BY SHENGLI TEAM

PROBLEM SOLVING CHALLENGE FOR ROUND 2

EXECUTIVE SUMMARY

Background

Top supplier of plumbing and mechanical products in Australia, serving industrial, commercial, and residential sectors.

Operates **486 branches** across the country, supported by a centralized Distribution Center in Inverell, NSW.

Focuses on the distribution of bulky and heavy items, including pipes, fittings, HVAC components, and water systems.

Challenges

Overreliance on a **Single Distribution** Center increases operational risk

High freight costs due to long-distance deliveries from a single DC.

Slow **Regional Response**
Distant DC limits ability to serve regional demand quickly and efficiently.

Mission

Redesign the Distribution Network
Shift from a centralized to a more resilient, cost-efficient **multi-DC model.**

Reduce Total Logistics Costs
Minimize transportation, storage, and handling expenses across the network.

Faster Delivery, Lower Risk
Improve **delivery speed** and **flexibility** while reducing vulnerability to disruptions.

Impact

Significant Logistics Cost Savings
Reduces total costs by approximately **21.3%** with the **4-RDC** model.

Improved delivery times
Closer RDCs lead to shorter last-mile delivery times.

Enhancing supply chain resilience.
Improve **delivery speed** and **flexibility** while reducing vulnerability to disruptions.

Let's look at some insight and assumption

Data Analysis

Insight		Plans of action
Customers are concentrated in certain areas	→	Segment the country into delivery zones.
Too many branches concentrated in single locations	→	We'll group branches by location, then segment the country.
Handling a high volume of small, individual orders.	→	Consolidate these orders for more efficient processing and delivery.
The anticipated cost follows a probability distribution.	→	Defect risk in the proposed system

Assumption

1 Delivery Window

Each branch only order from DC **five times** a year at the same time and the time window for receiving is within **3 days** (branches are willing to receive in the time window)

2 Shipment

Every truck can carry a complete range of products and ship to numerous branches in one shipment

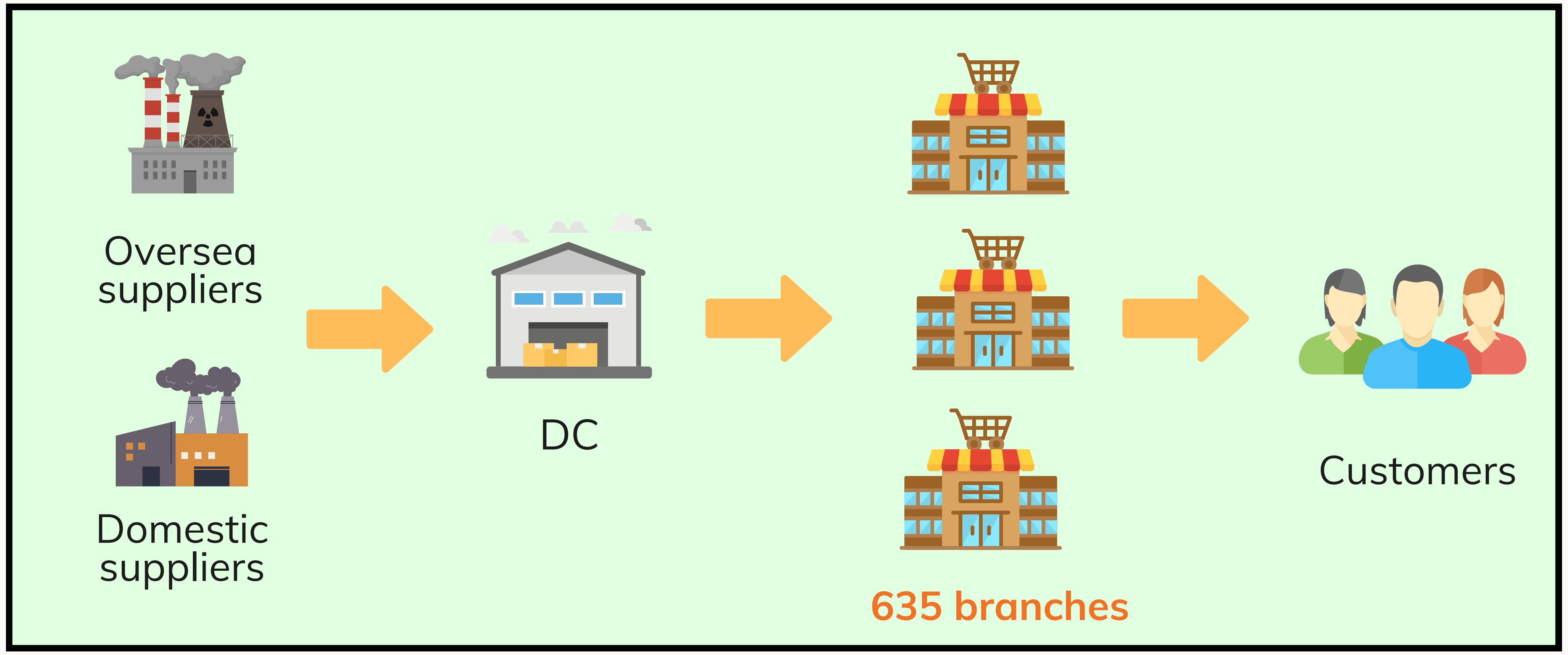
3 Speed & Capacity

Average speed of LTL is **55 miles/hour**, full capacity is 25,000 kg, and the LTL is qualified to run when reach **80%** of the full capacity

4 DC & Time Window

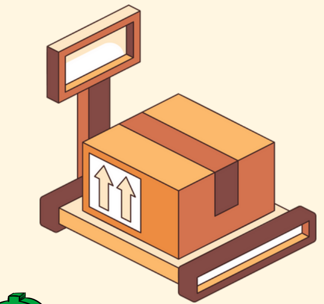
Each truck assigned to a cluster operates in a single direction per day — it makes one delivery trip and returning to the distribution center for another run within a day.

LOGage is suffering colossal transportation cost and exposing inventory to significant risks

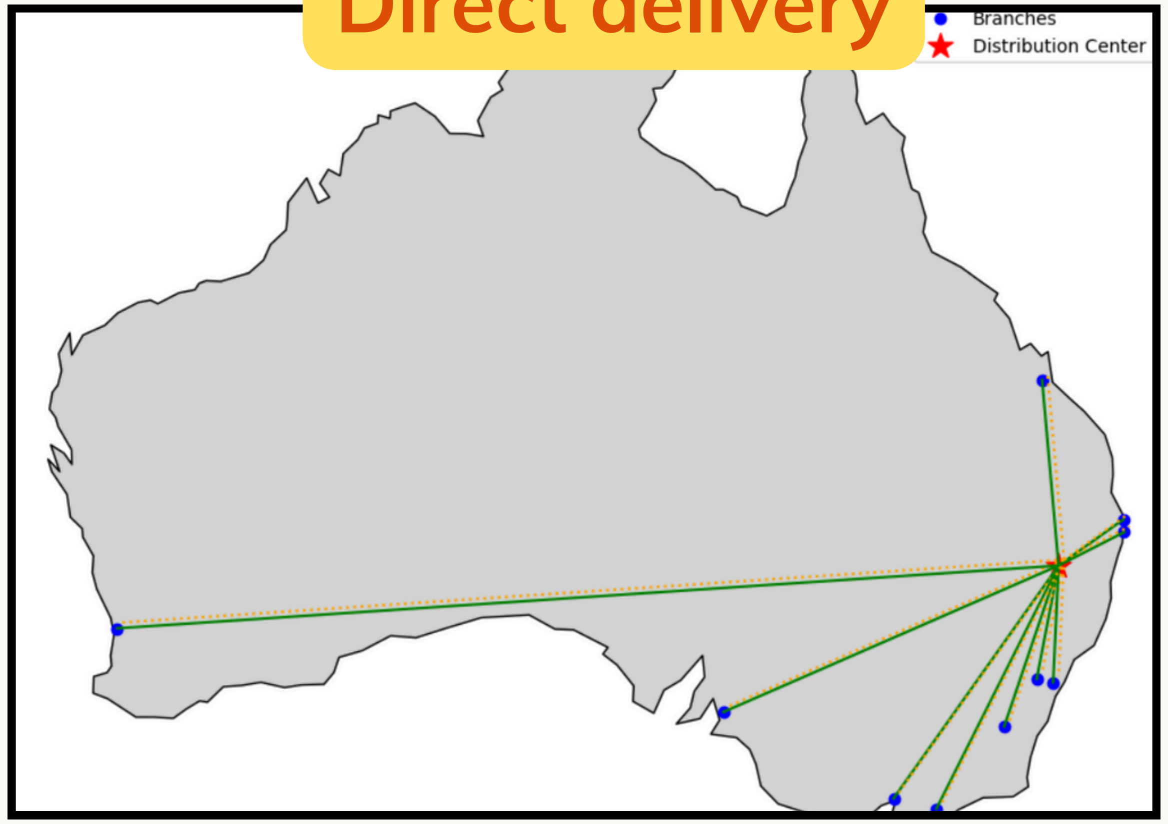


The distribution network with only **1 DC** could optimize the inventory cost, but it **increases** significantly the **transportation cost**, lower the resilience ability and service level (635 branches locating at 486 unique locations require 2485 deliveries

Current distribution system

Handling cost	Storage cost	Branch delivery
		
$ 747,932	$ 446,940	$ 3,663,853

Direct delivery



These **2485 deliveries** report **2,482,405 km** which is considered ineffective and environmentally unfriendly

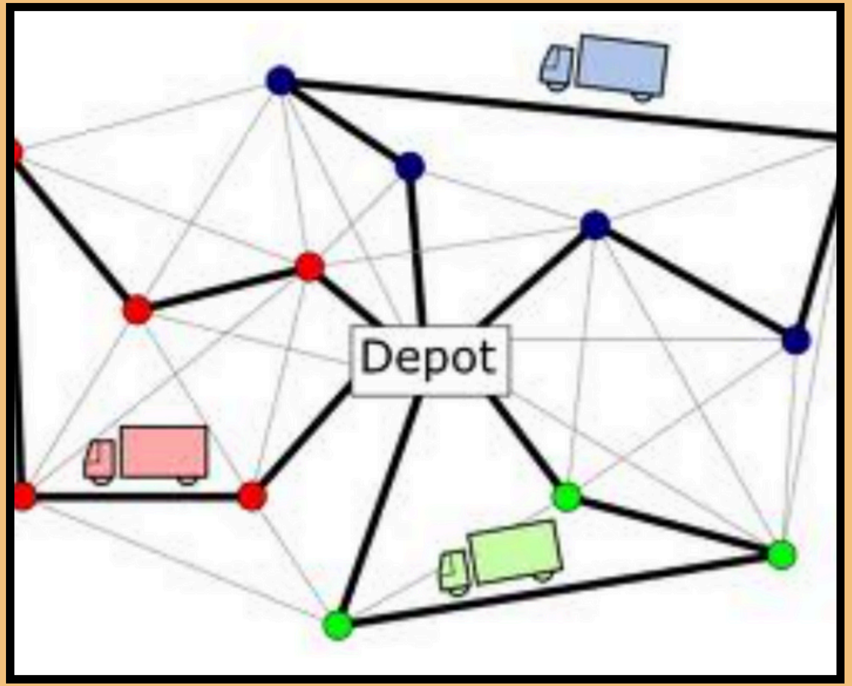
Total CBM of demand **74,743** / **14,898** Average capacity in CBM of DC = **5** The number of dispatch

It means that branches receive 5 times a year within 3 days time window

Executive | **Analysis** | Proposed system | Comparison | Risk Management

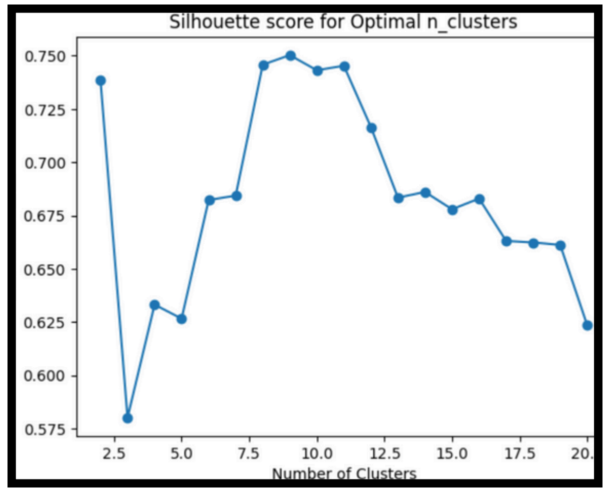
Even when we apply the Traveling Salesman method, the cost reduction is quite considerable but not enough

The more tightly branches' locations in a cluster are, the more optimized transportation cost is



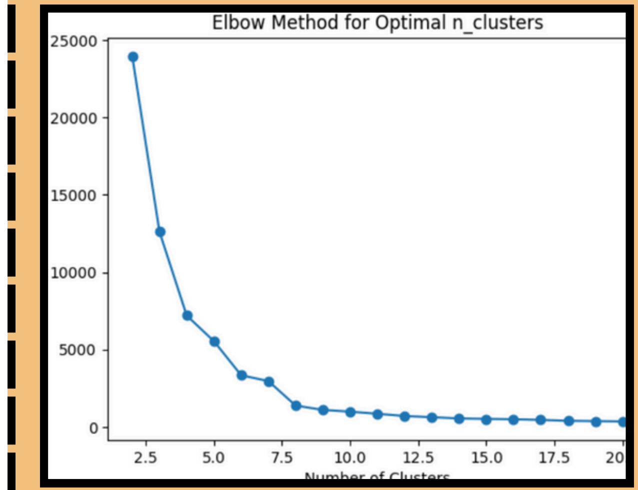
Cluster branch locations based on their proximity and assign fleet to each region

That's why

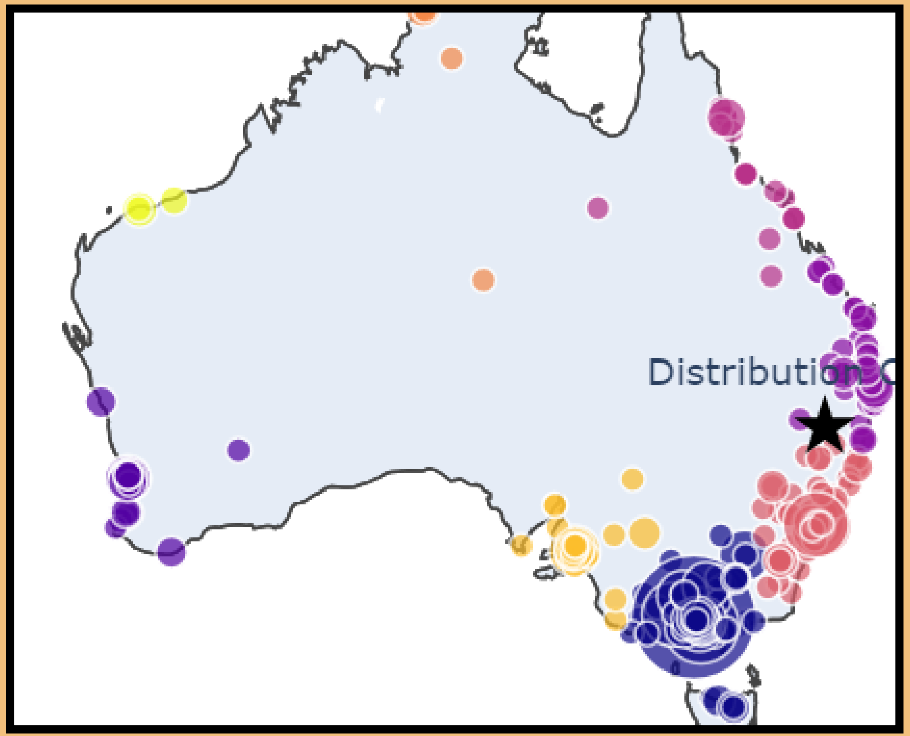


The highest silhouette score is reported at 8 n_cluster, implicating the best quality of clustering efficiency.

We need to group into numerous clusters, aiming, to serve customer within 3 days and specialize drivers for each region



This suggests that 8 clusters balance the trade-off between cluster tightness and computational efficiency.



Clustering into 8 regions is the optimal option

Branch delivery

48.58%

Compare to direct shipment method

$ 1,884,056

Number of truck hired in each day of time window

Cluster 0	14-14-14
Cluster 1	13-0-0
Cluster 2	6-6-6
Cluster 3	6-5-5
Cluster 4	1-1-1
Cluster 5	4-4-0
Cluster 6	1-1-0
Cluster 7	2-0-0

Number of needed deliveries for each cluster in one dispatch

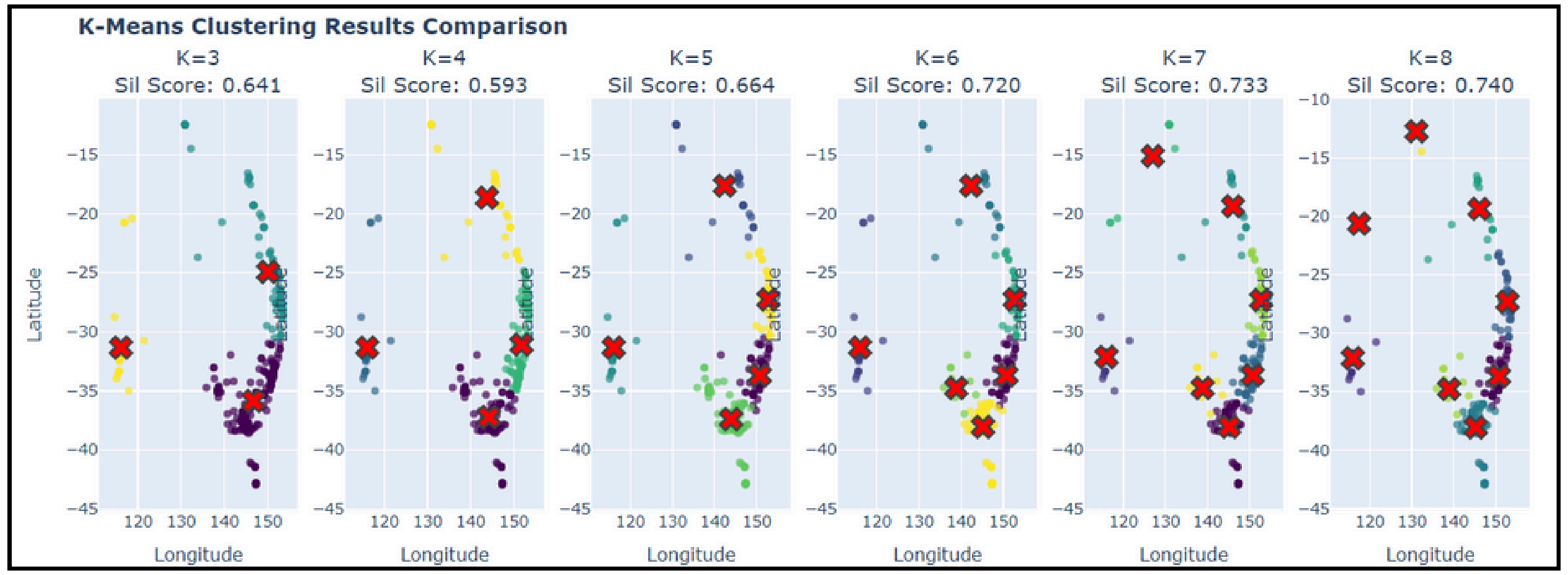
Cluster 0	42
Cluster 1	13
Cluster 2	18
Cluster 3	25
Cluster 4	3
Cluster 5	8
Cluster 6	2
Cluster 7	2

The minimum lead time in each cluster

Cluster 0	12.6
Cluster 1	51.6
Cluster 2	3.6
Cluster 3	17.8
Cluster 4	2.6
Cluster 5	33.5
Cluster 6	17.7
Cluster 7	62.3

Therefore, we propose a new approach to Network Optimization Strategy and Cost Analysis

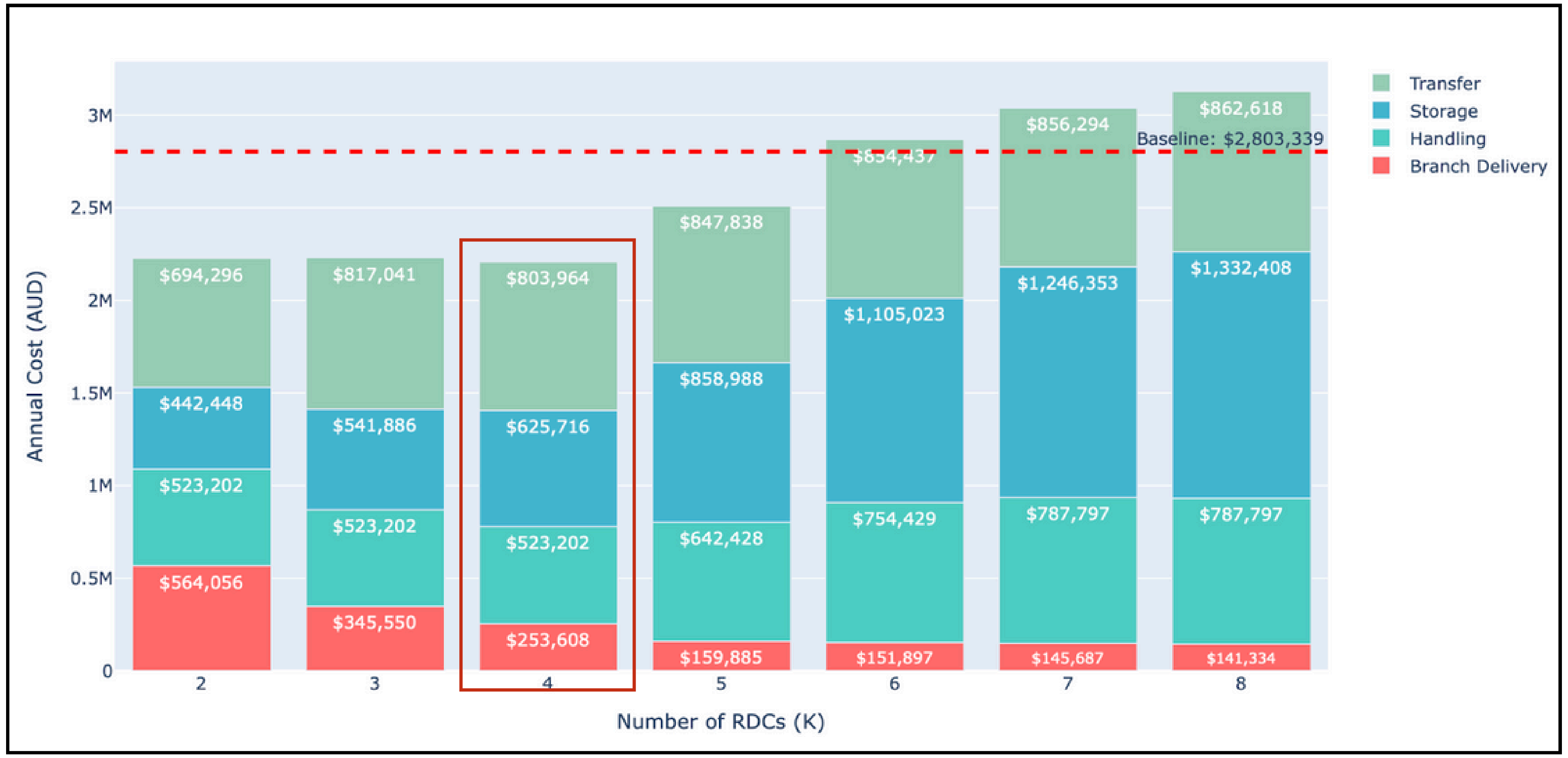
1 Customers (ShipToID) were clustered using K-Means on standardized geolocation data, with optimal K chosen via the Elbow Method and Silhouette Score.



2 Code Modelling Framework

Branch delivery	$$C_{\text{total}} = \sum_{i=1}^{k} \left(\sum_{j \in \text{Consolidate}(S_i, Q_{\text{truck}})} [\text{Slope}_j \times \text{TSP}(L_j) + \text{Intercept}_j] \right)$$
Handling cost	$$C_{\text{handling\_total}} = \sum_{i=1}^{K} \left(\frac{D_{\text{kg},i}}{\rho_{\text{kg/cbm}}} \times (C_{\text{base}} \times F_i) \right)$$
Storage cost	$$C_{\text{storage\_total}} = \sum_{i=1}^{K} \left(\left(I_{\text{current}} \times \sqrt{\frac{K}{N_{\text{current}}}} \right) \times \frac{D_i}{D_{\text{total}}} \times (C_{\text{base}} \times F_i) \right)$$
Transfer Cost Model	$$C_{\text{total}} = \sum_{i=1}^{N} \left[\frac{Q_{\text{annual},i}}{Q_{\text{trip}}} \times (\text{Slope}_i \times D_i + \text{Intercept}_i) \right]$$

3 Results & Optimal



Optimal Total Cost $2,206,490 $596,849 (+21.3%)

No	Location	Latitude	Longitude	Serves (Locations)	Demand (kg)	Distance from DC (km)	Transfer Cost ($)
RDC 0	Victoria (Rural)	-37.217	-144.264	205	5,082,761	1,042	384,080
RDC 1	Western Australia (Rural)	-31.329	-116.069	43	1,313,286	3,347	266,767
RDC 2	New South Wales (Rural)	-31.081	-151.795	203	3,838,235	157	102,375
RDC 3	Queensland (Rural)	-18.629	-143.78	35	502,556	1,447	50,742

After identifying locations and number of RDCs, we persist in estimating capacity

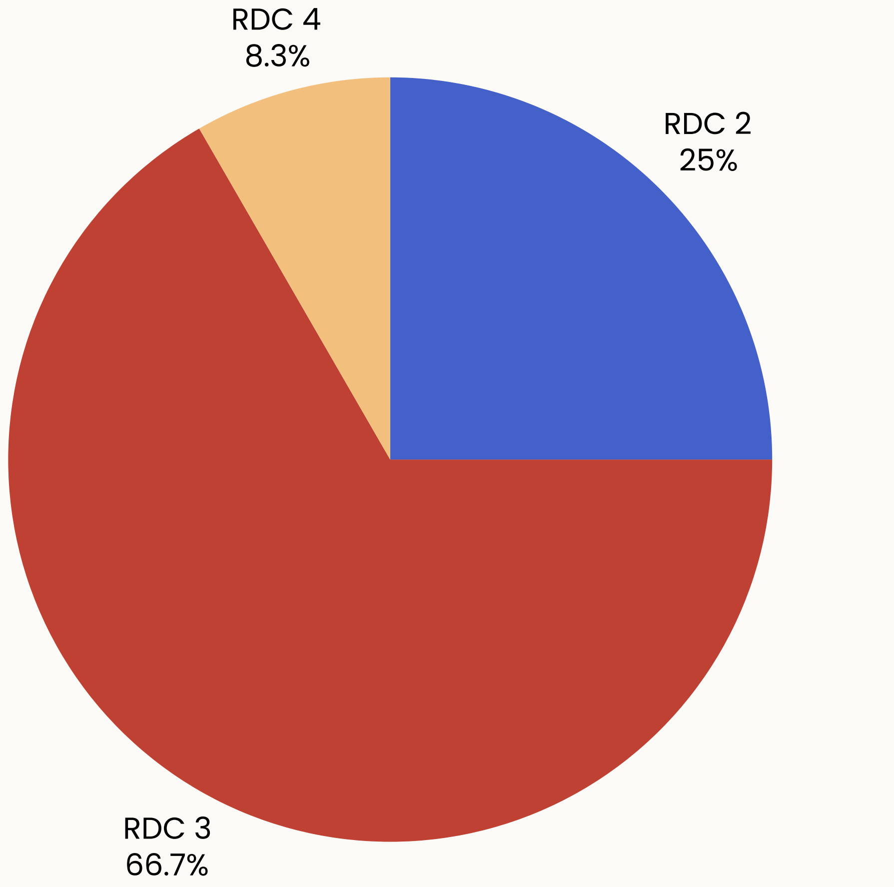
14,898 CBM

Because we choose option bulding more 4 RDCs, the total inventory cost of the whole network is

Apply the Square Root Law for Inventory Calculation, we multiply the current inventory by sqrt(4)

29796 CBM

Ratio of capacity between 4 RDCs



Capacity distribution

DC	14,898
DC	6,772
RDC 2	2,031
RDC 3	5,417
RDC 4	678

We conduct to compare between 2 systems to understand the efficency

The Old System

The New One

COST

Storage cost	446,940
Handling cost	747,932
Branch delivery	1,884,056

Total Cost 1 DC

$3,078,427

Optimal Total Cost

$2,471,949

829,538	Transfer Cost
625,716	Storage cost
532,202	Handling cost
493,493	Branch delivery

SERVICE LEVEL

Limited ability to handle disruptions can cause more stockouts and lower service reliability.

EXTENDED

Extended lead times contribute to reduced customer satisfaction due to delayed deliveries.

Maintaining elevated safety stock levels across a broad distribution center network effectively mitigates disruptions and ensures sufficient demand fulfillment

SATISFACTION GUARANTEE

Allocating deliveries to regional distribution centers (RDCs) based on clustering optimizes lead times, thereby enhancing customer satisfaction

SUSTANABILITY

Partial loads and frequent trips → inefficient truck usage, increasing traffic and emissions.

Full loads with fewer trips → maximize truck efficiency, reduce traffic and emissions.

Ad hoc, multi-directional routing → longer travel times, more congestion, increased fuel use.

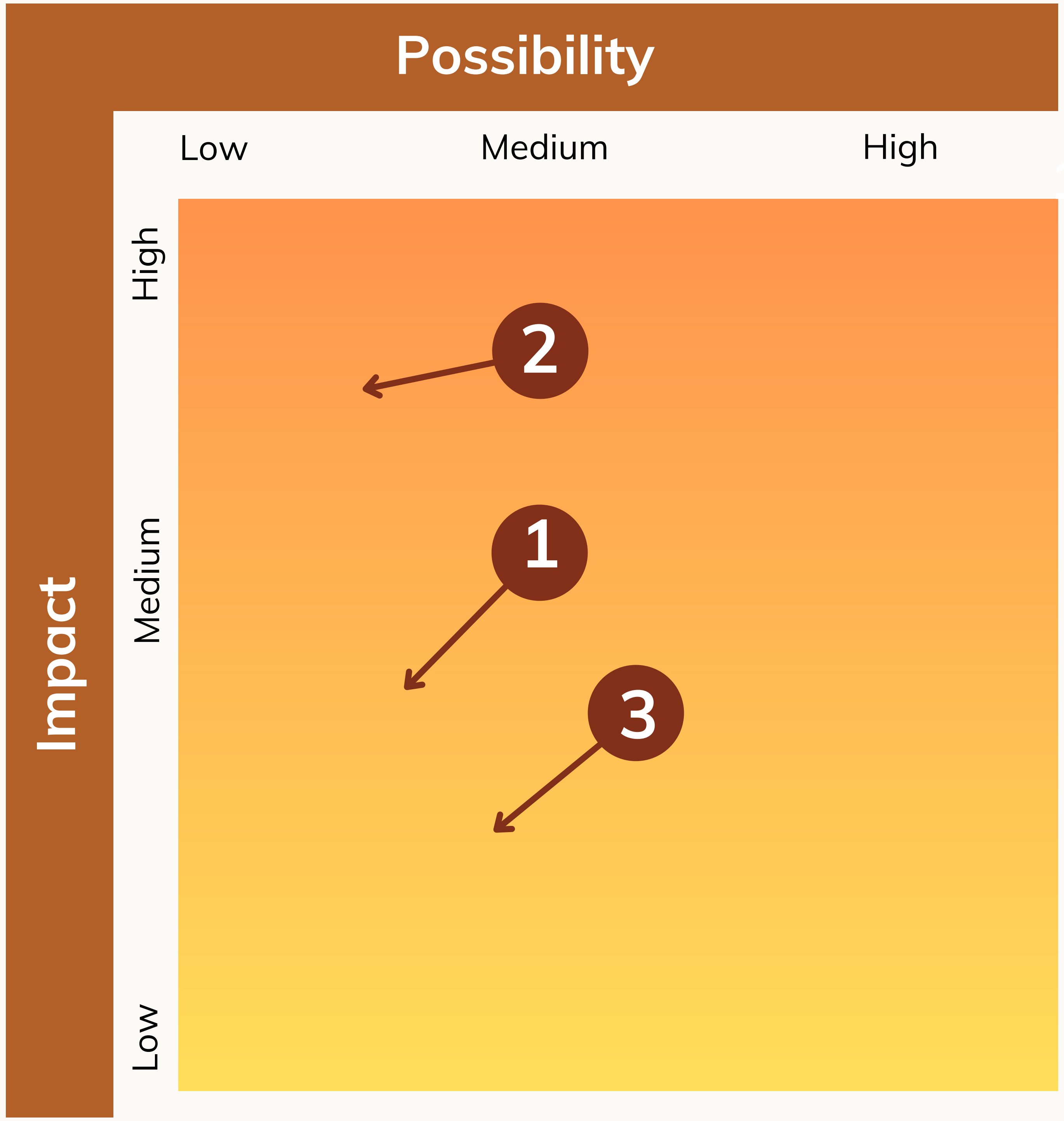
Cluster-based, one-directional routing → faster delivery, less congestion, lower fuel consumption.

Multiple small orders year-round → overstocking at branches, higher storage energy use.

One synchronized annual order → lean inventory, less storage energy, more sustainable operations.

Risk Management

Risk assessment heatmap



Risk	Mitigation
1 Investing in the wrong locations or overbuilding capacity can lead to sunk costs.	Pilot new DCs in key regions before full rollout; use ROI-based prioritization for site investments.
2 Poor-quality geographic or volume data can lead to flawed clustering or DC location decisions.	Phase implementation by region; maintain buffer stock at the central DC during the transition period.
3 Shifting to new DCs may temporarily impact service levels or lead to delivery delays	Audit and clean data before clustering; use GIS tools to validate branch coordinates and delivery patterns.

Thank You