

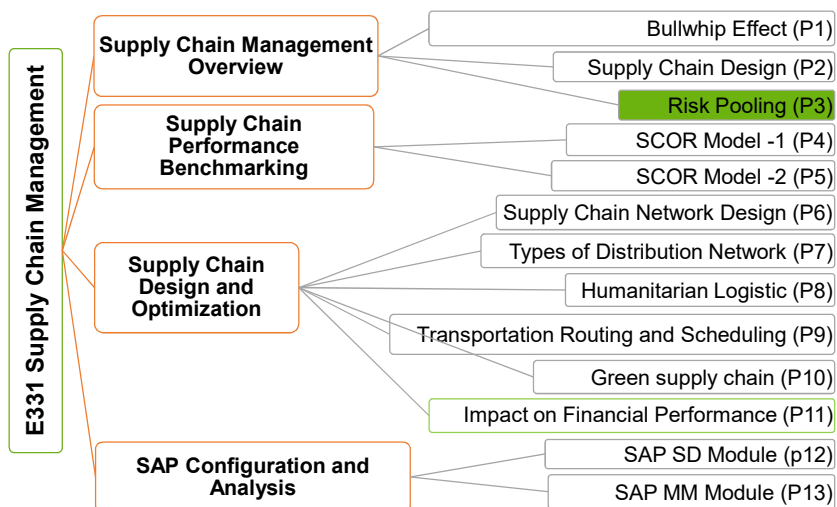
Problem 03

Pool of Risks

E331 – Supply Chain Management

Diploma in Supply Chain Management

E331 Module Overview



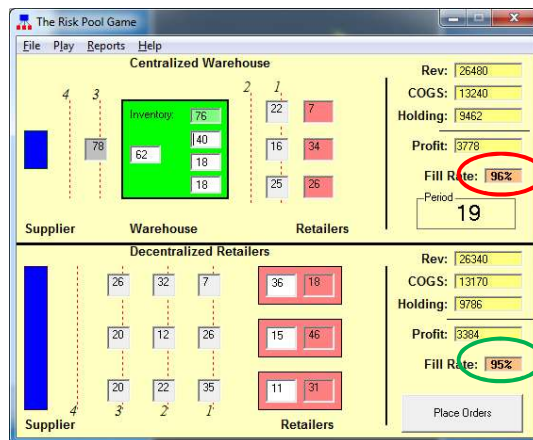
Centralized vs. Decentralized Systems

- Decentralized system (Honda Motor, eBay, etc.)
 - Each facility applies its most effective strategy ignoring the impact on other facilities
 - Leads to local optimization
- Centralized system (Apple, McDonald's, Amazon, etc.)
 - A central location coordinates the rest of supply chain
 - Decisions are made for the entire network.
 - Typical objective is to minimize the total cost of the system
 - Overall service level is maintained at least the same as the decentralized system
 - Leads to global optimization.

Risk Pooling by Centralization

- Risk pooling is an important concept in supply chain management.
- It suggests that **demand variability** is reduced if one aggregates demand across locations. As we aggregate demand across different locations, it becomes more likely that high demand from one customer (location) will be offset by low demand from another customer (location).
- This reduction in variability makes it possible to reduce safety stock and therefore reduce average inventory without compromising the customer service level.
- It works best for products with:
 - ✓ **High coefficient of variation.**
 - ✓ **Negatively correlated demand.**

The Risk Pooling Game



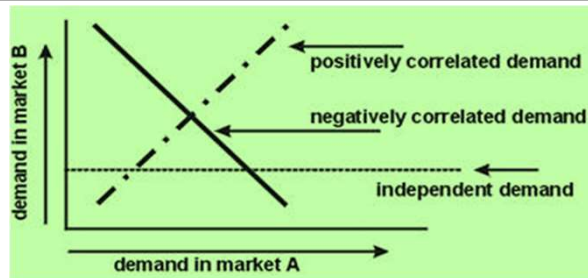
- The “Centralized Warehouse” is able to generate higher profits
- This is due to the benefits enjoyed by centralization (risk-pooling)

Positive / Negative Demand Correlation



- Demand correlation is the behavior of customer demand from one market relative to another market
 - If demand is **positively correlated**, it is likely that if one market has high/low demand, all the other markets will also have high/low demand
 - If demand is **negatively correlated**, it is likely that if one market has high demand, at least one other market will have low demand, and vice versa

Positive / Negative Demand Correlation



- Benefits of centralization (risk-pooling) **increases** when there is **negative correlation**, because items originally allocated in the centralized warehouse for one market (with lower demand) can now be diverted to another market (with higher demand)

Demand Correlation in the Risk Pooling Game



- Strongly Negative

Rev: 13700
COGS: 6850
Holding: 4947
Profit: 1903
Fill Rate: 92%
Period: 10

Week	Retailer 1	Retailer 2	Retailer 3
1	26	17	37
2	12	31	39
3	11	32	24
4	28	15	15
5	14	58	57
6	1	41	41
7	30	12	37
8	23	19	32
9	26	8	7

Random Demand Parameters

Demand Correlation: Strong Negative ☒ None ☐ Strong Positive

Mean: 22
Standard Deviation: 12

Rev: 13620
COGS: 6810
Holding: 5311.5
Profit: 1498.5
Fill Rate: 91%

- Strongly Positive

Rev: 11980
COGS: 5990
Holding: 5331
Profit: 659
Fill Rate: 97%
Period: 10

Week	Retailer 1	Retailer 2	Retailer 3
1	4	4	14
2	12	12	13
3	14	13	18
4	25	26	29
5	17	17	17
6	33	33	33
7	39	40	28
8	28	28	28
9	10	10	16

Random Demand Parameters

Demand Correlation: Strong Negative ☐ None ☐ Strong Positive ☒

Mean: 22
Standard Deviation: 12

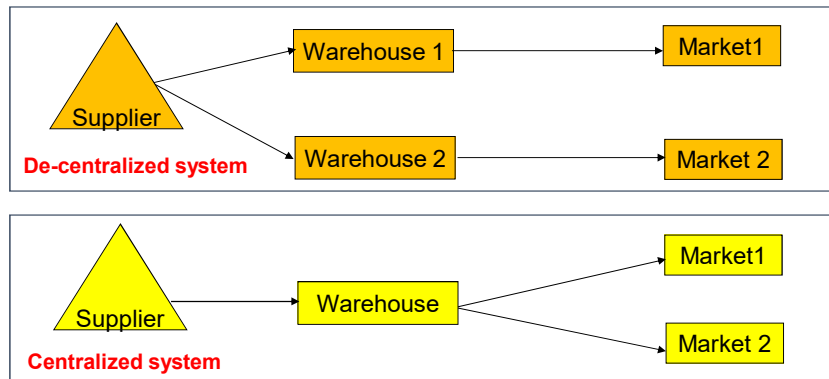
Rev: 12440
COGS: 6220
Holding: 5659.5
Profit: 560.5
Fill Rate: 101%

Risk Pooling works better for negatively correlated demand!

Effect of Risk-Pooling



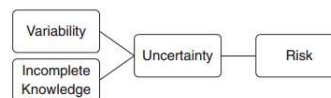
- For the same service level, which system will require more inventory, centralized or de-centralized system? Why?
- For the same total inventory level, which system will have better service? Why?
- What are the factors that affect the results?



Coefficient of Variation (COV)



- **Standard Deviation** measures the absolute variability of the customer demand



- **Coefficient of Variation (COV)** measures the variability relative to the average demand

➤ The greater the COV, the greater is the demand uncertainty faced by the product

$$COV = \frac{STDEV}{MEAN}$$

Coefficient of Variation (COV)



- Demand variability faced by the centralized warehouse is much smaller than the combined variability (sum) faced by the 2 existing de-centralized warehouses.
- This has a major impact on the inventory levels in the current (de-centralized) versus the proposed (centralized) system.

DC	Item	Mean	STDEV	COV
A	Armchair	201.25	10.35	0.05
A	Bookshelf	336.83	88.40	0.26
B	Armchair	342.33	19.68	0.06
B	Bookshelf	301.33	93.16	0.31
Centralized	Armchair	543.58	26.99	0.05
Centralized	Bookshelf	638.17	60.38	0.09

Safety Stock (s, S Policy)



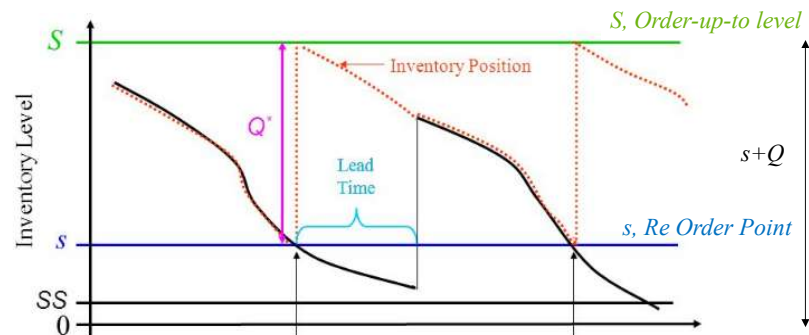
- Safety Stock, $SS = \text{Safety Factor} * STDEV * SQRT(L)$
- Centralization results in reduction on safety stock while maintaining the same customer service level

At 98% Customer Service Level, Safety Factor = 2.06

DC	Item	Safety Stock
A	Armchair	22
A	Bookshelf	183
B	Armchair	41
B	Bookshelf	192
Centralized	Armchair	56
Centralized	Bookshelf	125

Armchair	De-centralized	63.00
	Centralized	56.00
	Reduction	7.00
	% Reduction	11.11%
Bookshelf	De-centralized	375.00
	Centralized	125.00
	Reduction	250.00
	% Reduction	66.67%

(s,S) Policy



- s should be set to cover the demand during lead time with a safety stock that ensures the stock out probability is within the specific limit – customer service level (When to reorder).
- S depends on the fixed ordering quantity – EOQ (How much to order)

Reorder Point, s for (s, S) System



- $s = \text{average weekly demand} * \text{lead time} + \text{Safety Stock}$
 $= d * L + SS$
- Centralization results in a lower Reorder Point, while maintaining the same customer service level

DC	Item	Reorder Point
A	Armchair	224
A	Bookshelf	520
B	Armchair	384
B	Bookshelf	494
Centralized	Armchair	600
Centralized	Bookshelf	764

EOQ (Optimal Order Quantity)



$$EOQ = \sqrt{\frac{2RD}{H}}$$

- R → Ordering Cost
- D → Average Demand (weekly, monthly, annually, etc.)
- H → Holding Cost per item per week/month/year

DC	Product	EOQ, Q*
A	Armchair	142
A	Bookshelf	233
B	Armchair	186
B	Bookshelf	220
Centralized	Armchair	234
Centralized	Bookshelf	320

Average Inventory Level



- Average inventory = (EOQ / 2) + Safety Stock
- Centralization results in a lower average inventory level
 - For Armchair, average inventory levels → 24% reduction
 - For Bookshelf, average inventory levels → 53% reduction

DC	Product	Average Inventory Level
A	Armchair	93
A	Bookshelf	300
B	Armchair	134
B	Bookshelf	302
Centralized	Armchair	173
Centralized	Bookshelf	285
Armchair	De-centralized	227.00
	Centralized	173.00
	Reduction	54.00
	% Reduction	24%
Bookshelf	De-centralized	602.00
	Centralized	285.00
	Reduction	317.00
	% Reduction	53%

- The higher the COV, the larger is the impact of centralization on reduction of average inventory level
- This explains why Bookshelf, which has a higher COV, enjoys a higher percentage reduction on average inventory

Order-up-to-Level, S for (s, S) System

- $S = \text{Reorder Point (s)} + \text{EOQ}$
- Centralization results in a lower Order-up-to-Level, while maintaining the same customer service level

DC	Product	Order-Up-To-Level
A	Armchair	366
A	Bookshelf	753
B	Armchair	570
B	Bookshelf	714
Centralized	Armchair	834
Centralized	Bookshelf	1084

Armchair	De-centralized	936.00
	Centralized	834.00
	Reduction	102.00
	% Reduction	11%
Bookshelf	De-centralized	1467.00
	Centralized	1084.00
	Reduction	383.00
	% Reduction	26%

Recommendations

- Nature Living can proceed to consolidate DC A and B into a Centralized DC to serve the entire Asia market from **inventory cost saving** perspective.
- Centralization helps to reduce both the safety stock and average inventory level while maintaining the same customer service level.
- In a centralized system, the demand from one market with higher than average demand, can be diverted from the centralized warehouse, to another market with lower than average demand. This is the risk pooling effect.
- The process of the inventory re-allocation will not be practical in the case of a de-centralized system.

Further Considerations



- Typically, the overhead costs (ongoing expenses of running a business, includes rental, electricity bills, insurance) are much lesser in a centralized system because of the economies of scale.
- If a centralized and decentralized warehousing system both carry the same amount of total inventory, the service level provided by the centralized system will be higher.
- As we reduce the number of warehouses (centralized system), the outbound transportation costs (costs incurred for delivering the items from warehouses to the customers) increase, while the inbound transportation costs (costs of shipping the products from the suppliers and manufacturing facilities to the warehouses) decrease.

To Centralize or not to Centralize (1)



- **Centralized facilities**
 - ✓ Employ both fewer warehouses and distribution centers
 - ✓ Facilities are located further from customers
- **Economies of scale:**
 - ✓ Greater economies of scale with centralized facilities
- **Safety Stock**
 - ✓ Safety stock decreases from a decentralized to a centralized system
 - ✓ Depends on COV and correlation

To Centralize or not to Centralize (2)



- **Customer Service Level**
 - ✓ Given the same total safety stock, the service level provided by the centralized system is higher
- **Overhead Costs**
 - ✓ Typically, these costs are much greater in a decentralized system
- **Lead Time**
 - ✓ The response time for a decentralized system is much shorter
- **Transportation Costs**
 - ✓ Outbound costs are higher for the centralized system
 - ✓ Inbound costs are higher for the decentralized system

Other Types of Risk Pooling

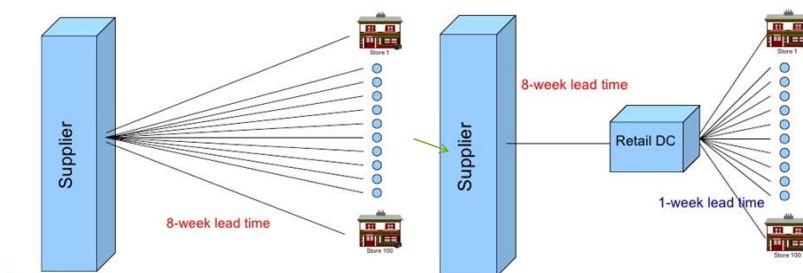


- Risk pooling is a statistical concept that suggests that demand variability is reduced if one can aggregate demand, for example, across locations, across products or even across time.
- The idea behind risk pooling is to redesign the supply chain, the production process, or the product to either reduce the uncertainty the firm faces or to hedge uncertainty so that the firm is in a better position to mitigate the consequence of uncertainty:
 - **Location** pooling (covered in today's lesson)
 - **Product** pooling (pooling products for different segments through an universal design, covered in lesson 2)
 - **Lead time** pooling
 - **Capacity** pooling

Lead Time Pooling



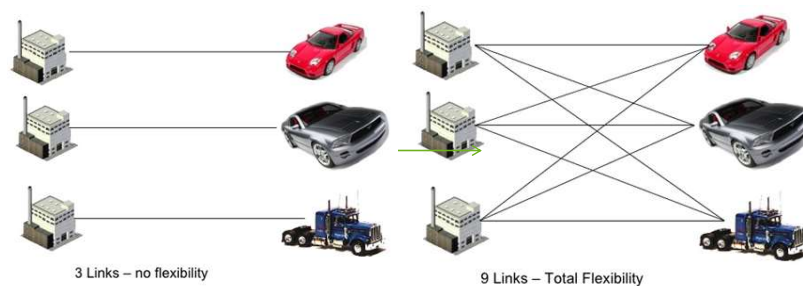
- Delaying time of deliveries to the customers
- This is to address the main problem with location pooling, the distance between inventory and customers:
 - ✓ Consolidated distribution
 - ✓ Delayed differentiation



Capacity Pooling



Introducing flexibility in manufacturing by pooling different plants with different capabilities so that they can produce the same final products



Learning Objectives



- Interpret the results of the Risk-Pooling Game
- Compare the pros and cons of a Centralized versus a De-centralized warehousing system
- Calculate the Coefficient of Variation (COV) and describe its impact on Centralization (risk-pooling)
- Compare the Safety Stock, Reorder Point, EOQ, Average Inventory Levels and Order-Up-To-Level for a Centralized versus a De-centralized warehousing system

