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# SC Resilience: Understanding The Financial Barriers

James B. Rice, Jr.

MIT CTL | Luxembourg | April 18, 2023



MIT Center for  
Transportation & Logistics



# Some relevant articles...

Operations And Supply Chain Management

## Overcoming the Financial Barriers to Building Resilient Supply Chains

by James B. Rice, Jr., Walid Klibi, and Kai Trepte

November 01, 2022



Allstair Berg/Getty Images

MIT Published in MITSupplyChain



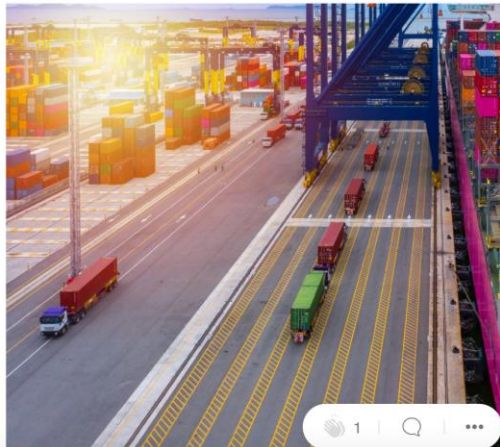
James B Rice Jr  
Aug 11 · 5 min read · Listen



## Building Supply Chain Resilience Is Much More than Fixing Supply Problems

Companies need to map these critical linkages when evaluating risk and resilience. When one is likely that other parts of the system will be i

by James B. Rice Jr. and Ken Cottrill



Supply Chain Management Review

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## Supply Chain Resilience Core Capacities Part 2: Lessons from Comparing Disruptions

The comparative matrix enables us to draw some important distinctions between these disruptions and how they compare to the fallout from the Covid-19 crisis.

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By Jim Rice · August 18, 2021

In the previous post in this two-part series **The 7 Core Capacities of Supply Chain Resilience**, we identified the core capacities that are the building blocks of supply chain resilience. And we explained how these building blocks can be used to avoid or manage a limited number of predictable outcomes (failure modes).



Latest News

How to talk to (with) the finance guy?

Use complete sentences and speak in financial terms, not cycle times or inventory turns.

# How to measure resilience?

We'll get to this in a bit...

But really,  
the question that we should be asking  
is....

Why aren't firms investing in SC resilience?

# Why aren't firms investing in SC resilience?

## 1. Risk $\neq$ Resilience

1. Source/cause focus versus outcome focus

## 2. The financial case has great uncertainty

## 3. Different monies are used to invest

1. Working Capital, OpEx, CapEx
2. Different dis-integrated processes

## 4. Lack of resilience measures that guide

1. How much to invest, on what, for what impact?
2. How to access the data necessary to measure and assess resilience?

.....There are more reasons but let's focus on these....

# Risk ≠ Resilience

- We are drawn to the cause, source, risk of disruption
  - The source of the most recent disaster lingers in our mind
  - The sources are fascinating (which sells news)
- Risk mitigation → reduces the probability of an event
  - There are an unlimited number of sources of risk
- Resilience action → recreates the 7 core capacities
  - SCs fail in only 7 ways
  - There are a very limited number of outcomes
  - Recreating those 7 capacities is resilience

# The financial case has great uncertainty

- What are the cash inflows?
  - Incremental net profits that would not have occurred without the investment
  - Ex. Carrying 2 weeks of extra inventory enables 2 weeks of additional fulfillment and profit in a disruption
- The cash inflows are unpredictable
  - When will the resilience investment be utilized?
  - For how long?
  - How effective will the investment be?
    - Will it enable 100% service or 50% service?
  - Benefits of inventory are clear, benefits of other investments not so
    - Having 2<sup>nd</sup> suppliers
    - Having backup facilities



# An Example – Toyota 2012 Investment In Inventory

- After suffering shutdowns after the Sendai disaster, Toyota invested in backup inventory in 2012
  - Estimated 6-9 months of some key items: semiconductors\*
- Toyota used the semiconductors in 2021-2022
  - All other major auto OEMS had to reduce production, Toyota was able to continue full operations for 6-9 months\*
- Toyota took a risk
  - Invested in advance
  - A benefit 10 years later....
  - How much did Toyota benefit?
    - We don't know but let's try to estimate it

# Estimating the Toyota 2012 Investment In Inventory

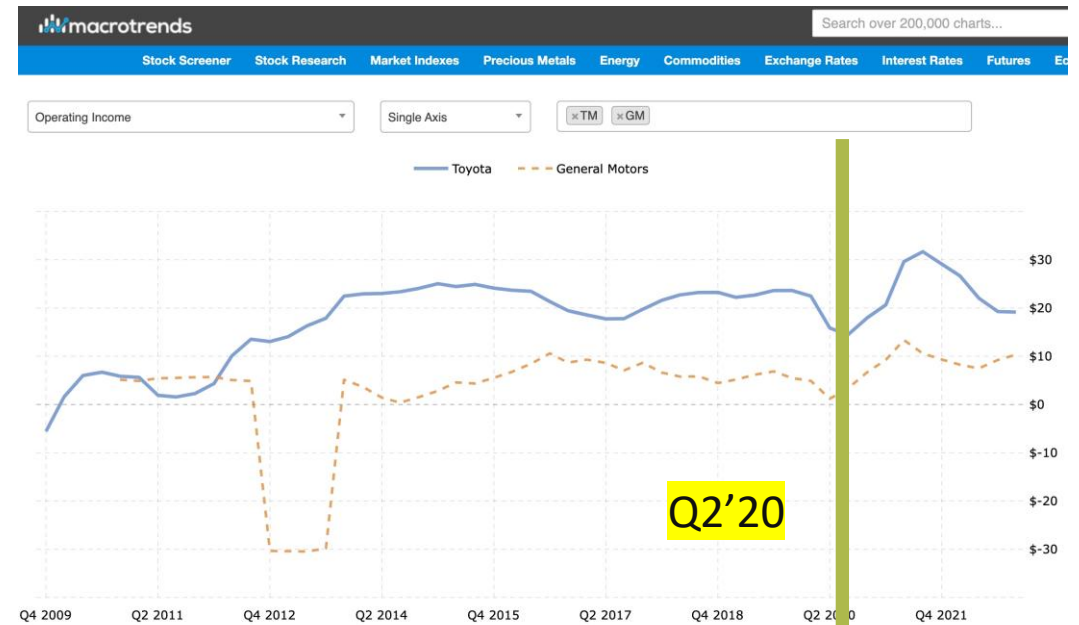
## The Calculus and estimations...

- Operating Income, Revenue, Total Inventory data from Macrotrends\*
- How much did they invest in inventory?
  - I estimated a 10% increase (~\$2B) in 2012
  - This is a guess, a starting point
- What was the benefit?
  - An estimated 6-9 months of incremental operating profit as indicated by comparative performance with GM, noting a distinct change in 2021-2022 and based on trade news reports
- Other estimates
  - Tax rate at 27.96%,
  - Discount rate on 5 year average of 11.5%\*\* , and
  - Rough estimated Non-capital inventory carrying costs of 15%
- Sensitivity analysis appropriate for
  - Non-capital inventory carrying costs
  - Initial Inventory investment
  - Benefit differential

\*\* Discount rate estimate from <https://finbox.com> and tax rate from <https://csimarket.com>

# Toyota & GM Revenue and Operating Income: 2009-2021...but focus on Q2'20-Q2'22

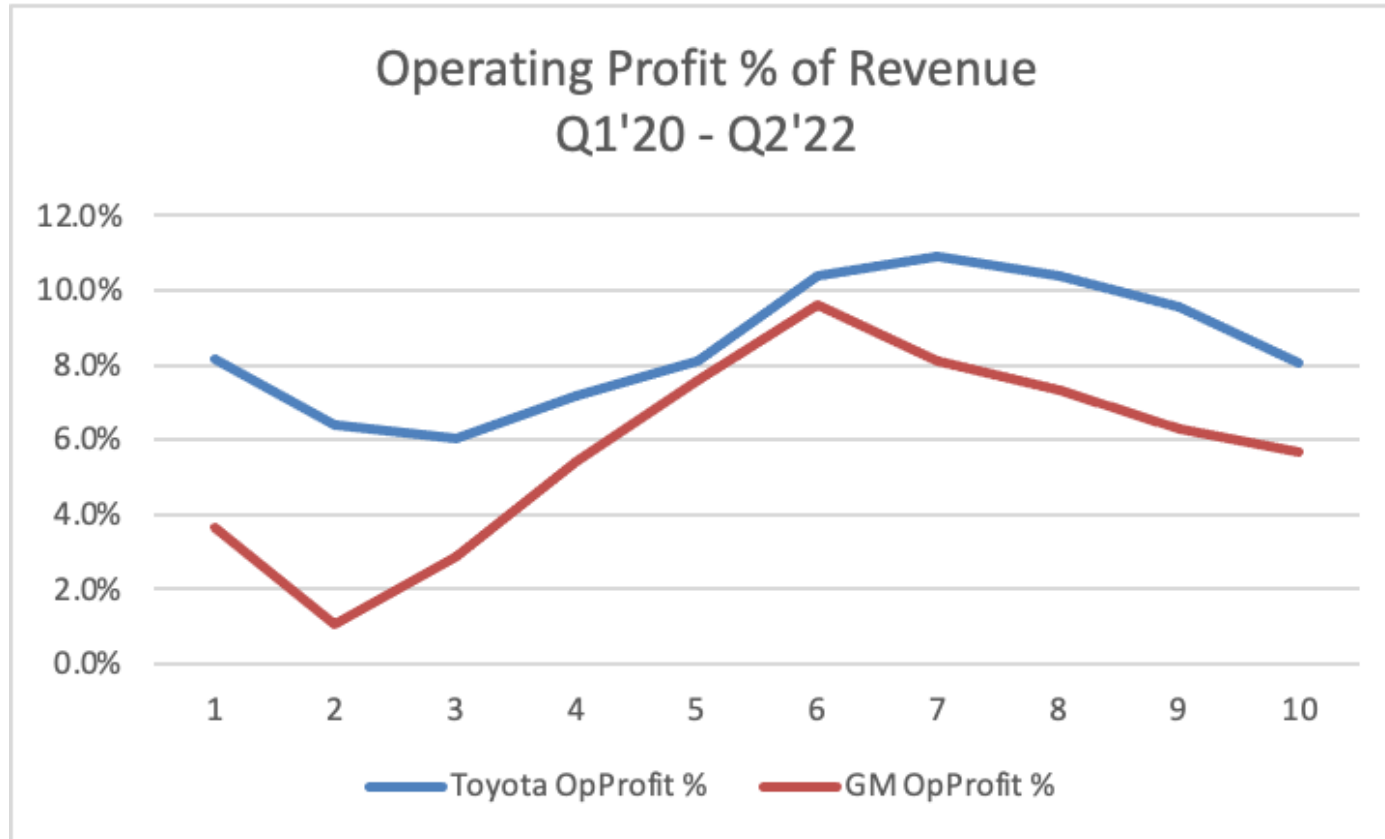
Revenue



Operating Income



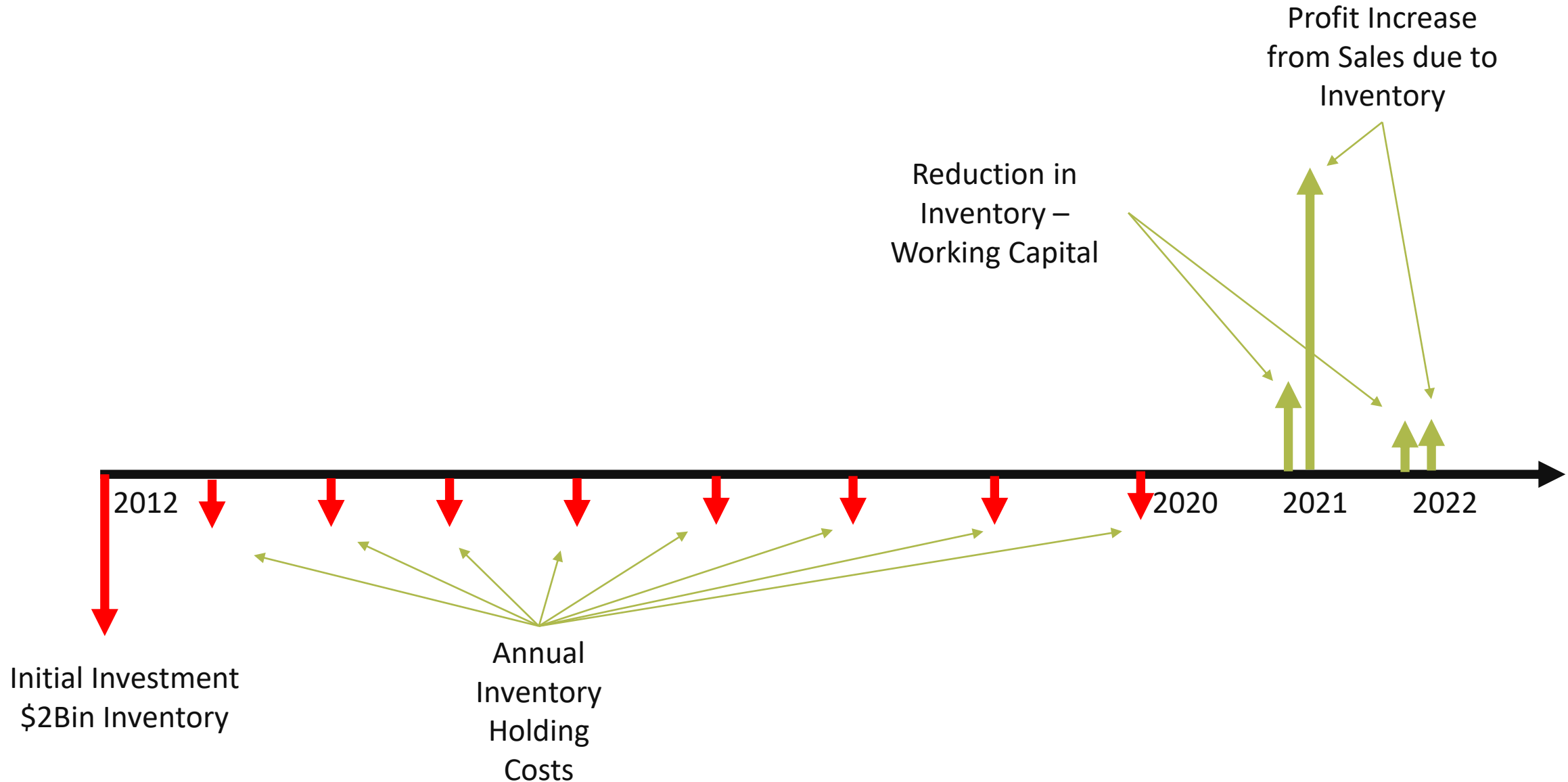
# Toyota & GM Operating Profit % of Revenue: Q1'20 – Q2'22



## Some observations

- Toyota's revenue increased sharply over this time but profit % was modest
- GM profit % increased significantly, then dropped similarly
  - Profit-taking when possible?
- From 3Q'21-1Q22, OpProfit delta between GM and Toyota increased ~\$8.4B-\$11.4B

# Ex. – Toyota 2012 Investment Cash Flows



# Ex. – Toyota 2012 Investment Cash Flows

Base Case:

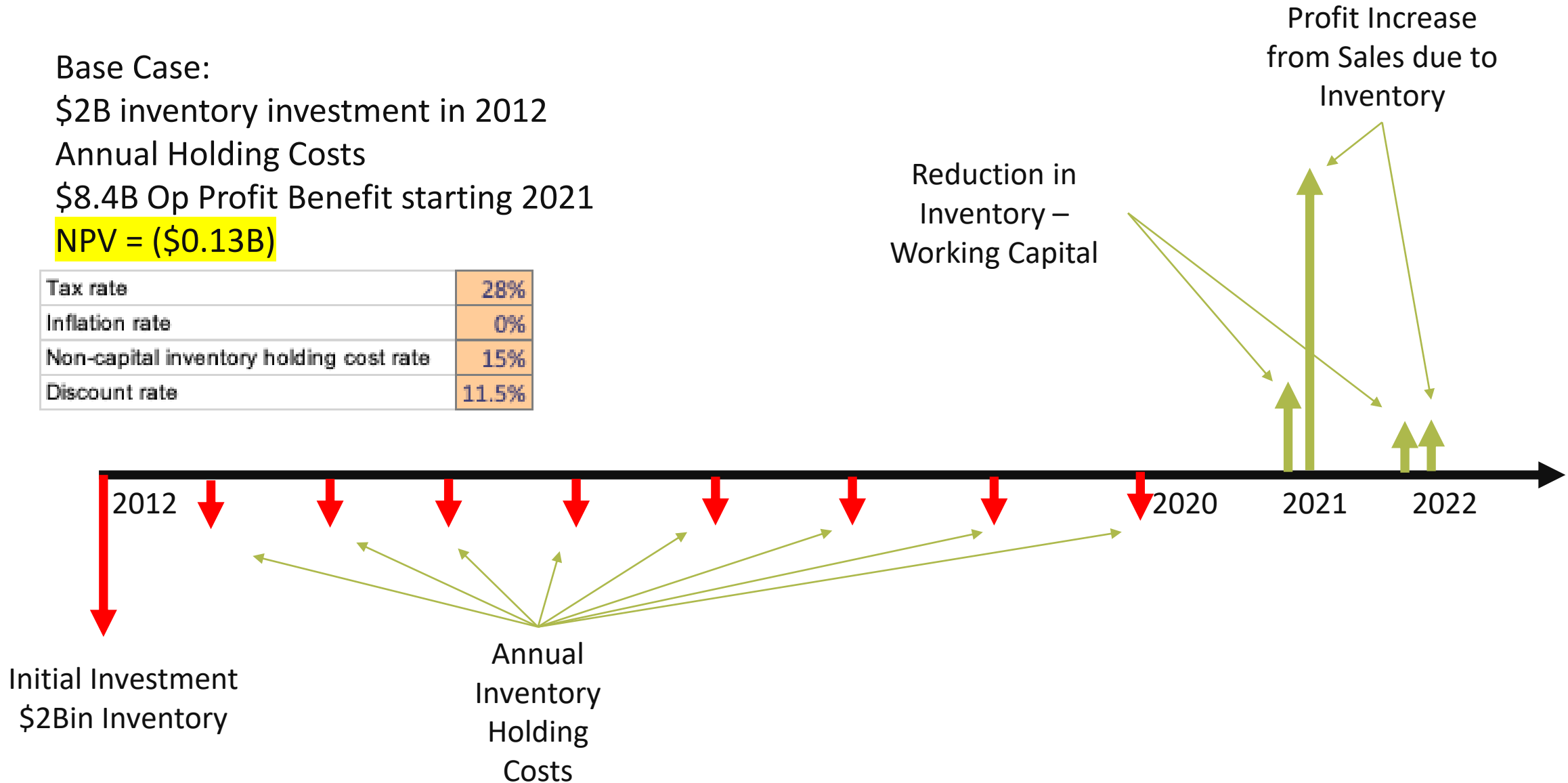
\$2B inventory investment in 2012

Annual Holding Costs

\$8.4B Op Profit Benefit starting 2021

**NPV = (\$0.13B)**

Tax rate	28%
Inflation rate	0%
Non-capital inventory holding cost rate	15%
Discount rate	11.5%



# Ex. – Toyota 2012 Investment Cash Flows

Higher Benefit Case:

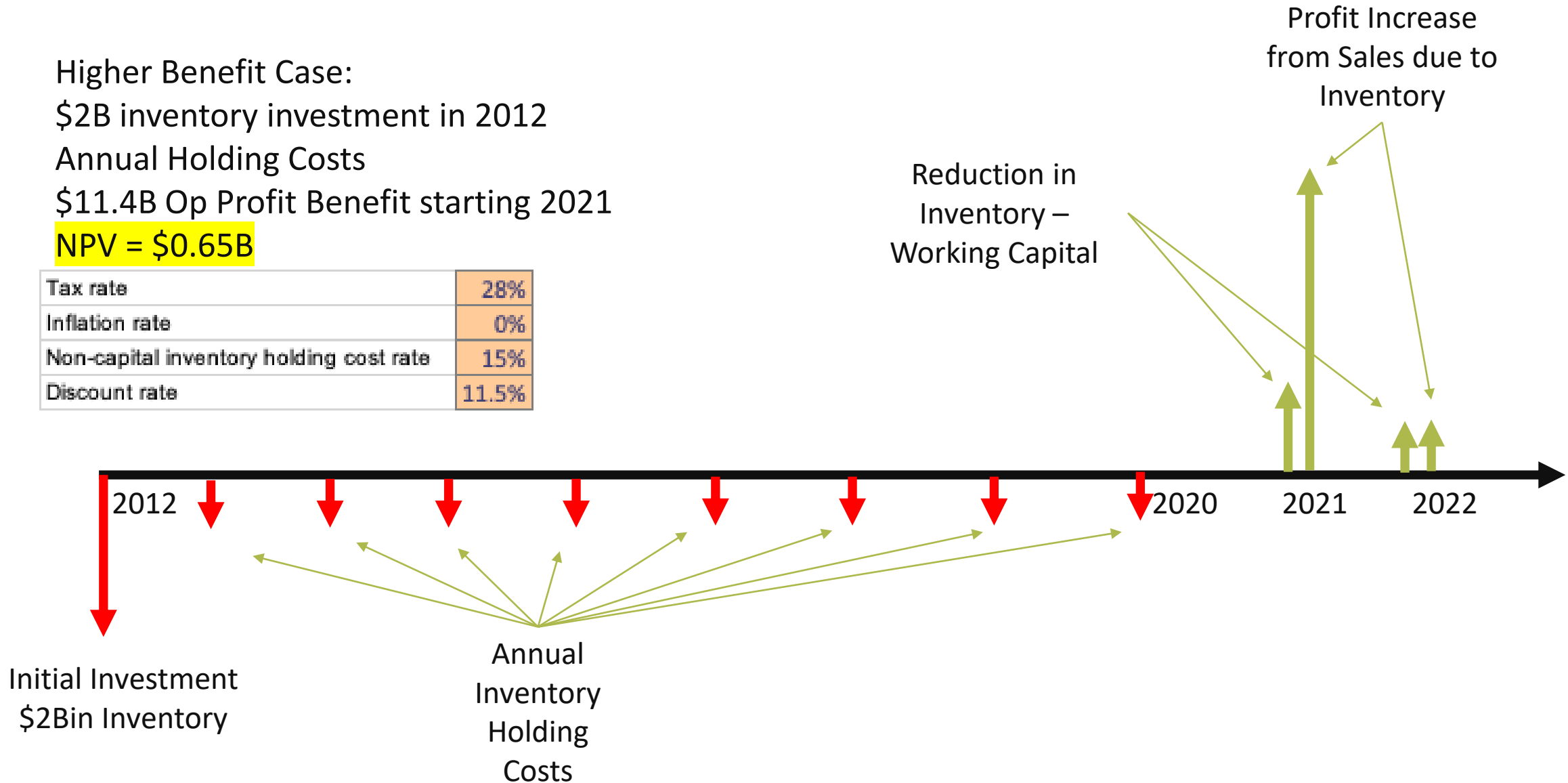
\$2B inventory investment in 2012

Annual Holding Costs

\$11.4B Op Profit Benefit starting 2021

**NPV = \$0.65B**

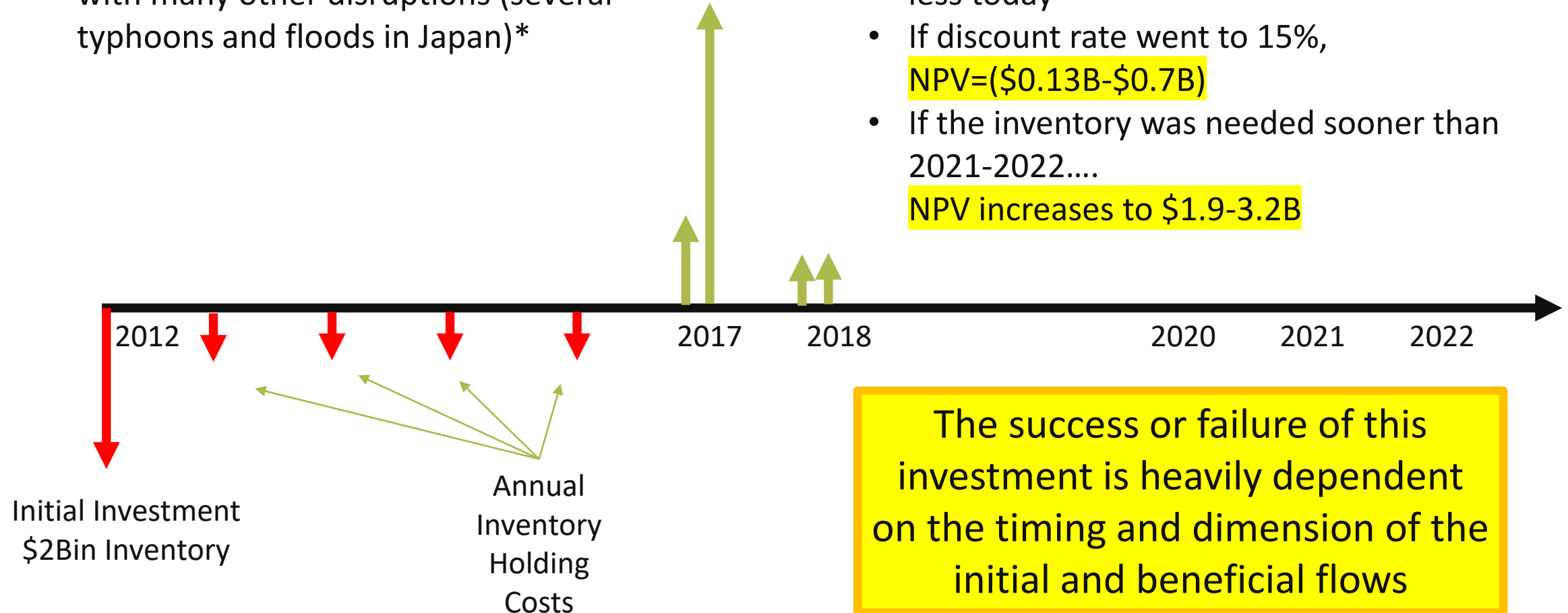
Tax rate	28%
Inflation rate	0%
Non-capital inventory holding cost rate	15%
Discount rate	11.5%



# Toyota 2012 Investment Cash Flows – What if....?

- This does NOT include any benefits from the additional inventory dealing with many other disruptions (several typhoons and floods in Japan)\*

- With higher inflation....the investment becomes less attractive, future flows worth less today
- If discount rate went to 15%,  
NPV=(\$0.13B-\$0.7B)
- If the inventory was needed sooner than 2021-2022....  
NPV increases to \$1.9-3.2B





# Different monies used, each with different processes

Resilience Action	Funds	Funding Process
Buy additional capacity	Capital Expenditure	Capital Budgeting
Add inventory	Working Capital	S&OP, Annual Operations Planning
Qualify additional suppliers	Operating Expense	Annual Budgeting Process

- Processes not integrated
- Processes often functional (siloes)
- Some are annual – limited opportunities to invest

# Ex. Different Monies (CapEx, OpEx, WkgCap) Used for SC Resilience

Capacity Lost / Core Capacity	Resilience Action	Higher Level Action Category	CapEx	Working Capital	Operating Cost (OpEx)
Distribution	Add inventory at Distribution Site	Add Inventory		x	
Distribution	Activate alternative location for order fulfillment	Add Backup option (facility, supplier, channel, location)	Buy		Lease
Distribution	Qualify alternate channels	Add Backup option			x
Distribution	Inventory transfer from other DCs	Shift resources (invty, personnel)			x
Internal Operations	Add External Capacity (+validate)	Add capacity	?		x
Internal Operations	Standardize equipment across sites (flexible manufacturing)	Modify process & systems (automation, standardization, etc.)	x		
Internal Operations	Finished Goods inventory	Add Inventory		x	
Internal Operations	Alternate manual process	Modify process & systems			x
Internal Operations	Backup power	Add Backup option	x		
Supply	Dual source, added supplier	Add Backup option			x
Supply	Multiple sites for same supplier	Add Backup option			x
Supply	FG inventory	Add Inventory		x	
Supply	Warm backup (capacity prepay)	Create options in advance	x		

# Measuring SC resilience elusive, Data sources elusive

- Node-level measures
  - TTR – time to recover: time required to replace lost capacity
  - TTS – time to survive: time until lost sales occur
  - VAR – value at risk: various versions, assess size of potential loss
  - But this data is very hard to access, especially TTR from every supplier, conditions change....
- Some work-arounds....
  - Measure Risk of events → adjust for outcomes
  - Use risk assessment as prediction of future needs
- Proxies
  - Measurements of abilities
    - Connectivity, Number of Suppliers, Complexity, etc.)
  - Resilinc R score

# Measuring SC resilience – 9 Proxies Identified

1. Delivery Delay and Quantity Loss
2. Percentage of Disrupted Suppliers
3. Multiple Sourcing Strategy – Cycle Service Level, Shortage Costs
4. Inventory Positioning – Capacity Restoration over time
5. Backup Suppliers – Expected Total Cost
6. Risk Assessment Tool – TTR & TTS
7. Stress Test – Digital Twin Exercising
8. Resilient Coefficient 1 – Connectedness of SC & Flows
9. Resilient Coefficient 2 – Capacity recovery rate by firm's inventory, backup suppliers, and current suppliers

Ref.: MIT Capstone Draft by Mostafa Khedr Elzanfy & Gianmarco Merino, April 2023

# Different Impact on TTS from Different Investments

Capacity Lost / Core Capacity	Resilience Action	Higher Level Action Category	TTR Impact	TTS Impact	CapEx	Working Capital	Operating Cost (OpEx)
Distribution	Add inventory at Distribution Site	Add Inventory		x		x	
Distribution	Activate alternative location for order fulfillment	Add Backup option (facility, supplier, channel, location)	x		Purchase		Lease
Distribution	Qualify alternate channels	Add Backup option	x				x
Distribution	Inventory transfer from other DCs	Shift resources (invty, personnel)		x			x
Internal Operations	Add External Capacity (+validate)	Add capacity	x		?		x
Internal Operations	Standardize equipment across sites (flexible manufacturing)	Modify process & systems (automation, standardization, etc.)	x		x		
Internal Operations	Finished Goods inventory	Add Inventory		x		x	
Internal Operations	Alternate manual process	Modify process & systems	x				x
Internal Operations	Backup power	Add Backup option	x		x		
Supply	Dual source, added supplier	Add Backup option	x				x
Supply	Multiple sites for same supplier	Add Backup option		x			x
Supply	FG inventory	Add Inventory		x		x	
Supply	Warm backup (capacity prepay)	Create options in advance	x		x		x

# Addressing the barriers to investing in SC resilience

1. Risk  $\neq$  Resilience
  - Focus on Resilience Action
2. The financial case has great uncertainty
  - Use range forecasts, consider strategic action
3. Different monies are used to invest
  - Develop integrated processes... S&OP as an example
4. Lack of resilience measures that guide
  - Calculate TTS
  - For TTR, use automated data and AI/ML to estimate
  - Use risk data as input

# Thank You.....Questions, Comments?

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# Reference



# There are only 7 core supply chain capacities that can fail

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

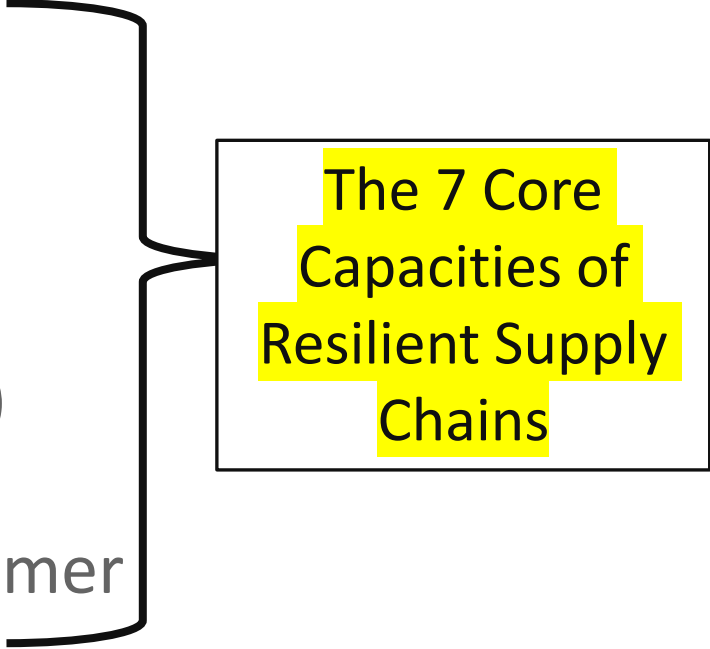
## The 7 Failure Modes of Supply Chains

- Capacity to acquire materials (supply)
- Capacity to ship/transport
- Capacity to communicate
- Capacity to convert (internal operations)
- Capacity of human resources (personnel)
- Capacity of financial flows
- Capacity to distribute to customer/consumer

# Recreate the lost capacities – these become 7 Core Capacities!

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)
- Capacity of human resources (personnel)
- Capacity of financial flows
- Capacity to distribute to customer/consumer



The 7 Core  
Capacities of  
Resilient Supply  
Chains