SUPPLY CHAIN FUNDAMENTALS

Core Supply Chain Concepts

THIS LECTURE IN ENABLED BY COURSE CONTENT FROM DR. CHRIS CAPLICE @ MIT

QUESTIONS

- What is Pull Vs. a Push in SCM
- What is (product) Segmentation in SCM
  - Power Law
  - Product segmentation
    - ABC Analysis
  - Functional vs. Innovative
  - Portfolio approach

PUSH VS. PULL PROCESSES

WHAT IS IN A SANDWICH?

Sandwich = Bread + Protein + Spread + Topping
18 6 10 20

How many different sandwiches can be made?

??,??? Unique Sandwiches!

What if you are allowed upto 2 Toppings?

Sandwich = Bread + Protein + Spread + Topping
18 6 10 ???

? K + ? K ~ 227K Unique Sandwiches!

What if you are allowed upto 2 Toppings, 2 Protein?

- SKUs Increases complexity
  - Make to Stock (~ 227K)
  - Make to Order
  - Engineer (Design) to Order

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Pull vs. Push Processes

- Push –
  - Execution is performed in anticipation of an order
  - Demand is forecasted
  - Proactive process based on projected need/demand

- Pull –
  - Execution is performed in response to an order
  - Demand is actual and known with certainty
  - Reactive process based on actual need/demand

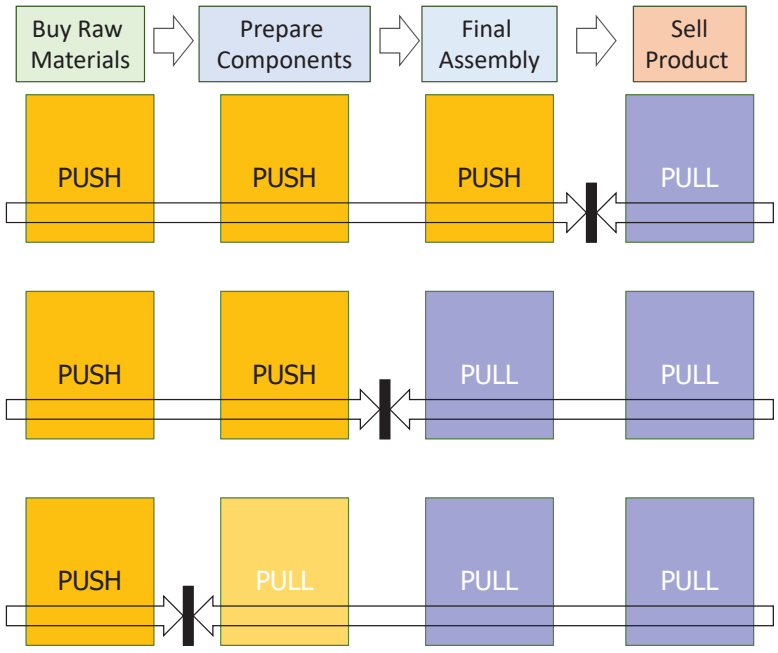
- Push / Pull Boundary
  - Point where push processes are separated from pull processes

A Tale of Three Sandwiches

Ready Made Turkey Wrap

Signature Ham Sandwich

One-of-a-Kind Dagwood



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PUSH VS. PULL PROCESSES

- What about pure systems?
  - Pure push – leads to higher inventory levels and potential spoilage / imbalance but faster cycle time
  - Pure pull – very rare
- Mixed systems are common – Where is the Push-Pull Point?
  - Push undifferentiated, raw product or components
  - Pull finished product
- Benefits of mixed systems
  - Allows for efficient mass customization (Postponement)
  - Allows for pooling of products – aggregating demand
- Key Principles
  - Maximize external variety with minimal internal variety
  - Keep in-process inventory as “Raw as Possible” (RAP)

SEGMENTATION

Supply Chain Segmentation

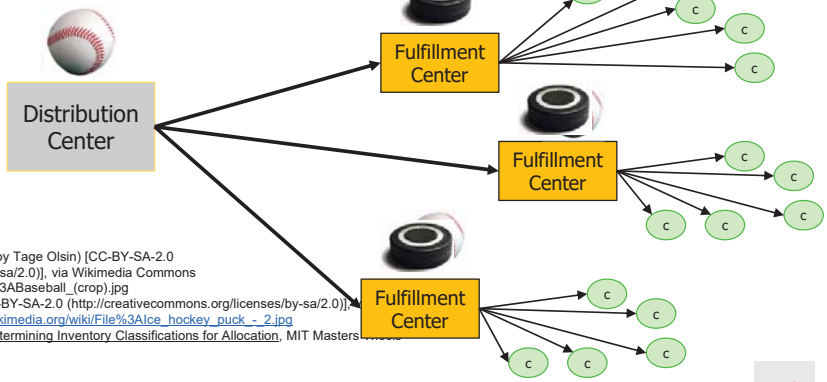
- In reality . . .
  - Firms operate multiple supply chains
  - There is no such thing as a one-size-fits-all supply chain
  - Firms segment in order to match the right method to the right product/customer/supplier combination
  - Firms can segment products, customers, suppliers, etc.

- Segmentation only makes sense if you do something different in how you buy, make, move, store or sell!
  - Purchasing / Procurement
  - Forecasting / Demand Planning
  - Inventory Planning
  - Inventory Control
  - Warehousing / Materials Handling
  - Order Management
  - Transportation Management
  - Customer Service

Product Characteristics - A Tale of Two Seasons

Summer

Winter



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Ball, Braden (2012) Simulation as a Method for Determining Inventory Classifications for Allocation, MIT Masters Thesis

SUPPLY CHAIN SEGMENTATION

- How many segments? (Rules of thumb)
  - **Homogenous**- within the segment should be similar
  - **Heterogeneous**- across segments should be very different
  - **Critical Mass** - should be big enough to make it worthwhile
  - **Pragmatic** - dimensions should be useful and communicable
- How can I segment my customers or suppliers?

• Lead time • Purchase History • Geography • Sales Trends	• Strategic Importance • Service Level • Order Size/Volume • Demographic • Channel Segmentation

- How can I segment my products?
  - Physical characteristics (value, size, density, value, etc.)
  - Demand characteristics (sales volume, volatility, sales duration, etc.)
  - Supply characteristics (availability, location, reliability, etc.)

Adapted from Prashant Yadav (2005) Course Notes, Zaragoza Logistics Center.

DISTRIBUTION OF SKUS

Product Segmentation

- Local Grocery Store
  - ~20,000 SKUs
  - Categories: Dry, Frozen, & Perishables
- Analysis of Dry Goods (~8,000 SKUs)
  - 1.156 M SKUs sold in 1 year
  - Number of units sold per SKU
    - Mean 144
    - Median 72
    - Mode 0
    - Std Dev 355
- Biggest Sellers?
- Biggest Sales Day?

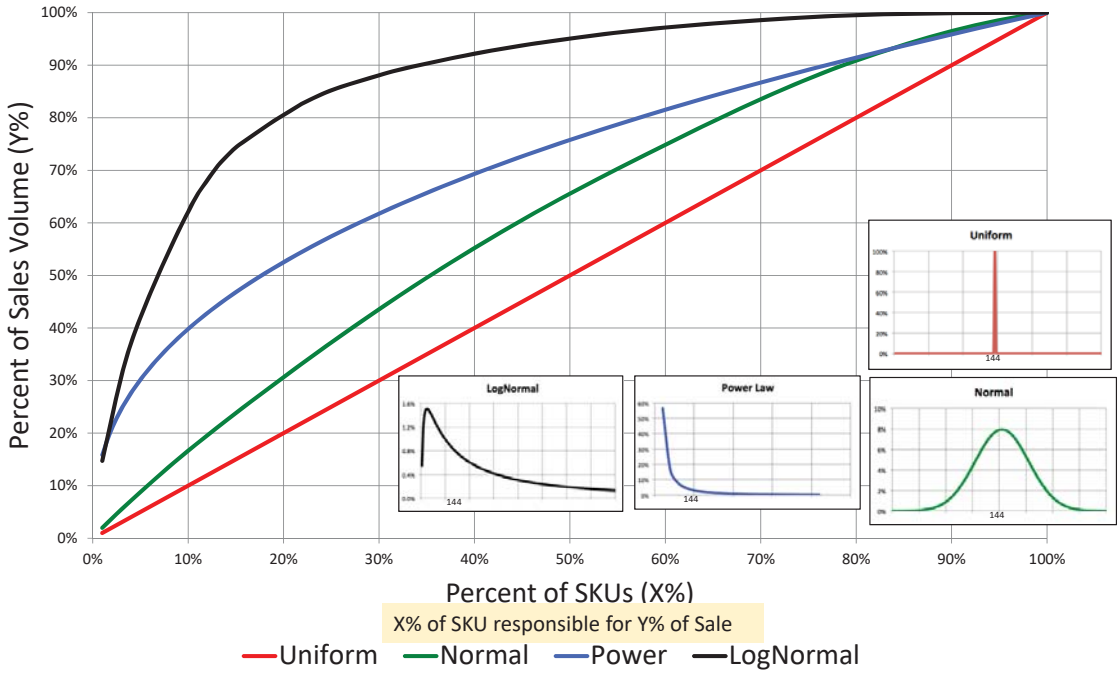
Top Sellers

1. EVAPORATED MILK 12 OZ
2. BATHROOM TISSUE
3. BOTTLED WATER 1 GALLON
4. MAC'N CHEESE
5. CANNED WHITE TUNA

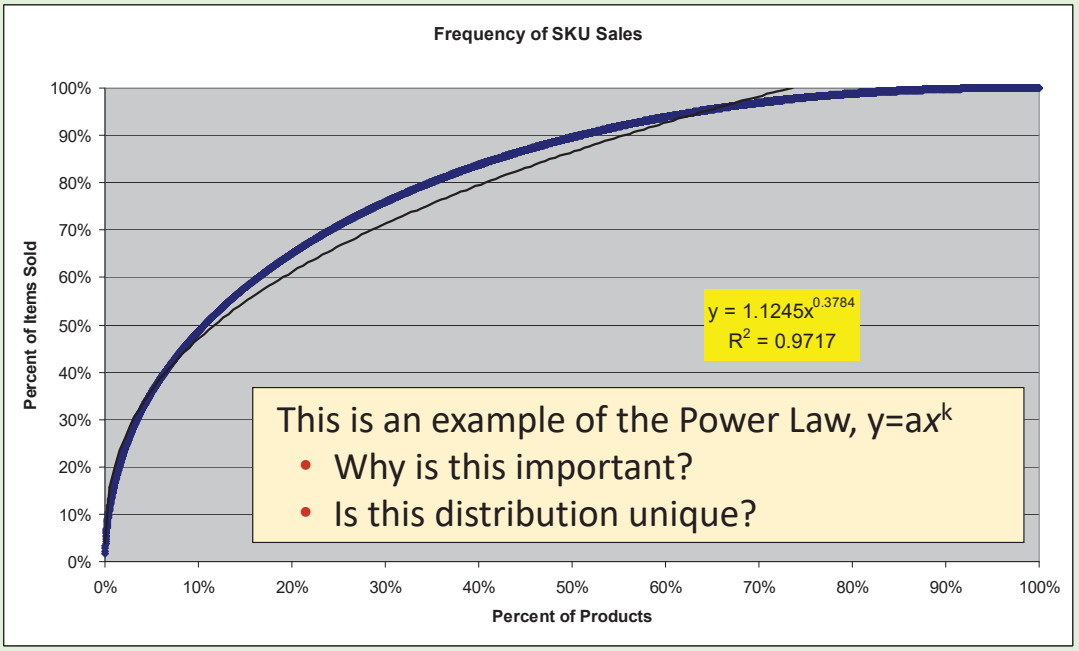
- How are products distributed in terms of sales volume?
- Uniform? Normal? Other?

Kerslake, Christopher (2005) A Method for Analyzing the Delivery Frequency From a Distribution Center to a Retail Grocery Store, MIT Masters Thesis
"Faced products on a supermarket shelf" by Amnesiac86 - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Faced_products_on_a_supermarket_shelf.JPG#mediaviewer/File:Faced_products_on_a_supermarket_shelf.JPG.

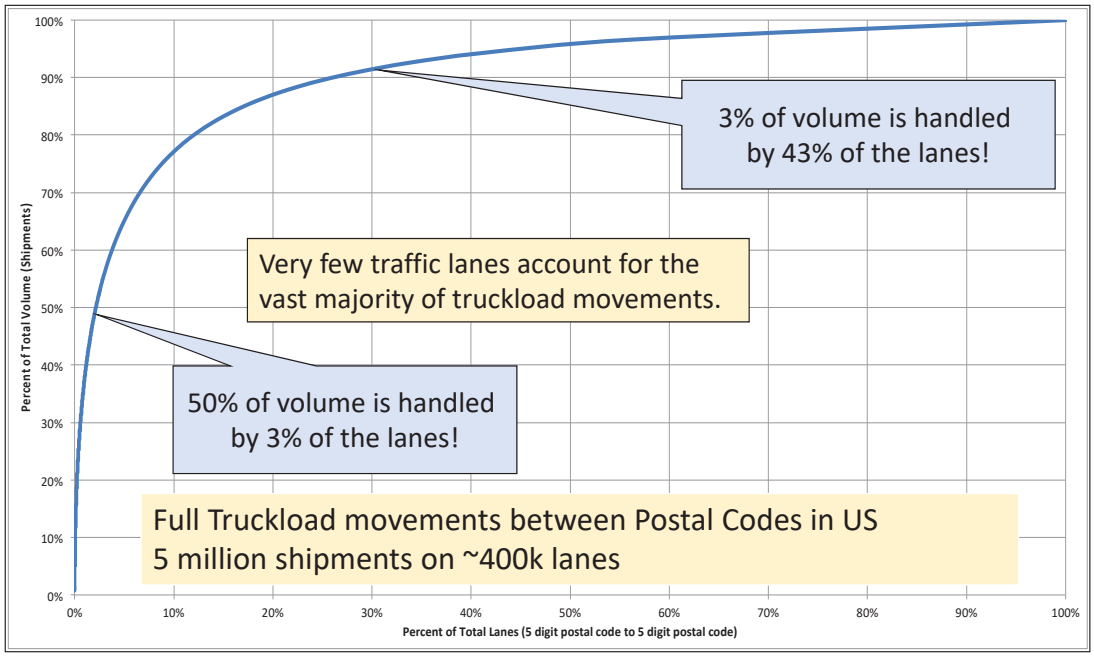
Potential Product Distributions



THE POWER LAW: Y = A*X^K



EXAMPLE: DISTRIBUTION OF TRAFFIC ON LANES



POWER LAW ($Y = A*X^K$)

Fundamental Insight

Distribution of many phenomena across a population follow a Power Law relationship

- **Exceptionally common in physical and social systems**

1. Income within a population (Pareto's Law)
2. Visits to websites (Nielsen's Law) & blogs
3. Frequency of words in any language (Zipf's Law)
4. Frequency of digits within tables (Benford's Law)
5. Frequency of authors citations in literature (Lotka's Law)
6. Animals' metabolic rates with respect to mass (Kleiber's Law)
7. Profitability of customers & products
8. Distribution of volume on traffic lanes
9. Questions from students in a class
10. Energy Radiated vs. Temperature (Stefan Boltzmann Law)

The important few versus the trivial many

ABC ANALYSIS

SEGMENTATION: ABC ANALYSIS

- Class A Items - *the important few*
  - Very few high impact items are included
  - Require the most managerial attention and review
  - Expect many exceptions to be made

Remember – these are arbitrary classifications

- Class B Items – *the middle-share*
  - Many moderate impact items (sometimes most)
  - Automated control w/ management by exception
  - Rules can be used for A (but usually too many exceptions)

- Class C Items - *the trivial many*
  - Many if not most of the items that make up minor impact
  - Control systems should be as simple as possible
  - Reduce wasted management time and attention
  - Group into common regions, suppliers, end users

SEGMENTATION: ABC ANALYSIS

	c_i	D_i	c_iD_i
Part ID	Price	Annual Demand	Annual $ Value
5497J	$ 2.25	260	$ 585.00
3K62	$ 2.85	43	$ 122.55
88450	$ 1.50	21	$ 31.50
P001	$ 0.77	388	$ 298.76
2M993	$ 4.45	612	$ 2,723.40
3HHT8	$ 6.10	220	$ 1,342.00
56M4	$ 3.10	110	$ 341.00
89KE	$ 1.32	786	$ 1,037.52
45O3	$ 12.80	14	$ 179.20
55K2	$ 24.99	334	$ 8,346.66
978SD3	$ 7.75	24	$ 186.00
78HJQ2	$ 0.68	77	$ 52.36
23LK	$ 0.25	56	$ 14.00
990RT	$ 3.89	89	$ 346.21
58JH4	$ 7.70	675	$ 5,197.50
2340P	$ 6.22	66	$ 410.52
3784	$ 0.85	148	$ 125.80
38JQ2	$ 0.77	690	$ 531.30
56TT7	$ 1.23	52	$ 63.96
7UJS2	$ 4.05	12	$ 48.60
		4,677	**$ 21,983.84**

1. Identify the SKUs that management should spend time on
2. Prioritize SKUs by their value to firm
3. Create logical groupings
4. Adjust as needed
   Example:
   i. Sample of 20 SKUs
   ii. Total of 4,677 units
   iii. Total ~$22k

SEGMENTATION: ABC ANALYSIS

Arrange in Decreasing Order

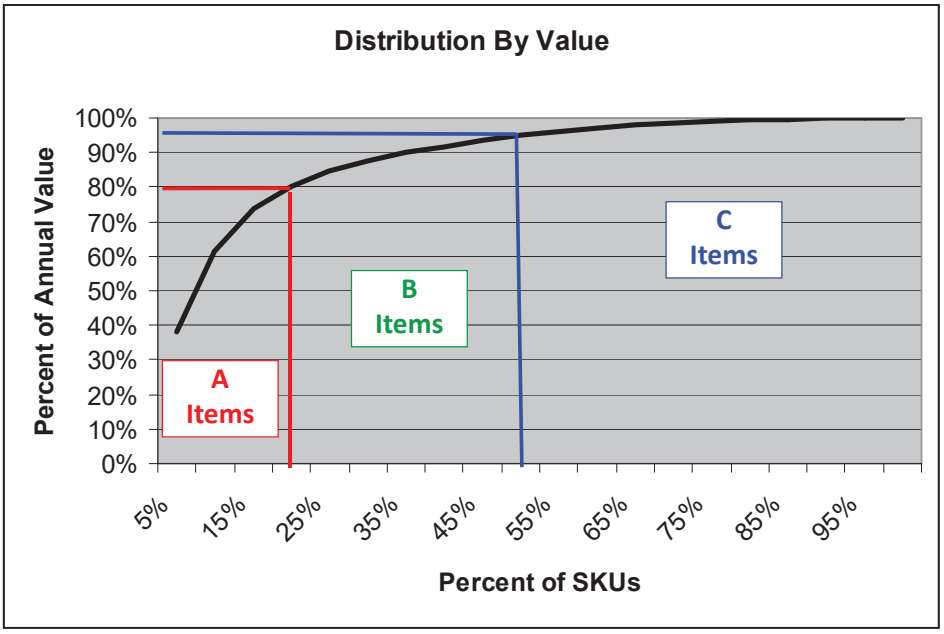
	c_i	D_i	c_iD_i	Σc_iD_i	
Part ID	Price	Annual Demand	Annual $ Value	Cum $ Value	Pct Ann $ Value
55K2	$ 24.99	334	$ 8,347	$ 8,347	38%
58JH4	$ 7.70	675	$ 5,198	$ 13,544	62%
2M993	$ 4.45	612	$ 2,723	$ 16,268	74%
3HHT8	$ 6.10	220	$ 1,342	$ 17,610	80%
89KE	$ 1.32	786	$ 1,038	$ 18,647	85%
5497J	$ 2.25	260	$ 585	$ 19,232	87%
38JQ2	$ 0.77	690	$ 531	$ 19,763	90%
2340P	$ 6.22	66	$ 411	$ 20,174	92%
990RT	$ 3.89	89	$ 346	$ 20,520	93%
56M4	$ 3.10	110	$ 341	$ 20,861	95%
P001	$ 0.77	388	$ 299	$ 21,160	96%
978SD3	$ 7.75	24	$ 186	$ 21,346	97%
45O3	$ 12.80	14	$ 179	$ 21,525	98%
3784	$ 0.85	148	$ 126	$ 21,651	98%
3K62	$ 2.85	43	$ 123	$ 21,773	99%
56TT7	$ 1.23	52	$ 64	$ 21,837	99%
78HJQ2	$ 0.68	77	$ 52	$ 21,890	100%
7UJS2	$ 4.05	12	$ 49	$ 21,938	100%
88450	$ 1.50	21	$ 32	$ 21,970	100%
23LK	$ 0.25	56	$ 14	$ 21,984	100%
		4,677	**$ 21,984**		

A Items:
80% of Value
20% of SKUs

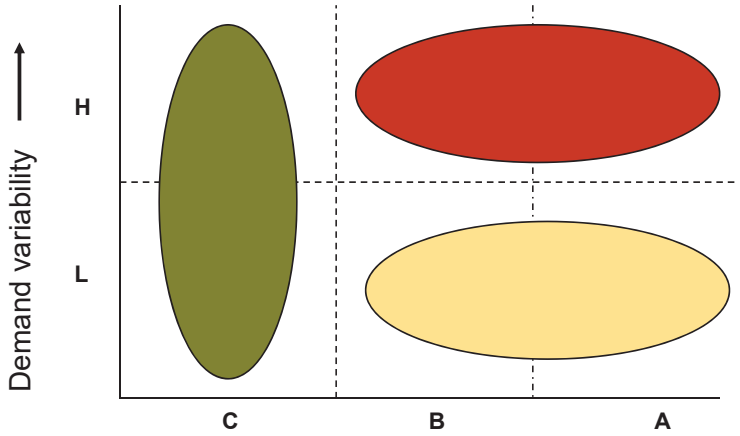
B Items:
15% of Value
30% of SKUs

C Items:
5% of Value
50% of SKUs

SEGMENTATION: ABC ANALYSIS



SEGMENTATION: OTHER METHODS



I would want to treat high variability items separately than the low variability steady state items

Volatile: Sophisticated techniques; frequent reviews

Stable: Less sophisticated techniques; less frequent reviews

Unimportant: Unsophisticated techniques; infrequent reviews

Adapted from Prashant Yadav (2005) Course Notes, Zaragoza Logistics Center.

SEGMENTING SUPPLY CHAINS

Refer to the 2 Reading texts:

What Is the Right Supply Chain for Your Products?
By Marshall L. Fisher, April 1997

A Portfolio Approach to Supply Chain Design -
By Thomas Olavson, Hau Lee and Gavin DeNyse, July 1, 2010

SEGMENTATION: INNOVATIVE VS. FUNCTIONAL

Source: Fisher, M. (1997) "What Is the Right Supply Chain for Your Product?," Harvard B… w … m Sheffi (2010) ESD.260 Course Notes
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	Functional	Innovative
Demand		
Life Cycle		
Margin		
Variety		
Error at Production		
Avg. Stock-out Rates		
Forced Mark down		
Lead time for MTO		
Supply Chain Objective		

- **FIND THE RIGHT POLICY TO MATCH THE SEGMENT**
  - Marshall Fisher 1997 HBR - Innovative versus Functional products
  - Supply chain focus is on "**mediating the demand & supply**" versus being efficient
  - Market Responsive versus Physically Efficient

SUPPLY CHAIN PORTFOLIO

Decision variables for SC Design: One option is chosen from each column

	Fast / High Cost	Intermediate Design	Slow/Low Cost
Manufacturing Location			
International Shipping			
Final Assembly Location			
Order Fulfillment Location			
Inventory Stocking Model			

Let's look at the different functions or activities that we need to look at for a Supply Chain (Portfolio Approach)

Unlike Marshall Fisher - this paper →) says it is NOT an all or nothing approach.

"Configure (the Decision Variables) to Order = Last Minute/Step Postponement"

Source: Olavsun, Lee, & DeNyse (2010) "A Portfolio Approach to Supply Chain Design," Supply Chain Management Review. Adapted from Sheffi (2010) ESD.260 Course Notes

SUPPLY CHAIN PORTFOLIO

Inkjet Supply Chain – I (Original, Late 80's, Early 90's)
French, German and Spanish Versions.
But they were having Overstock of one and Less Stock of other

	Fast / High Cost	Intermediate Design	Slow/Low Cost
Manufacturing Location	On shore (e.g., US/Europe)		
International Shipping		Rail/Truck	
Final Assembly Location	On Shore		
Order Fulfillment Location	On Shore (Factory/DC)		
Inventory Stocking Model	Build to Stock		

SUPPLY CHAIN PORTFOLIO

Inkjet Supply Chain – II / Dell _I
Postponement Inkjet Supply Chain

	Fast / High Cost	Intermediate Design	Slow/Low Cost
Manufacturing Location			Off shore (e.g., China, Vietnam)
International Shipping			Ocean
Final Assembly Location	On Shore		
Order Fulfillment Location	On Shore (Factory/DC)		
Inventory Stocking Model		Configure to Order	

Supply Chain Portfolio

Inkjet Supply Chain – III / Dell II
Cost Competition Inkjet:

	Fast / High Cost	Intermediate Design	Slow/Low Cost
Manufacturing Location			Off shore (e.g., China, Vietnam)
International Shipping			Ocean
Final Assembly Location			Off Shore
Order Fulfillment Location	On Shore (Factory/DC)		
Inventory Stocking Model	Build to Stock		

Key Points from Lesson

KEY POINTS FROM LESSON

- Push vs. Pull Systems
  - Push – proactive based on forecast demand
  - Pull – reactive based on actual demand
- Benefits of Mixed Systems
  - Maximize external variety with minimal internal variety
  - Keep in-process inventory as “Raw as Possible” (RAP)
  - Postponement & Aggregated Demand
- Segmentation Strategies
  - Segment for a purpose (functional vs. innovative)
  - Product segmentation (ABC) – good starting point
- Handling Uncertainty
  - Normal Distribution
  - Poisson Distribution

KEY POINTS FROM LESSON

Summary

KEY POINTS FROM LESSON

- Push vs. Pull Systems
  - Push – proactive based on forecast demand
  - Pull – reactive based on actual demand

- Benefits of Mixed Systems
  - Maximize external variety with minimal internal variety
  - Keep in-process inventory as “Raw as Possible” (RAP)
  - Postponement & Aggregated Demand

- Segmentation Strategies
  - Segment for a purpose (functional vs. innovative)
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