Risk Pooling in SC

Lect. delivered by
Prof. S P Sarmah

Concept of Risk Pooling

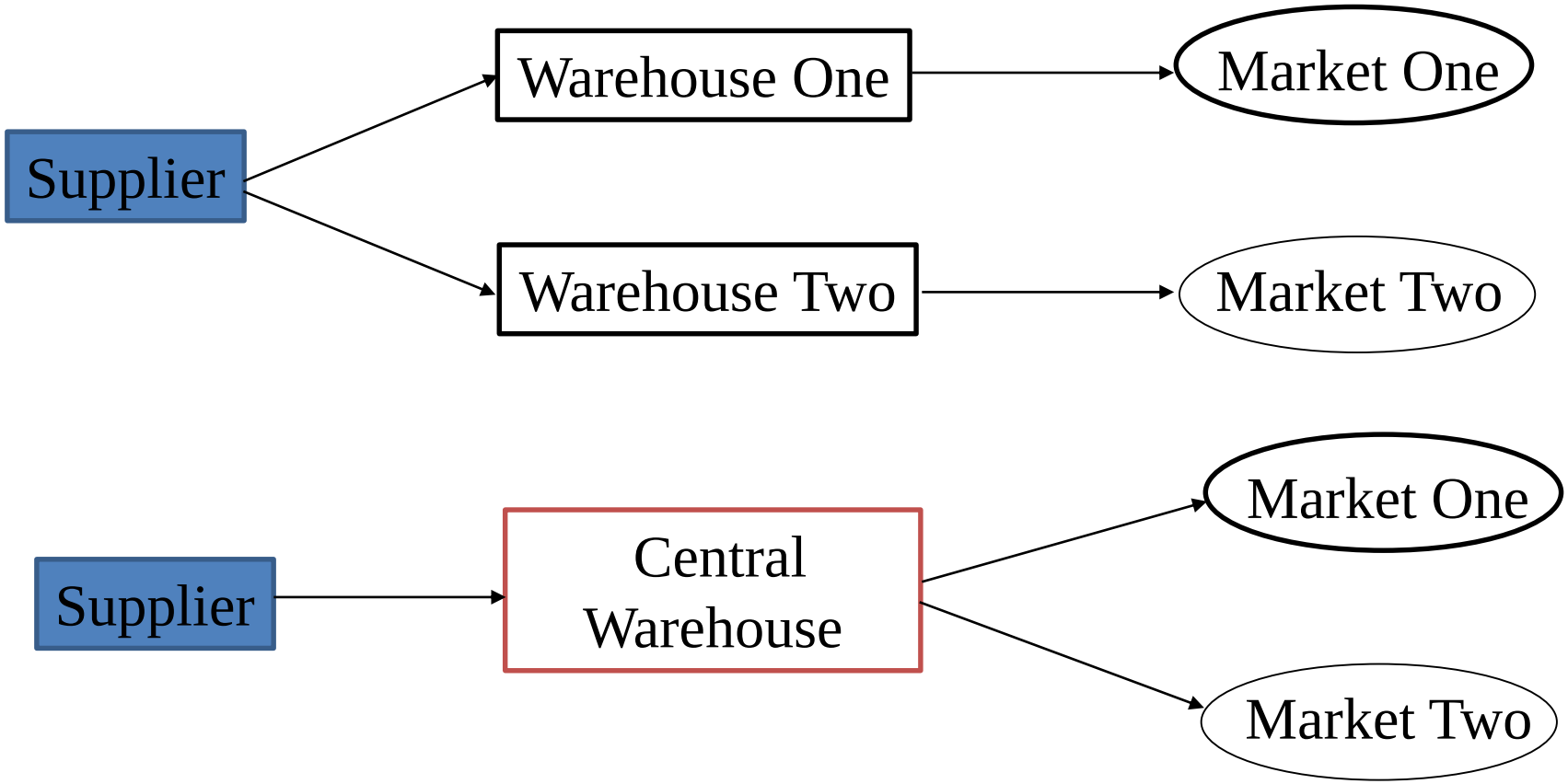
- Risk pooling suggests that demand variability is reduced if one aggregates demand across locations
- When demand is aggregated across different locations, it becomes more likely that high demand from one customer will be offset by low demand from another.
- Reduction in variability allows a decrease in safety stock and therefore, reduces average inventory
- Risk of carrying more inventory and obsolescence of product due to less demand in the market or risk of stock out due to more demand in the market.

Concept of Risk Pooling

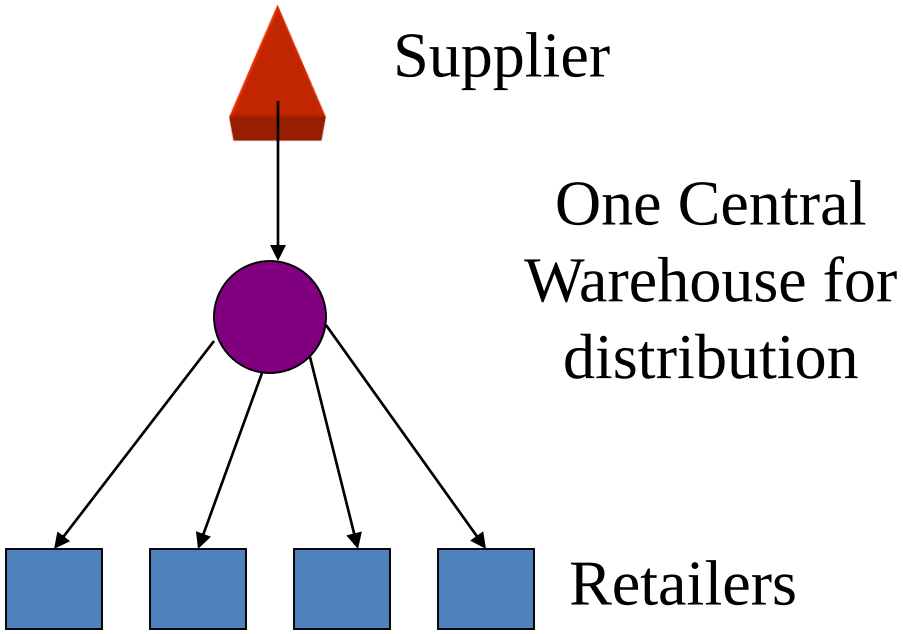
- Critical points about risk pooling
  - Centralized inventory reduces both safety stock and average inventory in the system
  - Process of reallocation of inventory is possible in centralized distribution system
- Higher the coefficient of variation, greater the benefit obtained from centralized system i.e. from Risk Pooling
- The benefits from risk pooling depend on the behavior of demand from one market relative to demand from another
- **Benefits from risk pooling decreases as correlation between demand from two market is +ve**

Risk Pooling Concept

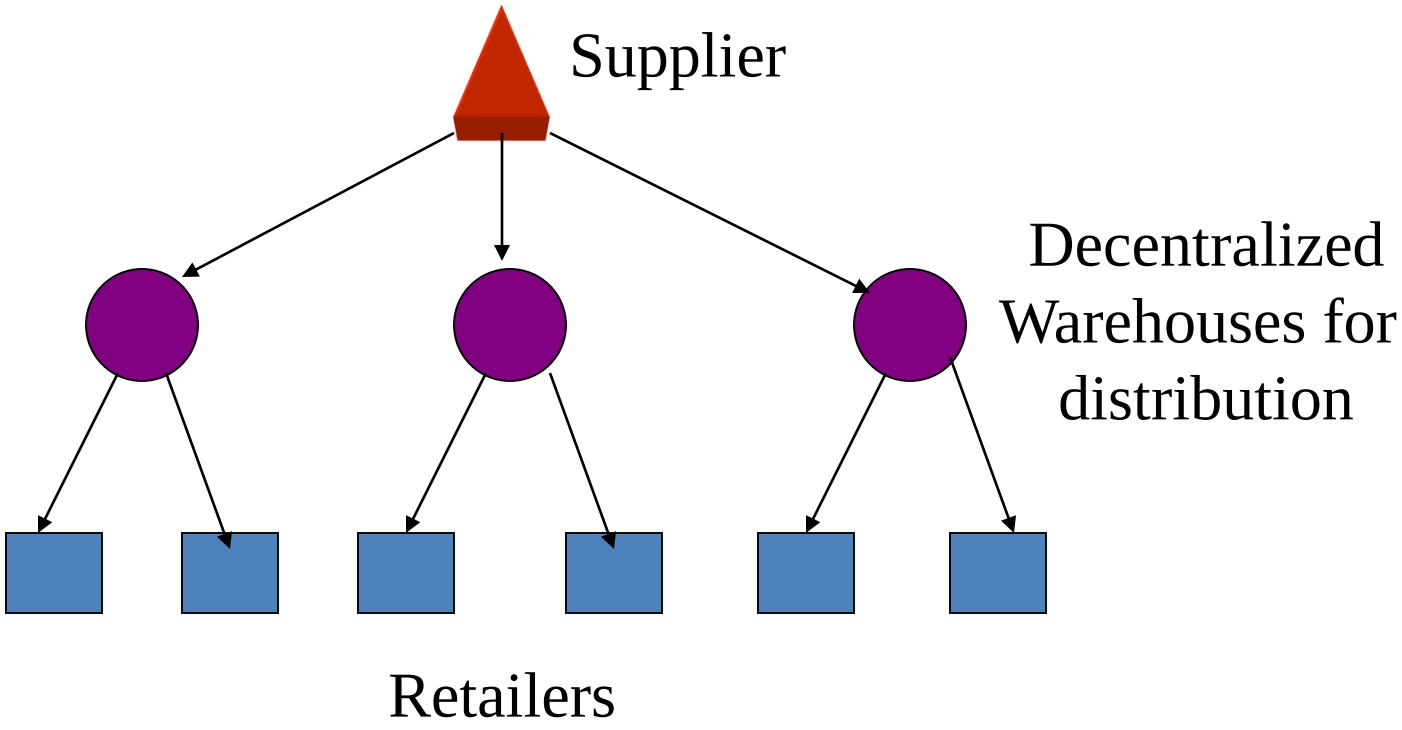
- Consider these two systems:



Centralized distribution systems



Decentralized distribution System



The distributor holds inventory to

- Satisfy demand during lead time
- Protect against demand uncertainty
- Balance fixed costs and holding costs

Implications of Risk Pooling

- If one aggregates the demand across different locations it becomes more likely that high demand from one customer will be offset by low demand from another
- As the number of retailers goes up this likelihood also goes up.
- Aggregate demands are easier to forecast
- Reduction in variability of demand
- Decrease in safety stock
- Reduces average inventory
- Cutting down the inventory holding cost for the warehouse.

Some key questions related to Risk Pooling

- For the same service level, which system will require more inventory? Why?
- For the same total inventory level, which system will have better service? Why?
- What are the factors that affect these answers?

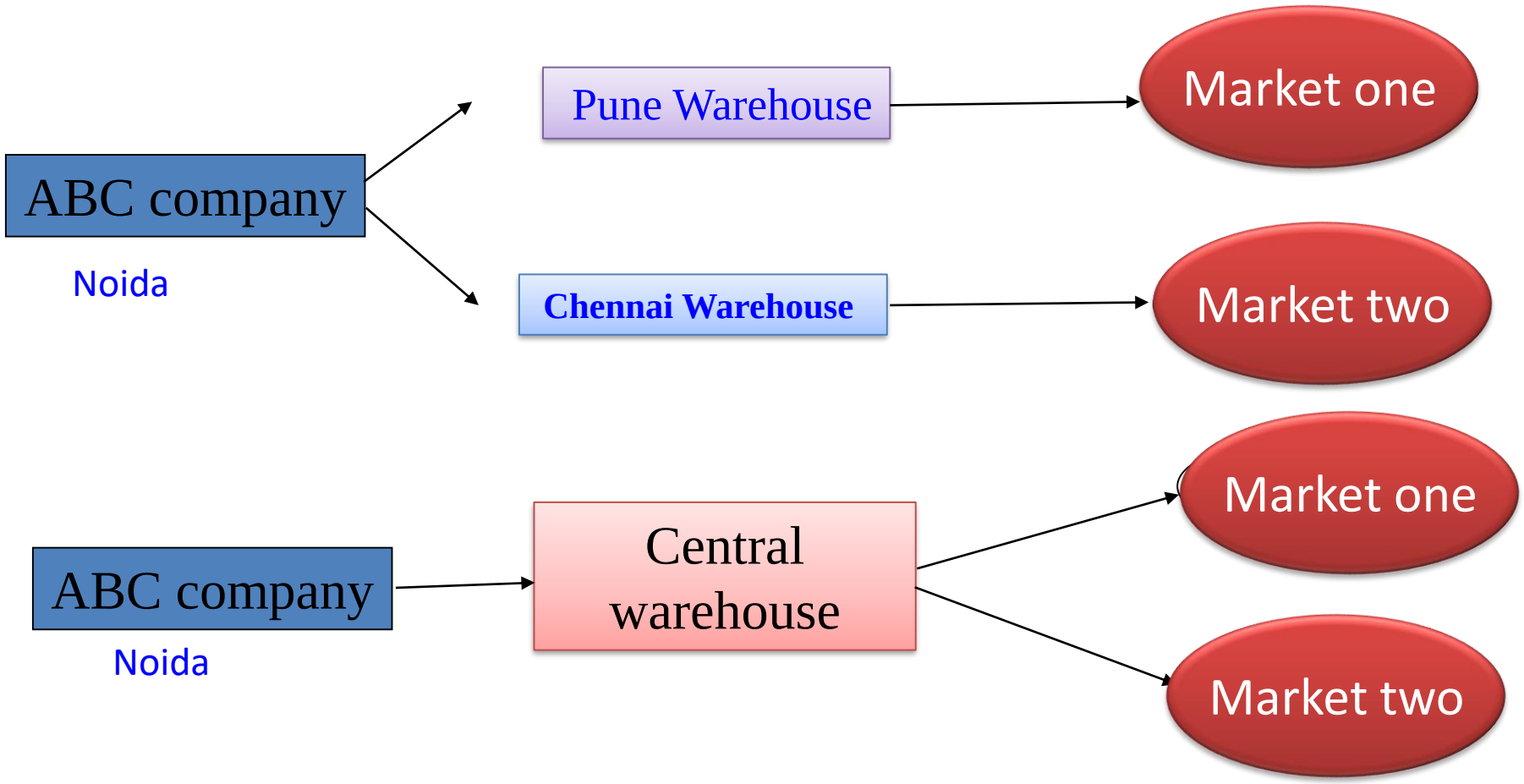
Example of Risk Pooling

Let us illustrate this with an example of a Noida based company ABC that produces certain type of products and distributes them in the Southern parts of India. The current distribution system partitions south Indian region into two markets each of which has a warehouse.

- **One warehouse is located in Pune**
- **Another one located in Chennai.**

Alternative strategy of centralized distribution system replaces two warehouses by a single warehouse located between the two cities in Bangalore that will serve all customer orders in both the markets.

Consider these two systems:



Given data and assumptions

- Manufacturing facility has sufficient capacity to satisfy any warehouse demand
- **Lead time for delivery to each warehouse is about one week** and is assumed to be constant.
- Delivery time does not change significantly if we adopt a centralized distribution system.
- **Service level is 97%** i.e. the probability of stocking out 3% is maintained.
- **Ordering cost**, S = $60 per order
- **Inventory holding charges** = $0.27 per unit per week

Data Analysis

- Now with analysis of weekly demand for two different products, **product A** and **product B** produced by **ABC company** for last 8 weeks in both market zones, we will examine which distribution strategy will be more efficient and cost effective.

Historical Demand Data for **PRODUCT A**

WEEK	1	2	3	4	5	6	7	8
Pune	33	45	37	38	55	30	18	58
Chennai	46	35	41	40	26	48	18	55
TOTAL	79	80	78	78	81	78	36	113

Historical Demand Data for **PRODUCT B**

WEEK	1	2	3	4	5	6	7	8
Pune	0	3	3	0	0	1	3	0
Chennai	2	4	0	0	3	1	0	0
TOTAL	2	7	3	0	3	2	3	0

Question?

How much can the ABC company reduce the inventory if it decides to switch to the centralized system but maintaining the same 97% service level?

Analysis

- In order to answer the question, we need to carry out an analysis from the give data.

- We calculate average weekly demand , standard deviation of demand and coefficient of variation.

- **Standard deviation measures the absolute variability of customer demands, while the coefficient of variation measures variability relative to average demand**.

Sample calculations

- **Product A, warehouse - Pune**

Week	1	2	3	4	5	6	7	8
Demand	33	45	37	38	55	30	18	58

- Average demand = (33+45+37+38+55+30+18+58)/8= 39.25
- Standard deviation of sample = average, *N- sample size*

$$S_d = \sqrt{\frac{\sum_{n=1}^{N} (X-\mu)^2}{(N-1)}}$$

where, μ is the

$$S_d = \sqrt{\frac{((33-39.25)^2+(45-39.25)^2+(37-39.25)^2+(38-39.25)^2+(55-39.25)^2+(30-39.25)^2+(18-39.25)^2+(58-39.25)^2)}{7}}$$

$$S_d = 13.1773$$

- Coefficient of variance = standard deviation/ average = 13.1773/ 39.25 = 0.3357

Summary of Historical DATA

	Product	Average Demand	Standard Deviation	Coefficient of Variation
Pune	**A**	39.25	13.1773	0.3357
Chennai	**A**	38.625	12.04	0.3117
Pune	**B**	1.25	1.488	1.1904
Chennai	**B**	1.25	1.5811	1.2648
CENTRAL	**A**	77.875	20.7118	0.2659
CENTRAL	**B**	2.5	1.9226	0.8095

- Average demand for product A is much higher than product B which is a slow moving product.

- The Standard deviation for product A is higher but on the other hand, coefficient of variation of product B is higher.

- For centralized distribution, average demand is simply the sum of the demand faced by each of existing warehouse

- However the variability of demand as measured by STD or COV faced by central warehouse is lower than that faced by the two existing ones.

Sample Calculation of inventory parameters

- **Product A , warehouse Pune**
- Average weekly demand = 39.25 units
- Lead time = 1 week
- Demand during lead time, DDLT = 39.25 units
- Safety stock = $Z*S'_d = Z*S_d\sqrt{LT} = 1.88*13.1773*\sqrt{1} = 25.82$ units
- ROP = DDLT + safety stock = 39.25 + 25.82 = 65.07 units

$$Q* = \sqrt{\frac{2DS}{IC}} = \sqrt{\frac{2(39.25)(60)}{0.27}} = 132.07 \text{ or } 132 \text{ units}$$

- **AIL = *Q**/2 + safety stock = 132/2 + 25.82 = 91 units**

SUMMAREY OF INVENTORY LEVELS FOR DECENTRALIZED SYSTEM

	Product	Average Demand During Lead time	Safety Stock (SS)	Reorder Point (s)	Order Quantity (Q*)	Average Inventory
Pune	**A**	39.25	25.82	65	132	91
Chennai	**A**	38.625	22.63	62	131	89
Total average inventory for product A						**180**
Pune	**B**	1.25	2.797	4.04	24	15
Chennai	**B**	1.25	2.972	4.22	24	15
Total average inventory for product B						**30**

For the centralized system

Product	Average Demand During Lead time	Safety Stock (SS)	Reorder Point (s)	Order quantity (Q*)	Average Inventory
A	77.875	38.93	116	186	**132**
B	2.5	3.61	6	33	**20**

% Reduction in Inventory

REDUCTION IN AVERAGE INVENTORY

$$\text{PRODUCT A} = \frac{(180-132)}{180} * 100 = 36.36\%$$

$$\text{PRODUCT B} = \frac{(30-20)}{30} * 100 = 33.33\%$$

Ideal Situation

Risk pooling works best for situation where

- High coefficient of variation, which reduces required safety stock.

- Negatively correlated demand as in such a case the high demand from one customer will be offset by low demand from another

Illustration 2: Risk pooling

Suppose there is a product stocked in two warehouses. The replenishment quantities are determined by the economic order quantity formula. The replenishment lead-time is 0.5 months, the cost for a replenishment order is $50, the inventory carrying cost is 2% per month, and the item value is $75 per unit. The probability of an out of stock during the lead-time period is 5%. The demand is normally distributed with typical demand over six months as follows.

Risk Pooling (Cont'd)

Month	Demand in WH-A	Demand in WH-B	Combined Demand in a Central WH
1	35	67	102
2	62	83	145
3	46	71	117
4	25	62	87
5	37	55	92
6	43	66	109
Avg. (D)	41.33	67.33	108.66
Std. Dev. (s_d)	11.38	8.58	19.07

Estimate the average inventory levels for two-warehouses and one-warehouse supply channels.

Risk Pooling (Cont'd)

Regular stock

$$RS = \frac{Q}{2} = \frac{\sqrt{\frac{2DS}{IC}}}{2}$$

$$RS_A = \frac{\sqrt{\frac{2(41.33)(50)}{0.02(75)}}}{2} = \frac{52.49}{2} = 26.25 \text{ units}$$

$$RS_B = \frac{\sqrt{\frac{2(67.33)(50)}{0.02(75)}}}{2} = \frac{67.00}{2} = 33.50 \text{ units}$$

Regular stock in system is

$$RS_S = RS_A + RS_B = 26.25 + 33.50 = 59.75 \text{ units}$$

Risk Pooling (Cont'd)

Regular stock if item is entirely in one warehouse

$$RS_C = \frac{\sqrt{\frac{2(108.66)(50)}{0.02(75)}}}{2} = \frac{85.11}{2} = 42.56 \text{ units}$$

Safety stock

$$SS = z(s_d)\sqrt{LT}$$

$$SS_A = 1.96(11.38)\sqrt{0.5} = 15.77 \text{ units}$$

$$SS_B = 1.96(8.58)\sqrt{0.5} = 11.89 \text{ units}$$

System safety stock in 2 warehouses

$$SS_A + SS_B = 15.77 + 11.89 = 27.66 \text{ units}$$

Risk Pooling (Cont'd)

Safety stock in 1 warehouse

$$SS_c = 1.96(19.07)\sqrt{0.5} = 26.43 \text{ units}$$

Total inventory

AIL = Regular stock + Safety stock

AIL = 59.75 + 27.66 = 87.41 units

Two warehouses

In a one-warehouse channel

One warehouse

AIL = 42.56 + 26.43 = 68.99 units

Conclusion There is a *reduction* in the average inventory level of an item as the number of stocking points in the supply channel is *decreased*. In this example, both regular stock and safety stock decline.

Concluding Comment

Risk pooling is an important concept in supply chain management. The idea of risk pooling is executed by a **centralized distribution system** which caters to the requirements of all the markets in a given region instead of separate warehouse allocated for different markets.

THANKS