Quality and lean management

Modern definition of quality

Quality is inversely proportional to variability

Quality https://www.youtube.com/watch?v=kib6uXQsxBA

The ability of a product or service to consistently meet or exceed customer expectations.
Fulfill customer (market) requirement
Fit for purpose.
……..

Product Quality dimensions

Performance – main characteristics of the product
Aesthetics – appearance, feel, smell, taste
Special features – extra characteristics
Conformance – how well the product conforms to design specifications
Reliability – consistency of performance
Durability – the useful life of the product
Perceived quality – indirect evaluation of quality
Serviceability – handling of complaints or repairs
Consistency – quality doesn’t vary

The Consequences of Poor Quality

Loss of business
Liability
Productivity
Costs

Costs of Quality

Appraisal costs
Costs of activities designed to ensure quality or uncover defects
Prevention costs
All TQ training, TQ planning, customer assessment, process control, and quality improvement costs to prevent defects from occurring

Failure costs - costs incurred by defective parts/products or faulty services
Internal failure costs
Costs incurred to fix problems that are detected before the product/service is delivered to the customer
External failure costs
All costs incurred to fix problems that are detected after the product/service is delivered to the customer

TQM Approach

1. Find out what the customer wants
2. Design a product or service that meets or exceeds customer wants
3. Design processes that facilitate doing the job right the first time
4. Keep track of results
5. Extend these concepts throughout the supply chain
6. Top management must be involved and committed

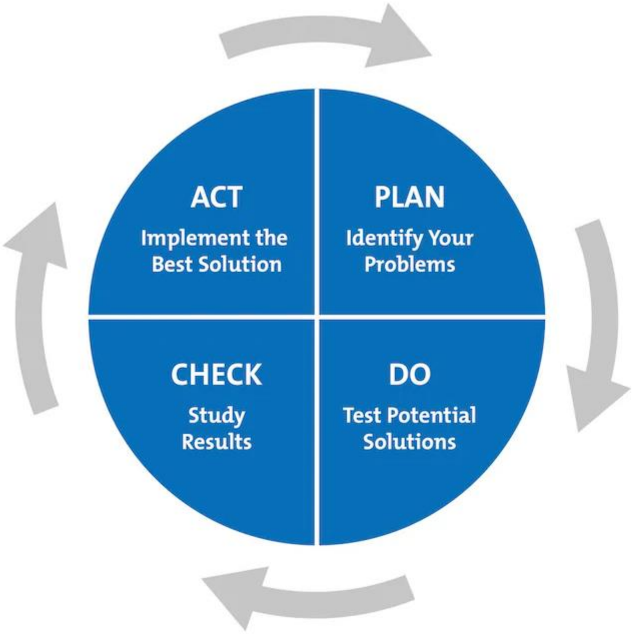
Continuous Improvement

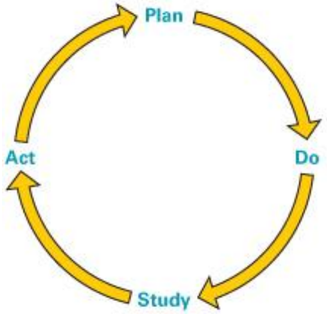
Continuous improvement

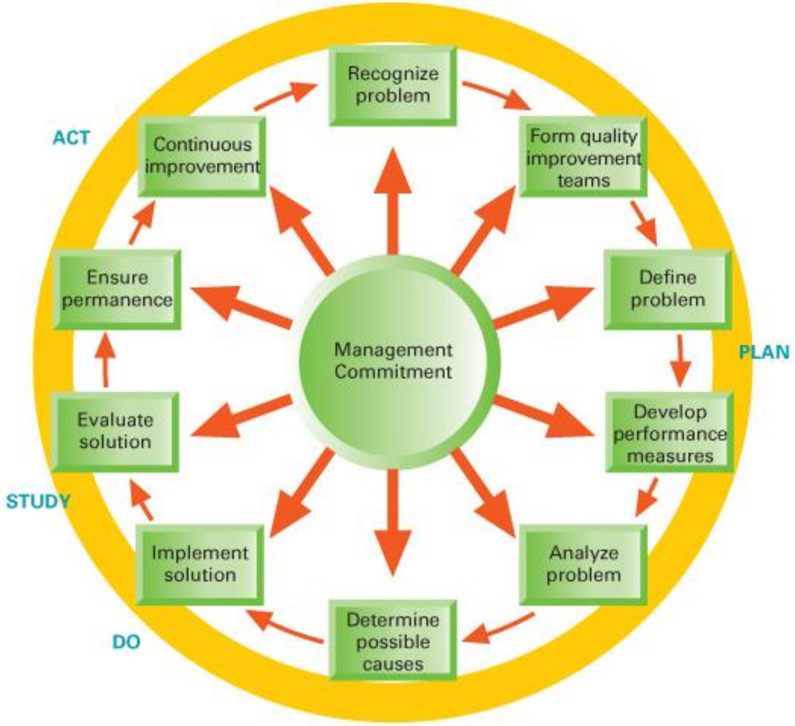
Philosophy that seeks to make never-ending improvements to the process of converting inputs into outputs

Kaizen

Japanese word for continuous improvement







Six Sigma

Six Sigma

- A business process for improving quality, reducing costs, and increasing customer satisfaction
- **Statistically**
  - Having no more than 3.4 defects per million
- **Conceptually**
  - Program designed to reduce defects
  - Requires the use of certain tools and techniques

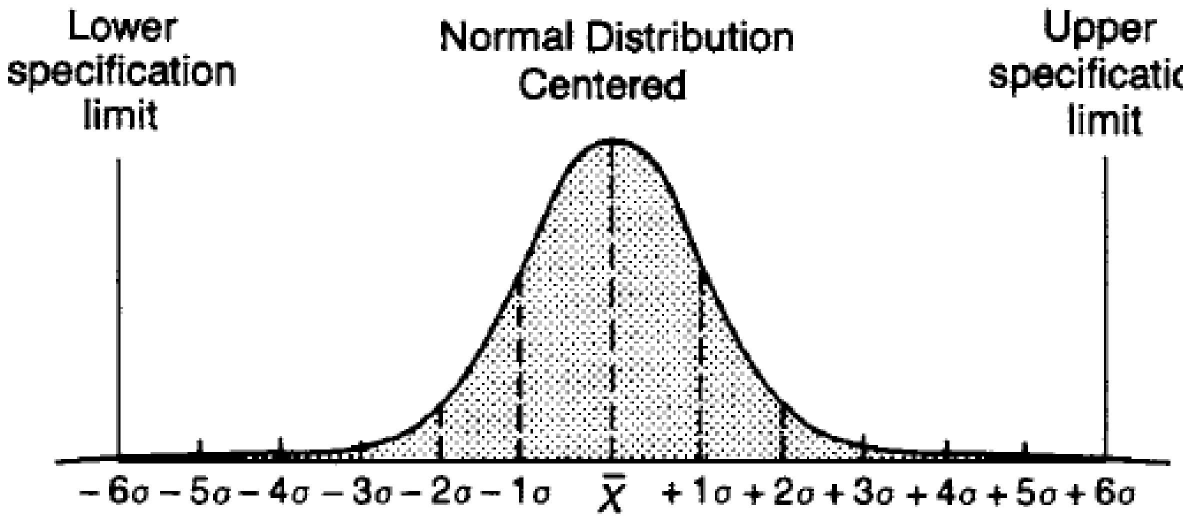
Principles

- Reduction in variation is an important goal
- The methodology is data driven; it requires data validation
- Outputs are determined by inputs
- Only a critical few inputs have a significant impact on outputs

DMAIC

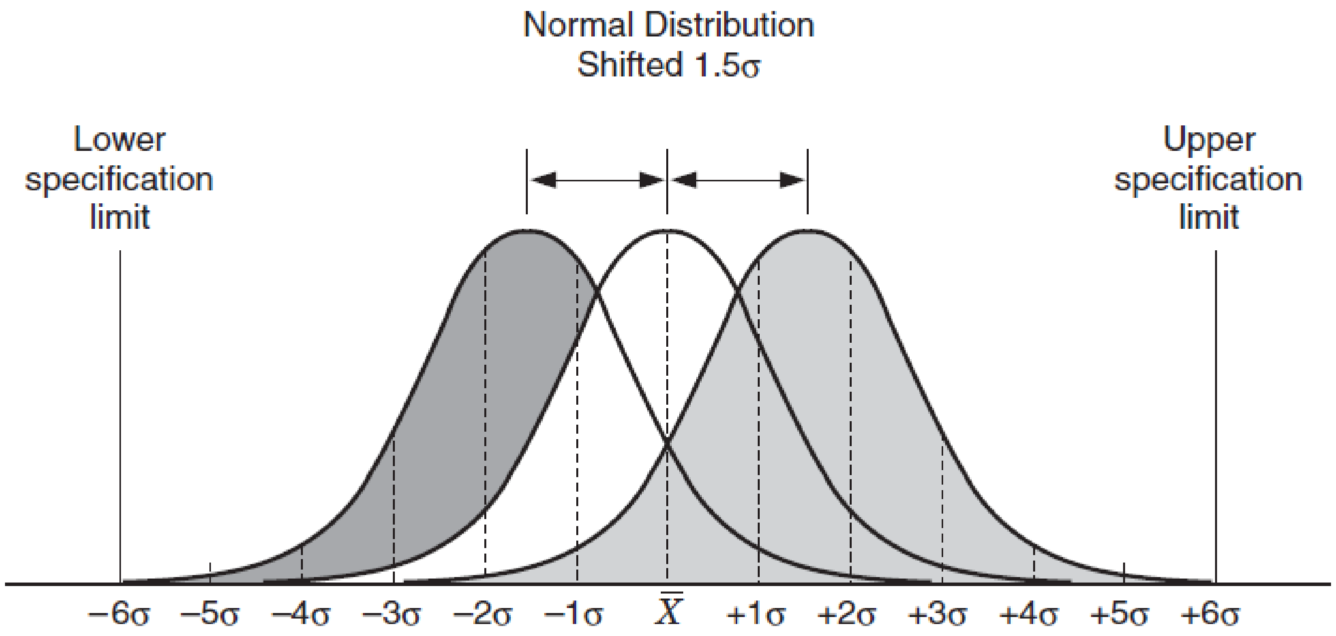
- Define: Set the context and objectives for improvement
- Measure: Determine the baseline performance and capability of the process
- Analyze: Use data and tools to understand the cause-and-effect relationships of the process
- Improve: Develop the modifications that lead to a validated improvement of the process
- Control: Establish plans and procedures to ensure that improvements are sustained

Centered normal distribution between Six Sigma limits



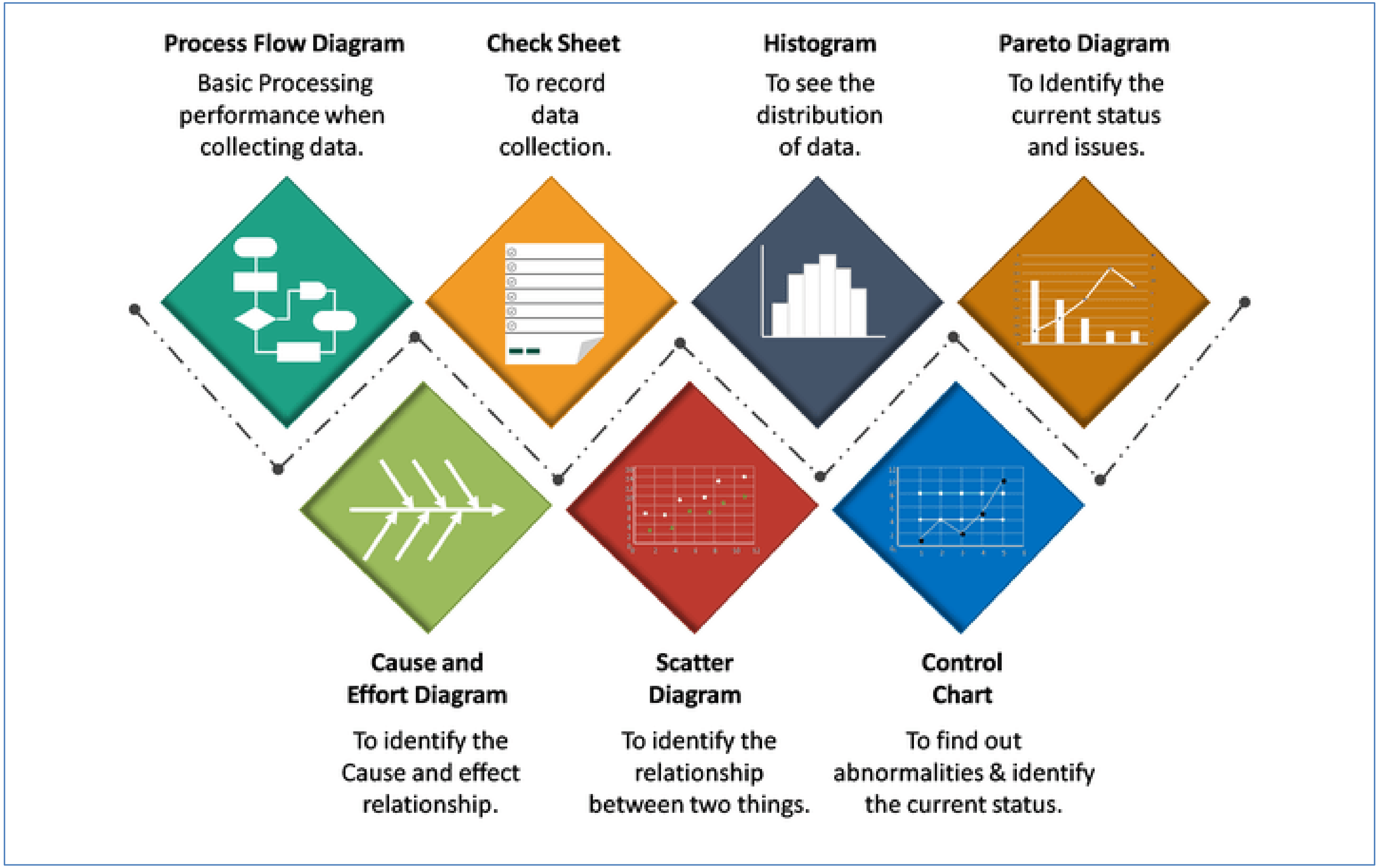
Spec. limit	Percent	Defective ppm
±1 sigma	68.27	317300
±2 sigma	95.45	45500
±3 sigma	99.73	2700
±4 sigma	99.9937	63
±5 sigma	99.999943	0.57
±6 sigma	99.9999998	.002

Effects of a 1.5 shift



Spec. limit	Percent	Defective ppm
±1 σ	30.23	697700
±2 σ	69.13	308700
±3 σ	93.32	66810
±4 σ	99.3790	6210
±5 σ	99.97670	233
±6 σ	99.999660	3.4

Basic Quality Tools (7QC) https://www.viddler.com/embed/ee24445d



Statistical Process Control (SPC)

Quality control seeks

Quality of conformance

A product or service conforms to specifications

A tool used to help in this process

SPC

Statistical evaluation of the output of a process

Helps us to decide if a process is "in control" or if corrective action is needed

Process Variability

Two basic questions: concerning variability:

1. Issue of process control
   - Are the variations random? If nonrandom variation is present, the process is said to be unstable.
2. Issue of process capability
   - Given a stable process, is the inherent variability of the process within a range that conforms to performance criteria?

Variation

Variation

- *Random (common cause) variation*:
  - Natural variation in the output of a process, created by countless minor factors
- *Assignable (special cause) variation*:
  - A variation whose cause can be identified
  - A nonrandom variation

Control Process

Sampling and corrective action are only a part of the control process

Steps required for effective control:

- **Define:** What is to be controlled?
- **Measure:** How will measurement be accomplished?
- **Compare:** There must be a standard of comparison
- **Evaluate:** Establish a definition of *out of control*
- **Correct:** Uncover the cause of nonrandom variability and fix it
- **Monitor:** Verify that the problem has been eliminated

Control Charts: The Voice of the Process

Control chart

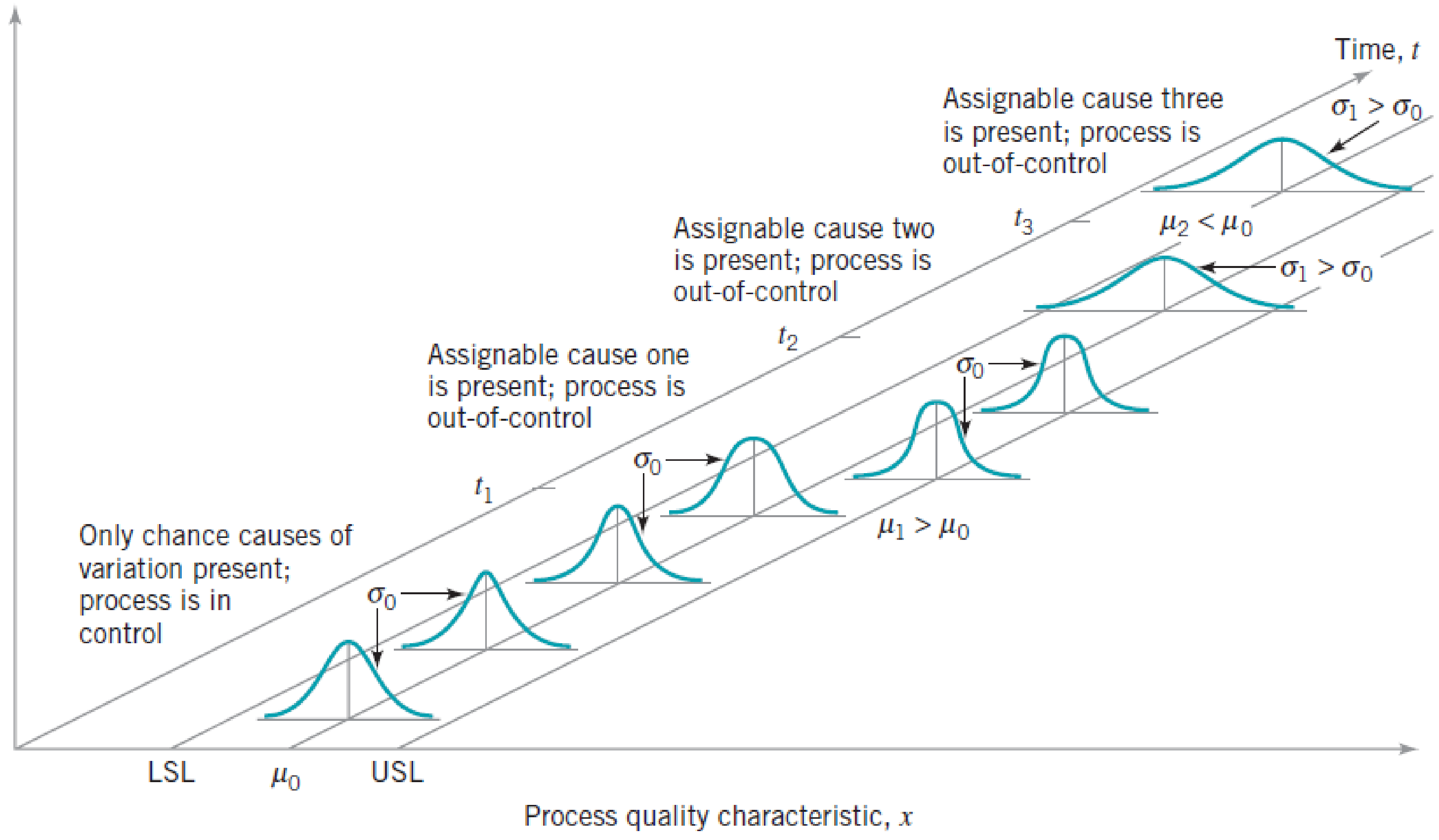
A time ordered plot of representative sample statistics obtained from an ongoing process (e.g., sample means), used to distinguish between random and nonrandom variability

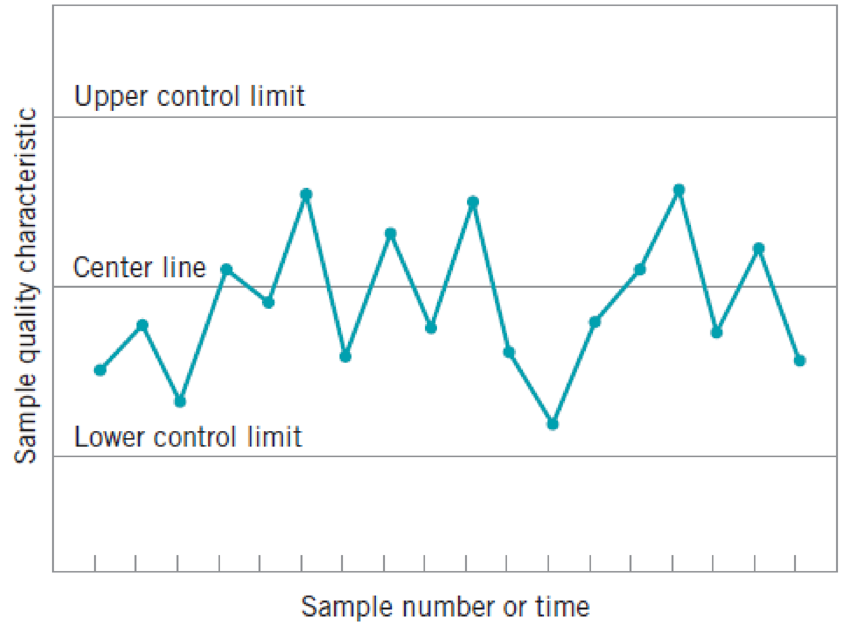
Control limits

The dividing lines between random and nonrandom deviations from the mean of the distribution

Upper and lower control limits define the range of acceptable variation

Process Control and Capability Analysis





Control Charts for Variables

Variables generate data that are *measured*

- Mean control charts
  - Used to monitor the central tendency of a process
    - "*x*-bar" charts
- Range control charts
  - Used to monitor the process dispersion
    - R charts

$$\bar{R} = \frac{\sum_{i=1}^{k} R_i}{k}$$

where

$\bar{R}$ = Average of sample ranges

R_i = Range of sample i

$$\bar{\bar{x}} = \frac{\sum_{i=1}^{k} \bar{x}_i}{k}$$

where

$\bar{\bar{x}}$ = Average of sample means

$\bar{x}_i$ = mean of sample i

k = number of samples

X-Bar/ range Chart: Control Limits

Used to monitor the central tendency of a process

$\bar{x}$ – chart Control Limits

$$UCL_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R}$$

$$LCL_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R}$$

where

A_2 = a control factor based on sample size, n

When sd known
UCL=x double bar+z(sigma/sqrt(n))

R Chart Control Limits

$$ULR_R = D_4\bar{R}$$

$$LCL_R = D_3\bar{R}$$

where

D_3 = a control chart factor based on sample size, n

D_4 = a control chart factor based on sample size, n

Factors for Three Sigma Control Charts

Factors for three-sigma control limits for $\bar{x}$ and R charts

		FACTORS FOR R CHARTS	FACTORS FOR R CHARTS
Number of Observations in Subgroup, *n*	**Factor for $\bar{x}$ Chart, A_2**	**Lower Control Limit, D_3**	**Upper Control Limit, D_4**
2.........	1.88	0	3.27
3.........	1.02	0	2.57
4.........	0.73	0	2.28
5.........	0.58	0	2.11
6.........	0.48	0	2.00
7.........	0.42	0.08	1.92
8.........	0.37	0.14	1.86
9.........	0.34	0.18	1.82

		FACTORS FOR R CHARTS	FACTORS FOR R CHARTS
Number of Observations in Subgroup, *n*	**Factor for $\bar{x}$ Chart, A_2**	**Lower Control Limit, D_3**	**Upper Control Limit, D_4**
10.........	0.31	0.22	1.78
11.........	0.29	0.26	1.74
12.........	0.27	0.28	1.72
13.........	0.25	0.31	1.69
14.........	0.24	0.33	1.67
15.........	0.22	0.35	1.65
16.........	0.21	0.36	1.64
17.........	0.20	0.38	1.62
18.........	0.19	0.39	1.61
19.........	0.19	0.40	1.60
20.........	0.18	0.41	1.59

Problem 1

A quality inspector took five samples, each with four observations ($n = 4$), of the length of time for glue to dry. The analyst computed the mean of each sample and then computed the grand mean. All values are in minutes. Use this information to obtain three-sigma (i.e., $z = 3$) control limits for means of future times. It is known from previous experience that the standard deviation of the process is .02 minute.

		SAMPLE				
		1	2	3	4	5
Observation	1	12.11	12.15	12.09	12.12	12.09
	2	12.10	12.12	12.09	12.10	12.14
	3	12.11	12.10	12.11	12.08	12.13
	4	12.08	12.11	12.15	12.10	12.12
	$\bar{X}$	12.10	12.12	12.11	12.10	12.12

$$\bar{\bar{x}} = \frac{12.10 + 12.12 + 12.11 + 12.10 + 12.12}{5} = 12.11$$

$$\text{UCL:} \quad 12.11 + 3\left(\frac{.02}{\sqrt{4}}\right) = 12.14$$

$$\text{LCL:} \quad 12.11 - 3\left(\frac{.02}{\sqrt{4}}\right) = 12.08$$

When sigma is unknown

Compute R bar= (0.03+0.05+0.06+.04+0.05)/5=0.46

$\bar{x}$ – chart Control Limits

$$UCL_{\bar{x}} = \bar{\bar{x}} + A_2 \bar{R}$$

$$LCL_{\bar{x}} = \bar{\bar{x}} + A_2 \bar{R}$$

where

A_2 = a control factor based on sample size, n

UCL=12.11+ 0.73(0.046)= 12.14
LCL= 12.11-0.73(0.046)=12.08

R Chart Control Limits

$$ULR_R = D_4 \bar{R}$$

$$LCL_R = D_3 \bar{R}$$

where

D_3 = a control chart factor based on sample size, n

D_4 = a control chart factor based on sample size, n

LCL=0
UCL 2.28*0.046=0.105

Control Charts for Attributes

Attributes generate data that are *counted*.

p-chart

Control chart used to monitor the proportion of defectives in a process

c-chart

Control chart used to monitor the number of defects per unit

When observations can be placed into two categories

- Good or bad
- Pass or fail
- Operate or don't operate

When the data consists of multiple samples of several observations each

$$\bar{p} = \frac{\text{Total number of defectives}}{\text{Total number of observations}}$$

$$\hat{\sigma}_p = \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$UCL_p = \bar{p} + z\left(\hat{\sigma}_p\right)$$

$$LCL_p = \bar{p} - z\left(\hat{\sigma}_p\right)$$

Problem

An inspector counted the number of defective monthly billing statements of a telephone company in each of 20 samples. Using the following information, construct a control chart that will describe 99.74 percent of the chance variation in the process when the process is in control. Each sample contained 100 statements.

Sample	Number of Defectives	Sample	Number of Defectives	Sample	Number of Defectives	Sample	Number of Defectives
1	7	6	11	11	8	16	10
2	10	7	10	12	12	17	8
3	12	8	18	13	9	18	12
4	4	9	13	14	10	19	10
5	9	10	10	15	16	20	21
							220

$$\bar{p} = \frac{\text{Total number of defectives}}{\text{Total number of observations}} = \frac{220}{20(100)} = .11$$

$$\hat{\sigma}_p = \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \sqrt{\frac{.11(1-.11)}{100}} = .0313$$

Control limits are

$$UCL_p = \bar{p} + z(\hat{\sigma}_p) = .11 + 3.00(.0313) = .2039$$

$$LCL_p = \bar{p} - z(\hat{\sigma}_p) = .11 - 3.00(.0313) = .0161$$

c-chart

Use only when the number of occurrences per unit of measure can be counted; non-occurrences cannot be counted.

- Scratches, chips, dents, or errors per item
- Cracks or faults per unit of distance
- Breaks or tears per unit of area
- Bacteria or pollutants per unit of volume
- Calls, complaints, failures per unit of time

$$\text{UCL}_c = C + Z\sqrt{C}$$

$$\text{LCL}_c = C - Z\sqrt{C}$$

Sample	Number of Defects	Sample	Number of Defects	Sample	Number of Defects
1	3	7	4	13	2
2	2	8	1	14	4
3	4	9	2	15	2
4	5	10	1	16	1
5	1	11	3	17	3
6	2	12	4	18	1
					45

$\bar{c} = 45/18 = 2.5 =$ Average number of defects per coil

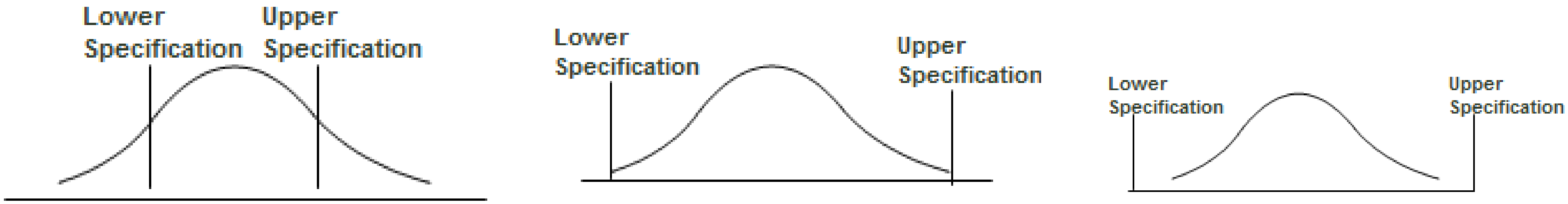
$$UCL_c = \bar{c} + 3\sqrt{\bar{c}} = 2.5 + 3\sqrt{2.5} = 7.24$$

$$LCL_c = \bar{c} - 3\sqrt{\bar{c}} = 2.5 - 3\sqrt{2.5} = -2.24 \rightarrow 0$$

Process Capability

Once a process has been determined to be stable, it is necessary to determine if the process is capable of producing output that is within an acceptable range

- Tolerances or specifications
  - Range of acceptable values established by engineering design or customer requirements
- Process variability
  - Natural or inherent variability in a process



$$C_p = \frac{UTL - LTL}{6\sigma}$$

UTL = upper tolerance (specification) limit
LTL = lower tolerance (specification) limit

Process Capability

C_{pk}

Used when a process is not centered at its target, or nominal, value

$$C_{pk} = \min\{C_{pu}, C_{pl}\}$$

$$= \min\left\{\frac{\text{UTL} - \bar{x}}{3\sigma}, \frac{\bar{x} - \text{LTL}}{3\sigma}\right\}$$

Problem

A manager has option of using any one of the three machines for a job. The processes and their standard deviations are listed below. Determine which m/cs are capable if the specifications are 10.00 mm and 10.80 mm.

Process	Sd	Process width	Cp
A	0.13	0.13*6=0.78	0.8/0.78=1.03
B	0.08	0.48	0.8/0.48=1.67
C	0.16	0.96	0.8/0.96=0.83

Cp is not a true measure for process capability; therefore, measuring Cpk is necessary to collude process capability.

Min [(USL-mean)/3sd, (mean-LSL)/3sd]
A process has a mean of 9.2 grams and the sd of 0.3 grams. The LSL is 7.5 grams and USL is 10.50 grams. Compute Cpk.

Lower index= (9.2-7.5)/3 *0.3=1.89; upper index= (10.50-9.20/3*0.3)=1.44
Min is 1.44 hence process is capable

Class practice

Process	Mean	Sd	LSL	USL
1	7.5	0.1	7	8
2	4.5	0.12	4.5	4.9
3	6.5	0.14	5.5	6.7

Determine process control nature.

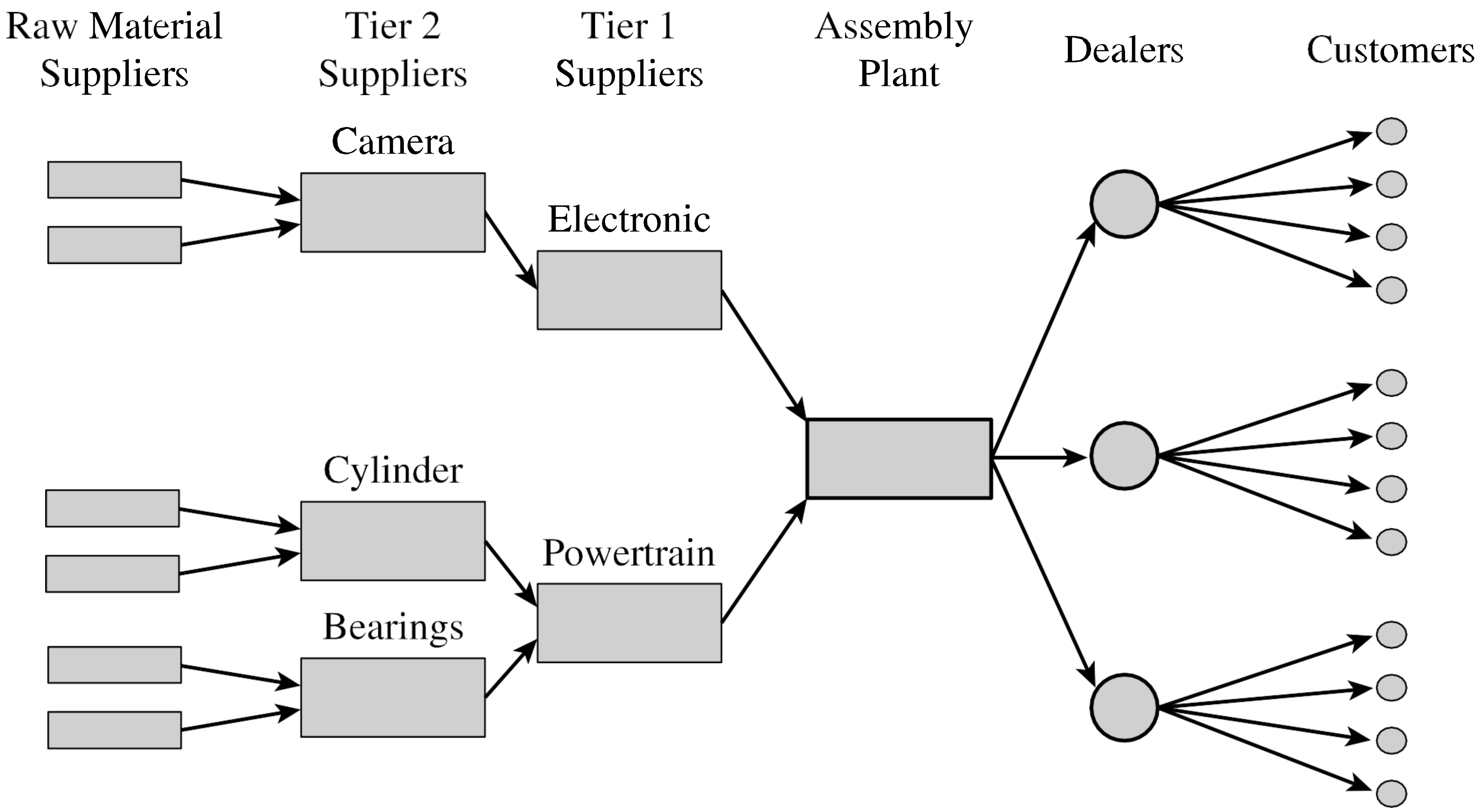
As part of an insurance company's training program, participants learn how to conduct an analysis of a client's insurability. The goal is to have participants achieve a time range of 30 to 45 minutes. The test results of three managers as Ashok, a mean of 38 min. and sd 2 min; Pooja, a mean of 37 minutes and sd 0f 2.5 min; and Jaya with mean of 37.5 and sd of 1.8 min. Compute

- Which of the participants would you judge to be capable? Explain
- Can the value of Cpk exceed the value of for given participant? Explain

A quality manager found an average of 3.9 defects in a car engine start while doing a quality check. Managers attempt to start before delivery to the dealer, but the engine is not started in the first go. The lot size of car is 100 and an average of 4 did not start (4%). Use a suitable control chart for modelling quality issue.

Digital Supply Chain & Logistics Management

Supply Chain

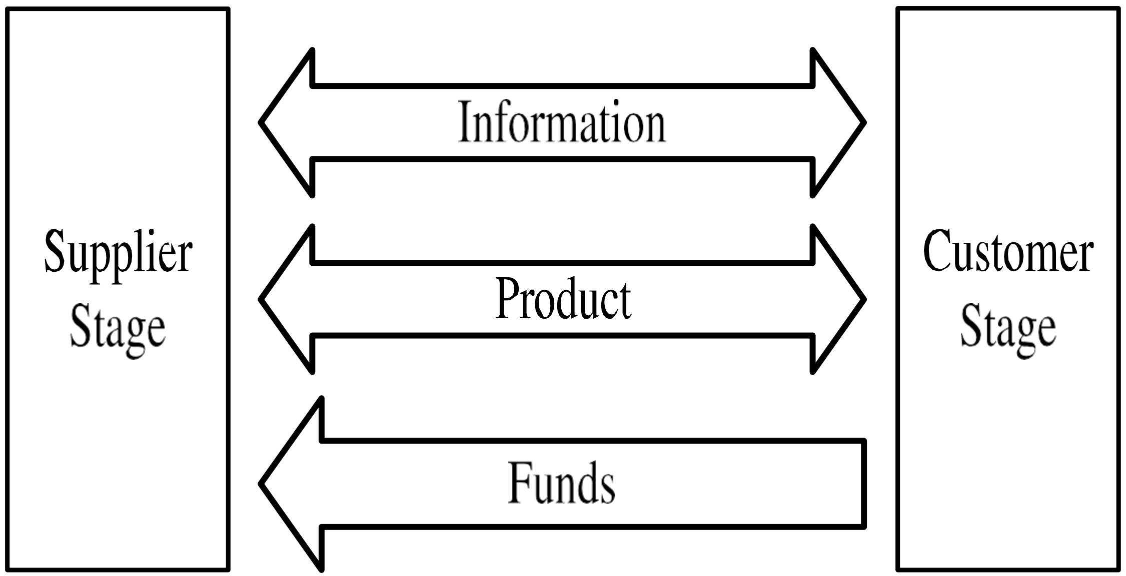


Source: Supply Chain Management by Sunil C. & Peter M.

All parties involved, directly or indirectly, in fulfilling a customer request includes manufacturers, suppliers, transporters, warehouses, retailers, and customers.

Maximize net value generated

Supply Chain Surplus = Customer Value − Supply Chain Cost



Digital supply chain

- Digitalisation in supply chain has come to encompass digital products and services as well as handling the supply chain processes.
- DSC is a bundle of interconnected activities with novel technologies for flow of goods/services.
- Therefore, DSC is an intelligent, value added, novel process that utilizes new approaches for digital transformation which create competitive value and network effect.

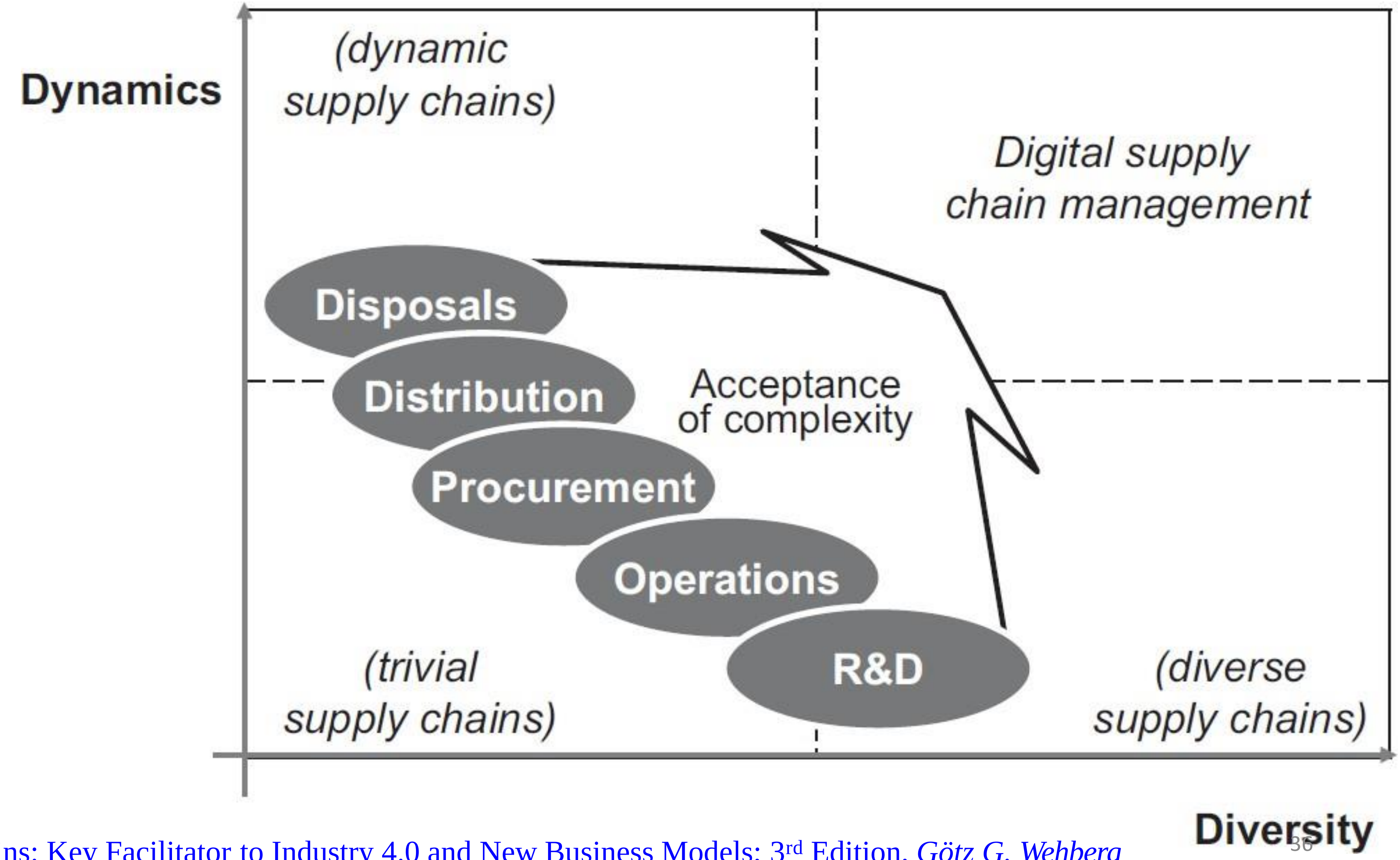
Possible way of digital transformation of SC

- Demand driven supply chain
- Customer expectations
- Value co-creation
- Connecting supply chain activities

DSCLM key points

- DSC means innovation
- DSC cope with complexity of the SC
- DSC is more than Cyberphysical system
- DSC need a clear concept
- DSC is not limited to delivery
- DSC must be specific
- DSC are at the beginning

Supply chain integration for DSC

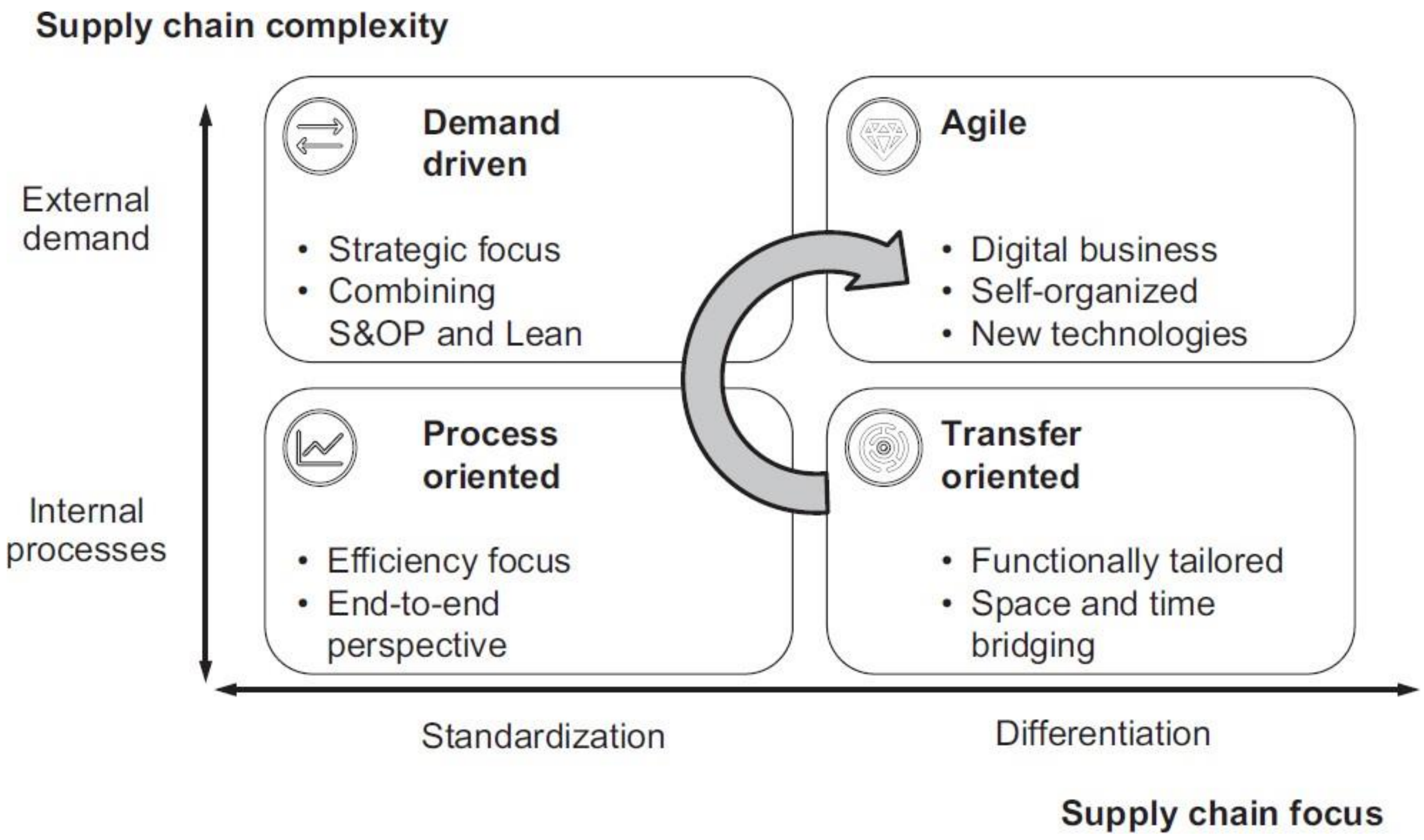


Source: Digital Supply Chains: Key Facilitator to Industry 4.0 and New Business Models; 3rd Edition, *Götz G. Wehberg*

Complexity, Information, and Coordination matrix

DSC would support

- Individualization of customer wishes.
- Flexibility of supply.
- Improved resource efficiency.



Source: Digital Supply Chains: Key Facilitator to Industry 4.0 and New Business Models; 3rd Edition, *Götz G. Wehberg*

Digital supply Chain benefits

- The digitalization of supply chain enables organizations to address the new requirements of the customers, supply challenges, and improvising the responsiveness/efficiency of the supply chain.
- Faster: (Amazon's predictive shipping)-Anticipatory shipping
- More flexible (adhoc and real-time planning allows a flexible reaction to changing demand/supply situation).
- Support to new business models like Supply Chain as a Service (SCaaS)—Uberization of transport
- More granular: The demand of customers for more and more individualised products is increasing day-by-day. (Drone delivery)
- More accurate
- More efficient
- Data capturing and management
- Integrated process optimisation

DSC application area

- Planning
- Physical flow
- Supply chain performance
- Customer order management
- Collaboration
- SC strategy

Finally supporting to *4V* of the production/supply system

V1: Value

V2: Variety

V3: Volume

V4: Variability

Decision Phases in a Supply Chain

1. Supply chain strategy or design
   - How to structure the supply chain over the next several years?
2. Supply chain planning
   - Decisions over the next quarter or year
3. Supply chain operation
   - Daily or weekly operational decisions

Process Views of a Supply Chain

1. **Cycle View:** The processes in a supply chain are divided into a series of cycles, each performed at the interface between two successive stages of the supply chain.

2. **Push/Pull View:** The processes in a supply chain are divided into two categories, depending on whether they are executed in response to a customer order or in anticipation of customer orders.

Pull processes are initiated by a customer order, whereas

Push processes are initiated and performed in anticipation of customer orders.

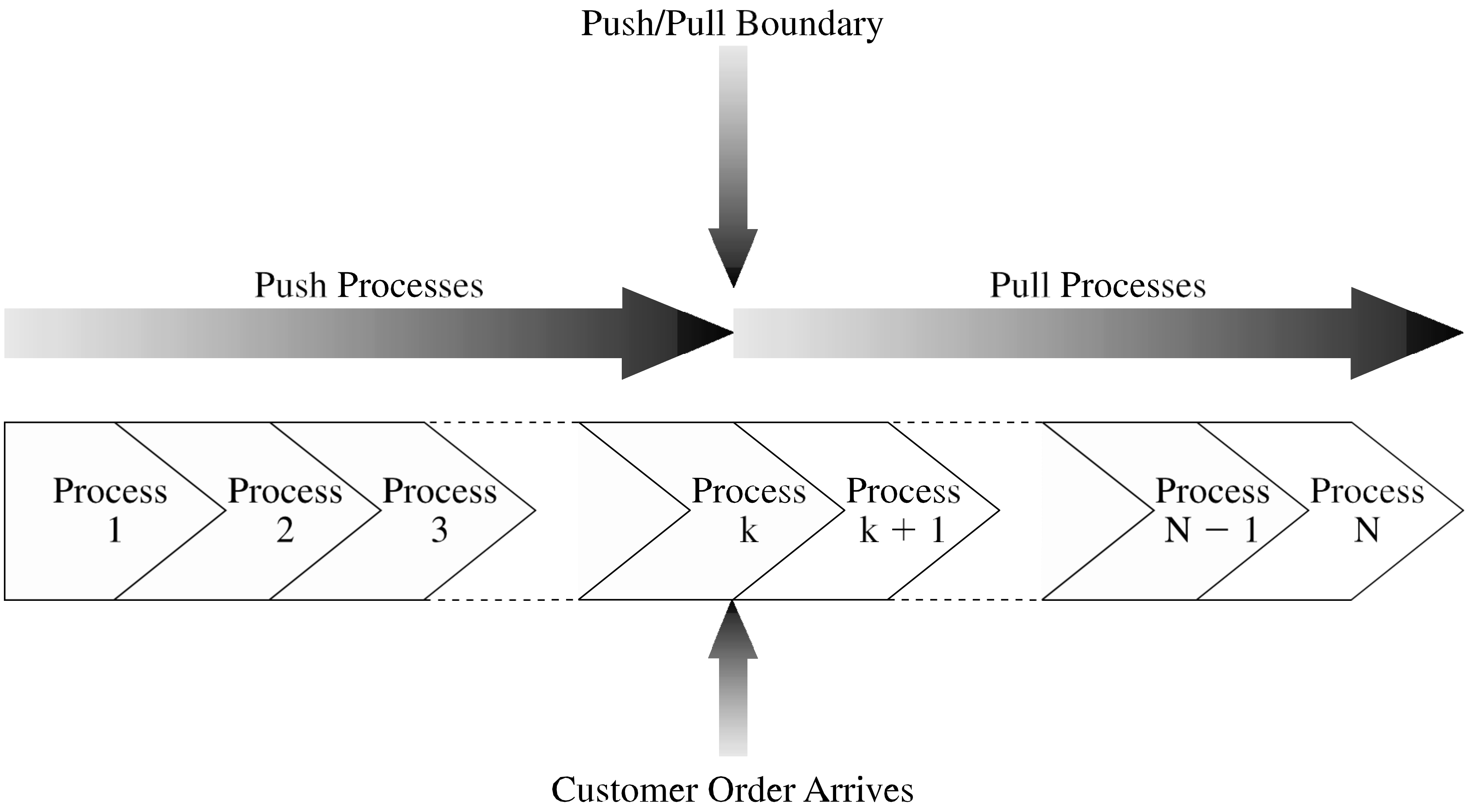
Push/Pull View of Supply Chain Processes

- Supply chain processes fall into one of two categories depending on the timing of their execution relative to customer demand

- Pull: execution is initiated in response to a customer order (**reactive**)

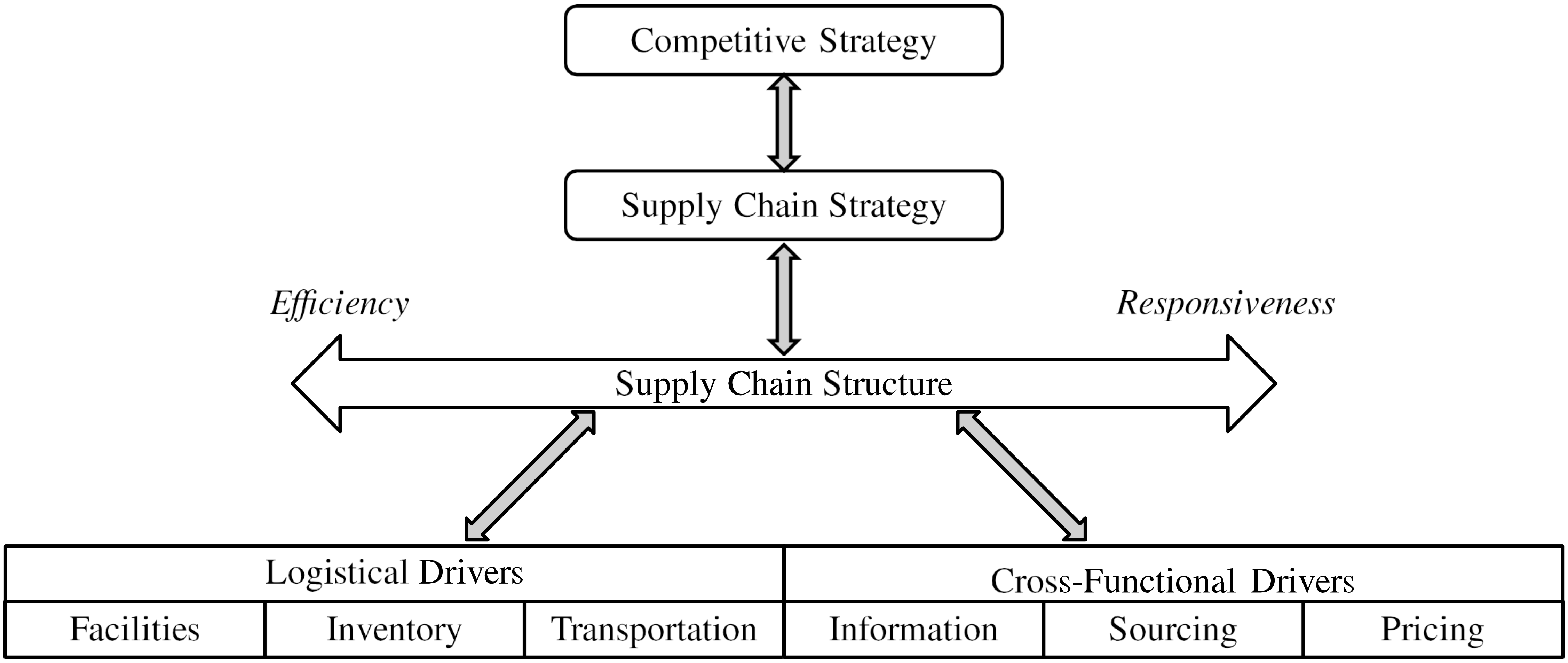
- Push: execution is initiated in anticipation of customer orders (**speculative**)
- **Push/pull boundary** separates push processes from pull processes

Push/Pull View of Supply Chains



Source: Supply Chain Management by Sunil C. & Peter M.

Framework for Supply Chain Decisions



Source: Supply Chain Management by Sunil C. & Peter M.

Framework for Supply Chain Decisions

- Logistical Drivers
  - Facilities
  - Inventory
  - Transportation
- Cross-Functional Drivers
  - Information
  - Sourcing
  - Pricing
- Interactions determine overall supply chain performance

Competitive and Supply Chain Strategies

- **Competitive strategy** defines the set of customer needs a company seeks to satisfy through its products and services.
- **Product development** strategy specifies the portfolio of new products that the company will try to develop.
- **Marketing and sales** strategy specifies how the market will be segmented and product positioned, priced, and promoted.
- **Supply chain** strategy determines the nature of material procurement, transportation of materials, manufacture of product or creation of service, distribution of product, follow-up service, whether processes will be in-house or outsourced.
- All functional strategies must support one another and the competitive strategy.

Achieving Strategic Fit

- **Strategic fit** – competitive and supply chain strategies have aligned goals

- A company may fail because of a lack of strategic fit or because its overall supply chain design, processes, and resources do not provide the capabilities to support the desired strategy.

https://www.livemint.com/news/india/modi-positions-india-as-alternative-to-china-in-global-supply-chain-11599150792839.html

Achieving Strategic Fit

1. The competitive strategy and all functional strategies must fit together to form a coordinated overall strategy. Each functional strategy must support other functional strategies and help a firm reach its competitive strategy goal.
2. The different functions in a company must appropriately structure their processes and resources to be able to execute these strategies successfully.
3. The design of the overall supply chain and the role of each stage must be aligned to support the supply chain strategy.

How Is Strategic Fit Achieved?

1. Understanding the customer and supply chain uncertainty
2. Understanding the supply chain capabilities
3. Achieving strategic fit

Step 1: Understanding the Customer and Supply Chain Uncertainty

- Quantity of product needed in each lot
- Response time customers are willing to tolerate
- Variety of products needed
- Service level required
- Price of the product
- Desired rate of innovation in the product

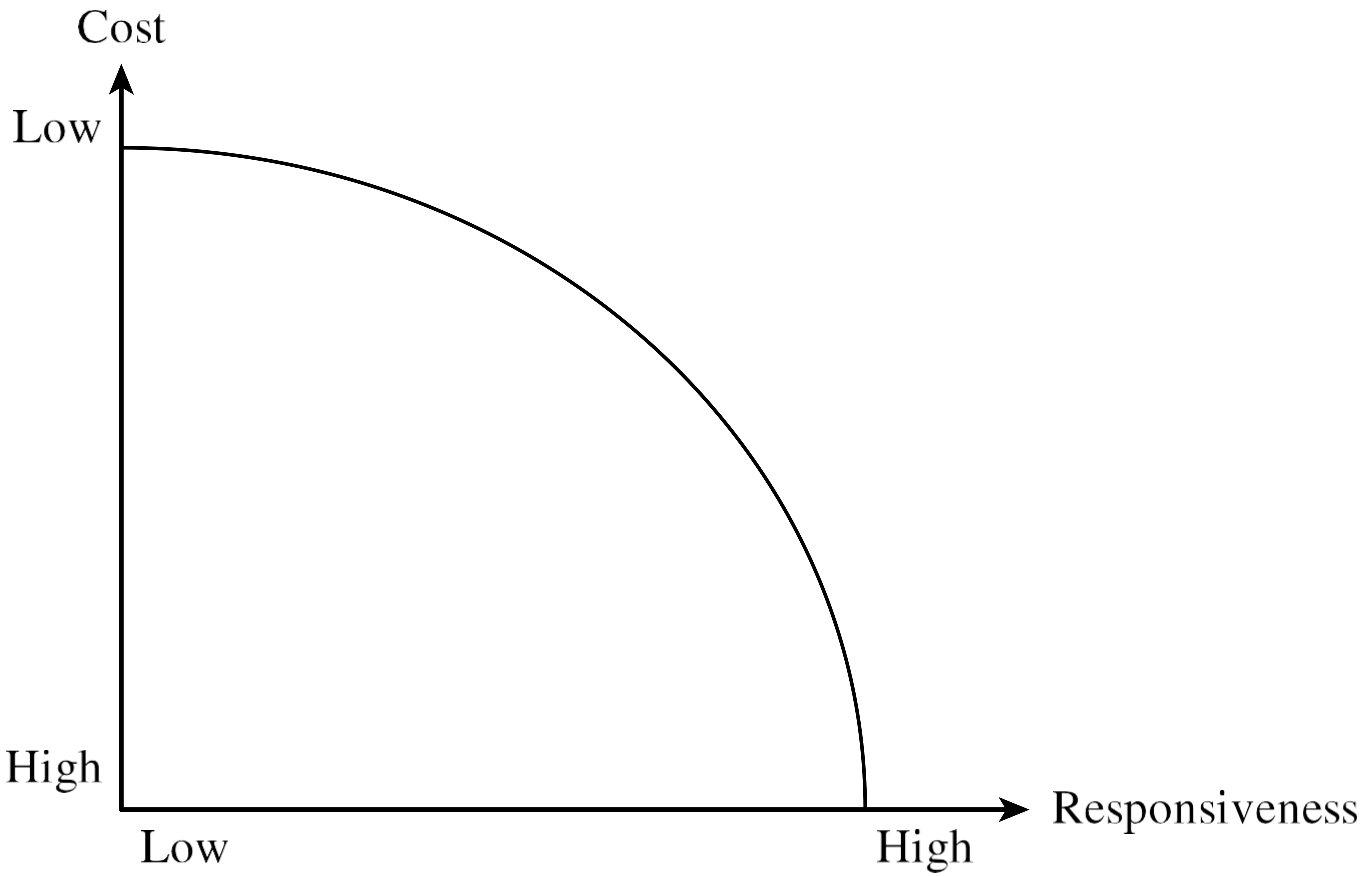
Step 2: Understanding Supply Chain Capabilities

- How does the firm best meet demand?
- Supply chain responsiveness is the ability to
  - Respond to wide ranges of quantities demanded
  - Meet short lead times
  - Handle a large variety of products
  - Build highly innovative products
  - Meet a high service level
  - Handle supply uncertainty

Step 2: Understanding Supply Chain Capabilities

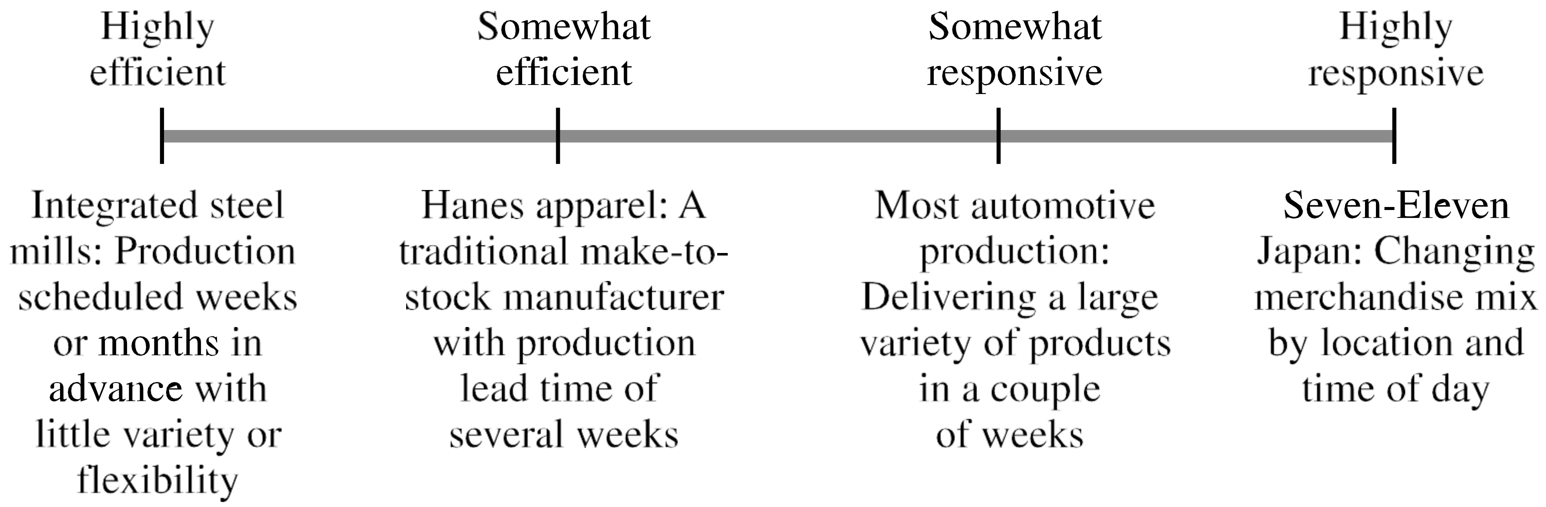
- Responsiveness comes at a cost
- **Supply chain efficiency** is the inverse to the cost of making and delivering the product to the customer
- The **cost-responsiveness efficient frontier** curve shows the lowest possible cost for a given level of responsiveness

Cost-Responsiveness Efficient Frontier



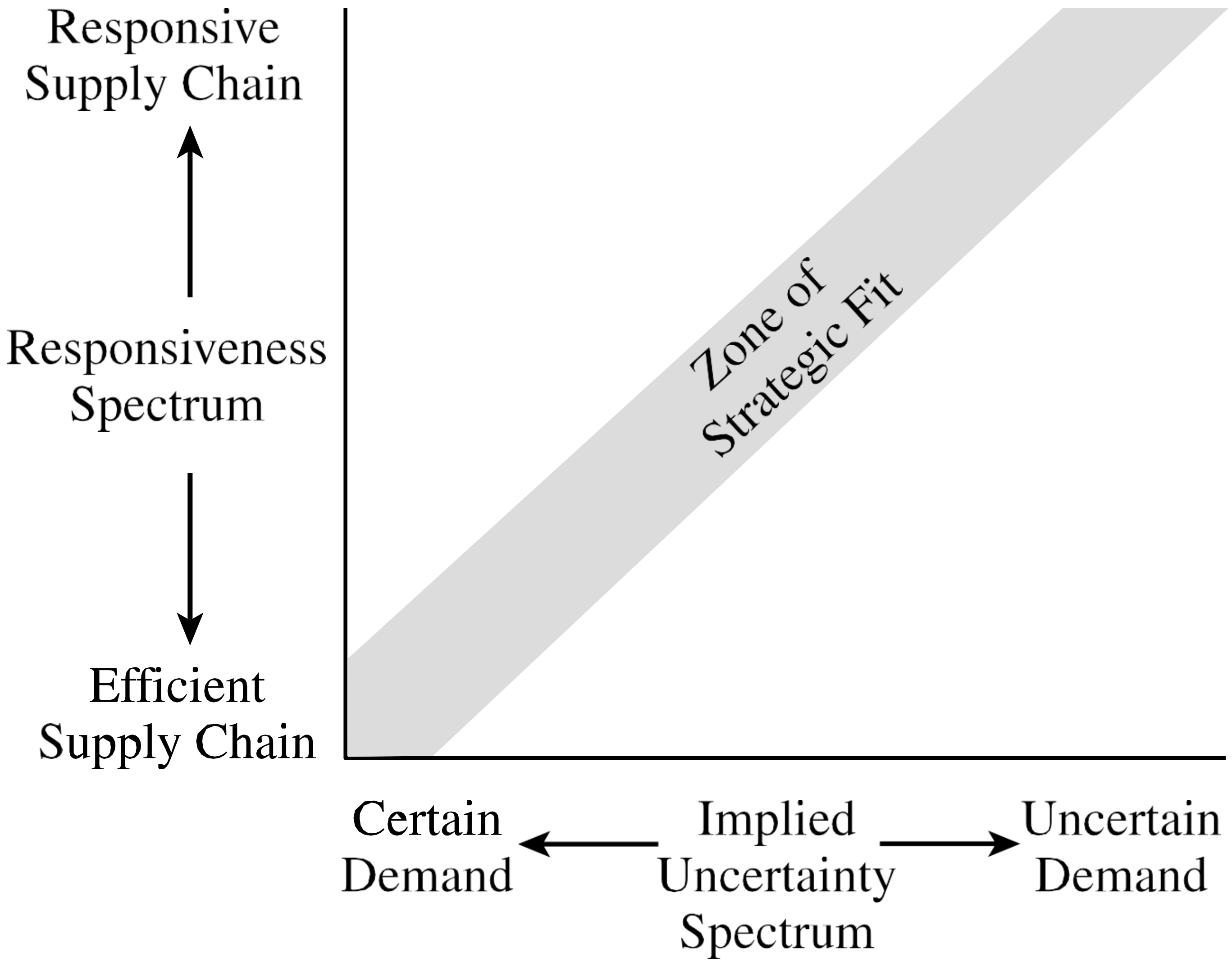
Cost-Responsiveness Efficient Frontier

Responsiveness Spectrum



The Responsiveness Spectrum

Zone of Strategic Fit



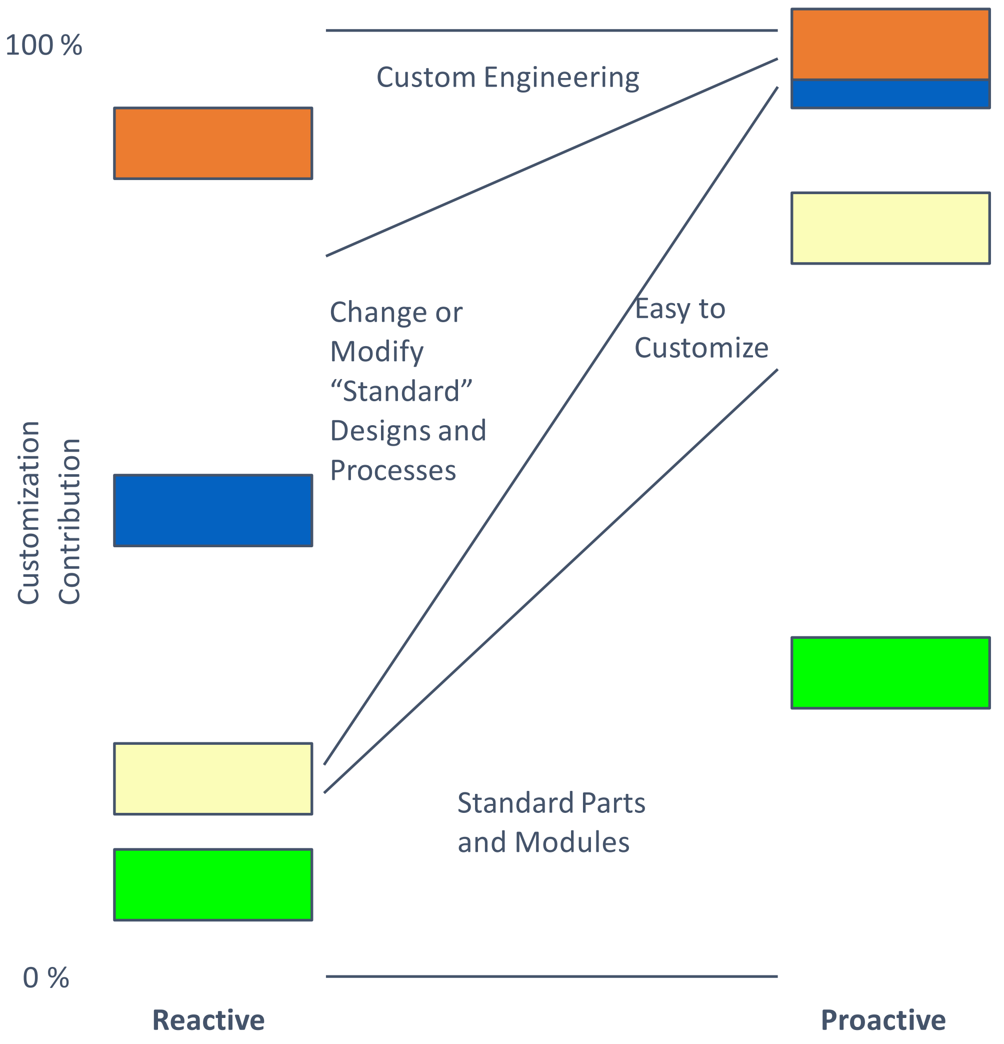
Efficient and Responsive Supply Chains

Comparison of Efficient and Responsive Supply Chains

	Efficient Supply Chains	**Responsive Supply Chains**
Primary goal	Supply demand at the lowest cost	Respond quickly to demand
Product design strategy	Maximize performance at a minimum product cost	Create **modularity** to allow postponement of product differentiation
Pricing strategy	Lower margins because price is a prime customer driver	Higher margins because price is not a prime customer driver
Manufacturing strategy	Lower costs through high utilization	Maintain capacity flexibility to buffer against demand/supply uncertainty
Inventory strategy	Minimize inventory to lower cost	Maintain **buffer inventory** to deal with demand/supply uncertainty
Lead-time strategy	Reduce, but not at the expense of costs	Reduce aggressively, even if the costs are significant
Supplier strategy	Select based on cost and quality	Select based on speed, flexibility, reliability, and quality

Affordable Customization and Variety

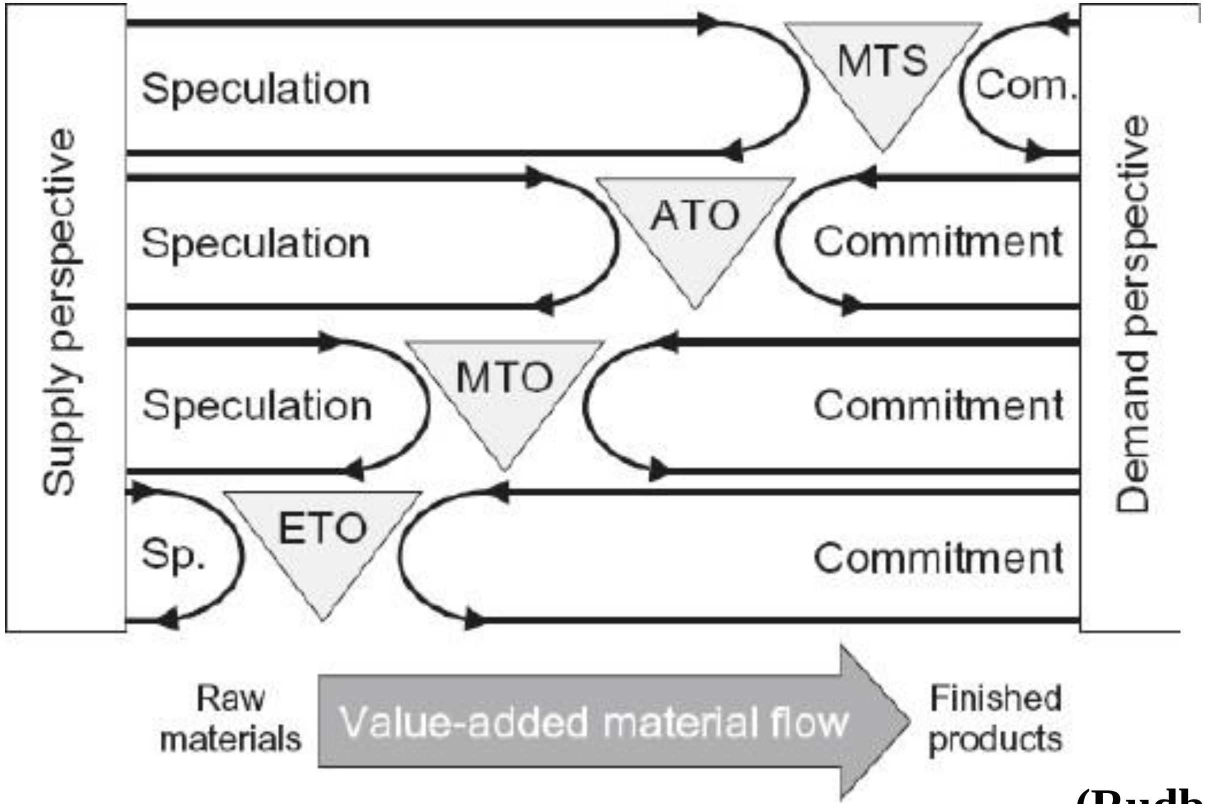
- Reactive vs. proactive modes of customization
- Must consider cost, control, time constraints
- Best to strive for platforms – product and process – that allow you to be proactive

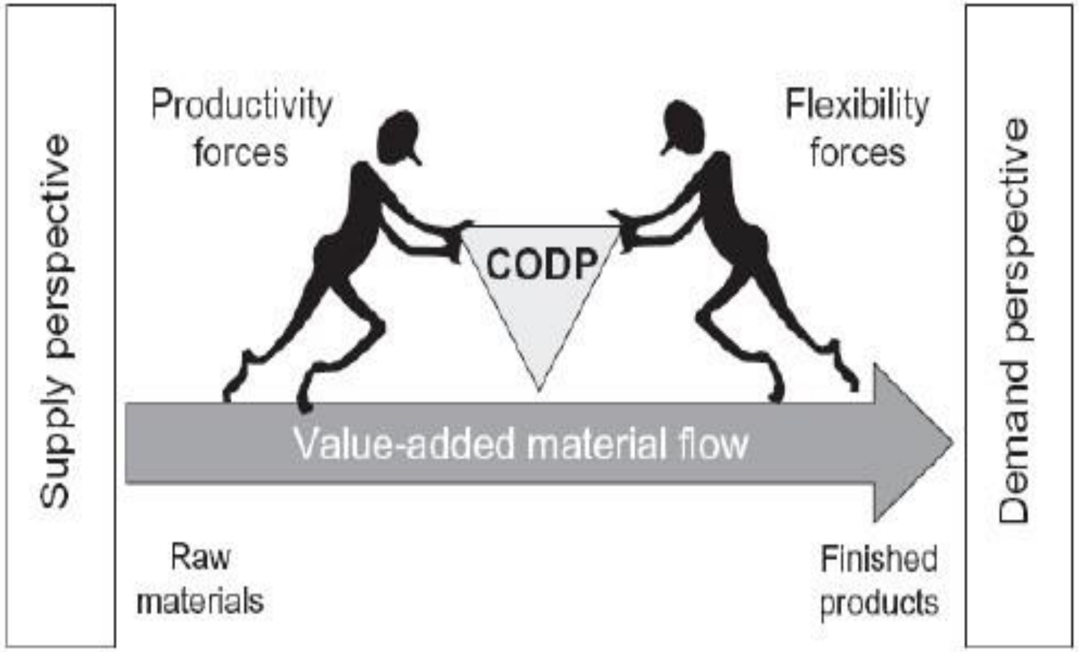


Adapted from: Anderson, D.M., 1997, Agile Product Development for Mass Customization, Irwin, Chicago, IL.

COPD

- Customer order decoupling point (CODP), also known as order penetration point,
- The COPD as the point where the product is linked to a specific customer order in the manufacturing value chain.

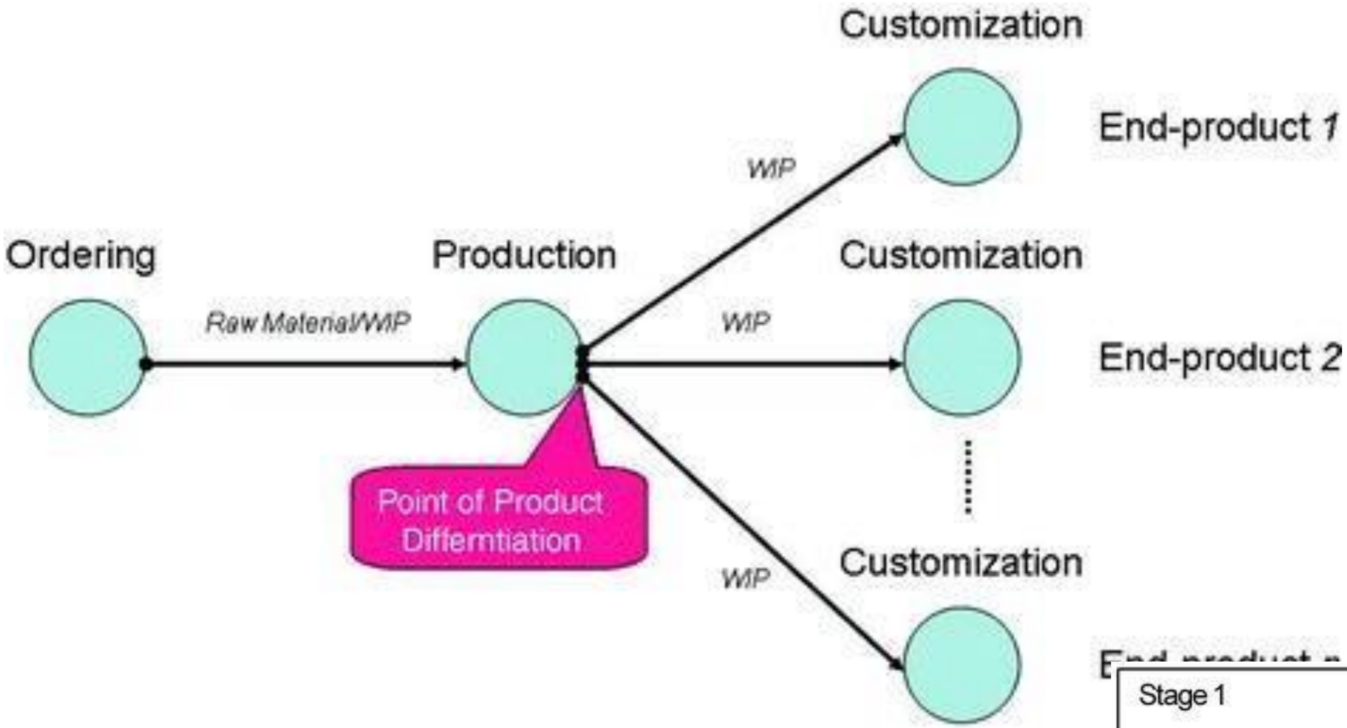


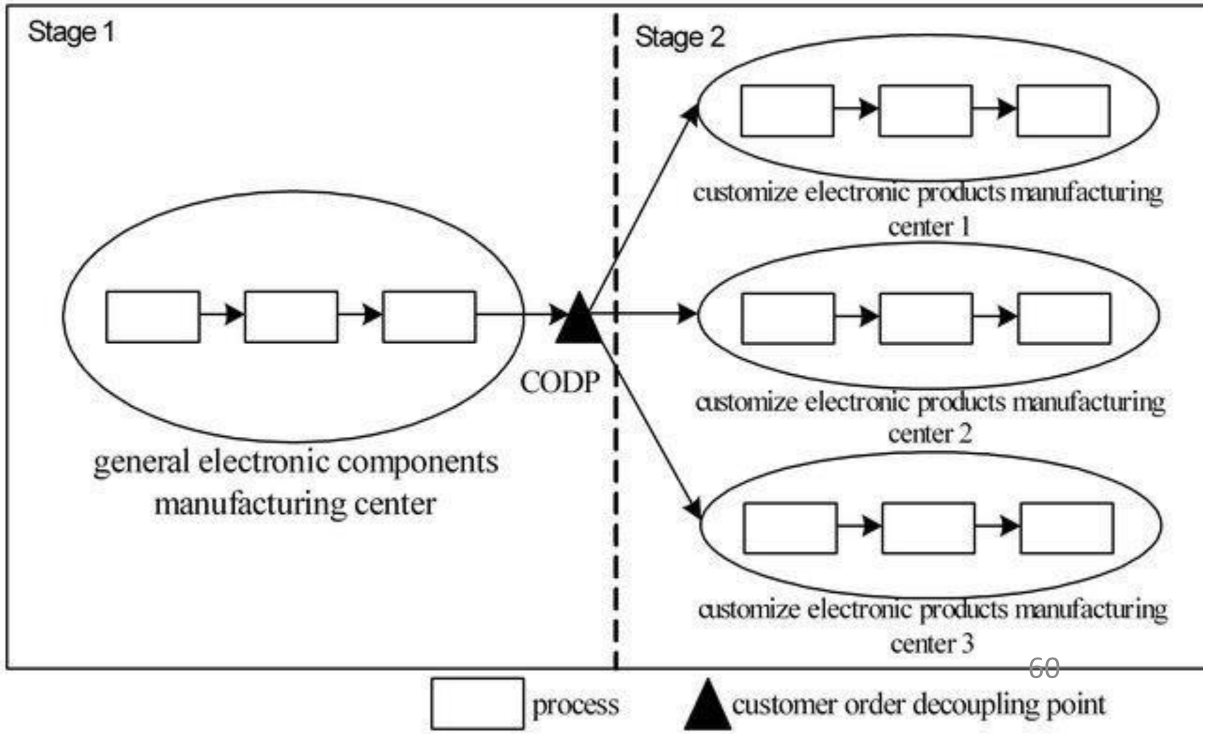


(Rudberg and Wikner 2004)

Postponement strategy

- Postponement is a concept which brings the efficiency of the lean concept and the responsiveness of the agile concept together.
- “Postponement means delaying activities in the supply chain until customer orders are received with the intention of customizing products, as opposed to performing those activities in anticipation of future orders.”
- According to this definition, companies can delay distribution, packaging, assembling, production or even purchasing until they receive exact customer orders


Customization
End-product 1
WIP
Ordering
Production
Customization
Raw Material/WIP
WIP
End-product 2
Point of Product Differntiation
WIP
Customization


Stage 1
Stage 2
customize electronic products manufacturing center 1
general electronic components manufacturing center
CODP
customize electronic products manufacturing center 2
customize electronic products manufacturing center 3
process
customer order decoupling point

Warehouse location exercise

An e-commerce company wants to locate a warehouse from which it will ship products to four demand points. The location (in the x-y plane) of the four demand points and annual shipment needed by each demand point is given in Table. The company needed an optimized warehouse location to optimize total distance travelled from central warehouse to demand points.

Demand Point	X-coordinate	Y-coordinate	Annual shipment cost
1	5	10	200
2	10	5	150
3	0	12	200
4	12	0	300

Using load distance method of facility.

- The load-distance method is **a mathematical model used to evaluate locations based on proximity factors**.
- The objective is to select a location that minimizes the total weighted loads moving into and out of the facility.
- The distance between two points is expressed by assigning the points to grid coordinates on a map.

Three different way to compute the distance
Actual
Euclidean
Rectilinear

Steps in load distance method

Find the product of load and the distance from each facililty centers/customer points.
Find the sum of the product for each perspective locations.
Select the smallest value of the sum as the most suitable location.

Decision variables

X=x-coordinate of the warehouse

Y=y-coordinate of the warehouse

Objective function

Min load1*sqrt((x1-x)^2+(y1-y)^2)+**load2*sqrt((x2-x)^2+(y2-y)^2)+**load1*sqrt((x3-x)^2+(y3-y)^2)+ load4*sqrt((x4-x)^2+(y4-y)^2)

Smart Warehouse

Smart warehouse design has a wide range of applications, from productivity initiatives at existing facilities to mergers, warehouse consolidations, and new warehouse construction.

In the United States, for example, employment levels across distribution centers are at all-time highs and wages have risen to well above $18 an hour, yet attracting and retaining warehouse employees remains elusive.

Automation industry has seen increased availability of new warehouse-automation innovations, supply chain as a service (SCaaS) models, and technology that integrates multiple solutions to help retailers.

The adoption of autonomous mobile robots (AMRs), technology that eliminates significant nonproductive walking time in warehouses.

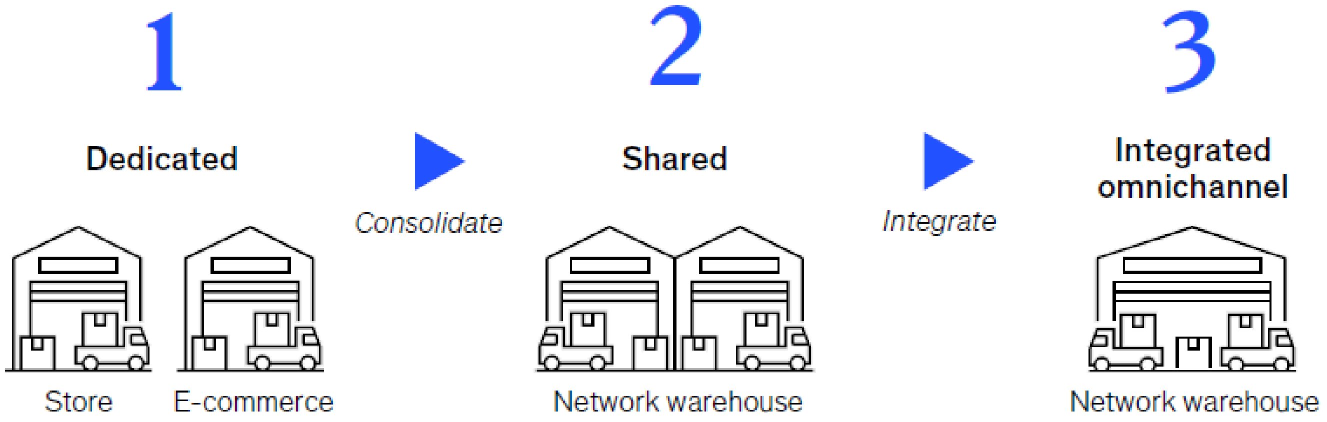
For example, DHL rolled out 1,000 Locus Robotics AMRs and will deploy up to 2,000 robots by 2022.

https://www.youtube.com/watch?v=4DKrcpa8Z_E

Walmart plans to allocate nearly $14 billion for warehouse automation and other business areas.

Leading retailers are aiming to make warehouses responsive, resilient, and reliable (3R) to accommodate the ever-growing e-commerce market.

Robotics as a service (RaaS) and Fulfillment as a service (FaaS).



FaaS

CapEx Model:
Automation equipment sold to the retailer on a CapEx basis. Real estate owned by the retailer

Not FaaS

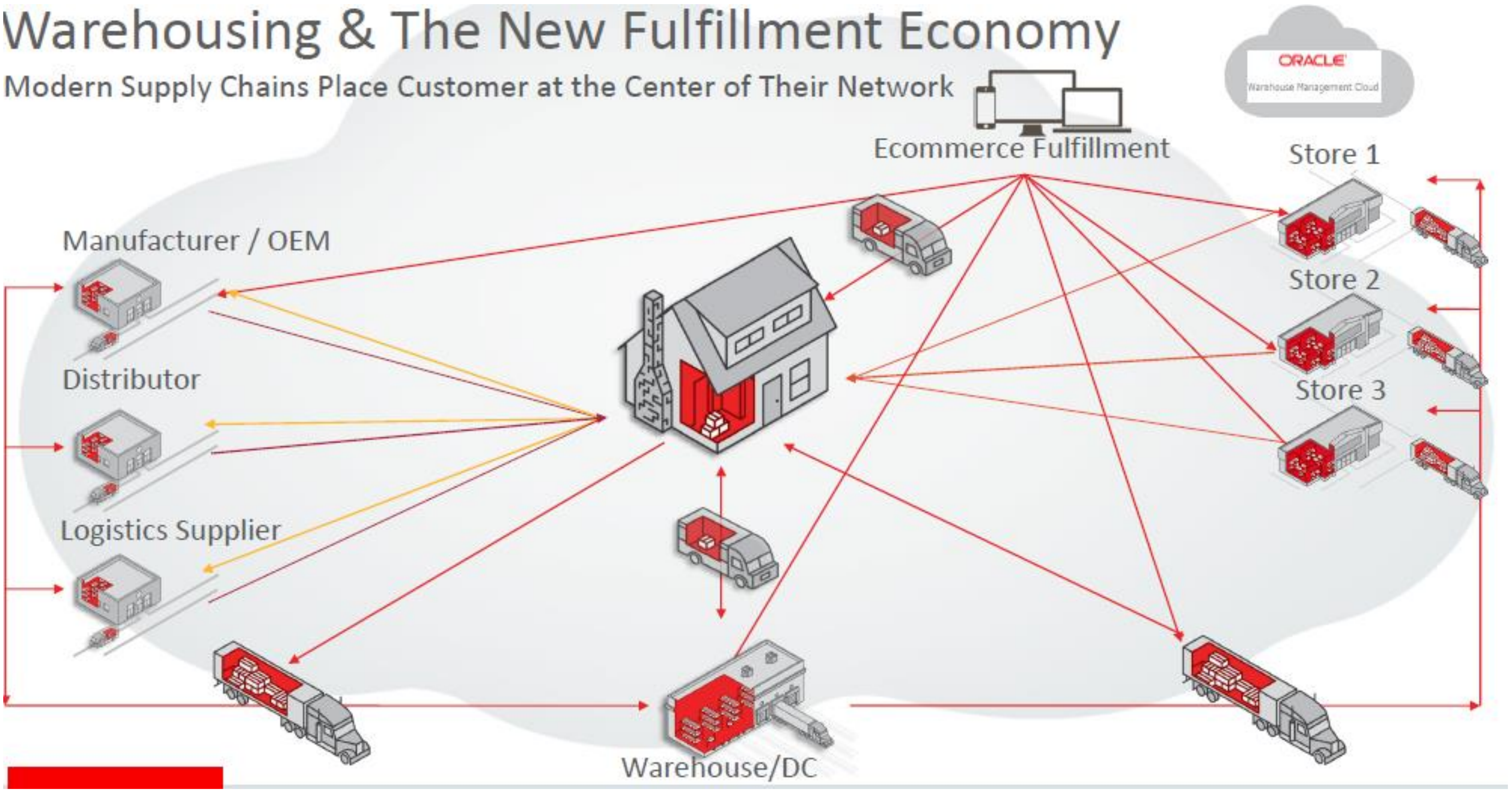
CapEx/OpEx Model:
Automation equipment sold to the retailer on a CapEx basis with fulfillment services licenced on a recurring OpEx basis. Real estate owned by the retailer

OpEx Model:
Automation equipment and fulfillment services sold or leased on a recurring OpEx basis. Real estate owned by retailer

Service-Based Model:
Fulfillment capacity 'leased' from fulfillment provider. Automation vendor owns real estate asset

Warehousing & The New Fulfillment Economy

Modern Supply Chains Place Customer at the Center of Their Network



Source: Oracle WMS

Class discussion

1. https://www.supplychaindive.com/news/dhl-carton-utilization-set-optimization-research-warehouse-box-shipping-cost-ecommerce-order/593164/

Question 1: What are benefits other than cost reduction ?
Question 2: What are the types of the food packaging?
https://www.youtube.com/watch?v=4klq3I3tZPw

2. https://finance.yahoo.com/news/amazon-plans-put-1-000-090053785.html?guccounter=1
https://www.youtube.com/watch?v=Cy_Sj82OL8c
Question1: What is the advantage of small delivery hub creation?
Question2: what are the locational challenges for small delivery hub and cons of creating small delivery hub?