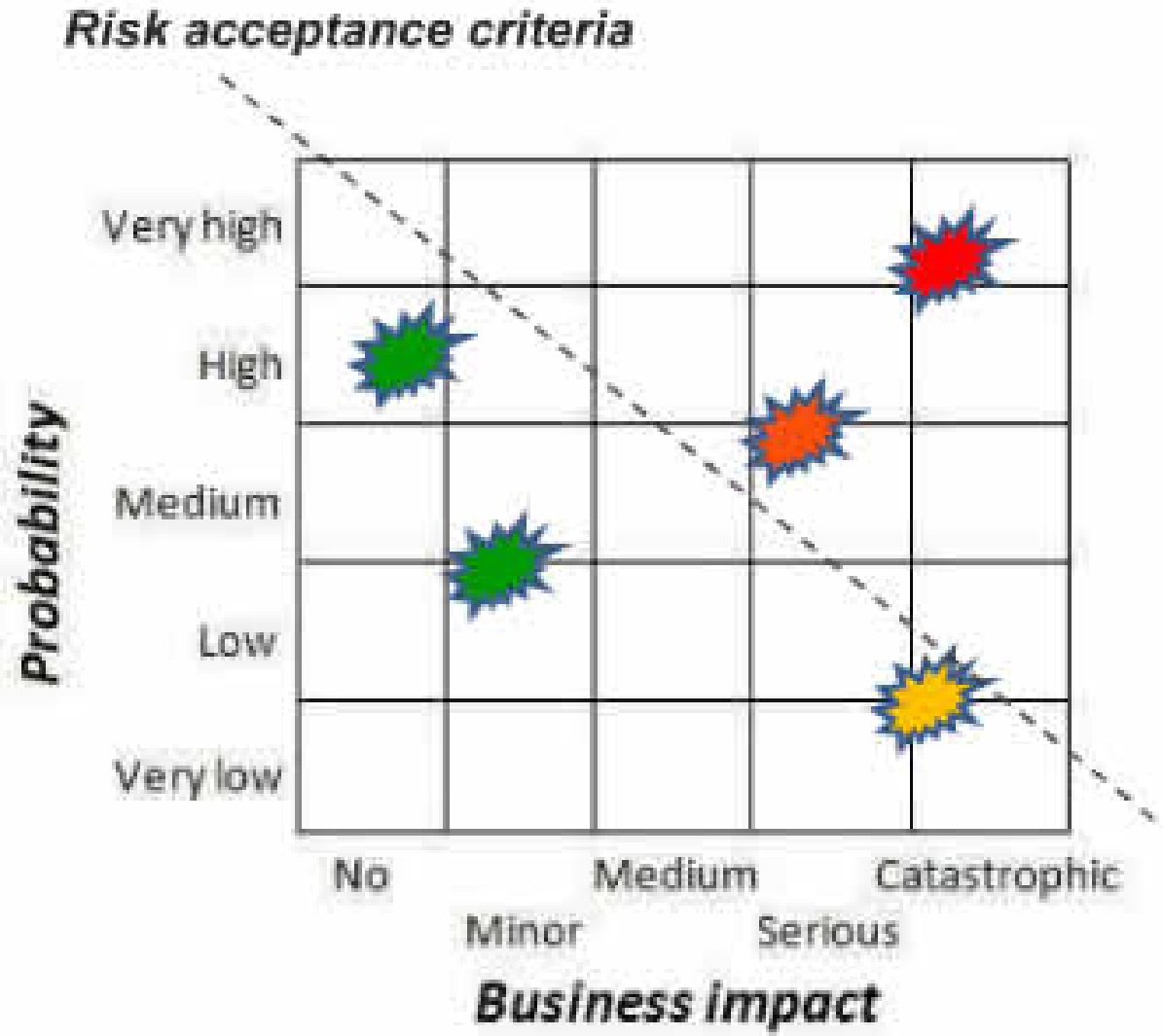
- High-Impact Low-Likelihood (sometimes called Black Swan events)– Low-Impact High-Likelihood
- Environment-Organization-Network

High-Impact Low-Likelihood Events

Click on underlined text for video.

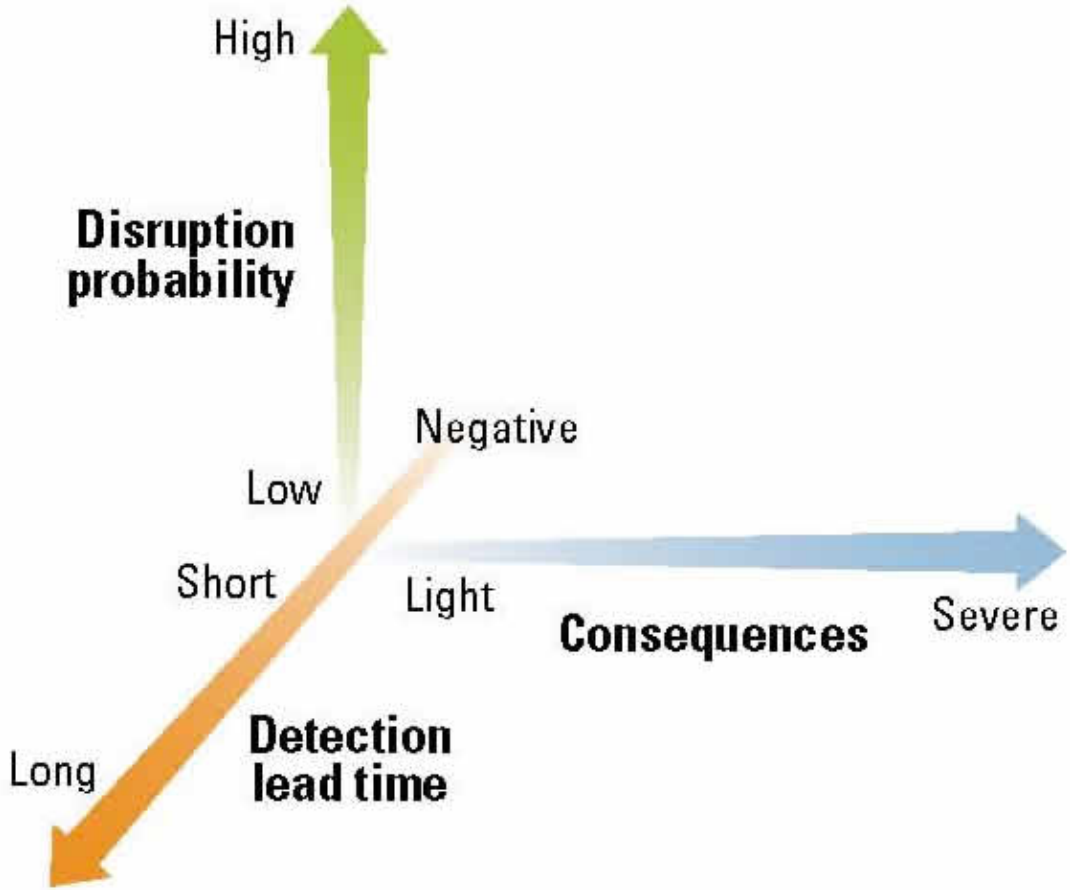
Mr. Patrick Dixon, futurist, on High-Impact events

The Risk Matrix



Source: A. Norman and R. Lindroth, 2004. Categorization of Supply Chain Risk and Risk Management, in *Supply Chain Risk*, C. Brindley, Editor, Ashgate, pp 14-27.

Importance of Early Detection



Y. Sheffi, 2015, Preparing for Disruptions Through Early Detection, *MIT Sloan Review*, Fall, 31-42.

Importance of Early Detection

Recommendations:

1. Monitor the weather
2. Track the news
3. Use sensor data
4. Monitor the supply base
5. Visit the suppliers
6. Be on the alert for disruption
7. Develop traceability capabilities
8. Monitor social media
9. Track regulatory developments.

Mapping of the supply chain can assist in early detection of possible disruptions.

Supply Chain Risk Management

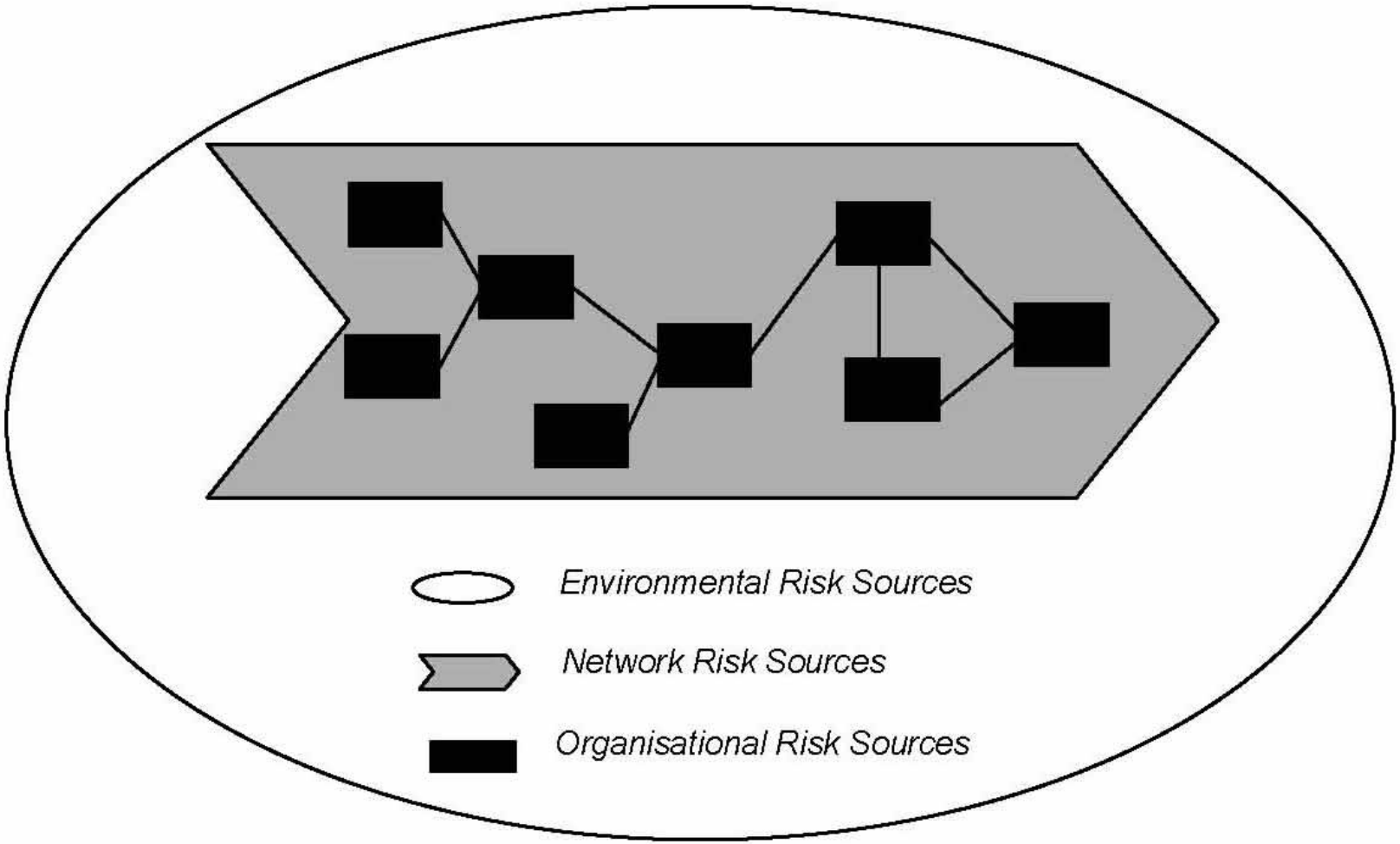


Figure: Risk Sources in Supply Chains

Source: U. Juttner, H. Peck, M. Christopher, 2003. *International Journal of Logistics* **6**, 197-210.

Supply Chain Risk Management – Environmental Risk Sources

Environmental risk sources consist of any uncertainties arising from the supply chain and environmental interactions.

These may be the result of accidents (such as fires, explosions, etc.), man-made (terrorist attacks), or natural disasters (earthquakes, tsunamis, and other extreme weather events).

Supply Chain Risk Management – Network-Related Risk Sources

Network-related risk sources arise from interactions between the organizations involved in the supply chain.

Supply Chain Risk Management – Network-Related Risk Sources

- **Lack of Ownership**

Lack of ownership risk sources is due from the blurring of boundaries between buying and supplying companies in the chain. With outsourcing, there may be confused lines of responsibility.

- **Chaos**

There may be chaos effects in a supply chain due to mistrust, overreaction, and distorted information.

- **Inertia**

Such risks are due to a lack of responsiveness to changing environmental conditions and market signals. Flexibility may be sacrificed, especially in global supply chains, where they may be an emphasis on cost reduction.

Supply Chain Risk Management – Organizational Risk Sources

Organizational risk sources lie within the scope of the boundaries of the supply chain parties and include labor issues such as strikes, production uncertainties (quality and machine failures) to IT-based uncertainties.

Supply Chain Risk Management – Adverse Risk Consequences

Risk may have adverse consequences that can be measured ex post through performance indicators.

Ex ante they are captured in the variances of the indicator components.

Three of the most important adverse consequences are:

1. Financial consequences
2. Health and safety negative impacts
3. Reputation damage.

Supply Chain Risk Management – Drivers of Risk

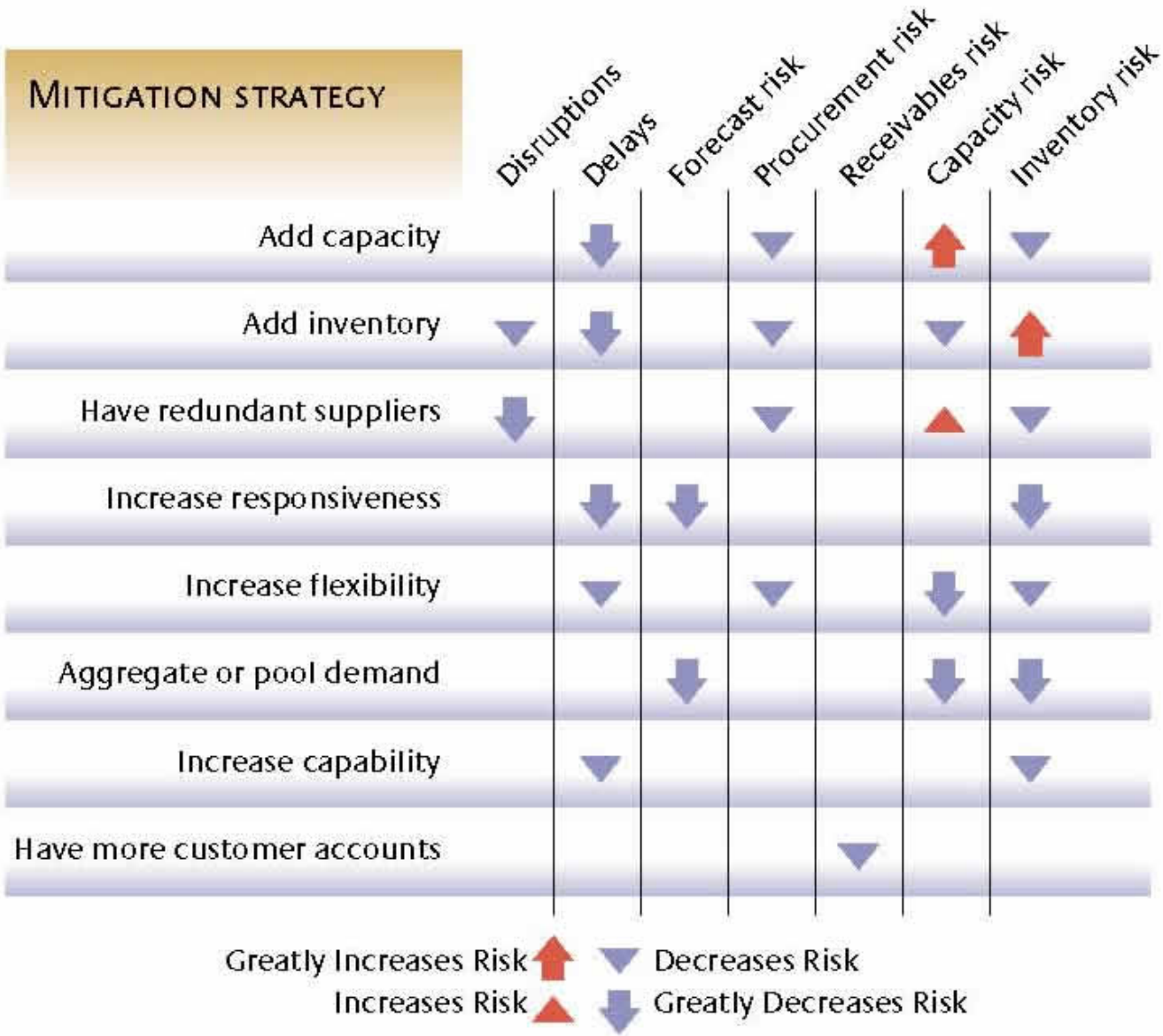
Category of Risk	Drivers of Risk
Disruptions	■ Natural disaster ■ Labor dispute ■ Supplier bankruptcy ■ War and terrorism ■ Dependency on a single source of supply as well as the capacity and responsiveness of alternative suppliers
Delays	■ High capacity utilization at supply source ■ Inflexibility of supply source ■ Poor quality or yield at supply source ■ Excessive handling due to border crossings or to change in transportation modes
Systems	■ Information infrastructure breakdown ■ System integration or extensive systems networking ■ E-commerce
Forecast	■ Inaccurate forecasts due to long lead times, seasonality, product variety, short life cycles, small customer base ■ "Bullwhip effect" or information distortion due to sales promotions, incentives, lack of supply-chain visibility and exaggeration of demand in times of product shortage

Supply Chain Risk Management – Drivers of Risk

Category of Risk	Drivers of Risk
Intellectual Property	■ Vertical integration of supply chain ■ Global outsourcing and markets
Procurement	■ Exchange rate risk ■ Percentage of a key component or raw material procured from a single source ■ Industrywide capacity utilization ■ Long-term versus short-term contracts
Receivables	■ Number of customers ■ Financial strength of customers
Inventory	■ Rate of product obsolescence ■ Inventory holding cost ■ Product value ■ Demand and supply uncertainty
Capacity	■ Cost of capacity ■ Capacity flexibility

Source: S. Chopra and M. Sodhi 2004. Managing Risk to Avoid Supply-Chain Breakdown, *MIT Sloan Management Review* **46**, 53-61.

Supply Chain Risk Management – Mitigation Strategies



Source: S. Chopra and M. Sodhi 2004. Managing Risk to Avoid Supply-Chain Breakdown, *MIT Sloan Management Review* **46**, 53-61.

Supply Chain Risk Management – Mitigation Strategies

According to Juttner, Peck, and Christopher (2003) risk mitigation strategies are:

- **Avoidance** dropping specific products / geographical markets, etc.
- **Control** through vertical integration, increased stockpiling, maintaining excess capacity in production, storage, etc., and composing contractual obligations on suppliers
- **Cooperation** through joint efforts to improve SC visibility, the sharing of risk-related information, and preparation of SC continuity plans
- **Flexibility** through postponement, multiple sourcing, localized sourcing

Supply Chain Risk Management – Stress Testing the Supply Chain

Companies can explore their risk through the investigation of various possible scenarios to stress test the supply chains.

They can then prioritize and work on mitigating the risks.

Supply Chain Risk Management – Stress Testing the Supply Chain

	Supplier-Related	Internal	Customer-Related
Disruptions	■ Supplier of a key part shuts down plant for a month or at a key part of the production cycle ■ Supplier capacity drops by 20% overnight	■ Key plant shuts down unexpectedly for one month ■ Capacity at a key plant drops by 20% overnight	■ Demand goes up by 20% ... for all products ... for a key product ... across the board ■ Demand goes *down* by 20% under conditions above
Delays	■ Purchase orders of key parts or raw materials delayed by month	■ Distribution or production orders delayed by a month	■ Customer orders delayed by a month
Systems	■ Supplier's order-entry system goes down for a week	■ Key customer's procurement system inside your company goes down for a week ■ Company's inventory/accounts system goes down for a week	■ Order entry system not working for a week ■ Key customer's procurement system inside your company goes down for a week ■ Credit card information stolen from hacked e-commerce system
Information Processing	■ Supplier rations supplies by 20% ■ Supplier increases minimum order size by 20% then 100%	■ To take advantage of volume discounts, company begins to order in quantities twice as large as usual, but half as frequently, which impacts supplier's ability to forecast	■ Key customer begins to order in batches that are twice as large as usual but less frequent (the impact of forecasting)
Intellectual Property	■ Key supplier redesigns parts and creates own product		
Procurement	■ Supplier delays in processing returns by twice as long ■ Supplier forced to increase price of key components by 20% ■ Transportation costs go up 20% overnight	■ Unforeseen cash squeeze requires month-long delays in paying key suppliers	

Supply Chain Risk Management – Tailored Strategies

Mitigation Approach	Tailored Strategies
Increase Capacity	■ Focus on low-cost, decentralized capacity for predictable demand. ■ Build centralized capacity for unpredictable demand. Increase decentralization as cost of capacity drops.
Acquire Redundant Suppliers	■ Favor more redundant supply for high-volume products, less redundancy for low-volume products. ■ Centralize redundancy for low-volume products in a few flexible suppliers.
Increase Responsiveness	■ Favor cost over responsiveness for commodity products. ■ Favor responsiveness over cost for short life-cycle products.

Source: S. Chopra and M. Sodhi 2004. Managing Risk to Avoid Supply-Chain Breakdown, *MIT Sloan Management Review* **46**, 53-61.

Supply Chain Risk Management – Tailored Strategies

Mitigation Approach	Tailored Strategies
Increase Inventory	■ Decentralize inventory of predictable, lower-value products. ■ Centralize inventory of less predictable, higher-value products.
Increase Flexibility	■ Favor cost over flexibility for predictable, high-volume products. ■ Favor flexibility for low-volume unpredictable products. ■ Centralize flexibility in a few locations if it is expensive.
Pool or Aggregate Demand	■ Increase aggregation as unpredictability grows.
Increase Capability	■ Prefer capability over cost for high-value, high-risk products. ■ Favor cost over capability for low-value commodity products. ■ Centralize high capability in flexible source if possible.

Source: S. Chopra and M. Sodhi 2004. Managing Risk to Avoid Supply-Chain Breakdown, *MIT Sloan Management Review* **46**, 53-61.

More on Risk Reduction

Click on underlined text for video.

Professor Wilding of Cranfield University

Which Supply Chain Risk Management Strategies Are Relevant to Humanitarian Operations?

Supply Chain Risk Management – Humanitarian Relief Operations

Source: B. B. van Heeringen, 2010. Risk Management in Regional Humanitarian Relief Operations.

	Business logistics	Humanitarian relief operations
Risk sources	Environmental	Natural disasters create complex operating conditions
	Organisational	Natural disasters affect labour, communication, and transportation
	Supply-chain related	Interaction between many different humanitarian organisations
Risk consequences	Financial consequences	Risk of losing lives
Risk drivers	Focus on efficiency rather than effectiveness	More attention to efficiency and accountability
	Globalisation of supply chains	Globalisation of humanitarian supply chains
	Focussed factories and centralised distribution	Centralisation of most distribution
	Trend of outsourcing	Outsourcing of transportation
	Reduction of supplier base	Not mentioned in literature
Strategies	Avoidance	• Avoidance of suppliers due to risk
	Control	• Prepositioning inventory • Excess capacity in storage, handling and/or transport • Contracts with suppliers • Warning tools
	Cooperation	• Collaboration of key players in the humanitarian operations
	Flexibility	• Postponement • Multiple sourcing • Localised sourcing

Supply Chain Risk Management – Crises or Disasters

It is imperative to remember that **humanity, independence, neutrality and impartiality** are at the **heart of humanitarian action**. They are crucial to ensuring that humanitarian action is effective, and that it reaches those most in need.

Some risk in humanitarian operations and disaster relief is inevitable, including in areas of conflicts where political risk may also be paramount.

Risk Management – Humanitarian Crises or Disasters

The Index for Risk Management INFORM is a way to understand and measure the risk of a humanitarian crisis. INFORM is a composite indicator, developed by the Joint Research Centre of the European Union and endorsed by INFORM partners, combining 54 indicators into three dimensions of risk:

- Hazards (events that could occur) and exposure to them,
- Vulnerability (the susceptibility of communities to those hazards), and
- Lack of coping capacity (lack of resources that can alleviate the impact).

Risk Management – Humanitarian Crises or Disasters

INFORM is a partnership of a group of UN agencies, donors, NGOs and research institutions to develop a comprehensive and flexible, widely accepted, open and continuously updated, transparent and evidence-based multi-hazard humanitarian risk index with global coverage and regional/subnational scale and seasonal variation.

The INFORM index's results are published twice a year. They give an overall risk score out of 10 for each country, and for each of the dimensions, categories, and components of risk. The purpose of INFORM is to provide an open, transparent, consensus-based methodology for analyzing crisis risk at global, regional or national level.

Click on underlined text for full report.

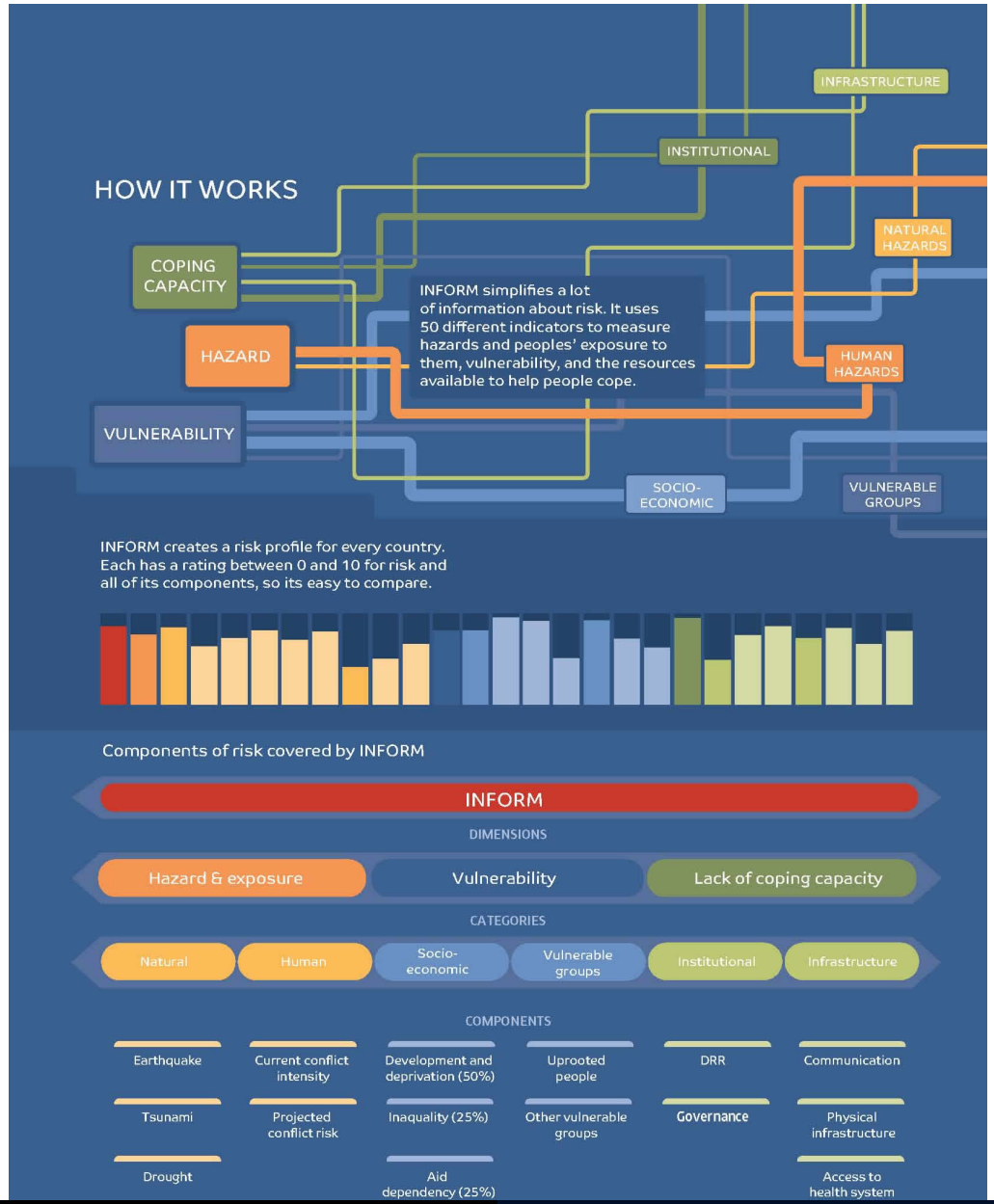
INFORM Index for Risk Management

Risk Management – Humanitarian Crises or Disasters

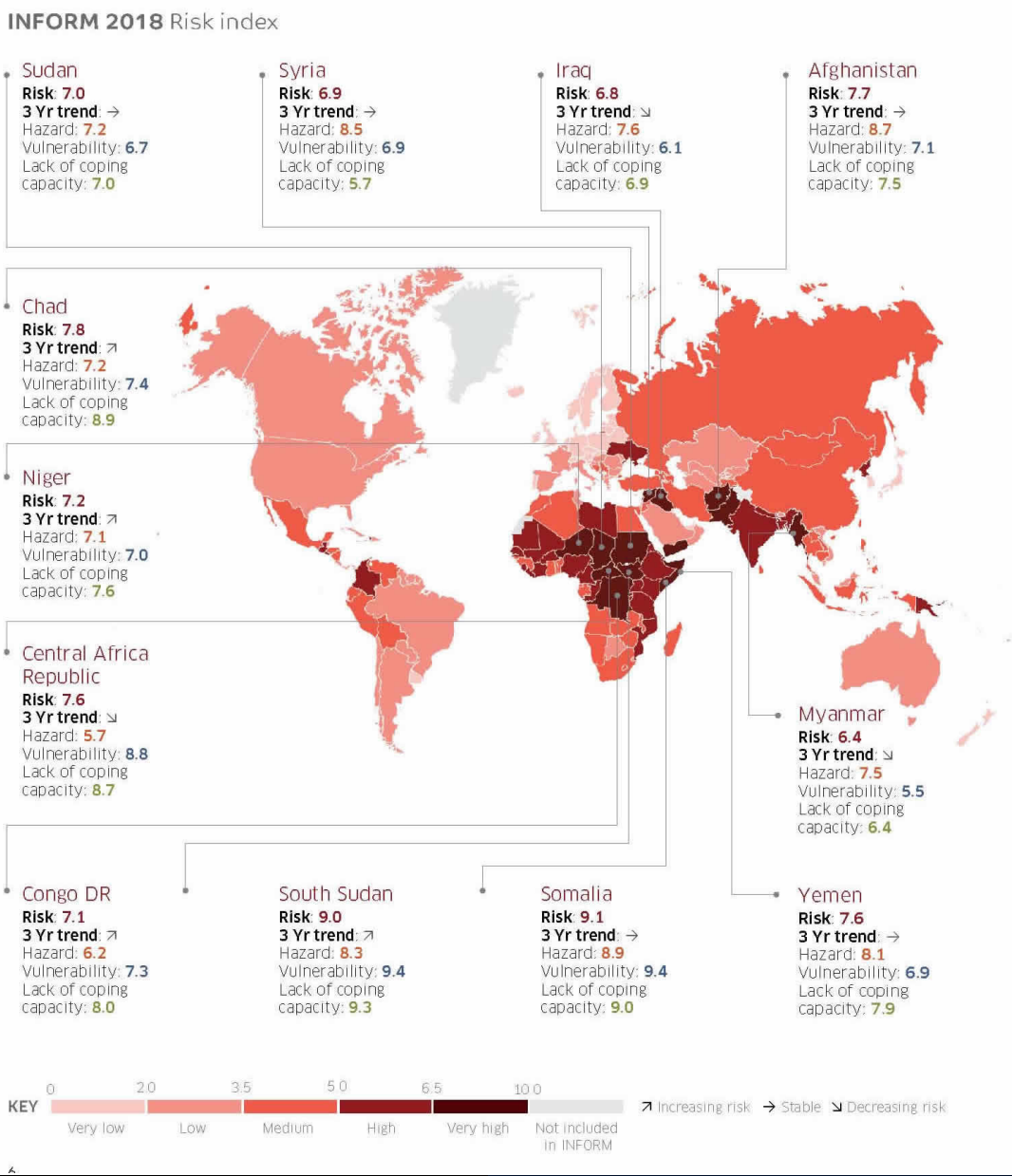
Table 1. INFORM model

Risk	INFORM																			
Dimensions	Hazard & exposure								Vulnerability						Lack of coping capacity					
Categories	Natural					Human			Socio-Economic			Vulnerable groups			Institutional		Infrastructure			
Components	Earthquake	Tsunami	Flood	Tropical cyclone	Drought	Current conflict intensity	Projected conflict intensity		Development deprivation (50%)	Inequality (25%)	Aid dependency (25%)	Uprooted people	Other vulnerable groups		DRR	Governance	Communication	Physical infrastructure	Access to health system	

Risk Management – Humanitarian Crises or Disasters



Risk Management – Humanitarian Crises or Disasters



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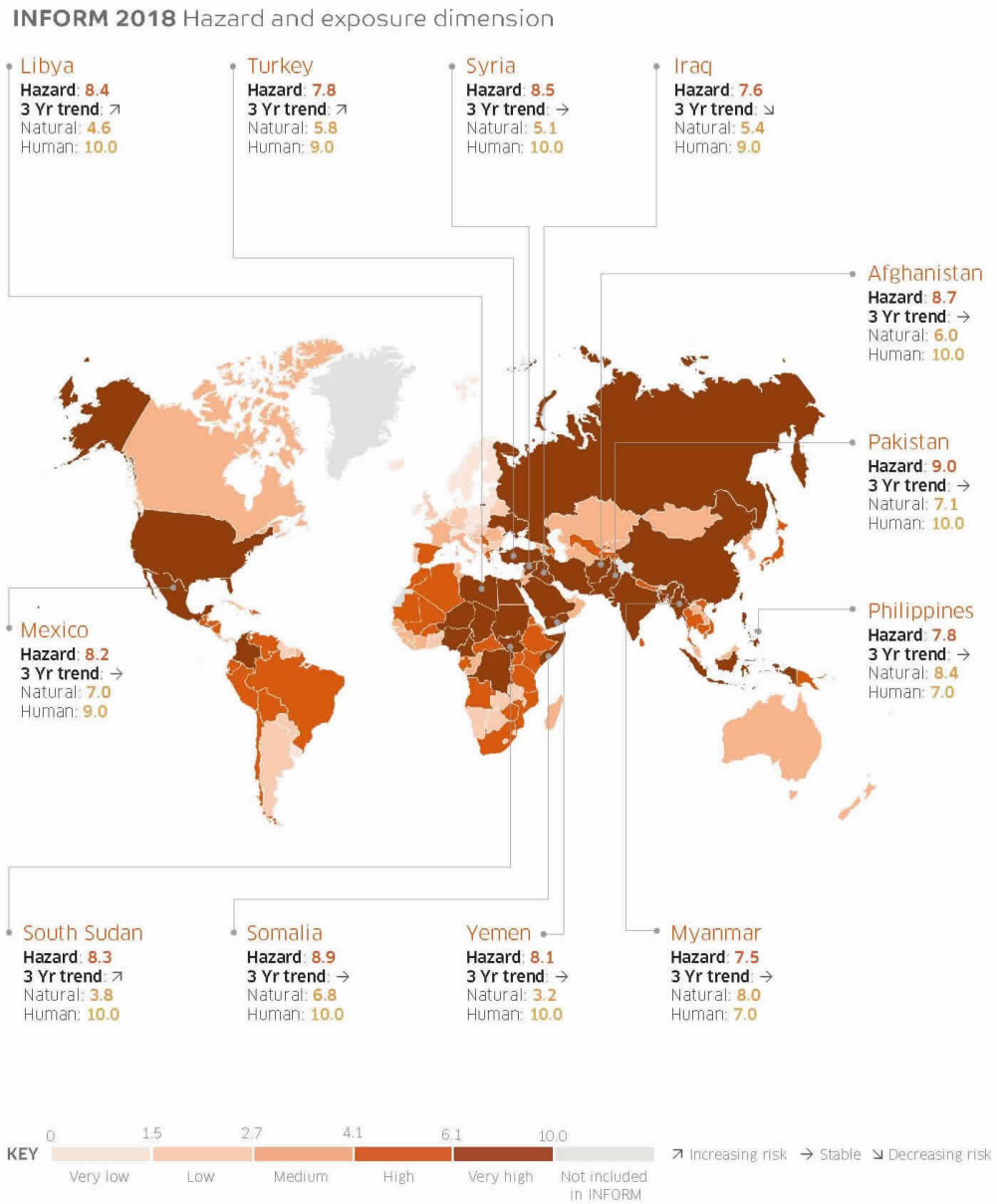

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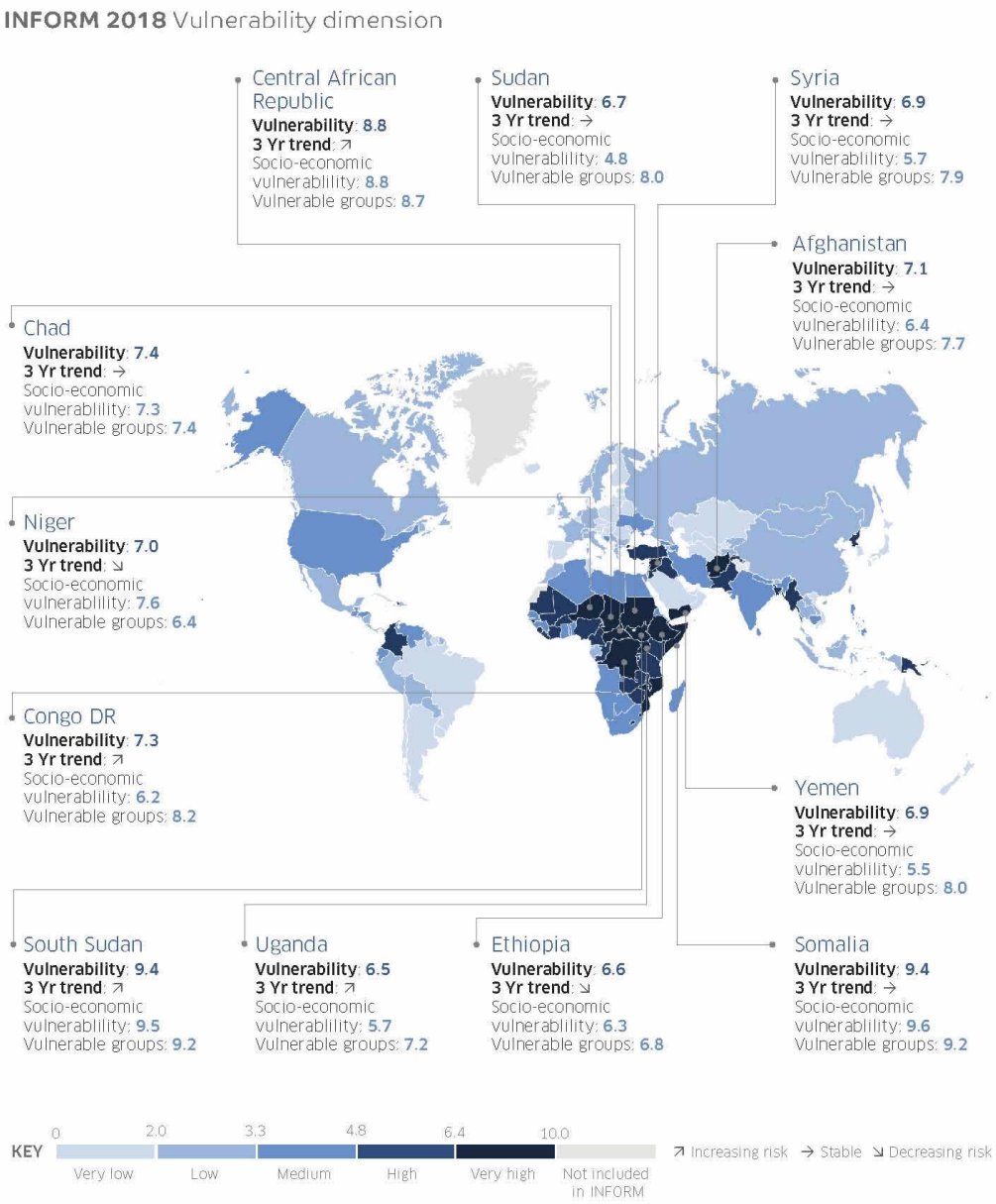
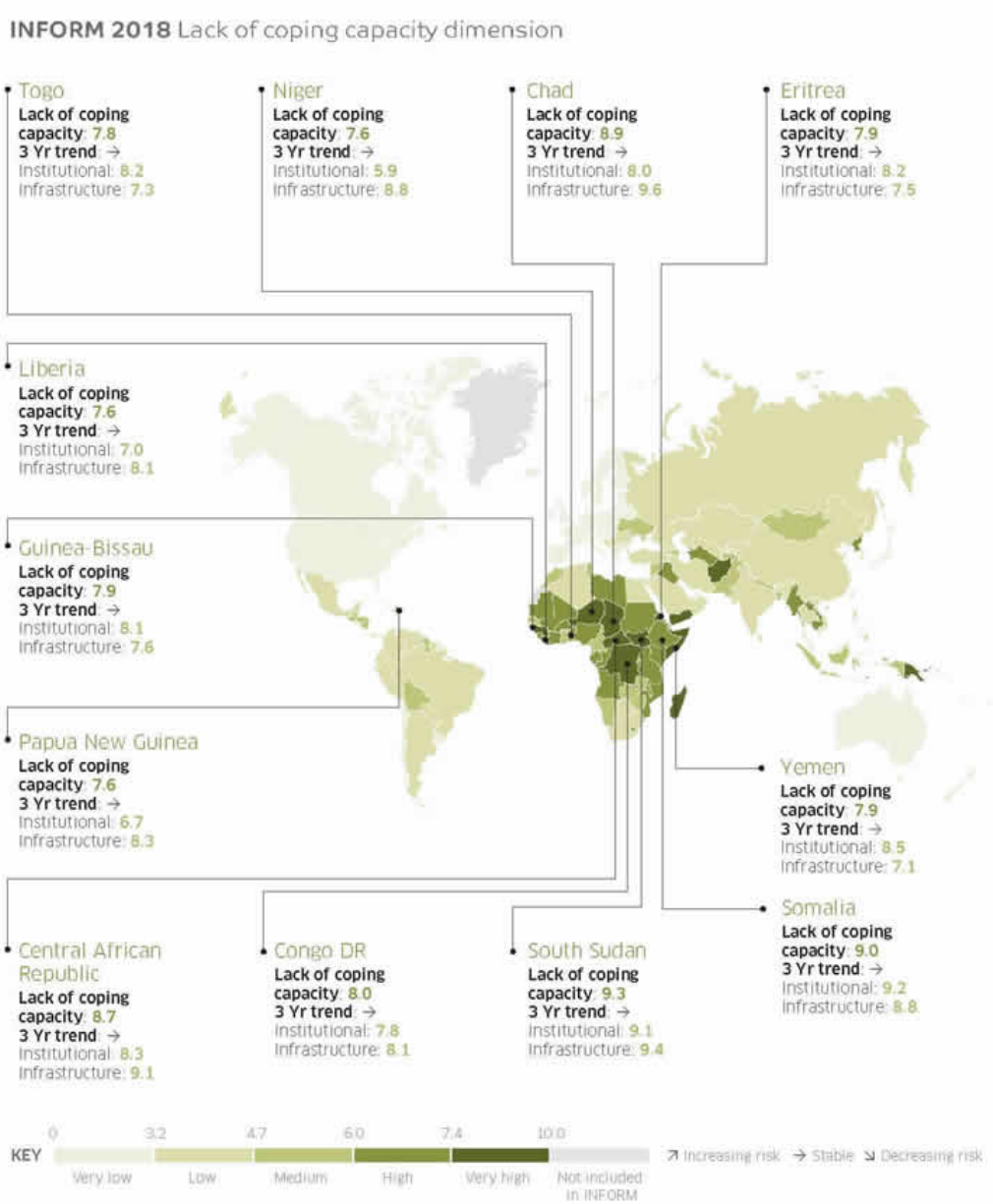


Risk Management – Humanitarian Crises or Disasters



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