


MIT MASSACHUSETTS INSTITUTE OF TECHNOLOGY

MIT Center for Transportation & Logistics



How Supply Chains Can Deal with Uncertainty and Risk



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Agenda

- Introduction
- **How Supply Chains Can Deal with Uncertainty**
- Uncertainty from a changing world
- Dealing with Uncertainty (concepts)
- Dealing with Uncertainty (examples)

SCREAM

Access xlsx file at
<http://ctl.mit.edu/jim>

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Uncertainty from a changing world



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Supply Chains Today → Uncertainty and Vulnerability

- Global sources of supply & customer destinations
 - Increasing distances → longer lead times
 - Many transborder imports & exports
 - Added security constrains flow, raises costs (C-TPAT, AEO)
- Product dynamics:
 - Fast NPI, product proliferation, increasing variety (margin*), shorter life cycle
 - How many variations of toothpaste are there on the shelf?
- Complexity! More parties in the supply chain
 - More outsourcing
 - More dependence on others in supply network
- Lean supply chains
 - Reduced inventories → Fragile supply chains
- Result → uncertainty and high vulnerability
 - Our vulnerability is a function of the supply network
 - Ex. Pan Am over Lockerbie; Williams Pipeline



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How do you predict the demand for new products?



“Why would you want to buy an Apple Watch? I’m still trying to figure that out.”**



Announced 3-2-11, for sale 3-11-11, 5 week delay by 3-15-11...then the tsunami impact hit



“It would have been nice if I’d made sure the product tasted good.”*



- * Yum Brands Chairman David Novak, December 2007
- ** WSJ 3-10-15, “With Apple Watch, Fewer Distractions” by Geoffrey A. Fowler



Cases of NPI Sales Forecasting Optimism

Before their time.....



It was never their time.....



Adapted from Y. Sheffi, Jan '12 MIT Executive Education Program



A Few Cases of Sunset Sales Forecasting Surprise






Don't be fooled by "LOOK-ALIKES"!

Despite their initial death....they're back



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A Ten-Year Look at High Consequence-Low Probability Disruptions

The timeline shows the following events:

- 1997: Toyota Brake Plant Fire
- 1998: UPS Labor Strike
- 1998: Quebec Ice Storm
- 1999: GM Labor Strike
- 2000: Taiwan Earthquake
- 2001: Firestone-Ford Tire Recall
- 2001: Philips Plant Fire
- 2001: Scandals: Enron, Andersen, Worldcom
- 2002: FMD in UK
- 2002: Sept. 11 Terrorist Attacks
- 2003: GM-Ok. tornado
- 2003: West Coast Ports Lockout
- 2003: Iraq War
- 2004: SARS
- 2004: Blackouts US - EU
- 2005: Katrina
- 2005: London Madrid Attacks
- 2005: Nor'Easter
- 2007: Tornadoes, Pirates, Wash. storms, bridge collapse
- 2008: Global Financial Crisis

Ref: Adapted from Dr. Debra Elkins, General Motors

Some Recent Disruptions...

- Avian Bird Flu Outbreak (US), April 2015
- GE Appliance Whse Fire, April 2015
- West Coast US Port Congestion & Labor Action, 2014-2015
- Typhoon Halong, SE Asia, Aug 2014 (\$10B revenue & 41 week impact)
- Severe flooding, NY USA, 2014 (\$4B revenue & 38 week impact)
- Typhoon Rammsun, SE Asia, July 2014, (\$1.5B rev & 38 week impact)
- Gas explosions, Kaoshing, Taiwan, 2014 (\$900M rev & 26 week impact)
- Hazmat spill, Arizona US, 2014 (\$900M revenue & 10 week impact)
- Building Collapse, Rana Plaza Bangladesh, 2013
- Thai Floods 2013
- Hurricane Sandy 2012
- Europe Financial Crisis 2012
- Thai Floods 2011
- Japan Quake/Tsunami 2011
- Haiti Earthquake 2010
- Gulf Oil Spill 2010
- Iceland Volcano 2010
- Russian Wildfires 2010
- Global Financial Crisis 2008+
- Beijing Olympics Summer 2008

How did these affect your supply chain?



Ref: Source material from "The Japan Disaster: Rebuilding Supply Chains" webinar for Journal of Commerce, by B. Artzen and J. Rice, March 24, 2011; and Resilinc Event Watch Annual Report 2014, March 2015 available at <https://www.resilinc.com/products/eventwatch-2014-annual-report/>



High Impact of Supply Chain Failures

- Japan Earthquake/Tsunami/Nuclear Meltdown 2011: \$Bs+
- Philips Fire 2000– Nokia vs Ericsson, Ericsson loses \$400m
- West Coast Lockout 2002, \$~20B economic loss
- Boeing 787 Outsourced SC 2007-8, 2-yr delay, \$2B charges
- Mattel Product Quality Recall, 2007, 50% stock price drop
- Hershey Halloween Miss (IT), 1999, \$150M loss, -30% stock
- Nike IT system failure, \$100M revenue drop, -20% stock
- P&G Folgers (Hurricane Katrina)
- GM (tornado at Oklahoma City)
- Land Rover/UPF Thompson frame supplier bankruptcy
- Toyota (Aisin) brake plant fire 1997
- Toyota defective gas pedals, \$1.2B settlement and equity/share loss
- And many others.....LA/LB port disruption/congestion 2014-2015, Hurricane Rita, London-Madrid-Bombay terrorist attacks, labor actions/strikes, SARS, H1NI, HiN5, Somali pirates....



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Effect of Supply Chain Problems

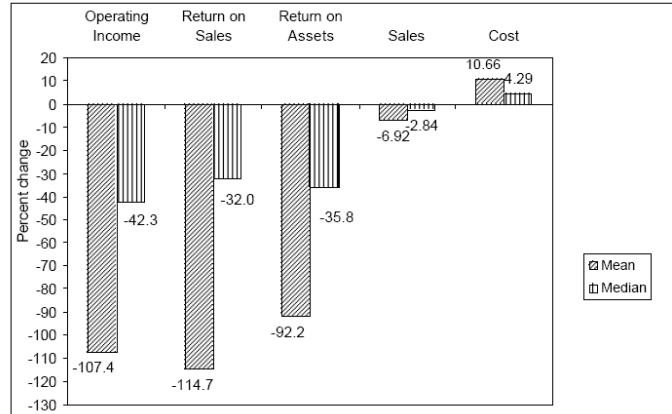


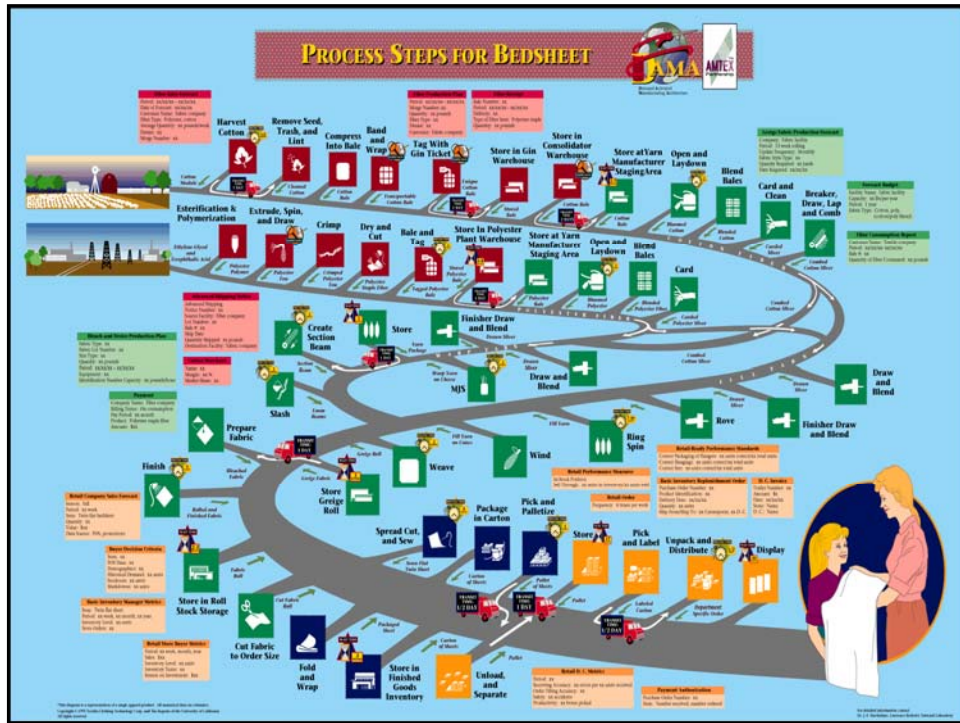
Figure 3: Change in control-adjusted operating performance of sample firms during the year before the announcement of glitches using the most-matched control sample.

Adapted from Y. Sheffi, June '10 MIT Executive Education Program

Source: Hendricks & Singhal, "Association Between Supply Chain Glitches and Operating Performance"

Complexity.....

How complicated is it to make a bedsheet?
(or other products...)



Suppliers to the 2010 Chevrolet Corvette

Suppliers to the 2010 Chevrolet Corvette

- CYLINDER HEAD GASKETS: ElringKlinger
- WIRE HARNESSING: Tesa Tape
- FUEL MANAGEMENT DIAPHRAGMS: Contitech
- AUTOMOTIVE CABLES: Leoni Kabel
- IGNITION COILS: Mitsubishi Electric
- INTERCOOLER FLUID CONNECTIONS: Jilly Tite
- TENSIONER: Gates
- TIMING CHAIN: INA
- HOOD HINGES: Multimatic
- TRANSMISSION SWITCH: TRW
- O-RINGS: Freudenberg
- QUICK CONNECTOR: A. Raymond
- ENERGY ABSORBER: JSP
- CLUTCH MASTER CYLINDER: FTE
- TWIN DISC CLUTCH: ZF
- CLUTCH: LuK
- PISTONS: Federal-Mogul
- INSTRUMENT PANEL: IAC
- CENTER CONSOLE: Draexmaier
- DRIVER AIRBAG: Autoliv
- ELECTRONIC WINDOW REGULATOR: Brose
- TAILLAMPS: Visjeon
- GAS SPRING HATCH: Stabillus
- DOOR ASSEMBLIES: Meridian
- FENDERS: Magna
- JOINT BUMPER: Vibraacoustic
- EXHAUST TIP: Valor
- REAR BRAKE CABLES: Dura
- LUG NUTS: Taper Pro
- HUB UNITS: SKF
- REAR AXLE DIFFERENTIAL: Getrag
- DRIVE PINIONS: American Axle
- REAR CONSTANT VELOCITY JOINT DRIVESHAFT: NTN
- FUEL TANK: TI Automotive
- FUEL PUMP ASSEMBLY: Shanghai SIZ
- TVS SUPERCHARGER: Eaton
- WIRING PROTECTION SYSTEMS: Delfingen
- SEAT MOTORS: Johnson Electric
- HEATED-SEAT SWITCHES: Panasonic
- SEAT CUSHION SUSPENSION: Leggett & Platt
- ALL-ALUMINUM SPACEFRAME: Dana
- FRAME RAIL: Prototech Laser
- WING: Nagoya, Japan
- FIXED TRAILING EDGE: Nagoya, Japan
- MOVABLE TRAILING EDGE: Australia
- WING TIPS: Korea
- TAIL FIN: Fredrickson, Washington
- PASSENGER ENTRY DOORS: Fraico
- HORIZONTAL STABILIZER: Foggia, Italy
- AFT FUSELAGE: Charleston, S.C.
- ENGINE NACELLES: Chula Vista, CA
- CENTER FUSELAGE: Grottaglie, Italy
- FORWARD FUSELAGE: Nagoya, Japan
- FORWARD FUSELAGE: Wichita, Kansas
- CARGO/ACCESS DOORS: Sweden
- WING/BODY FAIRING: Winnipeg, Canada
- LANDING GEAR DOORS: Gloucester, UK
- ENGINES: GE-Evenndale, Ohio; Rolls-Royce-Derby, UK
- FIXED AND MOVABLE LEADING EDGE: Tulsa, Oklahoma

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Complexity!

Partners Across The Globe Are Bringing The 787 Together

787 DREAMLINER

THE COMPANIES					
U.S.	CANADA	AUSTRALIA	JAPAN	KOREA	EUROPE
Boeing	Boeing	Boeing	Kawasaki	KAL-ASD	Messier-Dowty
Spirit	Messier-Dowty		Mitsubishi		Rolls-Royce
Vought			Fuji		Latecoere
GE					Alenia
Goodrich					Saab

- WING TIPS: Korea
- FIXED TRAILING EDGE: Nagoya, Japan
- MOVABLE TRAILING EDGE: Australia
- TAIL FIN: Fredrickson, Washington
- PASSENGER ENTRY DOORS: Fraico
- HORIZONTAL STABILIZER: Foggia, Italy
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- FIXED AND MOVABLE LEADING EDGE: Tulsa, Oklahoma

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Ref.: http://3.bp.blogspot.com/-WGCeDvDQx4/UHbqZTQVpXI/AAAAAAAAAArW/dK8CnoNSLyM/s1600/104664-Boeing_787_DreamLiner.gif

Dealing with Uncertainty (concepts)



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Some Observations about Forecasting or “we often depend on forecasts and are disappointed”

- “The only function of economic forecasting is to make astrology look respectable”
John Kenneth Galbraith
- “Wall Street indices predicted nine out of the last five recessions!” – Paul A. Samuelson in Newsweek, Science and Stocks, 19 Sep. 1966.
- “Prediction is very difficult, especially if it’s about the future.” – Nils Bohr, Nobel laureate in Physics
- “If you have to forecast, forecast often.” – Edgar R. Fiedler in The Three Rs of Economic Forecasting-Irrational, Irrelevant and Irreverent, June 1977.
- “An economist is an expert who will know tomorrow why the things he predicted yesterday didn’t happen today.” – Evan Esar



Ref.: E. Belasco, <http://www.montana.edu/ebelasco/agec421/Forecasting.pdf>

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Forecasting reality

- A point forecast is always wrong – high or low
- How to make the forecast more accurate?
 - A range forecast can be right and encompass the actual demand
 - Forecasts for near-horizons can be more accurate (there is less uncertainty)
 - Collaborate with upstream and downstream partners, sharing promotion/demand/supply plans
 - Learn from past patterns – but don't be slave to them if the conditions vary
 - Share risks with partners
 - Scenario planning for multiple options
- But there is always uncertainty about the outcome until occurs
- Consider other actions that can help address uncertainty
 - Supply chain design
 - Managing uncertainty



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Supply Chain Design Key Success Factors

- Design the supply chain as a System
 - Dell, Zara, Caterpillar, P&G, Walmart, Flextronics, Cisco
- Develop a portfolio of supply chains
 - Fast, responsive – low volume, high cost, near point of demand
 - Slow, efficient – high volume, low cost operation
- Right supply chain for product
- Design for Flexibility & Robustness

What is the Right Supply Chain for Your Product?

Matching Supply Chains with Products

	Functional Products	Innovative Products
Efficient Supply Chain	match	mismatch
Responsive Supply Chain	mismatch	match



Ref.: HBR "What is the right supply chain for your product?" Marshall Fisher, March 1997



Design for Flexibility and Robustness

- Flexibility: prior investments in capabilities & options
 - Workforce trained to perform multiple tasks
 - Products designed to be easily reconfigured based on material and supplier selection
 - Production assets designed to be reconfigured to accommodate variability in demand
 - Provides benefit dealing with daily variations
- Robustness/Redundancy: prior investments in assets
 - Inventory maintained throughout the supply chain, at suppliers, internally, finished goods inventory
 - Additional production capacity maintained beyond needs to serve known customer needs
 - Only provides benefit when assets are used



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Supply Chain Risk Management

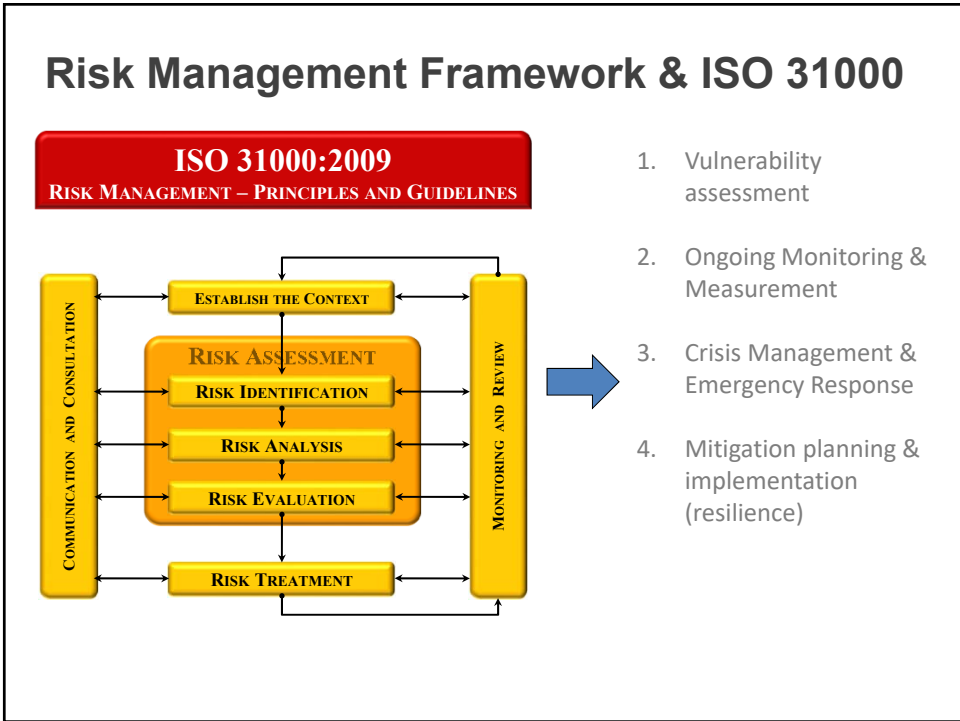
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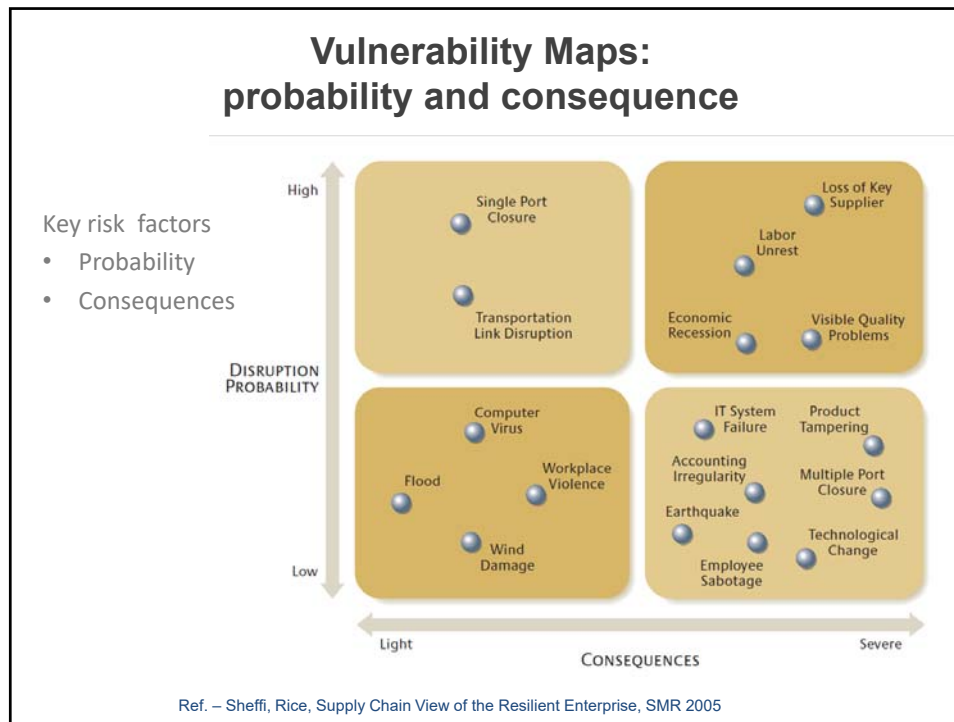
Supply Chain Risk Leadership Council

SCRLC
SUPPLY CHAIN RISK LEADERSHIP COUNCIL

An industry council comprised of world class supply chain firms working together to develop and share supply chain risk management standards and best practices

www.scrlic.com



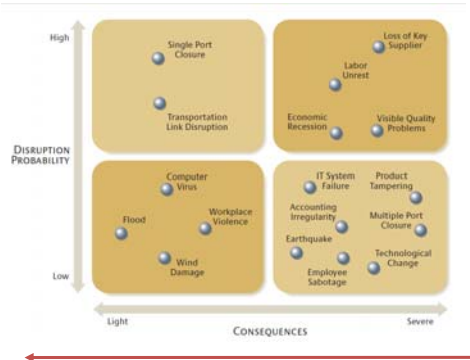


4. Mitigation Planning & Implementation

- Identify options for reducing probabilities & consequences
 - Identify company risk profile
 - Choose right mix of each for the business
 - Prevention or Response? How much of each?
- Reduce Probability → Security and Prevention
- Reduce Consequences → Response and Resilience

Reduce Vulnerability to Disruption

1. Reduce probability of disruption: increase security, prevention



2. Reduce consequences of disruption: increase resilience

Ref. – Sheffi, Rice & SC Response Project

Supply Chain Resilience

- Supply Chain Resilience:
 - In material science, resilience is the physical property of a material that can return to its original shape or position after a deformation that does not exceed its elastic limit.
 - In today's business environment, resilience is widely used to characterize an organization's ability to react to an unexpected disruption, such as one caused by a terrorist attack or natural disaster, and restore normal operations.
 - It's the ability to recreate supply chain capabilities, to 'bounce back' from variations and disruptions

- Examples of supply chain resilience?

Source: "Building a Secure and Resilient Supply Network" by J. Rice, F. Caniato, SCMR Sept-Oct 2003

SC Resilience Principles

- Failure Mode Analysis – predictable outcomes
 - Plan for recovery from failure modes, not on risk source
 - Design to 'fail smartly' – plan to fail with limited impact
 - 'Options' thinking and planning

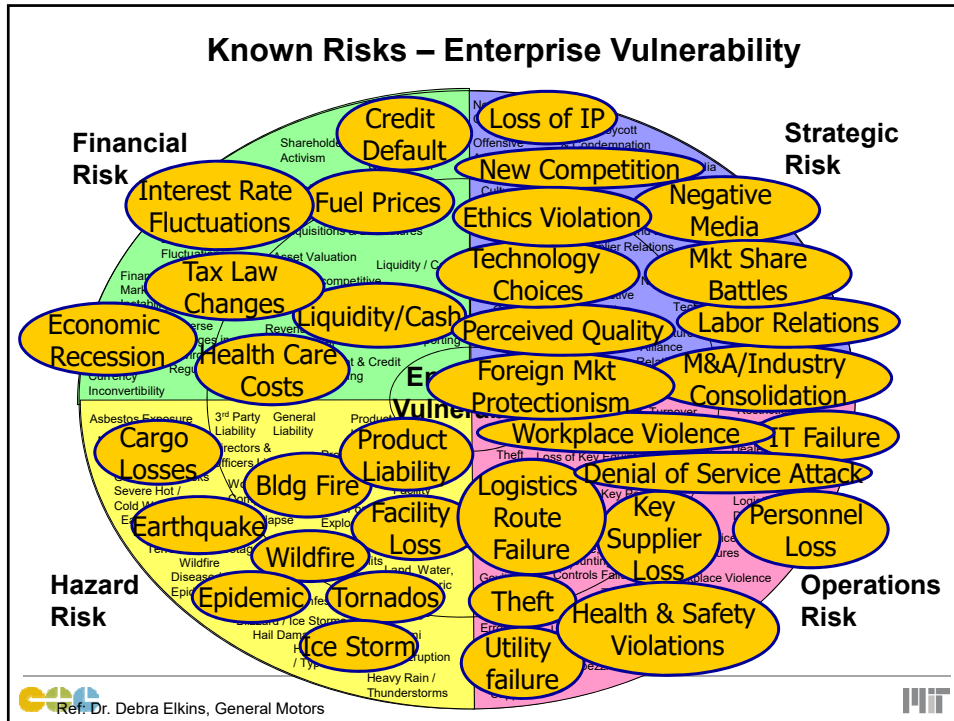
- Business Continuity Planning (BCP) for outcomes
 - Identify action plans to maintain & recreate business operations after disruption
 - Focus on responding to Failure Modes – outcomes
 - Prepare organization to response and recover
 - Choose mix of flexibility & redundancy
 - Design supply chain network for resilience
 - From upstream suppliers, internal operations and downstream to customer, plan for backup

Sources: "SC Response Project Interim Report" by J. Rice, F. Caniato, Aug 8, 2003; Draft of SC Response Book project, Oct. 2004

Supply Chain Failure Modes

All disruptions result in a loss of one or more of these capacities:

- Capacity to acquire materials (supply)
- Capacity to ship/transport
- Capacity to communicate
- Capacity to convert (internal operations)
- Human resources (personnel)
- Financial flows



Many Paths to Flexibility Through...

- Interchangeability
- Postponement
- Supply
- Distribution
- Flexibility culture

Sources: "SC Response Project Interim Report" by J. Rice, F. Caniato, Aug 8, 2003; Draft of SC Response Book project, Oct. 2004, later pub as "The Resilient Enterprise" by Y. Sheffi

Many Paths to Flexibility

- **Interchangeability**
 - Use standardized facilities
 - Intel 'Copy Exact' – same orientation to the sun....
 - Use standard parts
 - Common parts and platforms used at tech companies (Dell, Lucent), Lucent reduced platforms from 85→5
 - Single interface used by Southwest for pilots
 - Use standard processes
 - Helix Technologies reduced production process into many small steps that can be taught and performed quickly
 - Standard processes enable rapid response to disasters (UPS)
- **Postponement**
 - Delay customization of product
 - Benetton make greige sweaters, batch colors the final product
 - H-P makes std printer & tailors for EU markets once demand surfaces
 - Sherwin-Williams paint mixed at store for custom color



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Many Paths to Flexibility (continued)

- **Supply**
 - Contract with suppliers for different response rates (Jabil, Lucent)
 - Favorable relationship supports supplier collaboration in response to disaster (Toyota – Aisin fire)
- **Distribution**
 - Use distribution system to provide broad access to parts across entire network (Caterpillar)
 - Use make-to-order and direct distribution system to enable tailoring product sales to materials on hand (Dell)
- **Flexibility culture**
 - Make employees aware of risks & tradeoffs in decisions
 - Install early warning systems (Nokia)
 - Educate for awareness & train for response (Intel)
 - Distribute decision-making, open communications



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A few examples of flexibility....

- Auto part supplier: Fire burned facilities, data
 - [Standard production process, suppliers](#) provide 'lost' info
- Cantor Fitzgerald: Lost traders, customer info
 - Recaptured 50% of trades using CRM for info
- Intel
 - [Interchangeable plants](#) via "Copy Exact!", Earthquakes BCP
- UPS
 - [Standardized processes](#) enable work force flexibility
- Lucent Technologies
 - [Interchangeable parts](#), standard models, [concurrent SC](#)
- Reebok
 - [Postpone](#) customization of NFL jerseys
- Helix Technology
 - Simplified production so supplier produces in emergency
- Jabil Circuits
 - Builds flexibility into standard contracts, 100% in 4 weeks



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A few examples of robustness....

- Morgan Stanley
 - [Redundant IT system](#), restarted 9-12-01
 - Redundancy added after '93 attack on World Trade Center
- USPS: Anthrax
 - Used [excess capacity](#) to shift processing to other sites
- Boston Scientific
 - Financial analysis indicated cash flow crunch
 - Set up [redundant production facility, staff](#) – ready & waiting
- US Government & J&J
 - [Maintain stock](#) of medical supplies, rolling inventory



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Managing Uncertainty

Uncertainty Reduction

- Risk Pooling
 - Aggregation
 - Platform strategy, product modularization
 - Standardization
 - Inventory centralization
- Time compression
 - Cycle time reduction
 - Postponement
- Information Management:
 - Focus groups, expert opinions IT tools (ERP, cloud, SaaS)
 - CPFR, VMI
 - Demand shaping
 - POS data

Risk Management

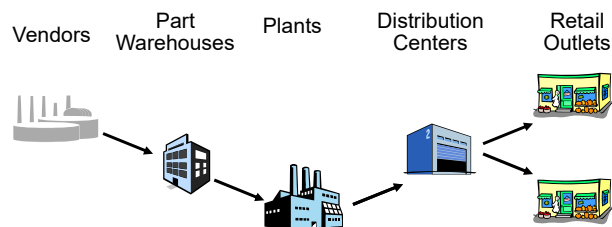
- Buffering
 - Inventory, capacity, time
- Capacity Segmentation
 - 80/20 rule,
 - ABC classification, customer profiles
- Diversify supply sources
- Flexible capacity
- Service level management
- Supply Contracts
- Outsourcing



Ref.: "Supply Chain Principle # 2; Topic: Uncertainty" MIT Supply Chain 2020 Working Paper, M. Singh July 24, 2006

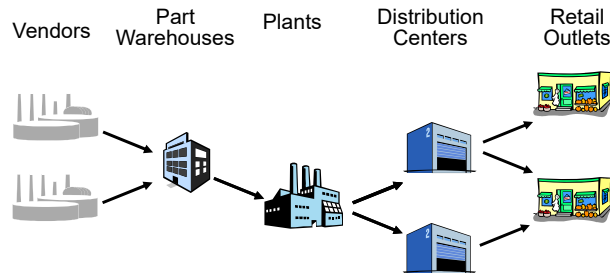


Adding Resilience to a Supply Chain



How would you add resilience to this supply chain?

Adding Resilience to a Supply Chain



Options include.....

- Redesign entire SC for resilience (streamline)
- Adding back up supplier
- Adding additional inventory
- Add additional facility
- Choices on response time
- Buying options for additional capacity in your network....

Break