Casework 1

Dodba Supply Chain Facility Network, Analysis, Planning, and Simulation

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Introduction:

Dodba is an e-commerce company in domestic collaborative robots, holding 3.6% of a 2,000,000-unit U.S. market. As volume has grown, reliance on South Korean production has driven long lead times, higher uncertainty, and tariff exposure. Dodba now seeks to evaluate a transition to U.S manufacturing supported by a flexible, 3PL-based fulfillment network, anchored to next year's forecast. Our mandate is to model, validate, and visualize Dobda's hypotheses across five areas: market demand, fulfillment network, delivery-time sensitivity, inventory autonomy targets, and replenishment.
We will proceed in ten tasks: (1-2) demand analysis, (3-4) test the three fulfilment-network hypotheses, (5-6) quantity delivery-time sensitivity, (7-8) set autonomy targets for inventory aligned with Dobda's goal, and (9-10) design the network replenishment strategy.

Task 1: No demand uncertainty and no demand seasonality

Starting from a 2024 baseline of 2,000,000 units, the 2025 U.S. market is projected under three scenarios (Figure 1):

- Optimistic scenario (+12%): 2,240,000 units in 2026;
- Expected scenario (+7.5%): 2,150,000 units in 2026;
- Conservative scenario (+4%): 2,080,000 units in 2026.

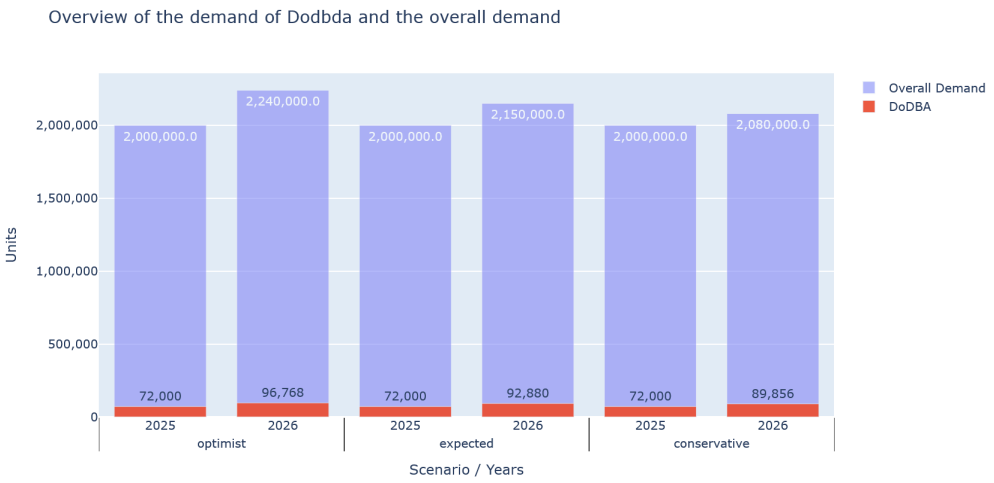


Figure 1: Overall Market in 1 year in units

In 2025, Dobda holds a 3.6% share of the U.S. market. For 2026, we evaluate three market-share growth scenarios relative to that baseline: +15% (minimum), +20% (median), and +25% (maximum). Figure 2 presents the resulting distribution of 2026 demand under each scenario. The final demand can vary between 86,112 units and 100,800 units, depending on the scenario (resp., optimistic maximum scenario and conservative minimum scenario), as the overall range.

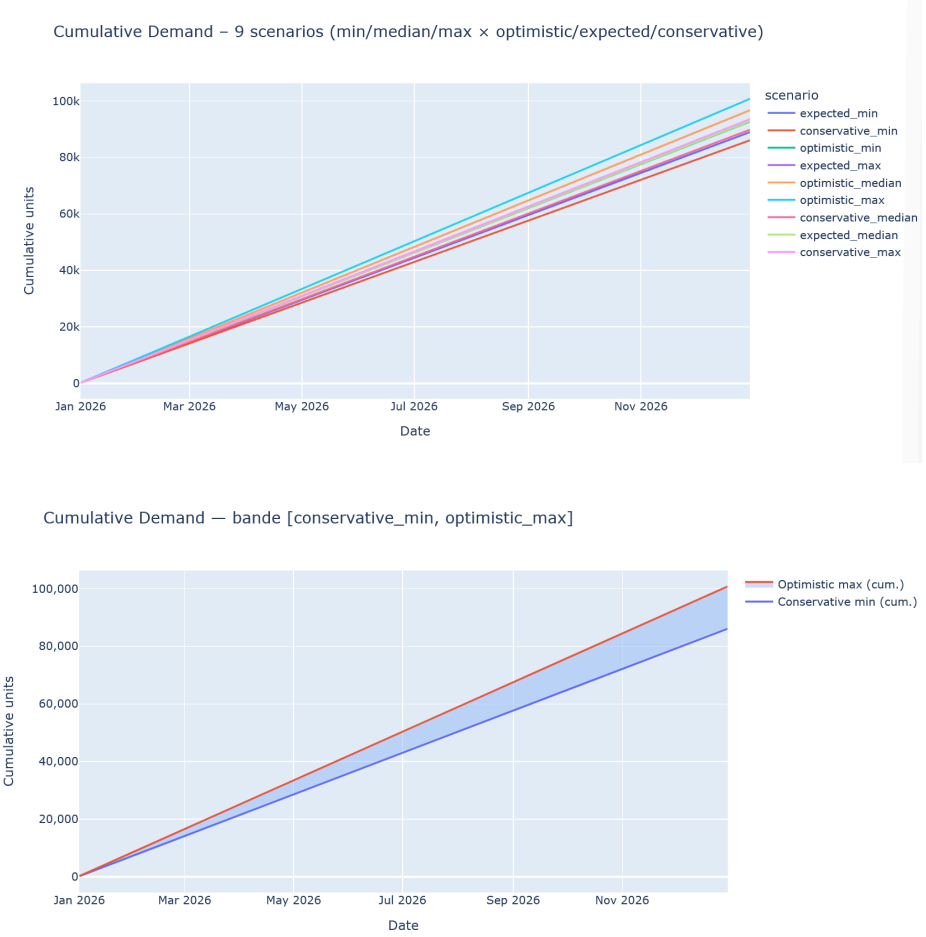


Figure 2: 9 scenarios for Dobda US Territory units

Units growth scenario			
Market growth	4%	7,5%	12%
Units 2026	2 080 000	2 150 000	2 240 000
Dodba growth			
15%	86 112	89 010	92 736
20%	89 856	92 880	96 768
25%	93 600	96 750	100 800

Table 1: Unit growth Scenarios

In 2025, Dobda sold 72,000 units, generating $216,000,000 in revenue ($3,000 per unit).
For 2026, projected revenue uplift ranges from $42,336,000 in the conservative case to $86,400,000 in the optimistic case.
The low end corresponds to +4% overall market growth combined with a +15% increase in Dobda's market share (+19.6% vs. 2025), while the high end reflects +12% market growth with a +25% share increase (+40% vs. 2025).

Above covers for units (#) for the overall USA territory for all the temporal cases (Y, M, D)
We now look at other spatial elements of Market type, state, and 3 Digit ZIP for units (#). The same kind of graphs with different scales (given scalar multiplication) will work for various other measures like dollars ($), volume (V), and weight (W), and hence we are not plotting the same here to prevent repetition. All the above would be multiplied of # values with $3,000, 12 cubic ft and 60 lbs respectively.

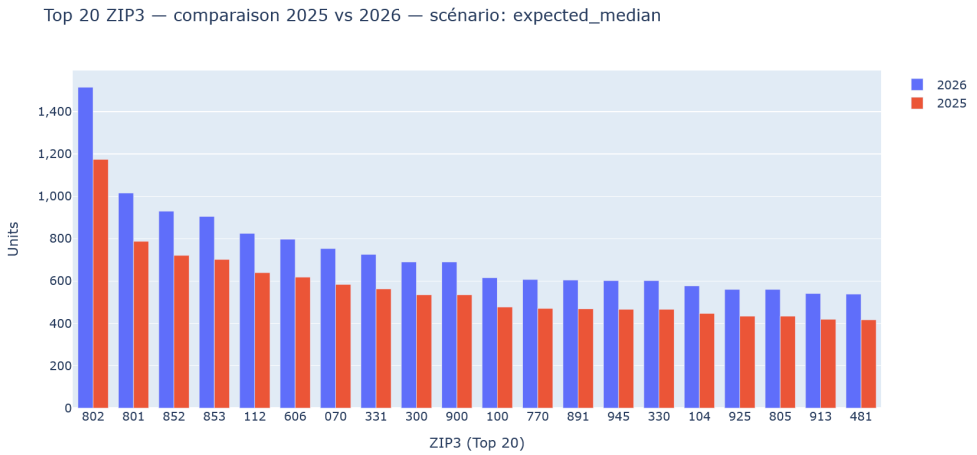


Figure 3: Top 20 ZIP by #

Figure 3 shows the top-20 three-digit ZIP territories by projected demand. ZIP 802 (Denver, CO) ranks first with 1,467 units in the expected-median scenario. Across the top 20, annual demand ranges from 1,467 to 521 units. At the long tail, some territories see as few as 3 units over the year, which implies the supply chain must remain flexible–capable of serving low-volume, remote areas efficiently while maintaining service for high-volume metros.

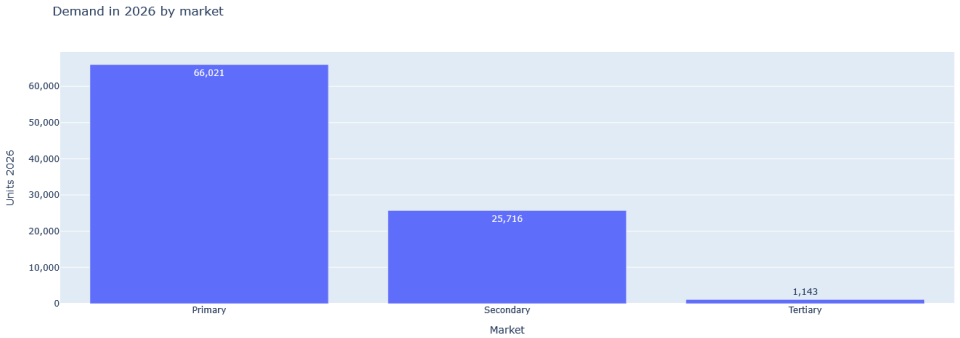


Figure 4: Demand in 2026 by market

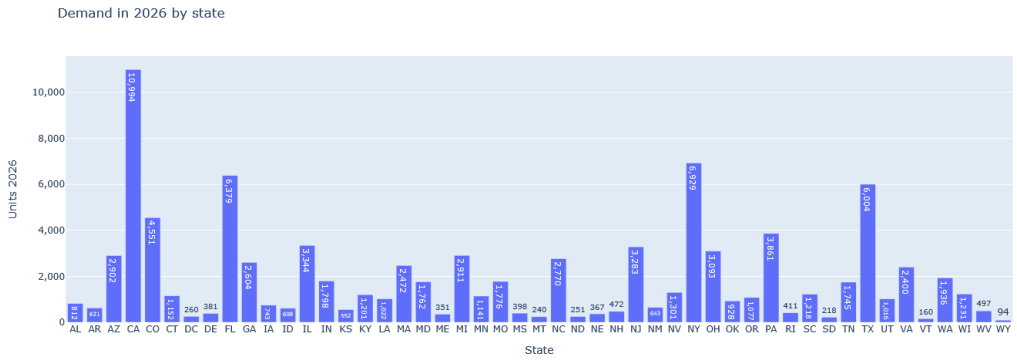


Figure 5: Demand in 2026 by state

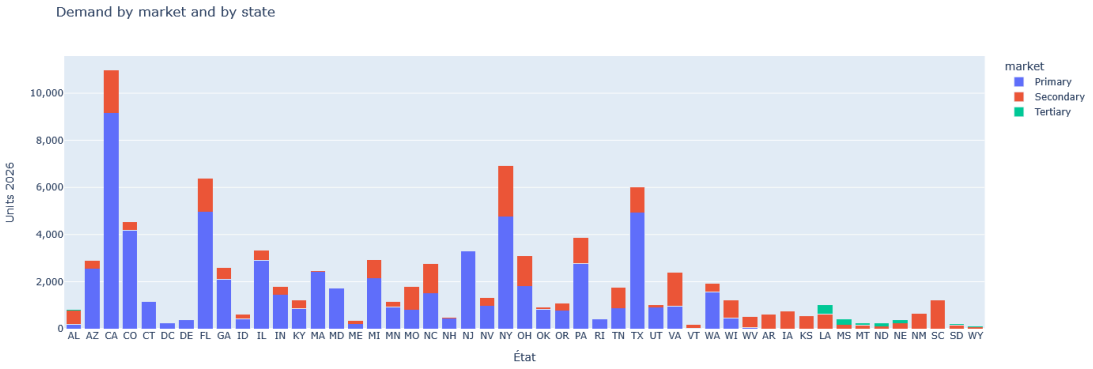


Figure 6: Demand in 2026 by state and market

Figure 5, Figure 6, and Figure 7 below show Yearly demand by market type, ZIP code-wise demand split for each Market type, and State distribution of Dobda demand, respectively. The primary market is about 67% of the overall demand for Dobda. Tertiary, on the other hand, is very small and is possibly about 2% of the demand share. California is the top state in demand, with 10,000 plus units for the year, with the next state being NY with about 7,000 units in demand. Three other states, CO, FL, and TX, are above 4,000 units, and all other states are less than 4,000 units. 33% of demand is between these five states themselves.

Task 2: With demand uncertainty and with demand seasonality

We now introduce seasonality by perturbing the expected probability mass function (PMF) ±20% at the week-of-year level and ±15% at the day-of-week level. These PMF variations are drawn from a uniform distribution and renormalized each draw so probabilities sum to 1. Total demand is modeled as Normal with a 20% mean (growth) and 5% standard deviation. We run a large Monte Carlo simulation to obtain a faithful distribution of outcomes. Results are summarized with 68%, 95%, and 99% confidence bands, as shown in Figure 9.

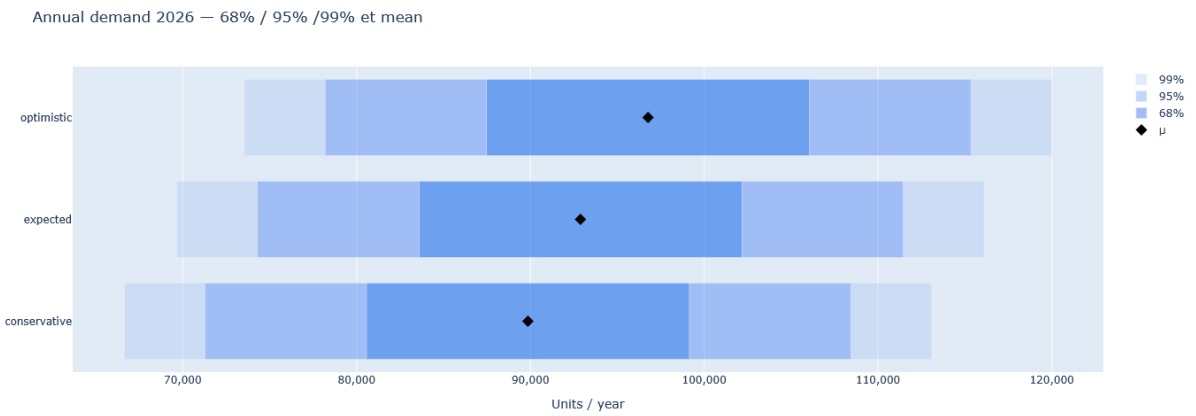


Figure 7: Dobda Year demand with confidence levels of 68%, 95% and 99%.

As expected, the demand band at a 99% confidence level is wider than at 68%.
Across the three scenarios, projected 2026 demand ranges from 78,246 to 108,378 units.
At a unit price of $3,000, that spread corresponds to a $90,396,000 revenue gap between the worst- and best-case scenarios.

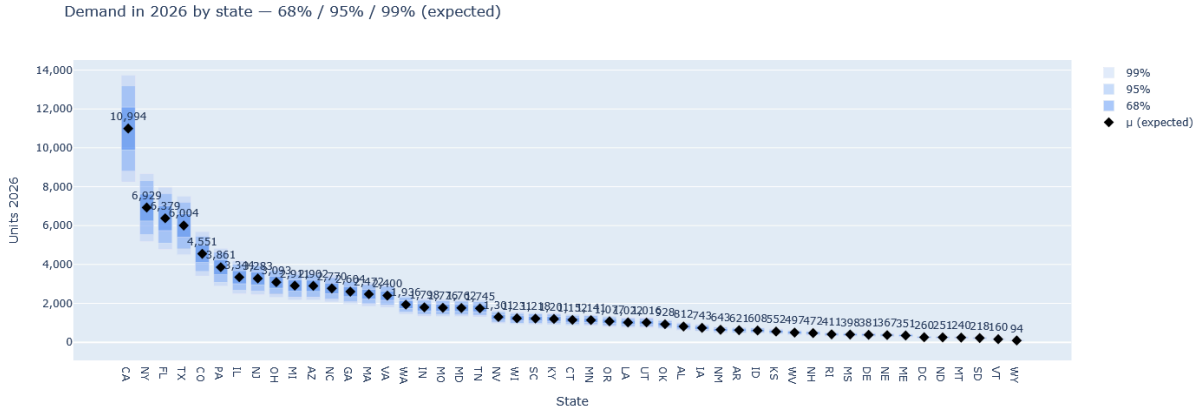


Figure 8: State-wise demand variation with uncertainty at the yearly level

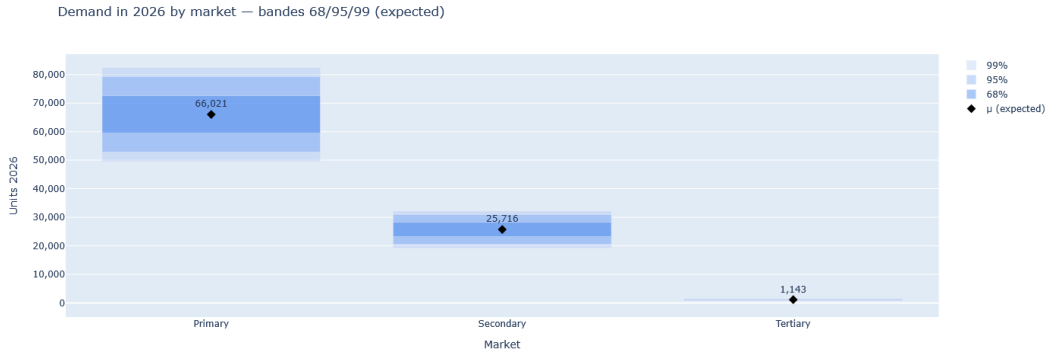


Figure 9: Market split of Dobda demand with uncertainty for three confidence levels at the yearly level.

Figures 8 and 9 provide complementary views of the demand distribution by market type and by state.
California remains the highest-demand state, and even under a worse scenario, it is likely to stay in the lead. A similar pattern holds for the primary market segment, which consistently outperforms the others across scenarios.

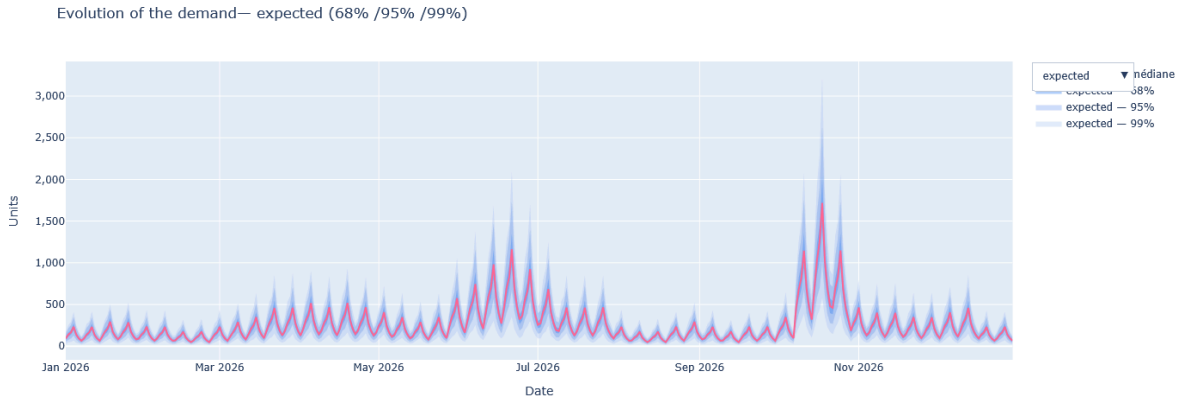


Figure 12: daily seasonality with confidence levels.

Daily demand fluctuates in a way that clearly reveals weekly seasonality. The PMF file confirms that mid-week is heaviest, with Thursday peaking at about 25% of weekly demand. The chart also highlights two ordering waves: a smaller bump in late June ahead of July and a much larger surge in late October. Under the 99% confidence band, October demand could approach 3,000,000 units.

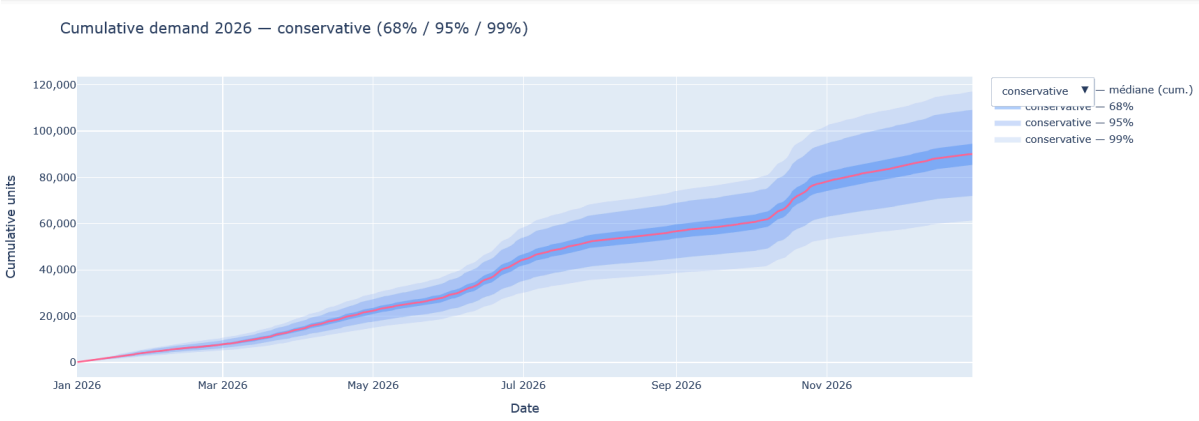


Figure 13: Cumulative daily demand with uncertainty - on Conservative market

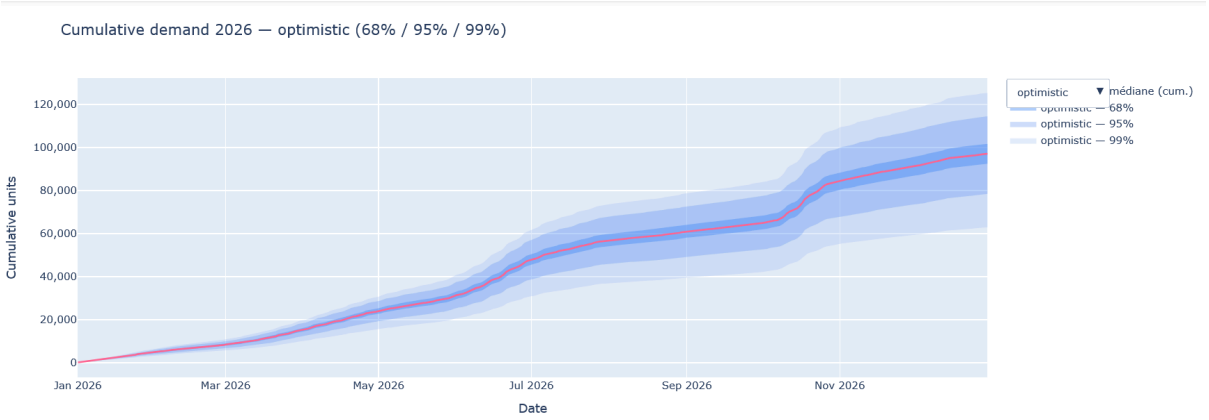


Figure 14: Cumulative daily demand with uncertainty - on Optimistic Demand.

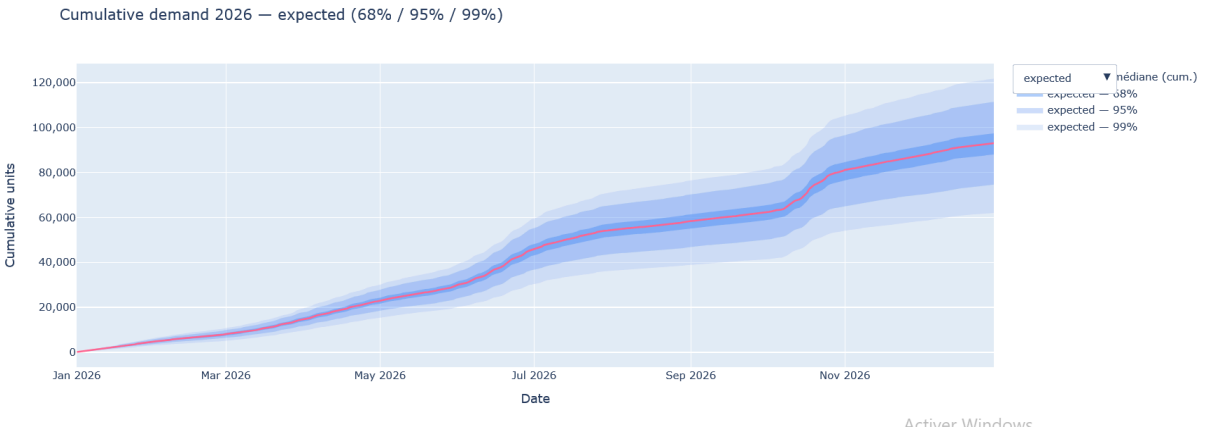


Figure 15: Cumulative daily demand with uncertainty -on expected market.

Analyzing cumulative demand smooths out the sharp fluctuations seen in daily volumes. This produces a clearer view of the underlying distribution and how it widens across the 99%, 95%, and 68% confidence levels.

For example in Figure 14 (Optimistic scenario), the range has widened for cumulative Dobda demand between 63,000 to 125,000 ! Comparing this to Figureure 13 of conservative scenarios for median Dobda demand, it ranges between 61,000 to 117,000. So not much of a difference between the levels but the high gap remains the same.

Task 3: Estimation of target regions for each FC

We now turn to Dobda's proposed fulfillment network configurations.
Specifically, we will evaluate three scenarios that the company has outlined for how to structure and operate the network.

- Single FC-Network, centralizing all fulfillment operations at FC-GA-303, fed by its nearby distribution center, as you can see in Figure 16.

- Four-FC Network relies on FCs in Georgia, New York, Texas, and Utah, as you can see in Figure 17.
- 15-FC Network, relying on the following FCs, as you can see in Figure 18.

a) ZIP3 Market Distribution by FC Network Scenario

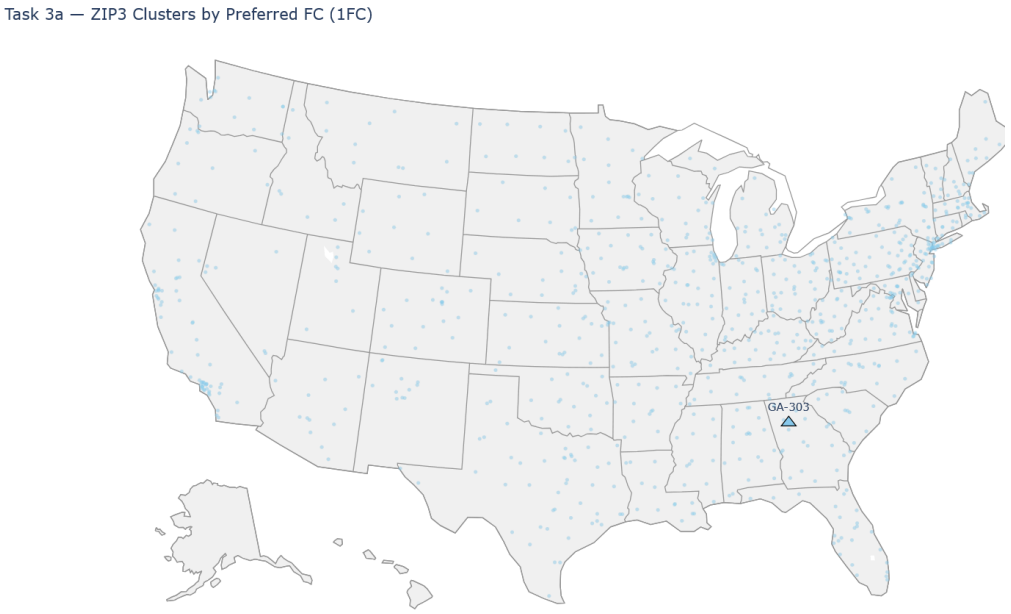


Figure 16: Single FC supplying all 970 ZIP codes

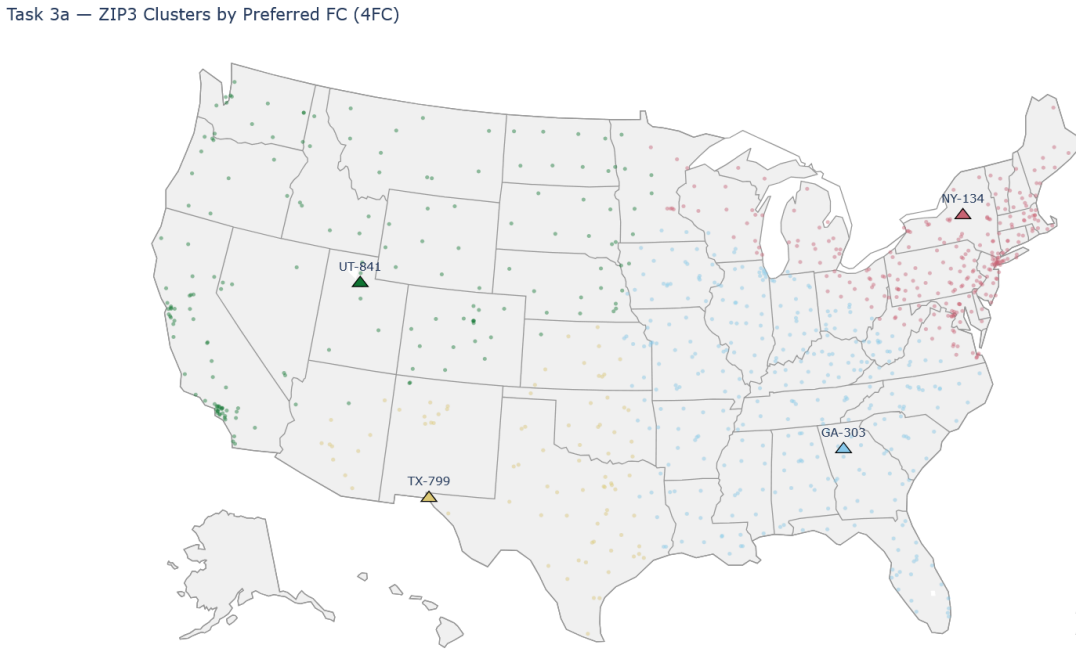


Figure 17: 4 FCs supplying all pincodes

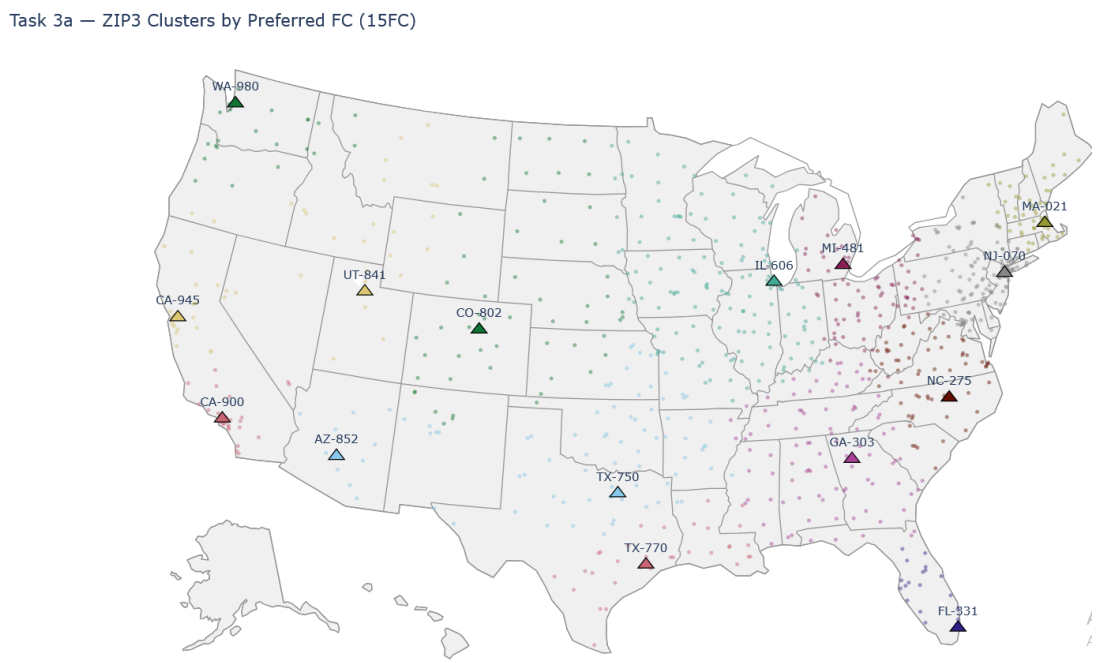


Figure 18: 15 FCs supplying to all the pincodes

The three network scenarios produce distinct allocation patterns: the more FCs, the closer each market sits to a serving node. Figures 16–18 illustrate this progression. Under the 1-FC network, a California market must be supplied from Georgia; with the 4-FC Network, it can be served from Utah; and with the 15-FC network, it can be fulfilled locally, potentially with two California FCs.

B) FC-Level Demand Share by Market — 4-FC vs 15-FC Scenario

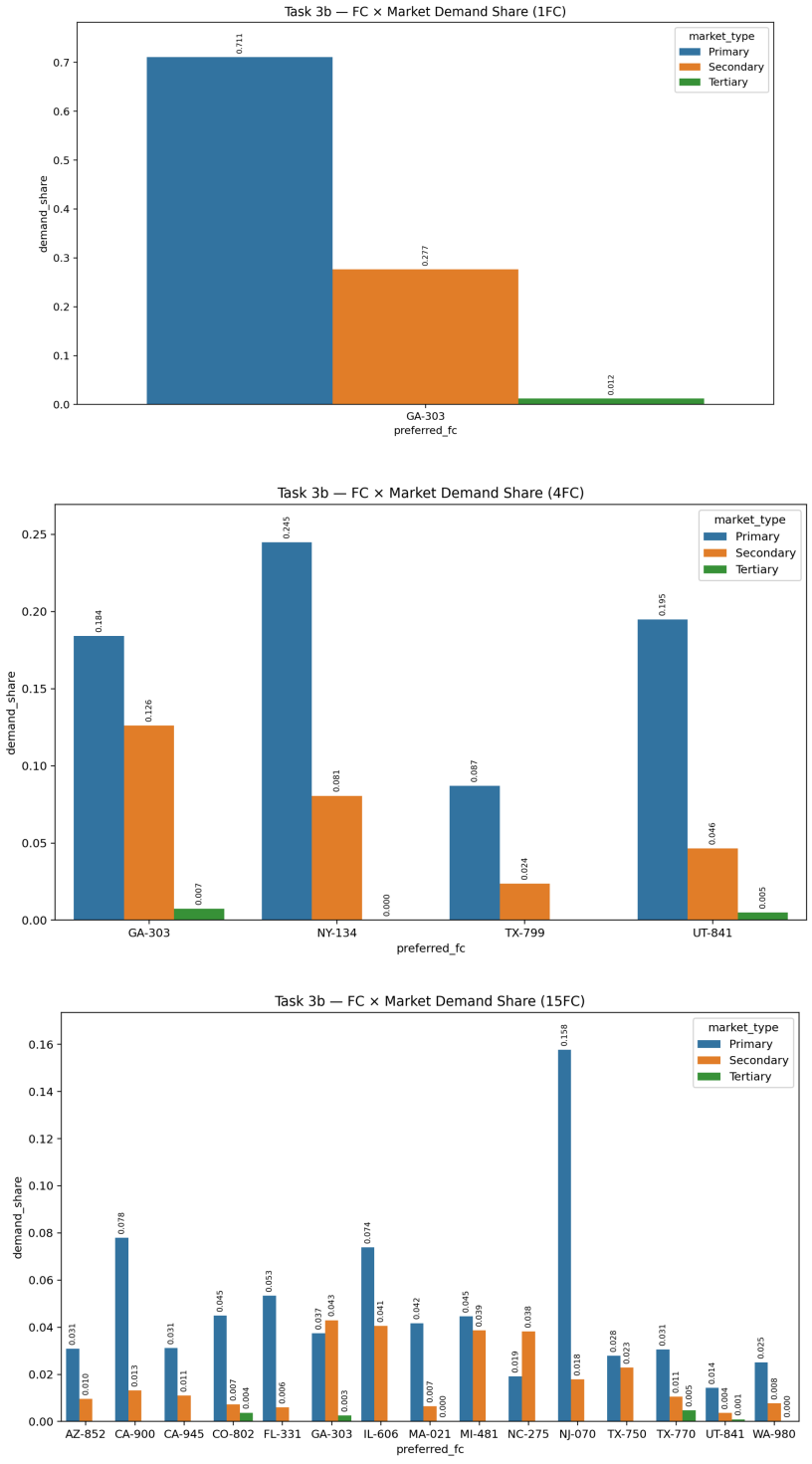


Figure 19: Market demand share for each scenario

Across all fulfillment scenarios, demand is dominated by the primary market.

- 1-FC network: the primary market represents 71% of total demand.

- Scenario 2: FC1 captures 26% of demand (about 24.5% from the primary market). The Utah FC is second with 20%. At the Georgia FC, demand is more evenly split across market types (~18% and ~13%, respectively).
- 15-FC network: the highest-demand node is NJ-070, accounting for 16% of total demand then CA-900 with 7.8%.

C) FC Demand Distribution by Market & Distance Type — Two Scenarios (4 and 15 FCs)

We have generated a table mapping each zip to its nearest FC, as shown below.

task4_assignment_15FC

zip3	pmf	market	market_type	lat	lon	pmf_norm	preferred_fc_zip3	preferred_fc_distance	preferred_fc	preferred_bucket
14	0.00074301	Primary	MA	42.5662325	-71.6967241	0.000743011	21	35	MA-021	<50
15	0.00145698	Primary	MA	42.2419752	-71.7676148	0.001456981	21	36	MA-021	<50
44	0.00038653	Secondary	ME	45.022289	-68.7946884	0.000386525	21	217	MA-021	151-300
46	0.0001482	Secondary	ME	44.591462	-68.0333257	0.000148201	21	218	MA-021	151-300
48	0.00020828	Secondary	ME	44.1538745	-69.1116196	0.000208283	21	159	MA-021	151-300
70	0.00811703	Primary	NJ	40.6674	-74.1146	0.008117038	70	0	NJ-070	<50
71	0.00196267	Primary	NJ	40.7339	-74.1617	0.001962669	70	5	NJ-070	<50
72	0.00133782	Primary	NJ	40.6965	-74.267	0.001337819	70	8	NJ-070	<50

Table 2: Mapping nearest FC to Zip and respective state and market (Except)

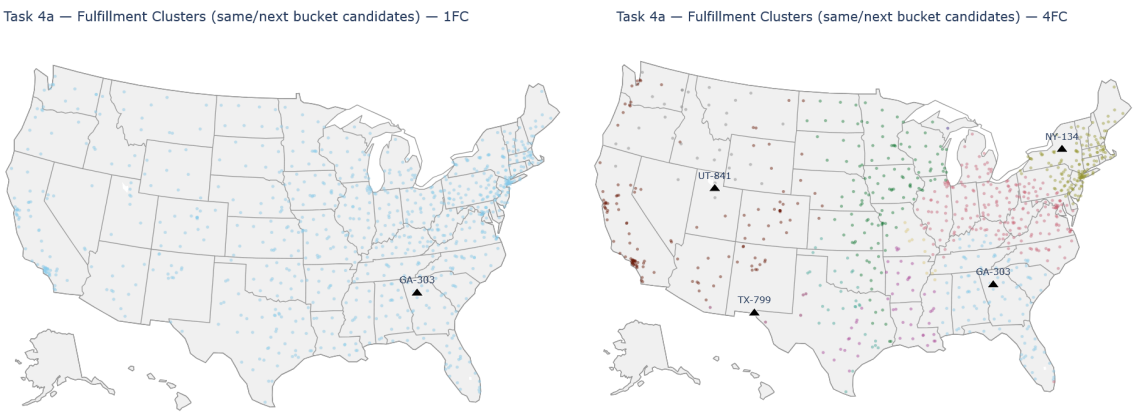
This shows that most of the demand lies in the <50-mile bucket and about 90% of demand share is in the <300 miles for a 15 FC scenario, while for a single FC it is between 601-1000 and for 4 FC it is between 301 and 600.

Task 4: Multi-source fulfillment

We now assume Dobda can route orders to a market from a more distant FC to improve resilience and avoid lost sales during disruptions. Practically, each market may be served by FCs in its assigned shipping bucket (distance tier) or the next higher bucket.

a) Geographic plot covering the FC clusters

We now classify markets by the set of fulfillment centers that can serve them, we still work on the three scenarios 1-FC Network, 4-FC Network and 15-FC Network.



Task 4a — Fulfillment Clusters (same/next bucket candidates) — 15FC

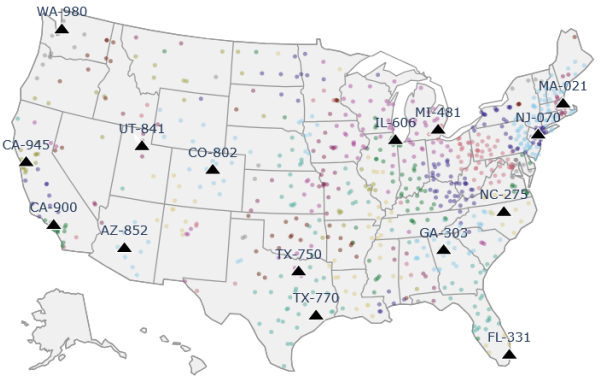


Figure 20: FC clusters for 1,4,15 FCs to the closest ZIP codes

The three charts depict clusters of markets that can be served by the same set of fulfillment centers (FCs).
In the 1-FC network, there is only one node, so all markets are supplied by that single FC.
By contrast, the 15-FC network yields many more clusters and higher complexity, because the larger number of nodes means multiple FCs can potentially serve the same market.
This overlap expands routing options but also increases coordination and planning effort.

b) Geographic plot covering the FC clusters based on the number of FCs that can serve a cluster.

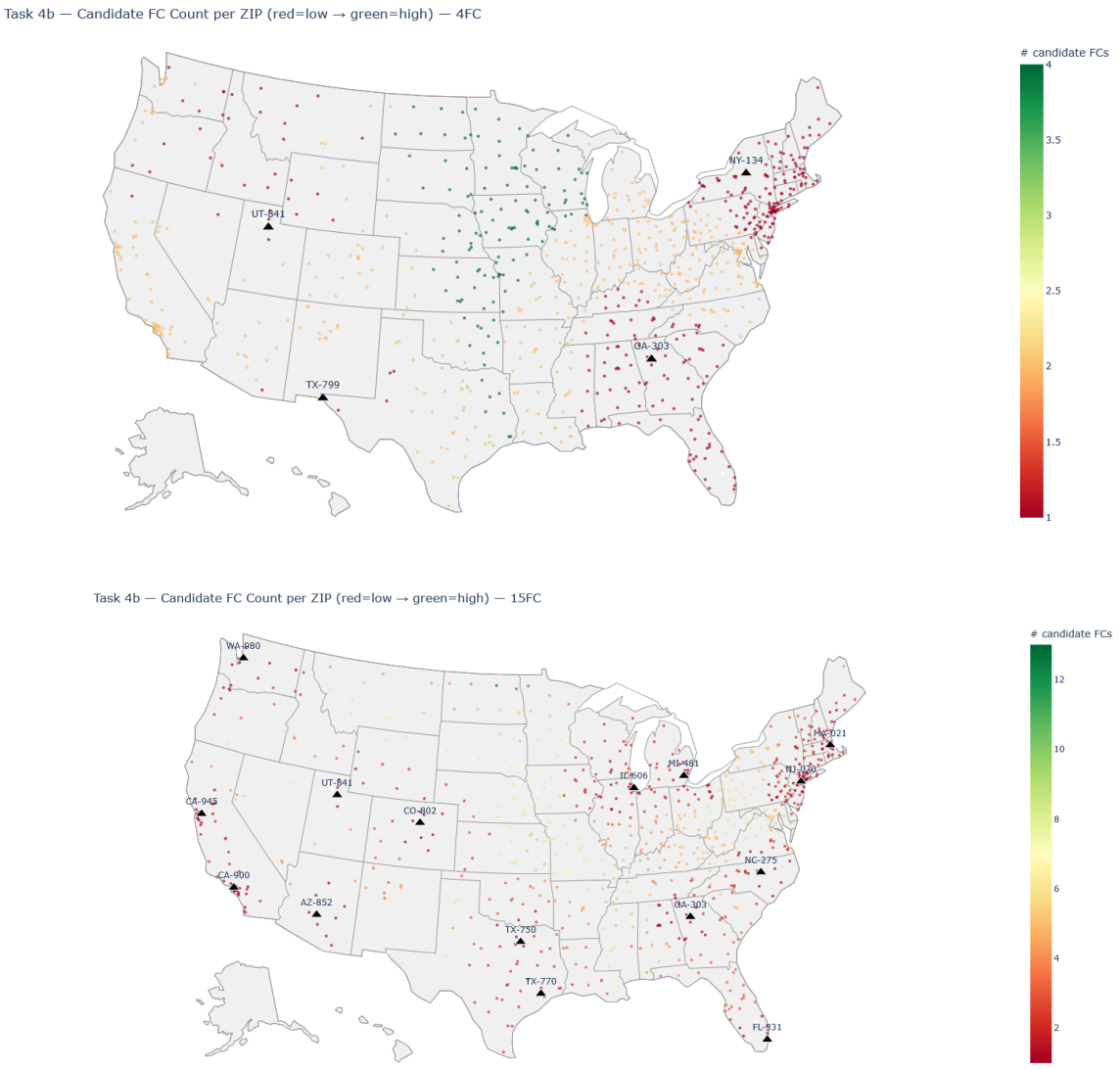


Figure 21: FC clusters for each of the zip

With a 4-FC network, most markets fall into clusters served by one or two FCs (two is the maximum). With a 15-FC network, most markets have up to six alternative FCs, while large option sets (8–12 FCs) are rare. We also observe that markets farther from FCs tend to have more serving options. This stems from the distance-bucket design: the outer buckets cover wider distance ranges, so remote markets fall into broader tiers and are eligible to be served by FCs in multiple adjacent buckets. Hence, most markets have multiple feasible fulfillment options.

c) Proportion of demand that can only be served by a single FC

task4_15FC_zip_assignment

	zip3	pmf	market	market_type	lat	lon	pmf_norm	preferred_fc_zip3	preferred_fc_distance	preferred_fc	preferred_bucket	candidate_fc_zip3_set	candidate_fc_name_set	candidate_count	cluster_id
14		0.00074301	Primary	MA	42.5662325	-71.6967241	0.000743011	21	35	MA-021	<50	21	MA-021	1	MA-021
15		0.00145698	Primary	MA	42.2419752	-71.7676148	0.001456981	21	36	MA-021	<50	21	MA-021	1	MA-021
16		0.00080309	Primary	MA	42.2645912	-71.7933808	0.000803092	21	37	MA-021	<50	21	MA-021	1	MA-021
17		0.00118962	Primary	MA	42.3351161	-71.4172503	0.001189618	21	17	MA-021	<50	21	MA-021	1	MA-021
18		0.0027948	Primary	MA	42.6090558	-71.204741	0.0027948	21	19	MA-021	<50	21	MA-021	1	MA-021
19		0.00226007	Primary	MA	42.5596404	-70.9448446	0.002260073	21	16	MA-021	<50	21	MA-021	1	MA-021
20		0.00160518	Primary	MA	42.1864764	-71.1453504	0.001605182	21	12	MA-021	<50	21	MA-021	1	MA-021
21		0.00564868	Primary	MA	42.3517043	-71.077176	0.005648682	21	0	MA-021	<50	21	MA-021	1	MA-021
22		0.0002974	Primary	MA	42.3538612	-71.0699312	0.000297404	21	0	MA-021	<50	21	MA-021	1	MA-021
23		0.00199171	Primary	MA	42.0778746	-70.9667673	0.001991709	21	20	MA-021	<50	21	MA-021	1	MA-021
24		0.00065389	Primary	MA	42.3563569	-71.1822087	0.00065389	21	5	MA-021	<50	21	MA-021	1	MA-021
27		0.00217095	Primary	MA	41.7704862	-71.0983599	0.002170952	21	40	MA-021	<50	21	MA-021	1	MA-021
28		0.00276476	Primary	RI	41.7031995	-71.4666119	0.002764759	21	49	MA-021	<50	21	MA-021	1	MA-021
29		0.00166526	Primary	RI	41.8087759	-71.424213	0.001665264	21	42	MA-021	<50	21	MA-021	1	MA-021
30		0.00145698	Primary	NH	42.8490088	-71.4380636	0.001456981	21	39	MA-021	<50	21	MA-021	1	MA-021
31		0.00038653	Primary	NH	42.9943635	-71.4652	0.000386525	21	49	MA-021	<50	21	MA-021	1	MA-021
42		0.0002974	Secondary	ME	44.2733384	-70.3671133	0.000297404	21	137	MA-021	51-150	21	MA-021	1	MA-021
43		0.00020828	Secondary	ME	44.2842824	-69.7942747	0.000208283	21	148	MA-021	51-150	21	MA-021	1	MA-021
68		0.00181346	Primary	CT	41.0788	-73.4713	0.001813466	70	44	NJ-070	<50	70	NJ-070	1	NJ-070
69		0.00035648	Primary	CT	41.1063	-73.549	0.000356484	70	42	NJ-070	<50	70	NJ-070	1	NJ-070
70		0.00811703	Primary	NJ	40.6674	-74.1146	0.008117038	70	0	NJ-070	<50	70	NJ-070	1	NJ-070
71		0.00196267	Primary	NJ	40.7339	-74.1617	0.001962669	70	5	NJ-070	<50	70	NJ-070	1	NJ-070
72		0.00133782	Primary	NJ	40.6965	-74.267	0.001337819	70	8	NJ-070	<50	70	NJ-070	1	NJ-070
73		0.00092125	Primary	NJ	40.7148	-74.0371	0.000921253	70	5	NJ-070	<50	70	NJ-070	1	NJ-070
74		0.00121866	Primary	NJ	41.0592	-74.1322	0.001218657	70	27	NJ-070	<50	70	NJ-070	1	NJ-070
75		0.00095129	Primary	NJ	40.9125	-74.1653	0.000951294	70	17	NJ-070	<50	70	NJ-070	1	NJ-070
76		0.00202175	Primary	NJ	40.887	-74.0391	0.00202175	70	16	NJ-070	<50	70	NJ-070	1	NJ-070
77		0.00226007	Primary	NJ	40.3038	-73.9858	0.002260073	70	26	NJ-070	<50	70	NJ-070	1	NJ-070

Table 3: Distribution of Zips with only single FC alternatives

We worked on the above table to arrive at a single FC alternative distribution. The single FC distribution works out to be 0.49082. This is for the case of 15 FC. A similar analysis for 4 FCs leads to a demand proportion of 0.372670

d) Now allocating 90% of its demand to the closest FC for each ZIP code and allocating the remaining 10% of demand equally among all other FCs in the same cluster.

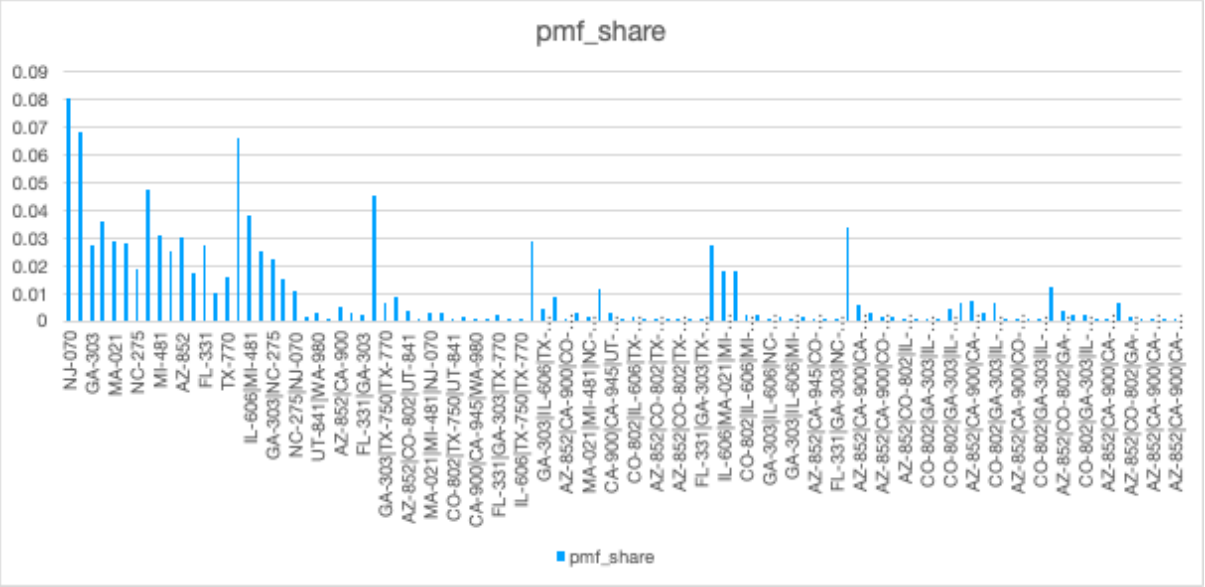


Figure 22: Distribution of demand across single to multiple clusters, with the primary FC getting 90%

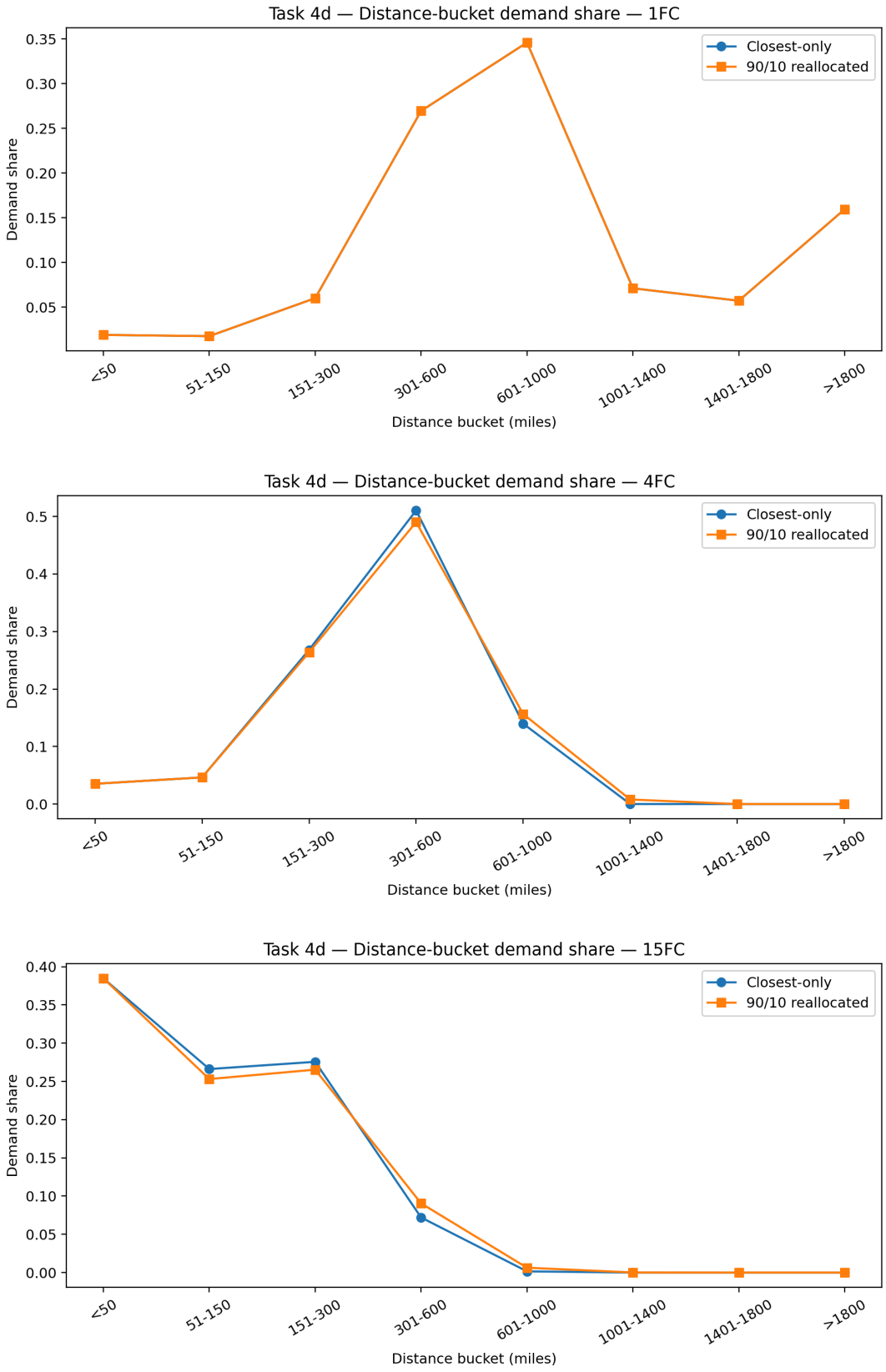


Figure 23: Distance bucket demand share for the 1, 4, and 15 FC scenarios

Task 5: Market-Level Conversion vs. OTD Promise

The objective of this task is to perform a comprehensive financial analysis to understand the impact of different Order-to-Delivery (OTD) promises on Dobda's profitability for three potential fulfilment networks: a 1-FC, 4-FC, and 15-FC configuration.

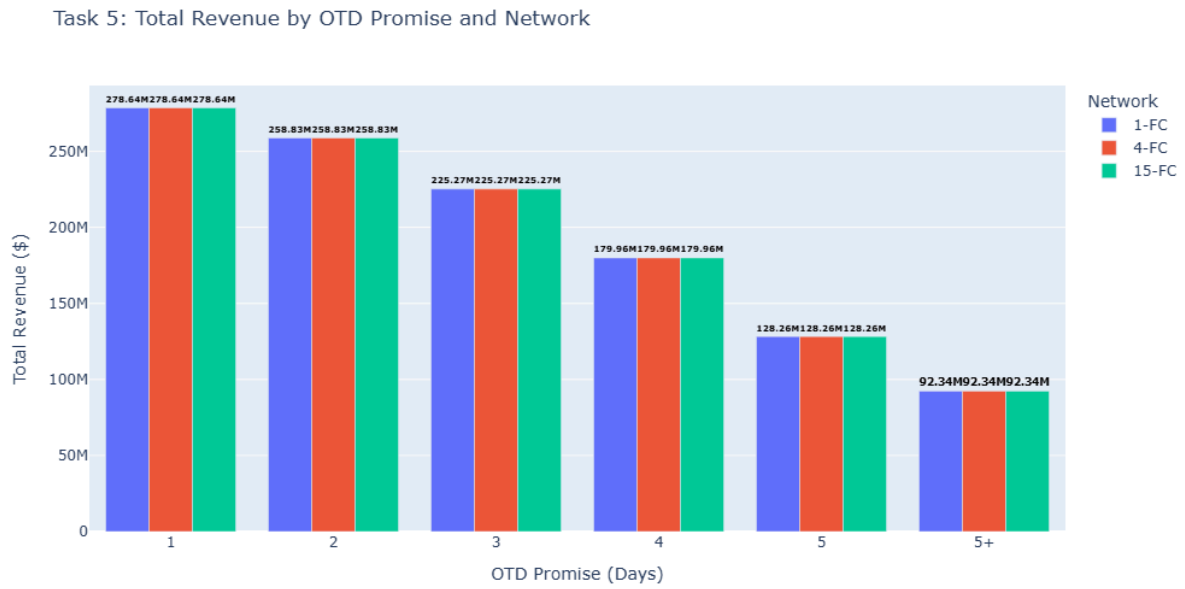
The task5.py script models the financial outcomes for each network under the six distinct OTD promises (1, 2, 3, 4, 5, and 5+ days).
Given: Gross Operating Profit = (Total Revenue - Total Shipping Cost) - Total COGS

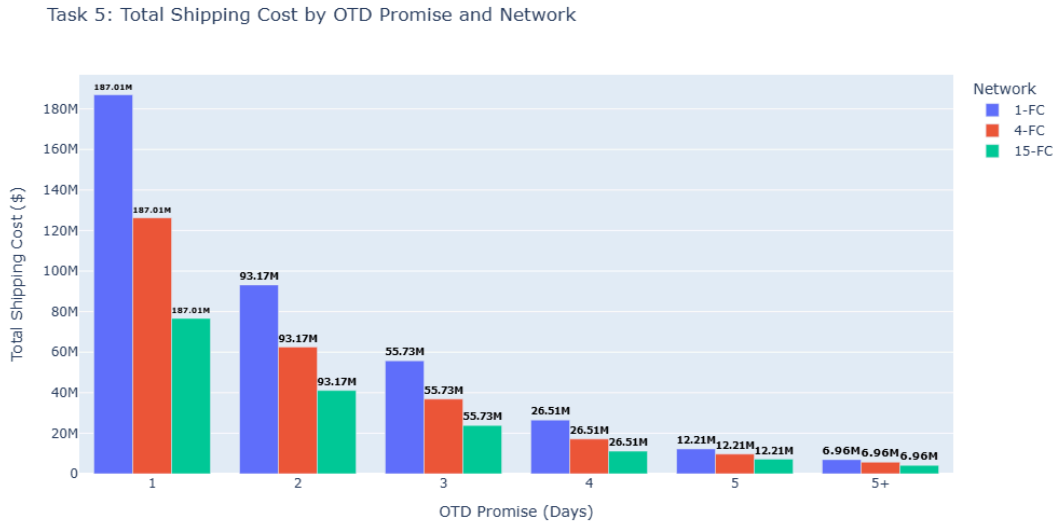
The script follows the following steps:
a. Demand Forecasting: It first calculates a detailed daily demand forecast for every 3-digit ZIP code by combining Dobda's overall annual demand forecast with the given seasonal trends and geographic demand distributions.

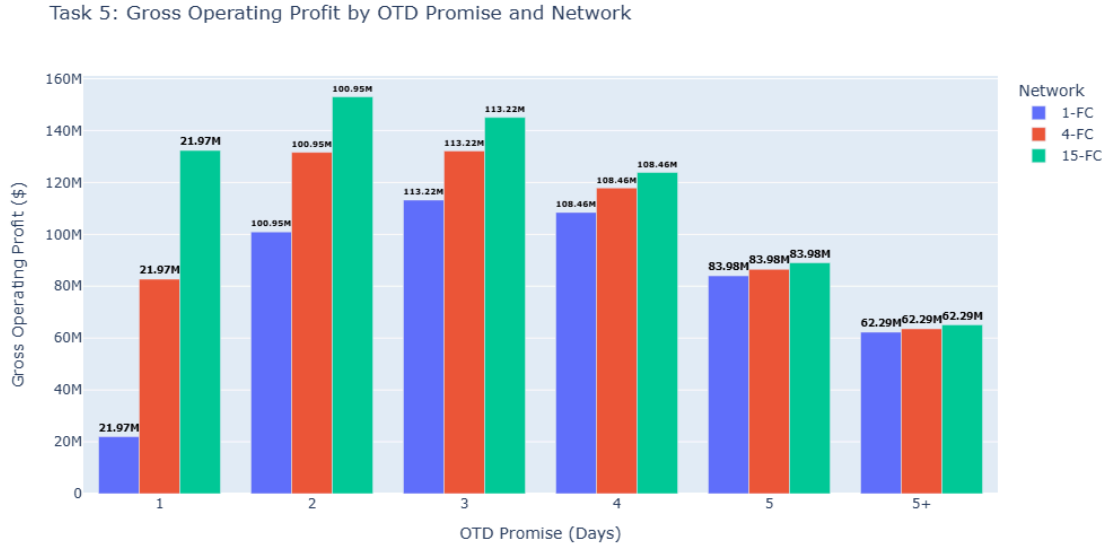
b. Data Integration: For each of the three network scenarios, the script uses the csv files from the output of Task 3 to link every customer ZIP code to its closest fulfillment center and its corresponding shipping distance bucket.

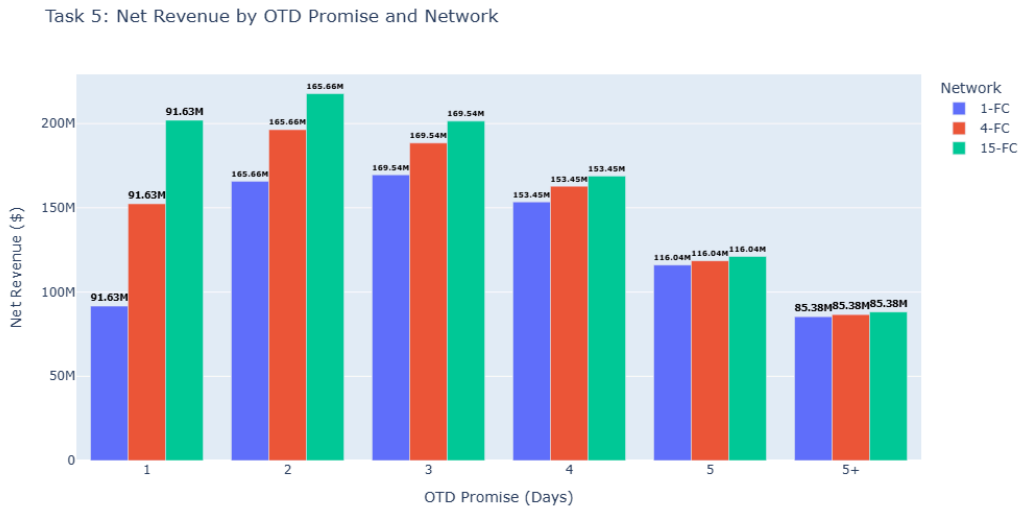
c. Financial Calculation: The script then iterates through every possible OTD promise. For each OTD, it calculates the Converted Demand by applying the demand conversion rates from Table 1 of the casework (conversion rates). Using this, it computes the Total Revenue (at $3,000/unit), Total Shipping Cost (using the distance bucket to look up the cost from Table 2), and the Total COGS (at $750/unit).

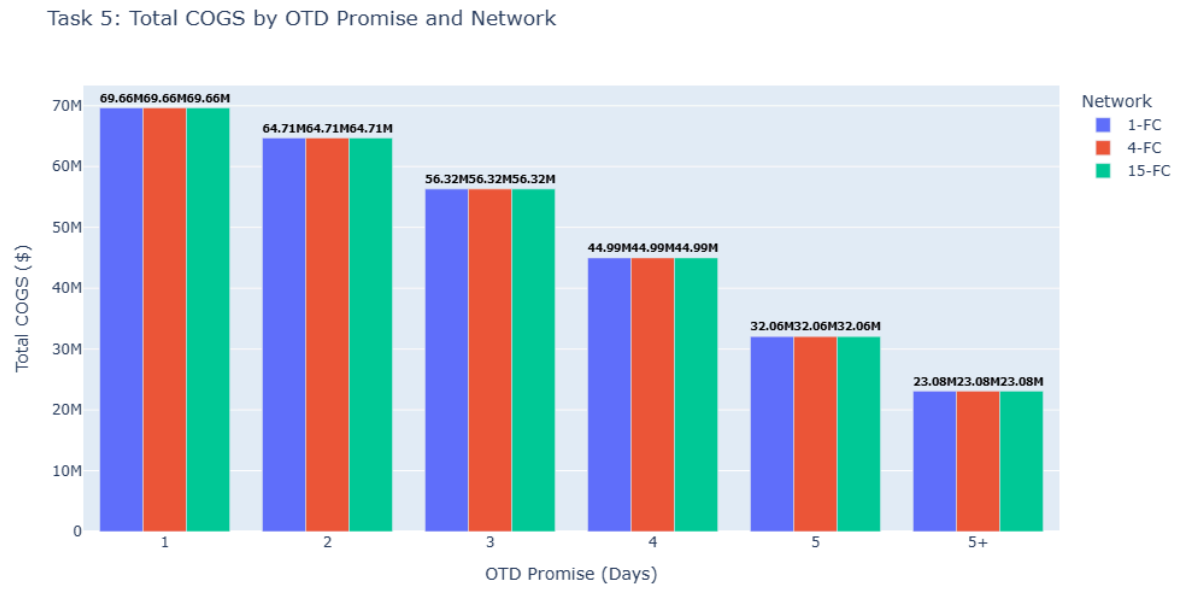
Financial plots:

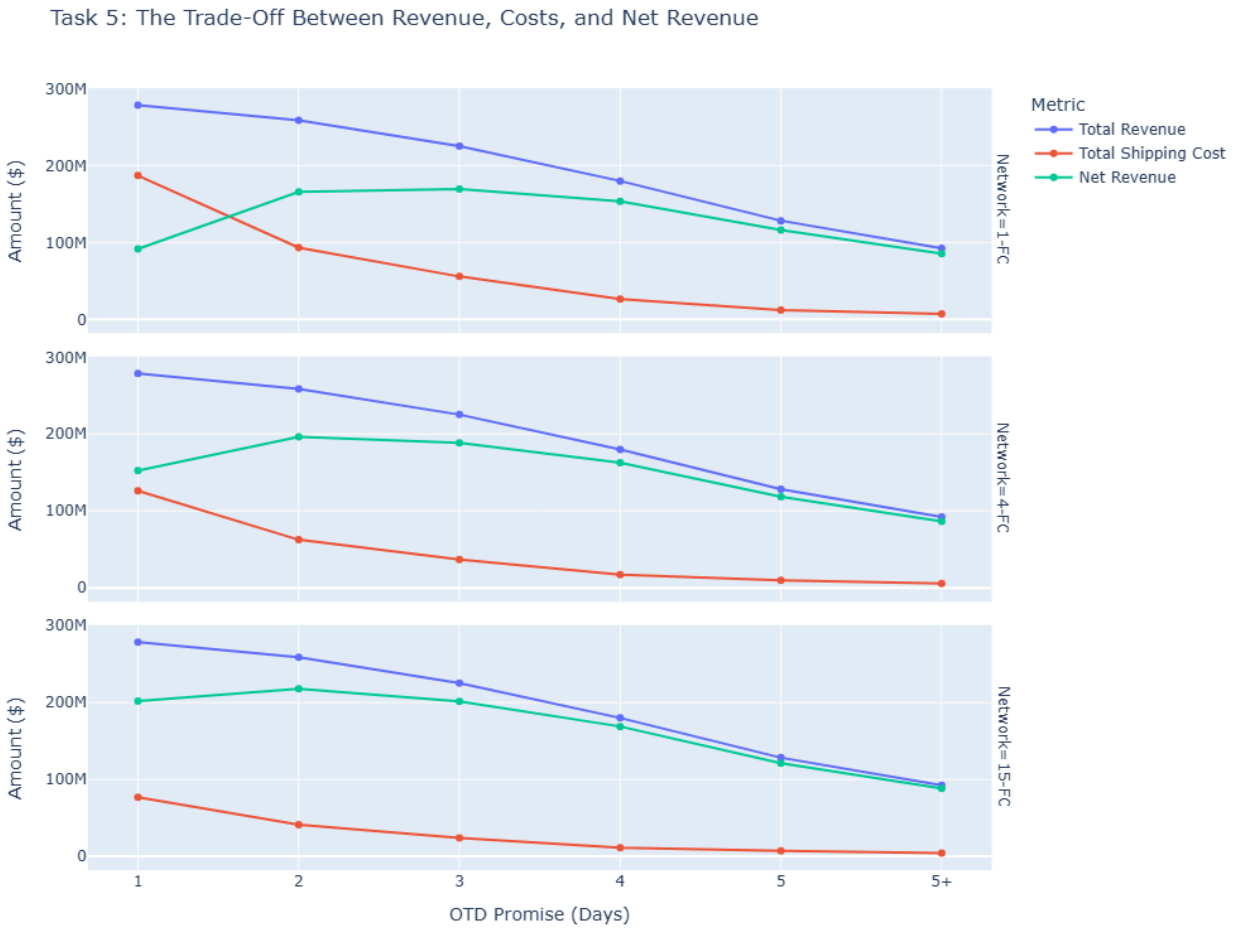



Task 5: Total Shipping Cost by OTD Promise and Network
Total Shipping Cost ($)
OTD Promise (Days)
Network
1-FC
4-FC
15-FC
187.01M
93.17M
55.73M
26.51M
12.21M
6.96M


Task 5: Gross Operating Profit by OTD Promise and Network
Gross Operating Profit ($)
OTD Promise (Days)
Network
1-FC
4-FC
15-FC
21.97M
100.95M
113.22M
108.46M
83.98M
62.29M


Task 5: Net Revenue by OTD Promise and Network
Net Revenue ($)
OTD Promise (Days)
Network
1-FC
4-FC
15-FC
91.63M
165.66M
169.54M
153.45M
116.04M
85.38M





Profitability Trade-Off: The highest revenue is always achieved with a 1-day promise due to the maximum demand conversion rate. However, this is never the most profitable option. The extreme shipping costs associated with 1-day delivery drastically reduce the profit

margin. The optimal profit is found at a "sweet spot" of 2 or 3 days, with the balance between a high conversion rate and manageable shipping costs.

Network Efficiency: The number of fulfillment centers has a direct impact on profitability. The 15-FC network is the most profitable, achieving a maximum profit of **$153.0M** because a more distributed network places warehouses closer to customers, thus reducing the average shipping distance and cost. This efficiency allows the 15-FC network to profitably offer a faster 2-day service, while 1-FC and 4-FC networks find their peak profitability at a 3-day promise.

Task 6: OTD Promise Optimization by Market: Maximizing Gross Operating Profit

This task asks for an optimized OTD strategy by setting a distinct OTD promise for each market type (Primary, Secondary, Tertiary), with the goal of maximising the overall gross operating profit.

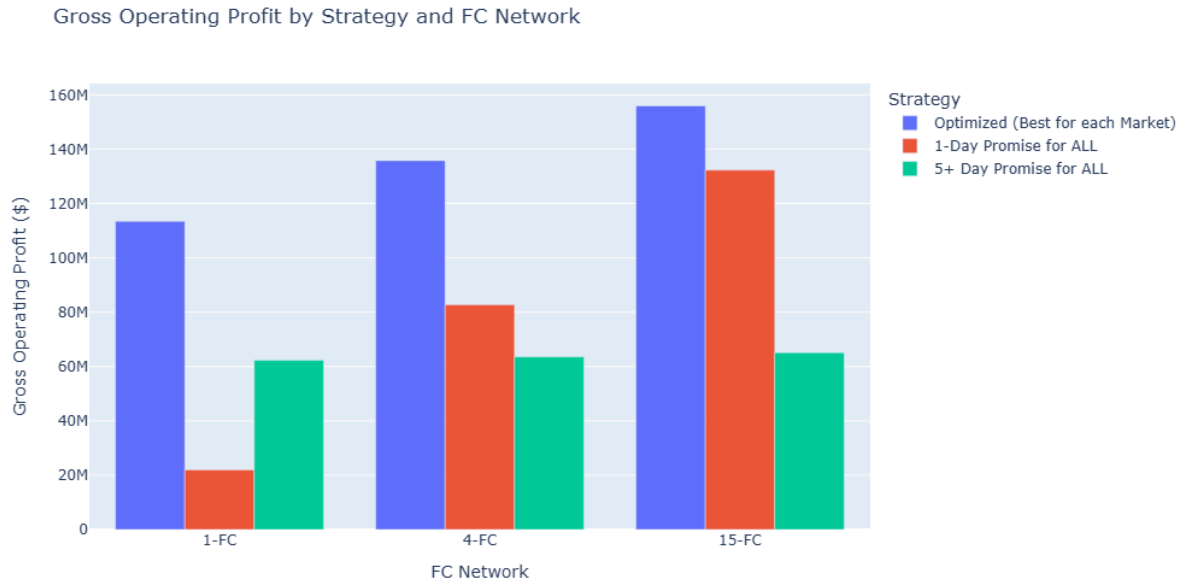
The task6.py script implements a greedy heuristic algorithm to find the optimal decision.

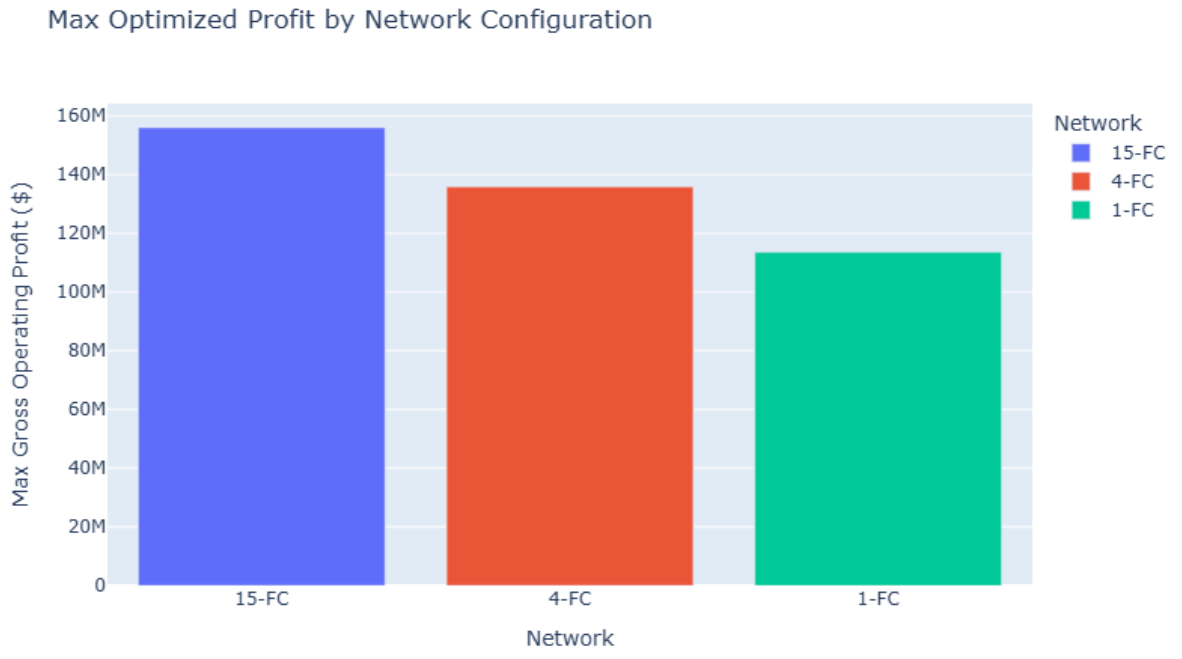
a. Algorithm Justification: The greedy algorithm works by making the best possible local choice at each step. Here, the script evaluates the total profit for every possible OTD promise (1 to 5+ days) for each market type individually. It then "greedily" selects the single promise that gives the highest profit for the Primary market, repeats this process independently for the Secondary market, and again for the Tertiary market.

b. Validity: This model is justified because the decisions for each market type are independent. The optimal choice for Primary customers (who are sensitive to time) does not constrain the optimal choice for Tertiary customers (who are more sensitive to cost). Therefore, by finding the local maximum for each market, we arrive at the global maximum profit for the overall strategy.

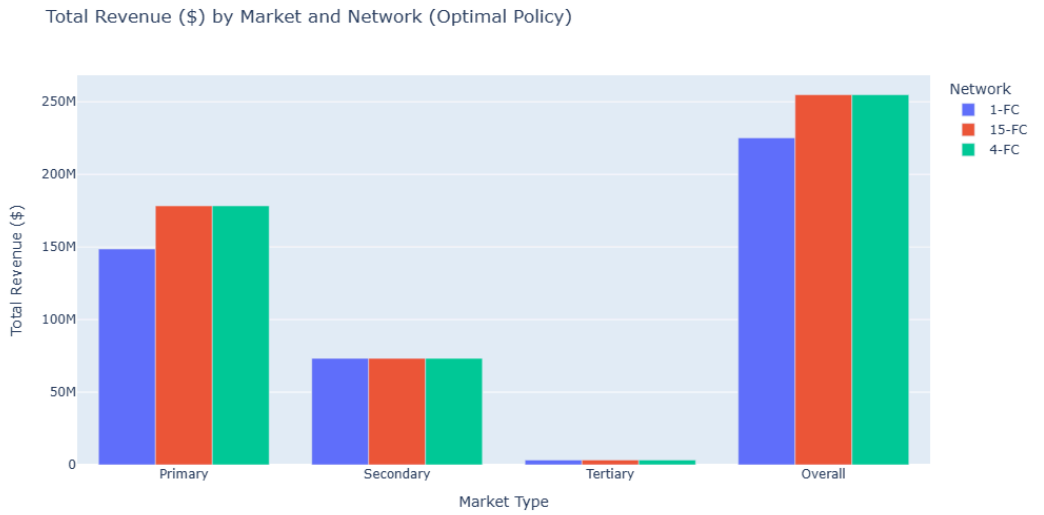
The script also calculates the optimal policy for each network and produces two key CSV files: task6_optimal_policy_details.csv, which provides a full financial breakdown for the best choice in each market, and task6_profit_comparison.csv, which summarizes the overall results.

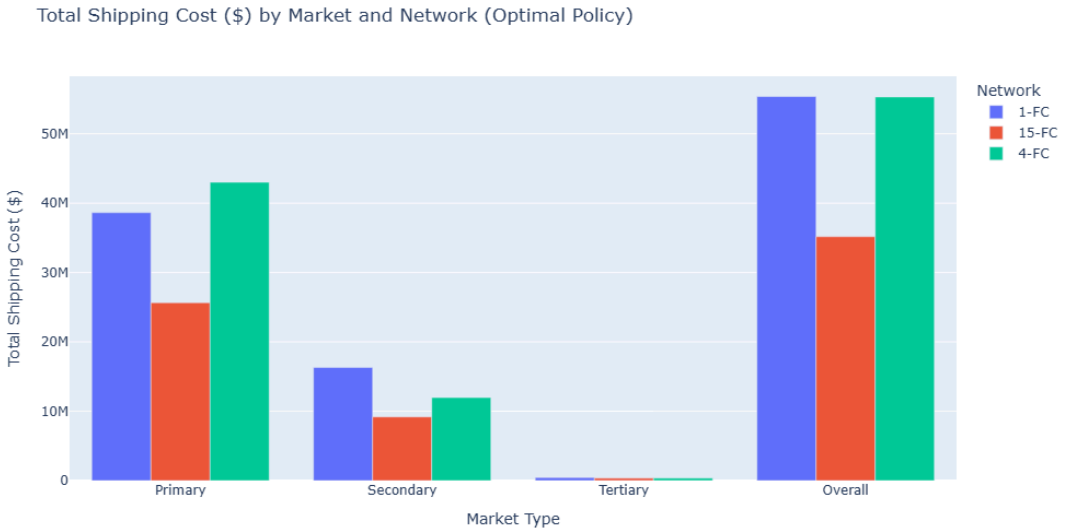
```
Network,Strategy,Gross Operating Profit
1-FC,Optimized (Best for each Market),"$113,445,772"
1-FC,1-Day Promise for ALL,"$21,972,952"
1-FC,5+ Day Promise for ALL,"$62,292,109"
4-FC,Optimized (Best for each Market),"$135,793,537"
4-FC,1-Day Promise for ALL,"$82,704,998"
4-FC,5+ Day Promise for ALL,"$63,552,108"
15-FC,Optimized (Best for each Market),"$155,940,648"
15-FC,1-Day Promise for ALL,"$132,322,333"
15-FC,5+ Day Promise for ALL,"$65,097,774"
```

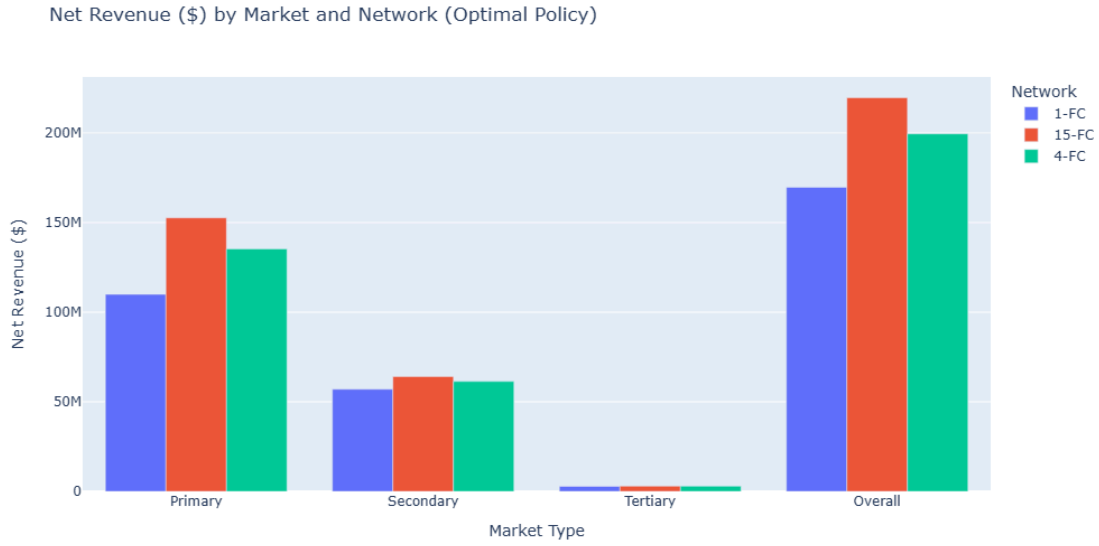





```
--- Corrected Optimal OTD Service Matrices ---
Network            1-FC                    4-FC                    15-FC
Market          Primary Secondary Tertiary Primary Secondary Tertiary Primary Secondary Tertiary
distance_bucket
<50               2-day     3-day     4-day   2-day     3-day     4-day   2-day     3-day     4-day
51-150            2-day     3-day     4-day   2-day     3-day     4-day   2-day     3-day     4-day
151-300           2-day     3-day     4-day   2-day     3-day     4-day   2-day     3-day     4-day
301-600           2-day     3-day     4-day   2-day     3-day     4-day   2-day     3-day     4-day
601-1000          3-day     3-day     4-day   3-day     3-day     4-day   3-day     3-day     4-day
1001-1400         4-day     4-day     4-day     NaN       NaN       NaN     NaN       NaN       NaN
1401-1800         4-day     5-day     5-day     NaN       NaN       NaN     NaN       NaN       NaN
>1800             4-day     5-day     5-day     NaN       NaN       NaN     NaN       NaN       NaN
```


Total Revenue ($) by Market and Network (Optimal Policy)
Total Revenue ($)
250M
200M
150M
100M
50M
0
Primary
Secondary
Tertiary
Overall
Market Type
Network
1-FC
15-FC
4-FC


Total Shipping Cost ($) by Market and Network (Optimal Policy)
Total Shipping Cost ($)
50M
40M
30M
20M
10M
0
Primary
Secondary
Tertiary
Overall
Market Type
Network
1-FC
15-FC
4-FC


Net Revenue ($) by Market and Network (Optimal Policy)
Net Revenue ($)
200M
150M
100M
50M
0
Primary
Secondary
Tertiary
Overall
Market Type
Network
1-FC
15-FC
4-FC

```
Network,market_type,OTD Promise (Days),gross_operating_profit,total_revenue,total_shipping_cost,total_cogs
1-FC,Primary,3,72786276.58424023,148546224.70060393,38623391.941212736,37136556.17515098
1-FC,Secondary,3,38655040.40207922,73290774.154864,16313040.214068783,18322693.538716
1-FC,Tertiary,4,2004454.5840363954,3258674.5577042834,439551.3342418171,814668.6394260708
4-FC,Primary,2,90689319.82995415,178255469.64072475,43002282.40058941,44563867.41018119
4-FC,Secondary,3,43011253.97871426,73290774.154864,11956826.637433743,18322693.538716
4-FC,Tertiary,4,2092963.067368065,3258674.5577042834,351042.8509101474,814668.6394260708
15-FC,Primary,2,108049261.06087896,178255469.64072475,25642341.16966459,44563867.41018119
15-FC,Secondary,3,45792469.84520065,73290774.154864,9175610.77094735,18322693.538716
15-FC,Tertiary,4,2098917.170569562,3258674.5577042834,345088.74770865054,814668.6394260708
```

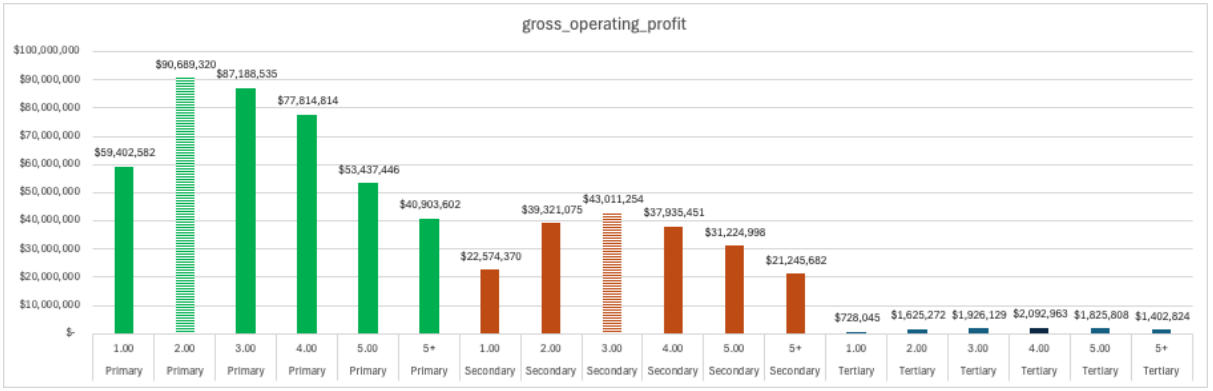


Figure 23: Gross operating profit by market type and OTD promise

We have the units over all the bucket types, which, when multiplied by the price per unit and COGS, give Total revenue and total COGS. Each bucket type, however, has a different shipping cost, and when applied to the units distributed across the same market type, we get the shipping cost across buckets for each market type. Subtracting this and the total COGS from revenue, we get the TOTAL GROSS PROFIT. The maximum for each market type gives a simple way of looking at profit maximization. Thus, maximum profits are

a. Primary Market: $90,689,320 with OTD of 2 days
b. Secondary Market: $43,011.254 with OTD of 3 days
c. Tertiary Market: $2,092,963 for OTD of 4 days

Task 7: Network Inventory under Autonomy Policies

The objective of this task is to estimate and compare the daily stocks required by FC and at the network level (including DC) to meet autonomy targets of 3 weeks–99% locally and 8 weeks–99% globally (with variants of 6/12 weeks and 50/68/95%), and to deduce the maximum inventories over the horizon.

Inputs used:

CV=0.15 and robust inventory window for FC=21 days & DC=56days

Service ability	Z
50	0
68	1
95	1.645
99	2.33

Table 4: Z levels for a Normal distribution

For finding FC demand for 21 days, we are using the sum of the next 21days till the end of the year. For 99% customer satisfaction, we are defining that as the safety stock where sigma σi is defined from the variance of the next 21 terms. Then, as for the network demand, we are following the 8-week minimum demand policy. So we are finding network demand for 56 days. We are using the sum of the next 56 days till the end of the year. For 99% customer satisfaction, we define that as the safety stock where sigma σi is defined from the variance of the next 56 terms. Then the network demand is the sum of FC and DC demand. So in this way, we find the DC demand. We perform all these tasks for all 1FC, 4FC, and 15FC models.

Formulas used

Di=FC Daily Demand

Di(Net)=Daily network demand

To be done for the whole year, 365 days,

FC Daily= $\sum_{i=1}^{i=21} Di$

FC Safety=Z.$\sqrt{\sum_{i=1}^{i=21} (\sigma i)^2}$

FC Target= FC Daily +FC Safety

56-day cycle

Network Daily= $\sum_{i=1}^{i=56} Di(net)$

$$\text{Network Safety=Z.}\sqrt{\sum_{i=1}^{i=56}(\sigma i)^2}$$

This graph shows the comparison of Target max of the 4FC model. In the 4FC model the FC NY-134 has the max target stock of 3968 units.

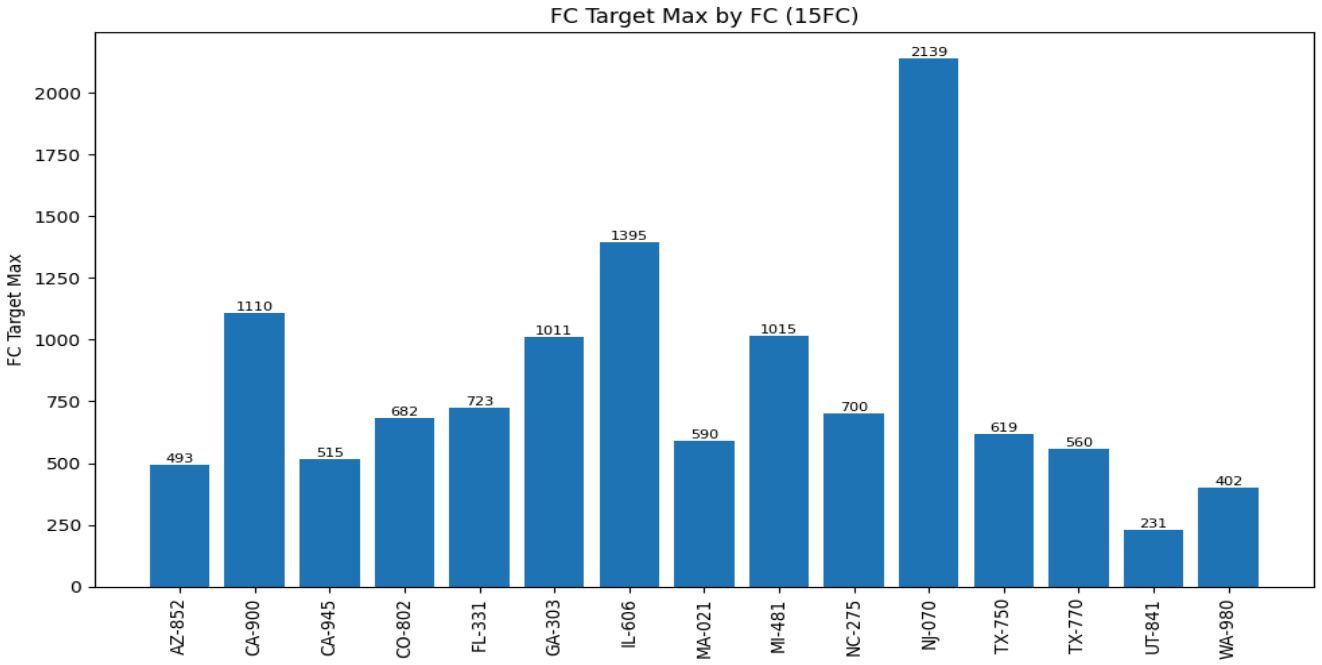


Figure 26: comparison of FCs for 15FC strategy

This graph shows the comparison of Target max of the 15FC model. In the 15FC model the FC NJ-070 has the max target stock of 2139 units.

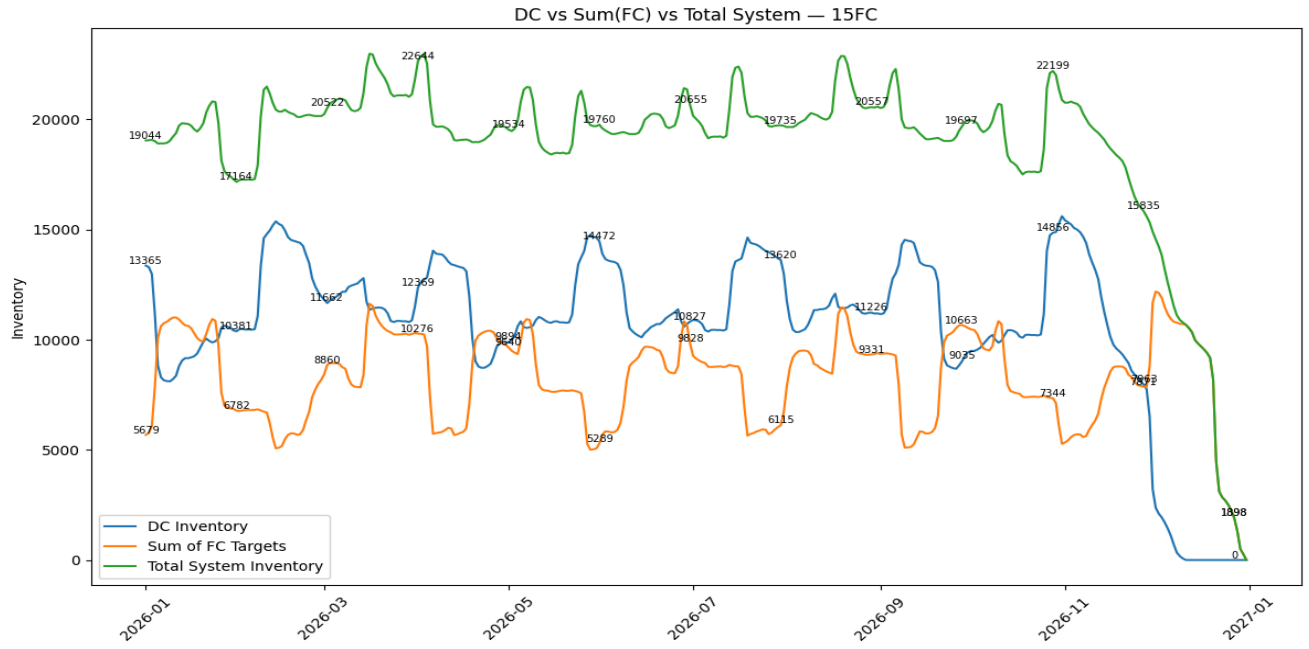


Figure *27: Comparison of DC inventory, Sum of FC target, and total system inventory*

The above provides the comparison of DC inventory, Sum of FC inventory and total system inventory over the span of the year. The higher overall FC stock in some cases than DC is mainly because the sum of safety stock in FC is much higher than the gap of FC and DC inventory.

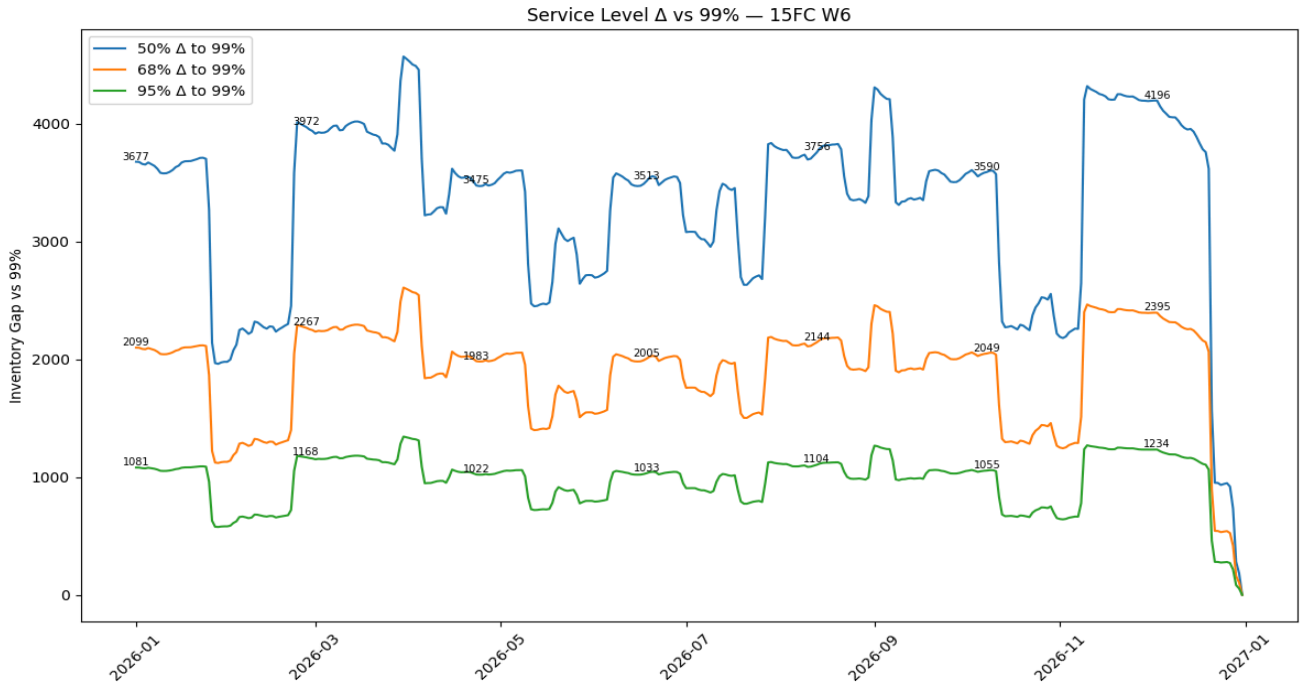


Figure 28: Inventory gap b/w 50%,68%,95% and 99% serviceability for 6 6-week time period

The above graph depicts the gap between each customer serviceability, ranging from 50% to 99% for the stock policy of 6 weeks.

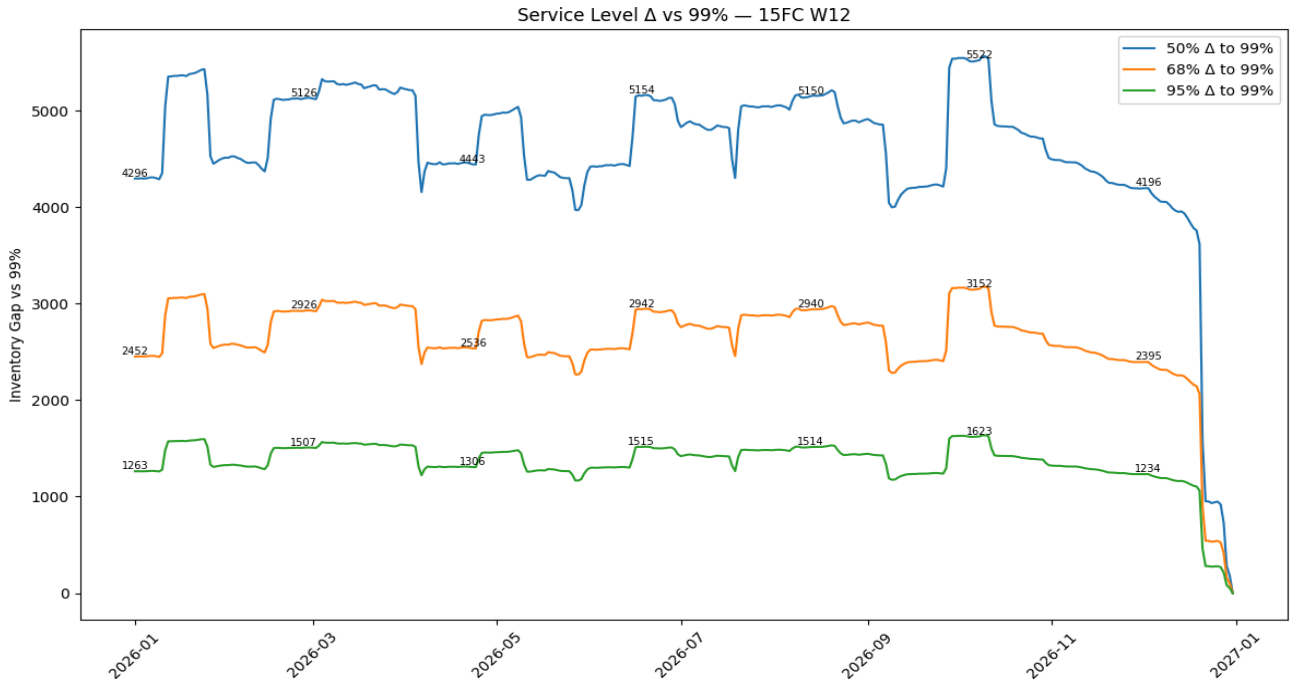


Figure 29: Inventory gap b/w 50%,68%,95% and 99% serviceability for 12-week time period

The above graph depicts the gap between each customer serviceability, ranging from 50% to 99% for the stock policy of 12 weeks.

Task 8: AF Capacity Planning for DC Replenishment

Assumption made:

Inventory on the first day, the DC and FC all have their target inventory, and no lead time=0.

Strategy A:

The AF production is only based on the demand. Strategy A capacity reserved is the maximum capacity that should be reserved to fulfill the demand at any point in time. Where the production is the same as the demand. The target inventory is the sum of inventory subtracted from the actual demand so the inventory is very less across the year. But the maximum capacity should be kept in reserve to fulfill the customer demand at 99% serviceability.

Strategy B:

The AF production is steady across the year by smoothening from data in strategy A. The smoothening is done in the minimal way so that the customer demand can be met. The steady AF production is good on the production basis but for the case of inventory the inventory is very high at the end of the year due to the steady production rate.

Formula used:

Strategy A(Chase):

P_i ->Production on day i

i ->No of days

M_i-> Mid-day Inventory

I_i-> Inventory

I_{i+1}-> End of the day inventory

D_i-> Demand for day i

$P_i = D_i$

$M_i = P_i + I_i$

$I_{i+1} = M_i - D_i$

Strategy B(steady):

T_i ->Target inventory required on day i.

I_i-> Initial inventory

D_k->demand up to day k.

P->per day production
Used on strategy A:

P=(Max((T$i - I_i + \sum_K D_k$) / (i+1)) (Referred ChatGpt for smoothening function)

I_{i+1}=I_i+P-D_i

M_i-=I_i+P

AF Peak Daily =Max(P_i)**DC Peak (Mid)** =Max(M_i)

DC Peak EOD =Max(I_{i+1})

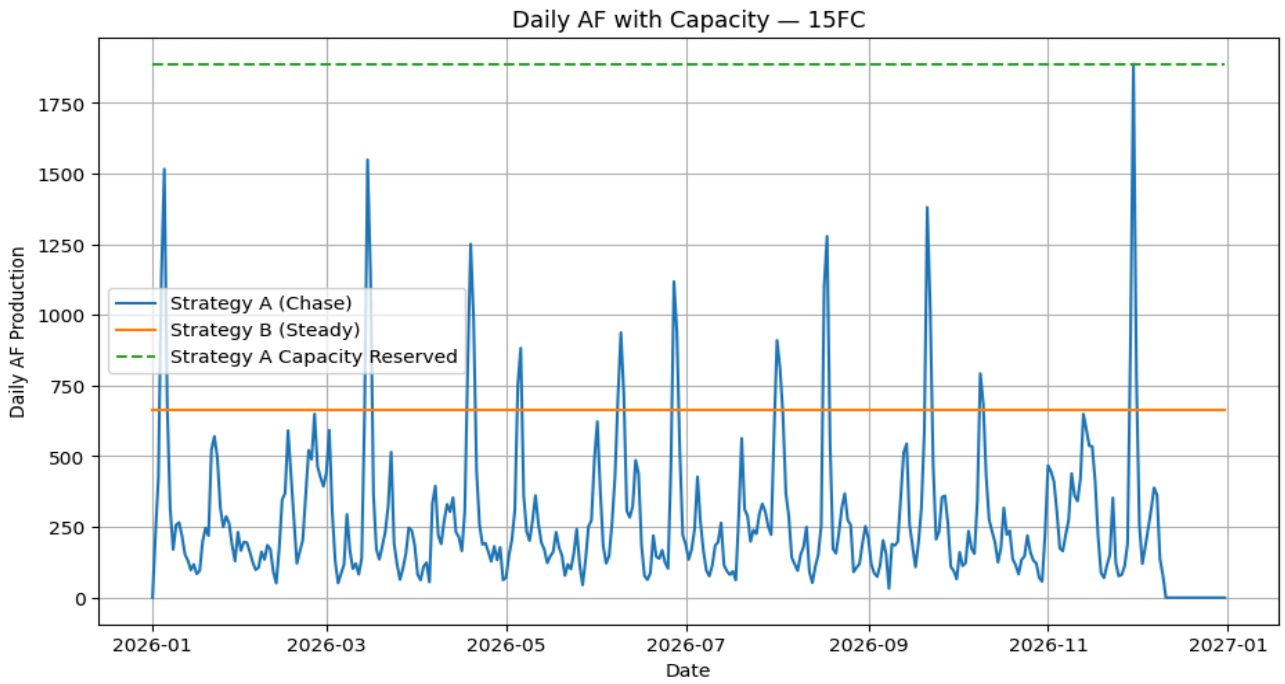


Figure 29: Daily AF capacity for Strategy A(Chase) vs Strategy B(Steady) vs Strategy A capacity reserved(max capacity)

The above graph shows the comparison between the daily AF capacity between Strategy A(Chase) vs Strategy B(Steady) vs Strategy A capacity reserved(which is the max capacity in chase) which we need to maintain for the fluctuation of the demand.

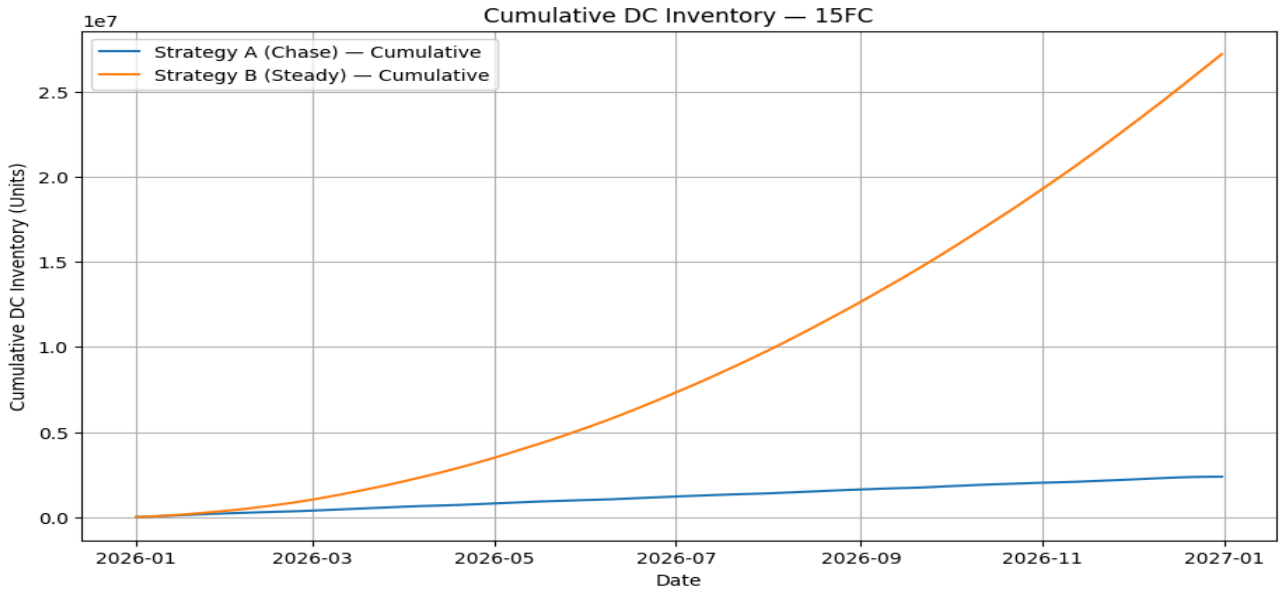


Figure 30: Cumulative Strategy A(Chase) vs Strategy B(Steady) inventory

This graph shows us the cumulative inventory for both Strategy A vs Strategy B. We can see the increase in inventory in the case of steady state strategy B. Where the inventory is skyrocketing, so Dobda have to pay for the all the dead inventory at the end of the year.

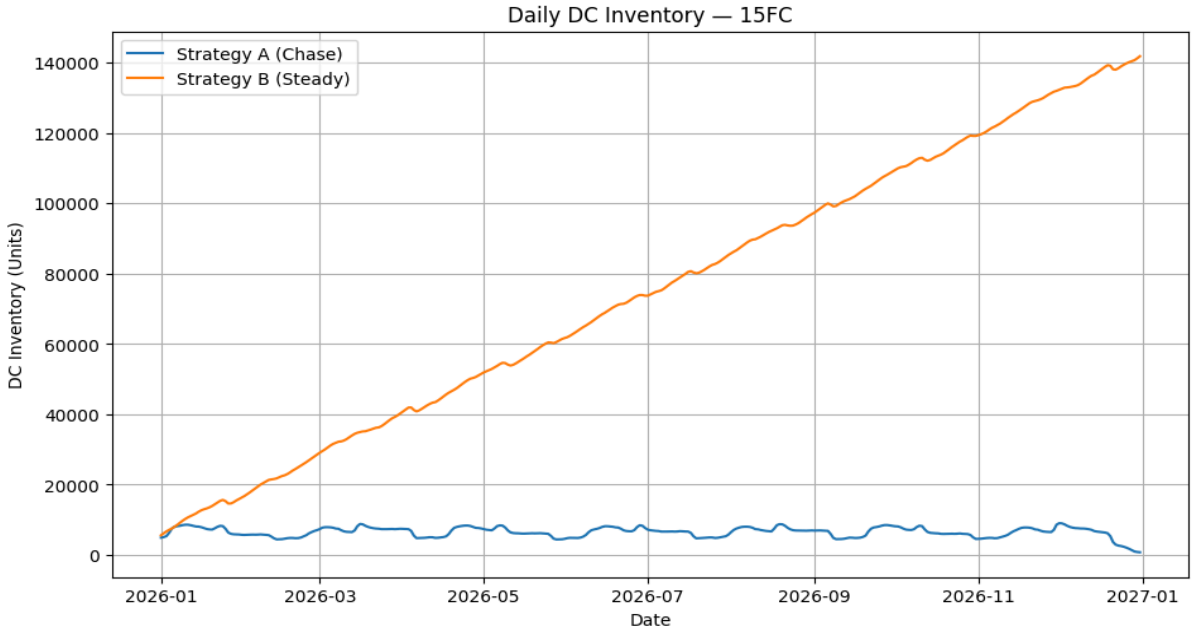


Figure 31: Daily Strategy A(Chase) vs Strategy B(Steady)

This graph shows us the daily inventory for both Strategy A vs Strategy B. We can see the increase in inventory in the case of steady state strategy B. Where the inventory is skyrocketing, so Dobda have to pay for all the dead inventory at the end of the year.

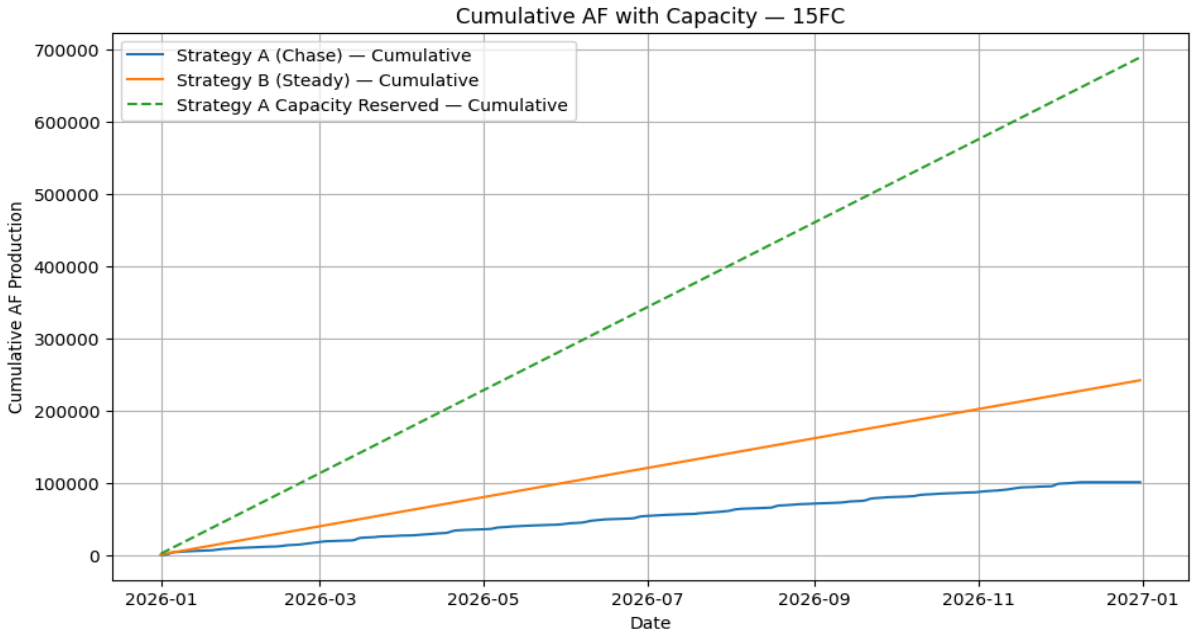


Figure 32: Cumulative AF capacity for Strategy A(Chase) vs Strategy B(Steady) vs Strategy A capacity reserved(max capacity)

The above graph shows the comparison between the cumulative AF capacity between Strategy A(Chase) vs Strategy B(Steady) vs Strategy A capacity reserved(which is the max capacity in chase), which we need to maintain for the fluctuation of the demand. The capacity reserved is nearly 700K where the production is only for 100k in the strategy A this shows how much money they waste in stand by capacity.

Task 9: Replenishment & Throughput Sizing: 7-Day Cycle, 14-Day Autonomy (FC & DC

For this cas,e we have selected the scenario with Market growth of 8% and Dobda growth of 20% leading to annual units of 92,880.

Logic deployed for replenishment in each FC is the basis for the comparison of Closing daily inventory (Previous day closing inventory-demand for current day+replenishments if any) to the robust inventory requirement of 2w 99% levels, which is calculated daily for the next 14 days. If closing inventory is less than that day's robust inventory levels, then replenishment is triggered, and the quantity replenished is the basis for 3w 99% levels (net of the current inventory). If no inventory replenishment is triggered, then this continues for day 7, and on day 7, it checks the inventory with respect to the 3w 99% levels. While RAD is specified, for ease of working, we consider it as inventory (virtually).

We do this so that each FC can find its replenishment levels. The sum of all the replenishments becomes the DC demand. We then look at combined FC and DC demand, aka FC demand + FC replenishment for all the FCs, and work out the inventory needed for 8w 99% robust autonomy over the network. Since we have the 3w inventory levels to be maintained for FC, we use the sum to subtract from Network 8w 99% robust autonomy levels and arrive at DC inventory levels.

We then work out replenishment at DC to maintain the required autonomy levels found on a daily basis if it goes below the same. Ordering quantity will be equal in this case to the gap between the autonomy levels. This becomes AF's production demand. Furthermore, the assumption taken is that DC's initial inventory (Day 1) is equal to that day's robust inventory requirement at DC to fulfill the network needs. Similarly, we start with 2w 99% robust inventory levels at each of the FCs. The Excel sheet Task 9 Logic covers all these.

We have taken the 15 FC scenario for our analysis. Further since the assessment of robustness is basis the forward looking data, we do not have demands beyond 364 days and hence the 8w robust inventory can only be taken till 364-8w=308 days. Similarly for 3w as well.

A) The daily replenishment profile looks like this for the year.

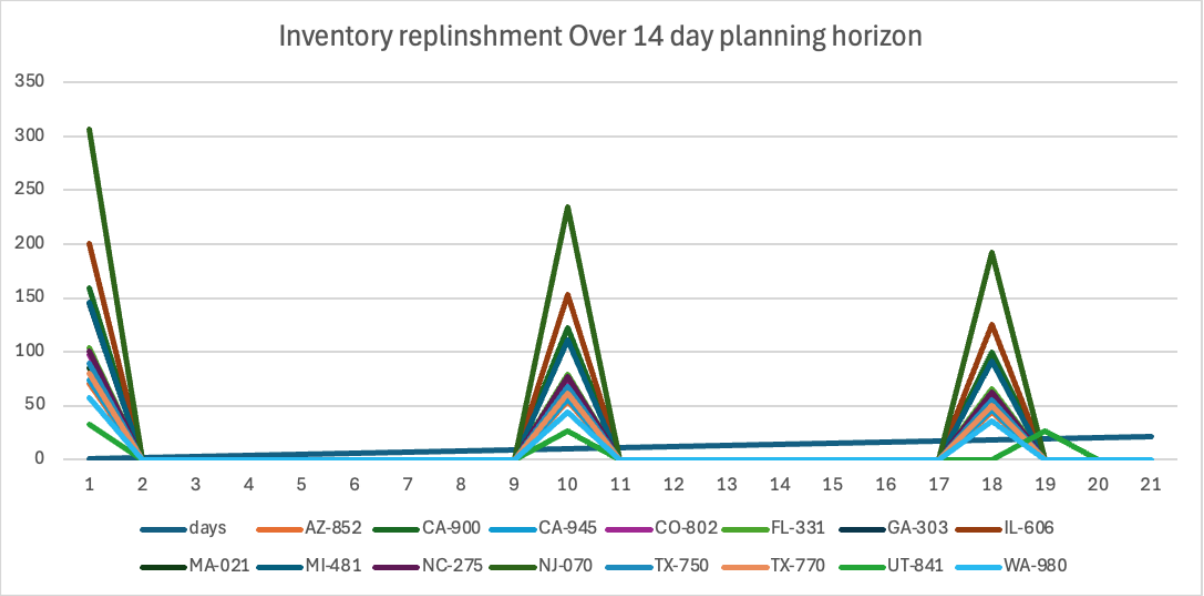


Figure 33: Profile of replenishments for an over 14-day horizon.

This pattern shows the inventory needing to be replenished is > 7 days threshold. Its all bunched up together since it started with replenishment for all on day 1 but over time it will stagger.
Looking at the excel very few 27 units (min inventory) replenishment is happening. Most of the FCs have just one day over the year of 27 units. Which begs the question: are we over ordering?

B) Maximum capacity to handle both inbound and outbound in FCs is as below (this is the maximum of daily throughput = max(daily demand + daily replenishment)

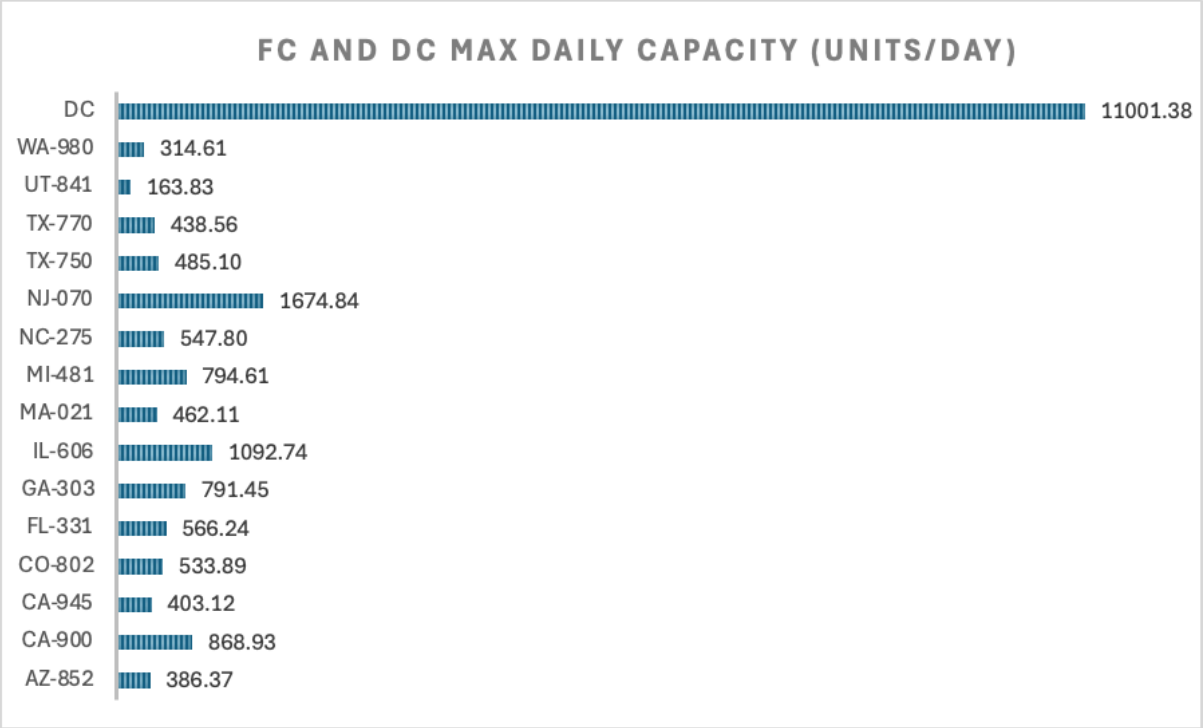


Figure 34: FC max capacities

The Figureure above shows the daily FC and DC capacity needed for throughput (max of the daily Inbound plus outbound).

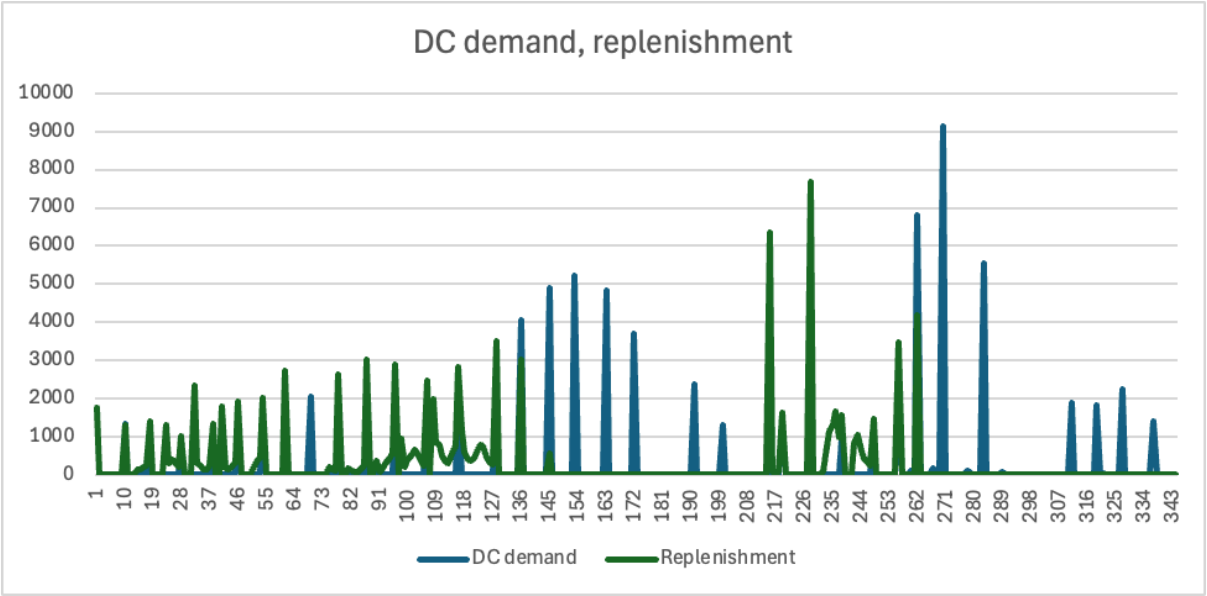


Figure 35: DC capacities

For DC throughput capacities to handle the robustness over a one-year horizon, below is the graph for the smoothed capacity

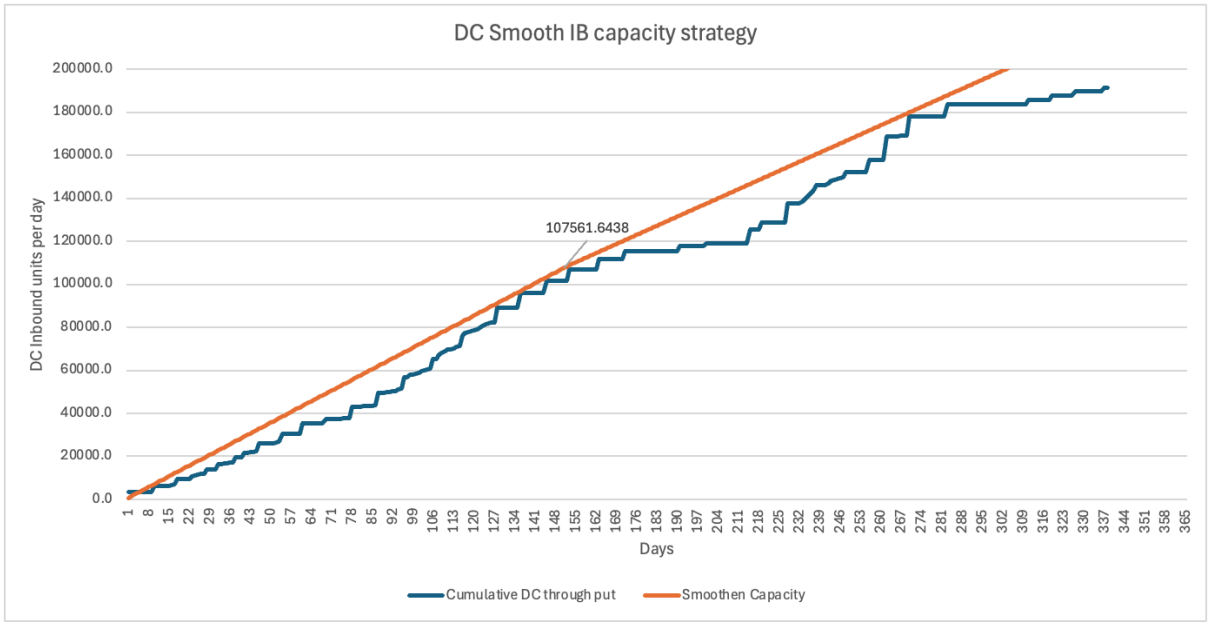
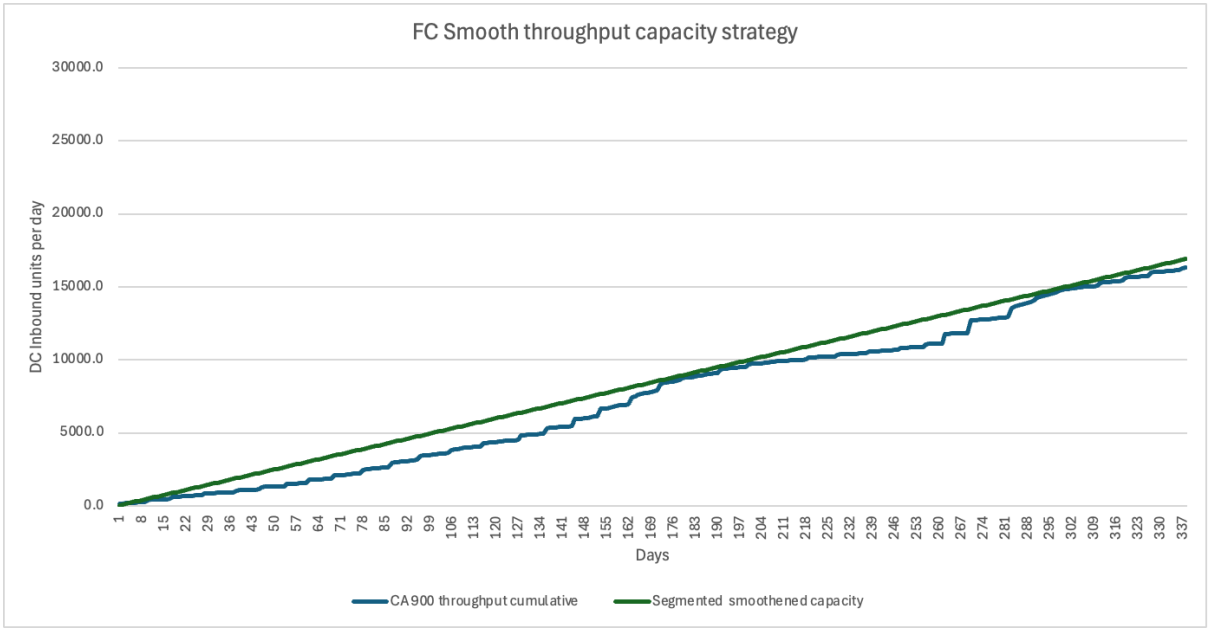


Figure 36: DC Throughput capacity

There is one smoothening at 155 days where the prior capacity of 712 units per day changes to 605 units per day.

We apply a similar approach to FCs to find their throughput capacity to meet the demand. Two plots are shown below.



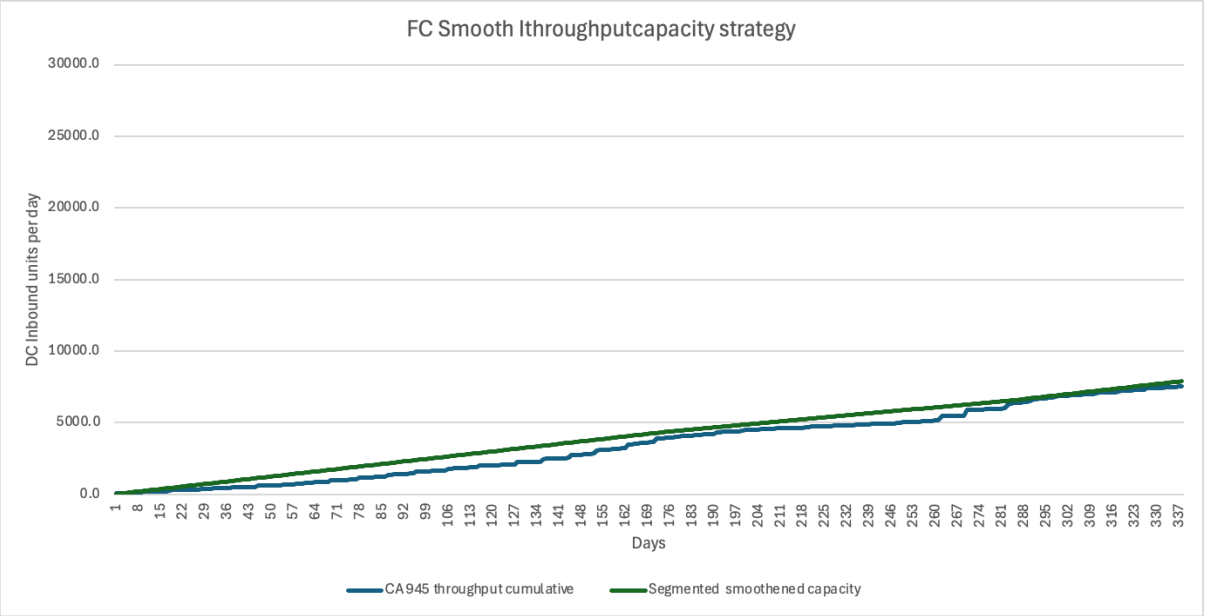
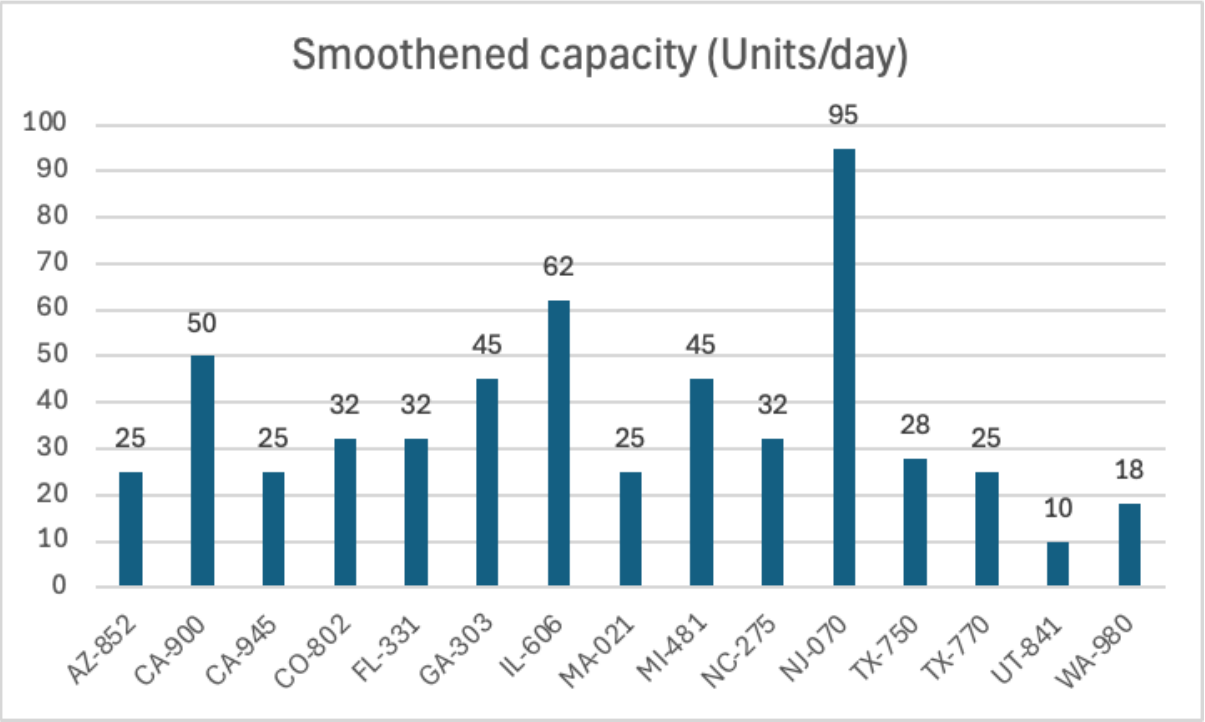


Figure 37: Smoothened FC throughput capacity of 2 FCs

The resultant capacity graph for throughputs is as follows. Details are in each of the FC tabs of the Excel Task 9 logic.



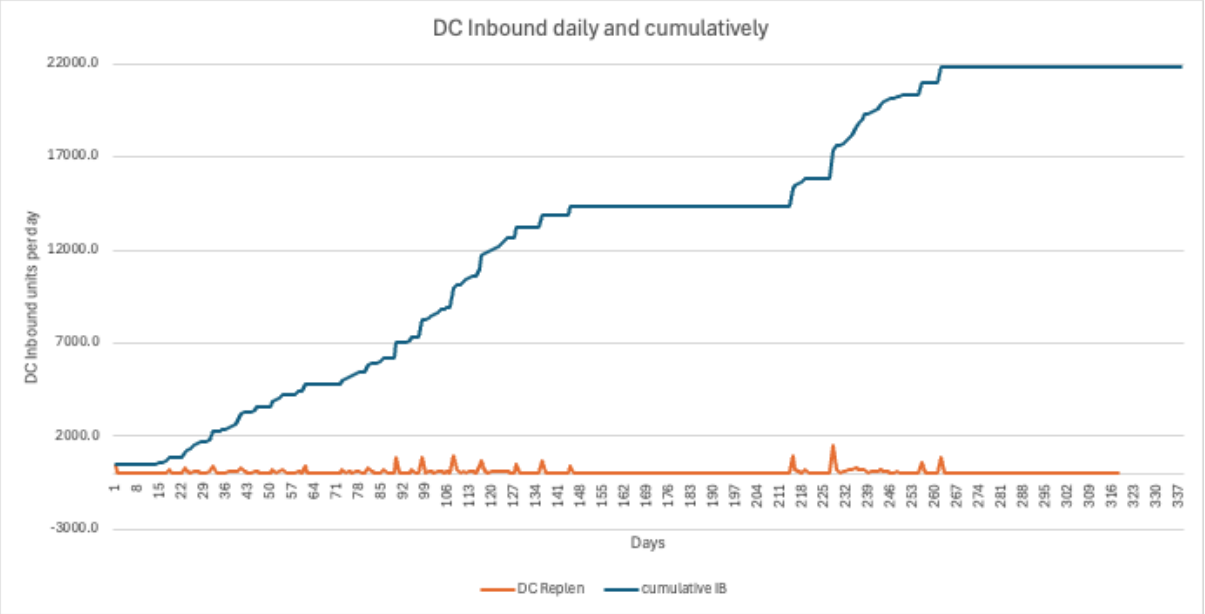


Figure 36: DC Inbound

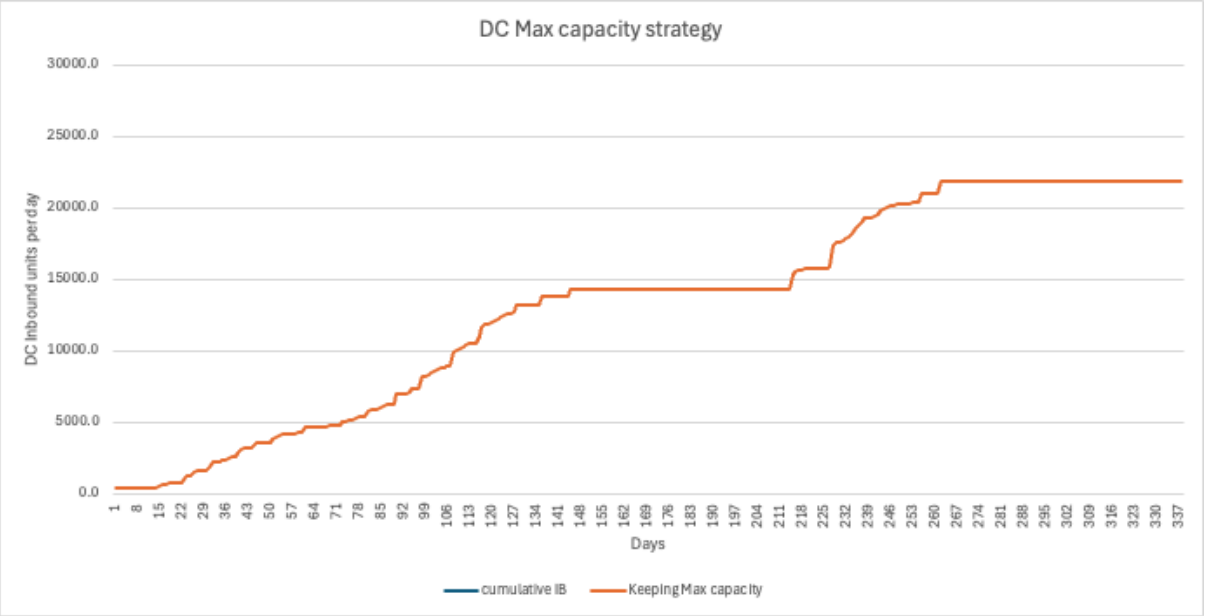


Figure 37: DC Inbound Max capacity strategy

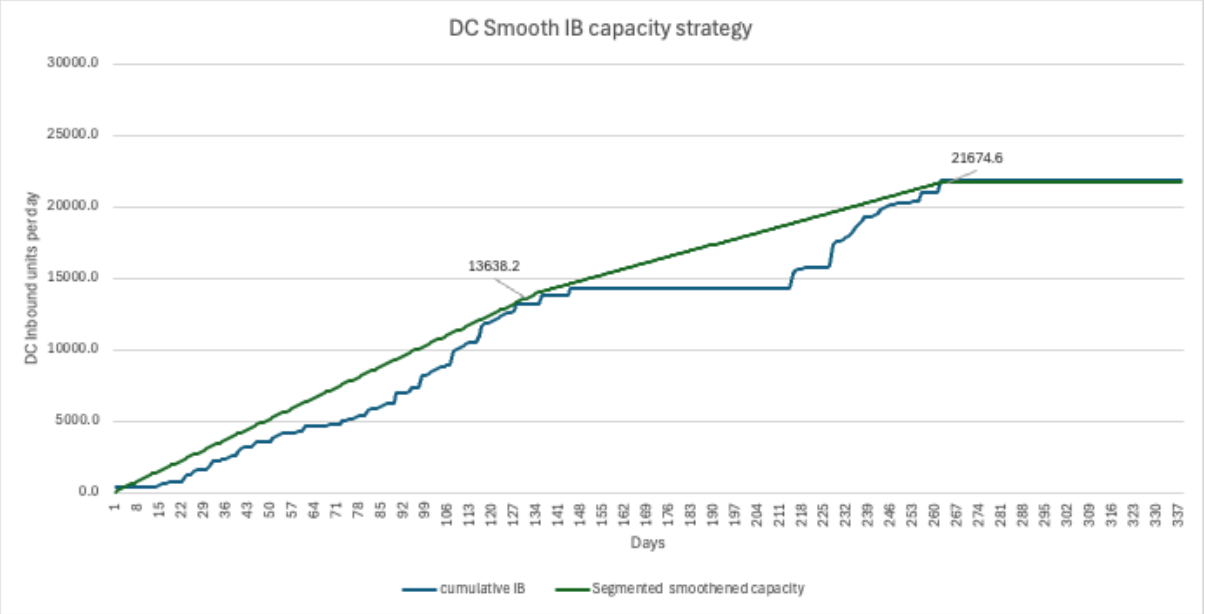


Figure 38: DC Inbound smooth capacity strategy

Our view based on the above Figure 38 is that the smoothened capacity enables a consistent capacity to be maintained daily, and hence, it is better for resource handling. The cumulative IB is a replica of the maximum capacity that enables variable capacity based on the demand, and can go up to the maximum. This has the advantage of not having any need for inventory buildup while in the smooth capacity, inventory builds up where the graph is above the cumulative one, and gets nullified when the graphs meet.

Task 10: FC-Specific Replenishment Parameter Tuning: Interval & Robust Autonomy to Minimize 10% FTL Bump-Ups

We look at the “working optimization” sheet in the Excel Task 910 to arrive at the said task. FC selected is NJ-070 (can be changed as a selection from the list). Columns K and M show the days when inventory was 27 that was replenished, and the gap between subsequent replenishments. This shows that for this FC, no ordering has been made for 27 units, and the gap between replenishments was 7. This means there is a need to order, but the quantity ordered is high. This FC ordered a total of 14922 units in the year. Now, let's reduce the minimum robust autonomy days from 14 to 10 and see what happens. We ran a few simulations, and the result is below.

Min autonomy days	Total annual replacement (Units)	No. of replin as 27
14	**14922**	**0**

10	**14995**	**0**
7	**15095**	**0**
5	**15122**	**0**
16	**14898**	**2**
17	**14903**	**4**
20	**14945**	**61**

Table 6: Min Autonomy days variation vs replins that need minimal units.

This shows that the need to have more days of minimum robust inventory triggers more frequent ordering, and hence keeping it at a lesser horizon seems to help. Incidentally, not much of a change in the overall annual replenishment seen

	No. of 27 units load under various replenishment days		
Min autonomy days	**7 days min replenishment**	**5 days min replenishment**	**19 days of replenishment**
14	**0**	**0**	**0**
10	**0**	**0**	**0**
7	**0**	**0**	**0**
5	**0**	**0**	**0**
16	**2**	**2**	**2**
17	**4**	**4**	**4**
20	**61**	**61**	**61**

Sensitivity to replenishment days seemed to have no sensitivity towards the same.

Table 1 shows - for example that in all primary markets, it is expected that only 60% of the demand can be converted into sales if the promised OTD time is four days. i.e share of demand depends on OTD time.