DS331

System Modeling and Simulation

[Car Dealer]

2023 & 2024

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Part 1 :

Problem Formulation:

The car dealer has an inventory with a maximum capacity of 10 cars and a showroom with a maximum capacity of 5 cars.

Daily demand follows a probability distribution with different probabilities for different demand levels (0, 1, 2, 3 cars).

The lead time for order arrival also follows a probability distribution.

The car dealer places an order every 3 days to replenish the inventory and showroom.

Orders are received after a certain lead time, during which additional demand may occur.

Objectives:

Inventory Management:

Manage the inventory and showroom to meet the daily demand.

Place orders strategically to maintain a balance between demand and inventory levels.

Profit Maximization:

Calculate the net profit based on selling cars, holding expenses, and order costs.

Analyze the average net profit over the simulation period.

Performance Metrics:

Track and analyze metrics such as average ending units in the showroom and inventory.

Identify the number of days with shortage conditions.

Comparison with Theoretical Values:

Compare experimental average demand and lead time with theoretical values based on specified probabilities.

Additional Considerations:

The simulation starts with an initial inventory of 3 cars and a showroom with 4 cars.

Orders are placed with a quantity to fill both the inventory and showroom to their maximum limits.

Shortages occur when the demand exceeds the available inventory and showroom capacity.

Notes:

The code calculates and prints various metrics, including average ending units, the number of shortage days, average net profit, and theoretical vs. experimental averages for demand and lead time.

Theoretical average demand and lead time are calculated based on the provided probability tables.

Part 2 :

System Components

Entities:

Car Dealer: Represents the main entity managing the entire system.

Cars: The products being sold, with attributes such as the number in inventory and showroom.

Showroom: The physical space where cars are displayed for customers.

Inventory: The storage space for cars that are not in the showroom.

Attributes:

Number of Cars in Inventory and Showroom: Represents the state of the system at a given point in time.

Order Quantity: The number of cars ordered to replenish inventory.

Shortage Quantity: The quantity of cars demanded but not available in the inventory or showroom.

Lead Time: The time it takes for an order to be fulfilled and inventory to be restocked.

Net Profit: The profit obtained from selling cars after considering expenses.

Activities:

Generating Demand: The process of determining the number of cars demanded on a given day.

Placing Orders: The action taken by the car dealer to replenish the inventory and showroom.

Selling Cars: The activity of selling cars to customers based on demand.

Managing Inventory Levels: Activities related to adjusting inventory based on demand and order arrivals.

States:

Inventory State: Describes the current status of the inventory, including the number of cars.

Showroom State: Describes the current status of the showroom, including the number of cars.

Order State: Represents the state of an order, including the lead time and arrival status.

Events:

Demand Event: The occurrence of customers wanting to buy cars, leading to a demand for a certain quantity.

Order Placement Event: The event where the car dealer decides to place an order to restock inventory.

Order Arrival Event: The event when the ordered cars arrive, affecting the inventory state.

System analysis

Random digit assignment→any random number in domain (01—20), this mean demand = 0 we don't need any order today.

Lead Time	Lead Time Probabilities	Cumulative probabilities	Random digit assignment
1	0.40	0.40	01—40
2	0.35	0.74	41—75
3	0.25	1.00	76—00

Demand	Demand Probabilities	Cumulative probabilities	Random digit assignment
0	0.20	0.20	01—20
1	0.34	0.54	21—54
2	0.36	0.90	55—90
3	0.10	1.00	91—00

Calendar Table for 10 Days:

CYCLE	DAY	BEGIN INV	BEGIN SHOWROOM	RAND DEMAND	DEMAND	END INV	END SHO	SHORTAGE	ORDER	RAND LEAD TIME	DAYS TO ARRIVE
1	1	3	4	0.81	2	1	4	0	_	_	1
1	2	1	4	0.42	1	0	4	0	_	_	0
1	3	4	5	0.02	0	4	5	0	6	0.71	2
2	4	4	5	0.87	2	2	5	0	_	_	1
2	5	2	5	0.01	0	2	5	0	_	_	0
2	6	8	5	0.44	1	7	5	0	3	0.88	3
3	7	7	5	0.92	3	4	5	0	_	_	2
3	8	4	5	0.72	2	2	5	0	_	_	1
3	9	2	5	0.33	1	1	5	0	9	0.59	2
4	10	1	5	0.002	0	1	5	0	_	_	1

Part 3 :

Experimental Design Parameters

Number of Cycles: 4

Review Period (N): 3

Max Inventory Capacity: 10

Max Showroom Capacity: 5

Initial Inventory: 3

Initial Showroom: 4

Initial Order Quantity: 5

Order Lead Time: 2

Profit per Car: 10,000 LE

Holding Cost per Car per Day: 1,000 LE

Order Cost: 20,000 LE

Justification of Experiment Parameters Values

Number of Cycles (4): Chosen to cover a sufficient number of days for analysis.

Review Period (N = 3): A common practice to review inventory levels and place orders at regular intervals.

Max Inventory and Showroom Capacities: Realistic values based on the size of the showroom and storage capacity.

Initial Inventory and Showroom: Set to mimic a starting scenario where some inventory is already present.

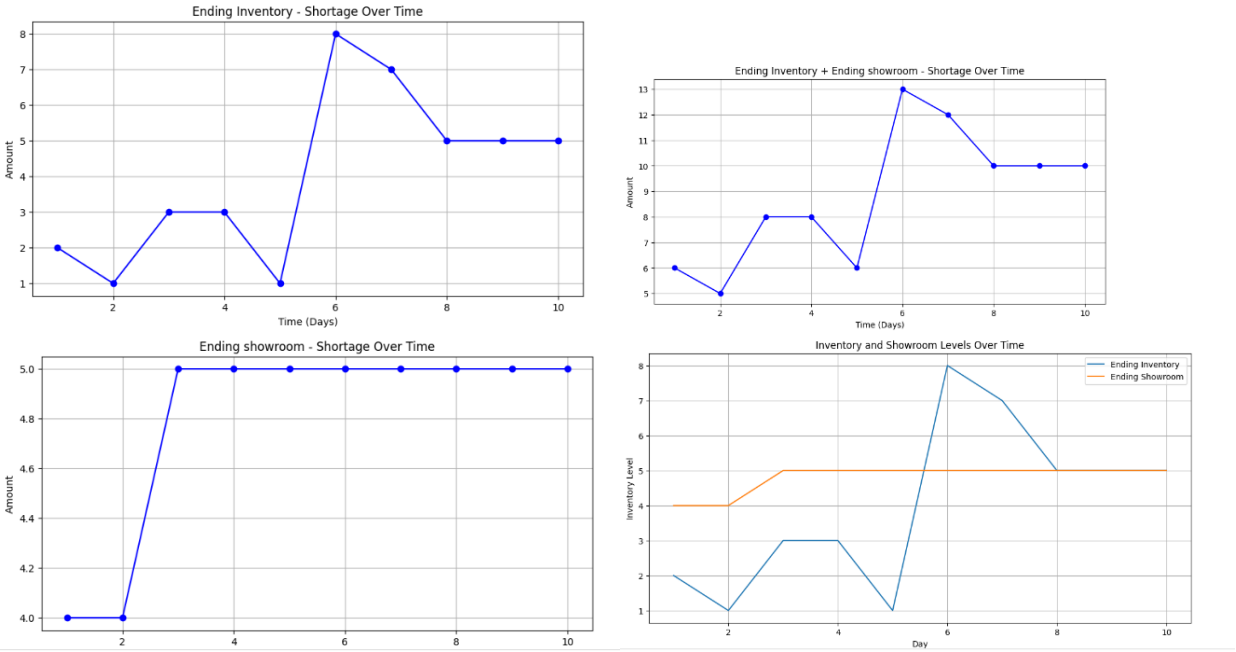
Initial Order Quantity and Lead Time: Represents an initial order already placed before the simulation starts.

Profit per Car, Holding Cost, and Order Cost: Hypothetical values to analyze the financial aspects.

Part 4 :

Results Analysis:

Graphs & Discussions



Ending Inventory - Shortage Over Time:

The graph shows the dynamic changes in ending inventory levels and the occurrence of shortages over the 10-day period.

Ending Showroom - Shortage Over Time:

Similar to the first graph, but focusing on the changes in the showroom and the impact on shortages.

Ending Inventory + Ending Showroom - Shortage Over Time:

Combines both inventory and showroom levels to provide an overall view of available cars and shortages.

Inventory and Showroom Levels Over Time:

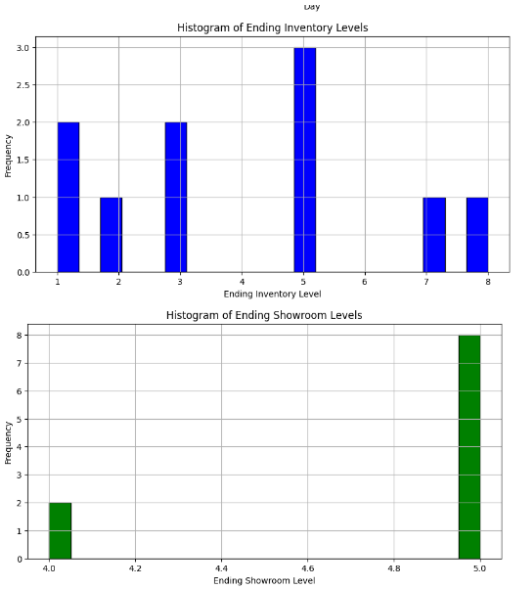
Compares the ending inventory and showroom levels over time, showing their individual trends.

Histogram of Ending Inventory Levels:

Displays the distribution of ending inventory levels, providing insights into the variability.

Histogram of Ending Showroom Levels:

Similar to the previous histogram, but for ending showroom levels.



Results for the 5 Questions

Average Ending Units in Showroom and Inventory:

Average Ending Showroom: 4.80

Average Ending Inventory: 2.40

Number of Days with Shortage Condition: 0

Shortage occurred on 0 days.

Average Net Profit: 4800

Theoretical vs. Experimental Average Demand:

Theoretical Average Demand: 1.36

Experimental Average Demand: 1.20

[NOT MATCHES]

Theoretical vs. Experimental Average Lead Time:

Theoretical Average Lead Time: 1.85

Experimental Average Lead Time: 2.33

[NOT MATCHES]

Best Review Period Length: 6

Conclusion

In conclusion, the simulation provides valuable insights into the car dealership's inventory management. The analysis of ending inventory, showroom levels, net profit, and other metrics helps in understanding the system's behavior under the given parameters. Further experimentation and parameter adjustments can optimize the system for increased profitability.