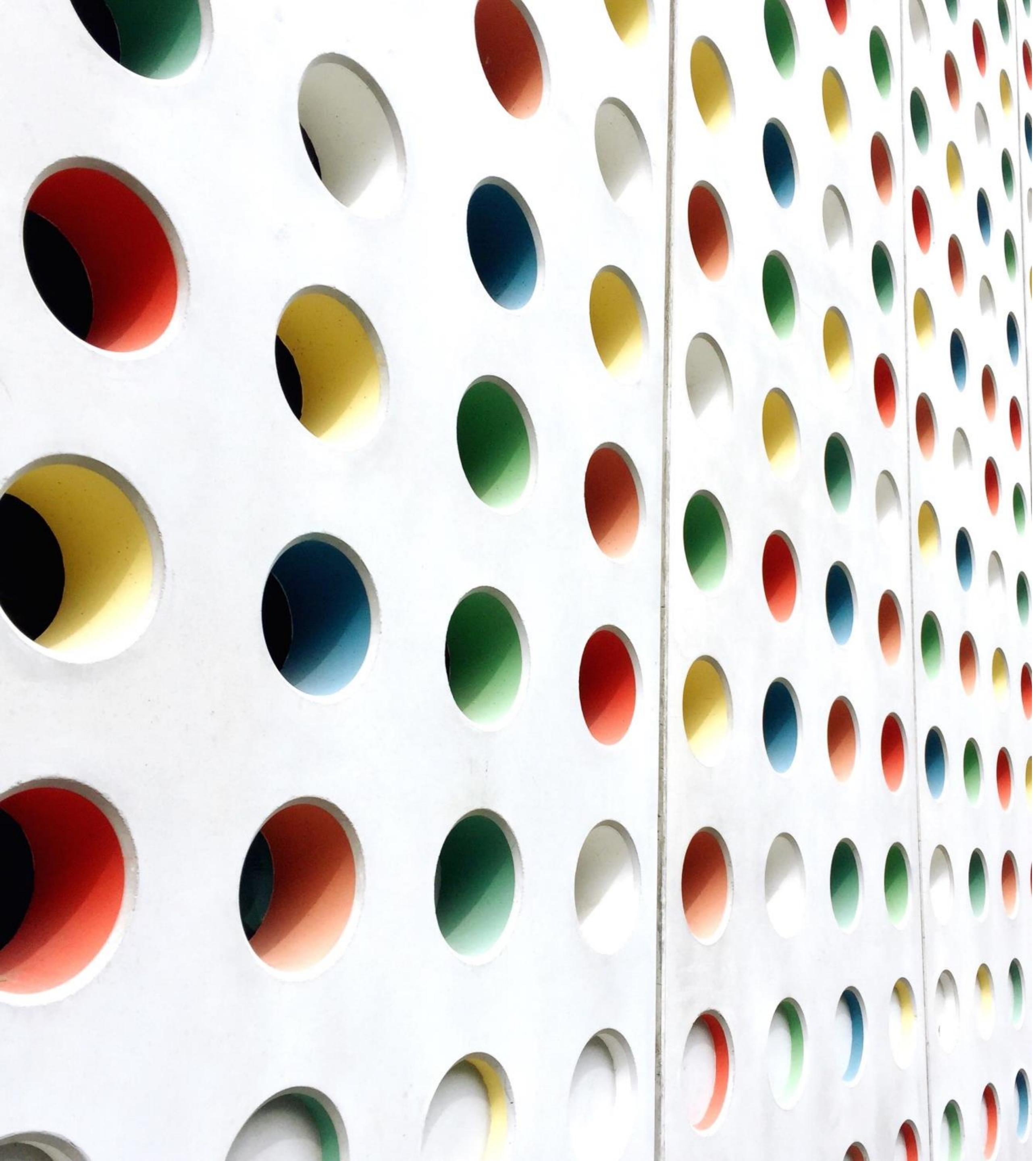


Demand Forecasting and Optimizing Transportation Decisions

CHANDU BHUJANG

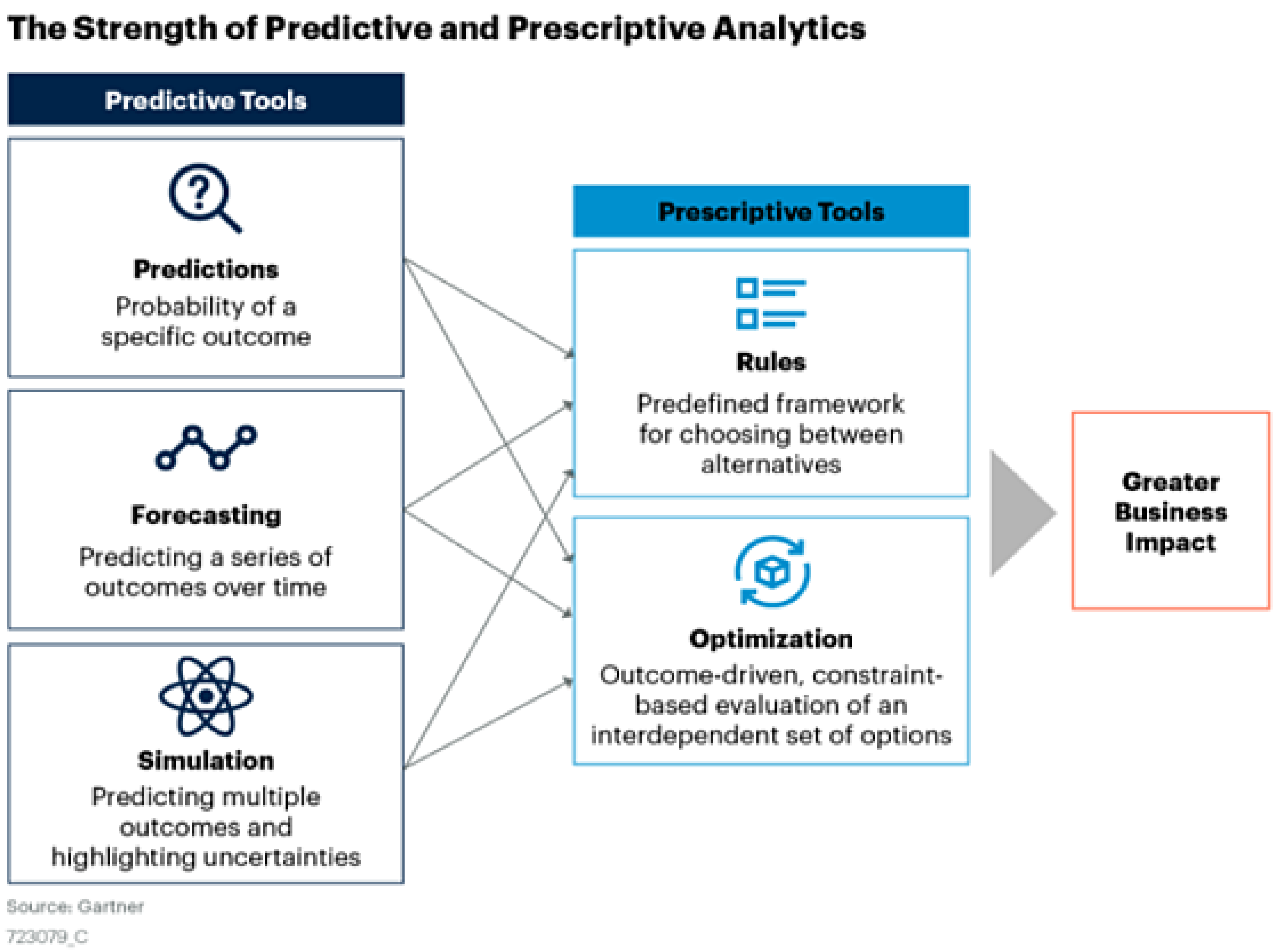
Outline

- Business uncertainty
- Demand forecasting using ML
- Optimizing the transportation logistics
- Q&A

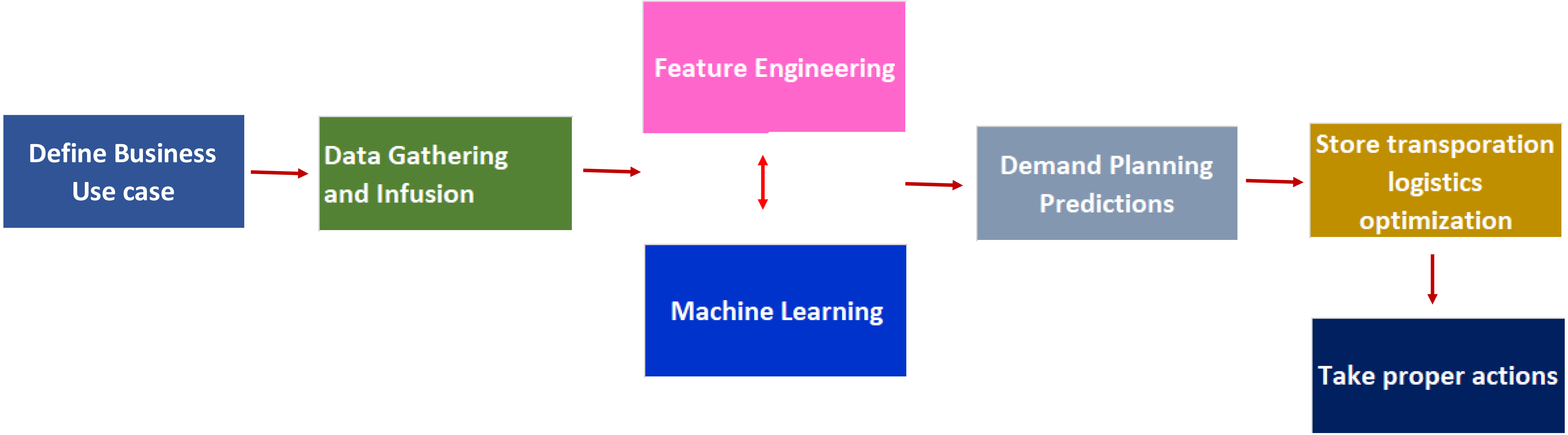
Business uncertainty during covid-19

- Uncertainty of demand
- Inconsistency of supply
- Scarcity of materials
- Delay in delivery

Integration of ML and OR



Framework



Define Business Use case
Data Gathering and Infusion
Feature Engineering
Machine Learning
Demand Planning Predictions
Store transporation logistics optimization
Take proper actions

Demand Forecasting

ML ENGINE

Univariate vs. Multivariate Time Series

Date	Feature1
1/1/2018	25
1/2/2018	46
.	.
.	.
.	.

Target Variable
.
.
.
.

Date	Feature1	Feature2	Feature3
1/1/2018	25	0.45	TRUE
1/2/2018	46	1.47	FALSE
.	.	.	.
.	.	.	.
.	.	.	.

Target Variable
.
.
.
.

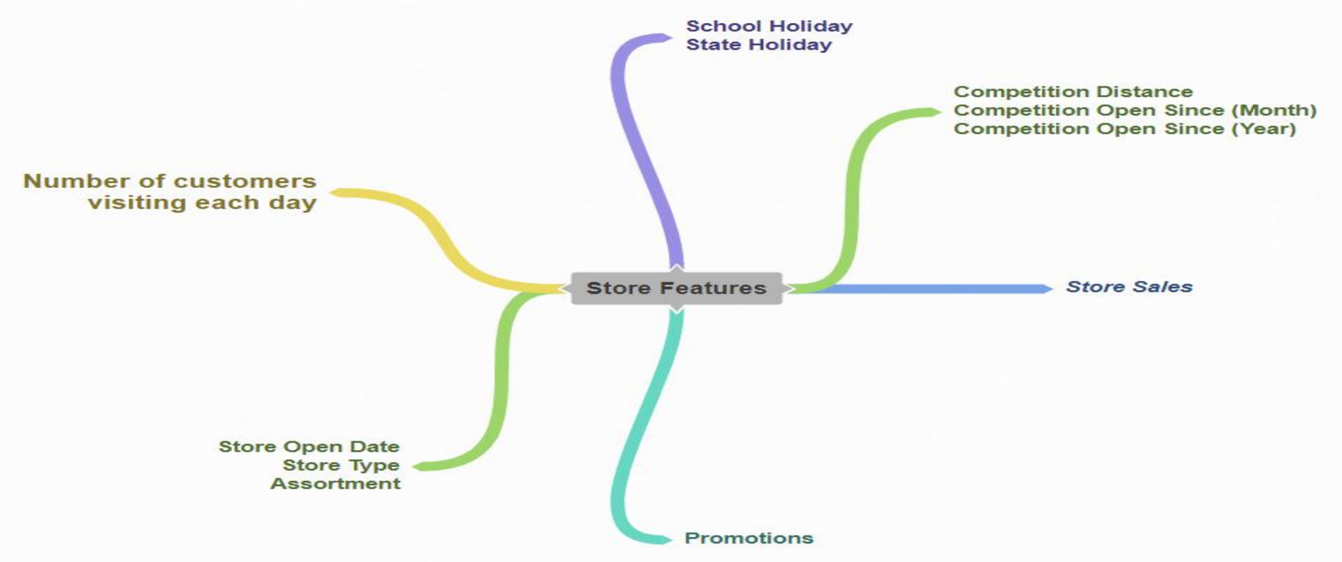
Resilient demand forecast using ML

- Application of multivariate time series
- Deep learning techniques to:
  - ✓ learn arbitrary complex mappings
  - ✓ learn trends and seasonality
  - ✓ improve the accuracy

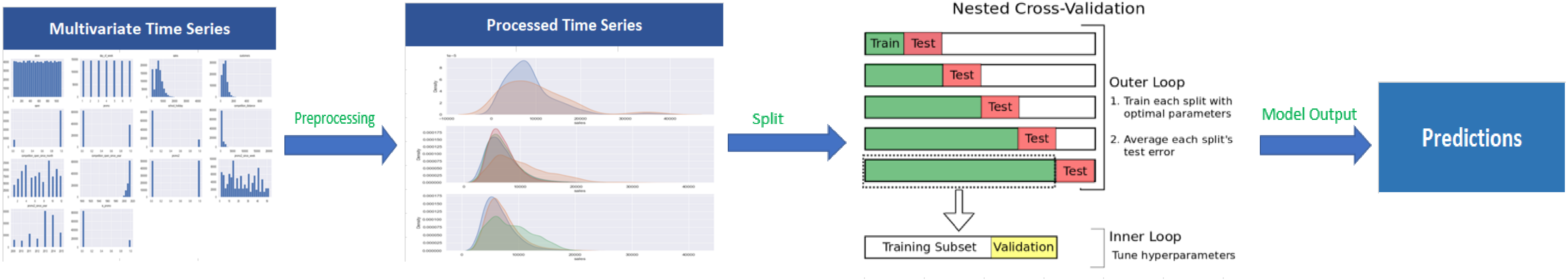
Data Description

Store	StoreType	Assortme	Competition Distance	Competition OpenSinceMonth	Competition OpenSinceYear	Promo2	Promo2 SinceWeek	Promo2 SinceYear	PromoInterval
1	c	a	1270	9	2008	0			
2	a	a	570	11	2007	1	13	2010	Jan,Apr,Jul,Oct
3	a	a	14130	12	2006	1	14	2011	Jan,Apr,Jul,Oct
4	c	c	620	9	2009	0			
5	a	a	29910	4	2015	0			
6	a	a	310	12	2013	0			
7	a	c	24000	4	2013	0			
8	a	a	7520	10	2014	0			
9	a	c	2030	8	2000	0			
10	a	c	960	11	2011	1	1	2012	Jan,Apr,Jul,Oct

Store	DayOfWeek	Date	Customers	Open	Promo	StateHoliday	SchoolHoliday	Sales
1	5	7/31/2015	555	1	1	0	1	5263
2	5	7/31/2015	625	1	1	0	1	6064
3	5	7/31/2015	821	1	1	0	1	8314
4	5	7/31/2015	1498	1	1	0	1	13995
5	5	7/31/2015	559	1	1	0	1	4822
6	5	7/31/2015	589	1	1	0	1	5651
7	5	7/31/2015	1414	1	1	0	1	15344
8	5	7/31/2015	833	1	1	0	1	8492
9	5	7/31/2015	687	1	1	0	1	8565
10	5	7/31/2015	681	1	1	0	1	7185



Methodology



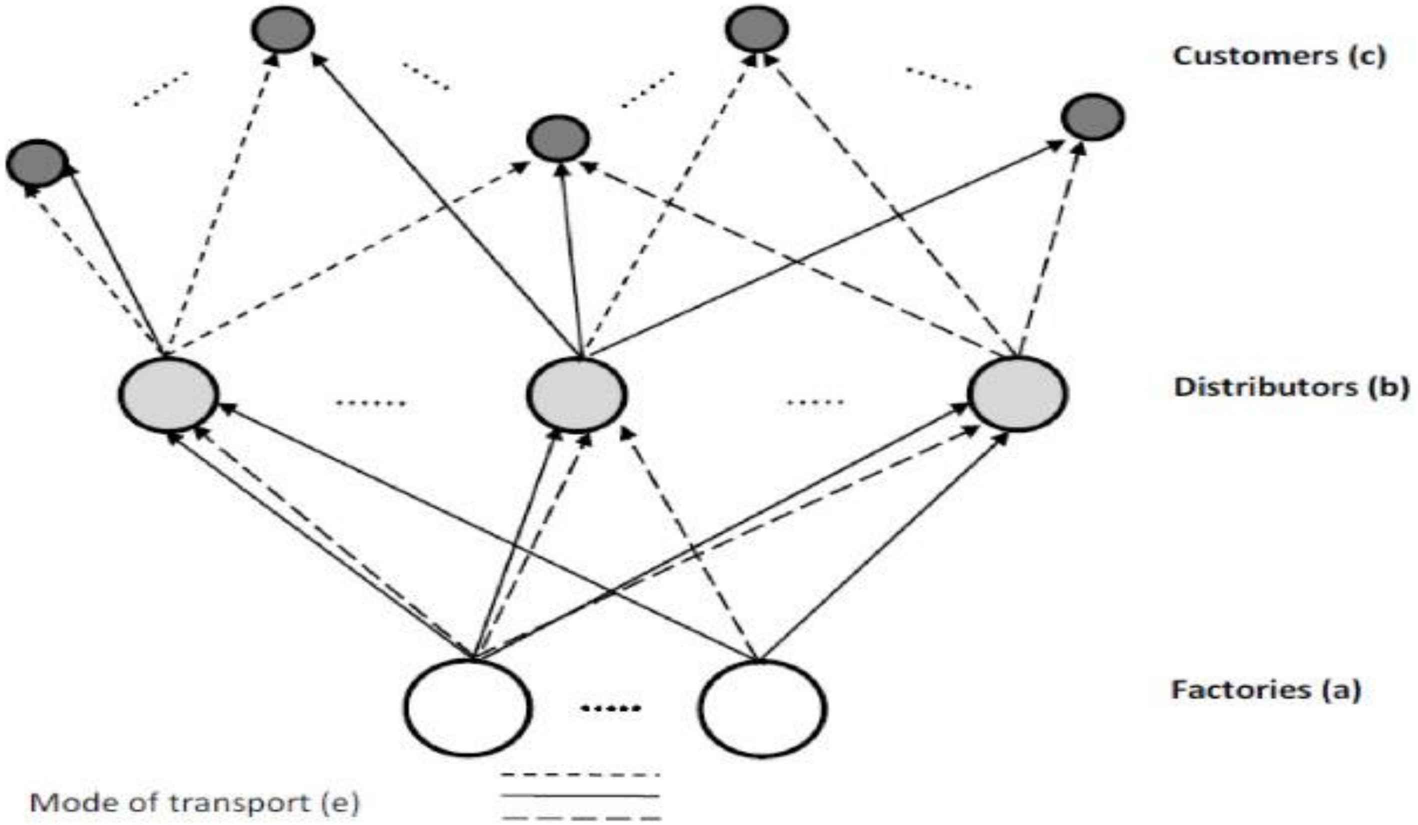
Notebook

CODE WALKTHROUGH

Store Transpiration Logistics

OR ENGINE

Problem Statement



Data Description

Factory	Supply (tons)
Liverpool	150000
Brighton	200000

Depot	Throughput (tons)
Newcastle	70000
Birmingham	50000
London	100000
Exeter	40000

Customer	Demand (tons)
C1	50,000
C2	10,000
C3	40,000
C4	35,000
C5	60,000
C6	20,000

Input from ML forecast model

Problem Formulation

Objective Function

- **Cost**: Minimize total shipping costs.

$$\text{Minimize} \quad Z = \sum_{(s,t)\in \text{Cities}\times\text{Cities}} \text{cost}_{s,t} * \text{flow}_{s,t}$$

Constraints

- **Factory output**: Flow of goods from a factory must respect maximum capacity.

$$\sum_{t\in \text{Cities}} \text{flow}_{f,t} \leq \text{supply}_f \quad \forall f \in \text{Factories}$$

- **Customer demand**: Flow of goods must meet customer demand.

$$\sum_{s\in \text{Cities}} \text{flow}_{s,c} = \text{demand}_c \quad \forall c \in \text{Customers}$$

- **Depot flow**: Flow into a depot equals flow out of the depot.

$$\sum_{s\in \text{Cities}} \text{flow}_{s,d} = \sum_{t\in \text{Cities}} \text{flow}_{d,t} \quad \forall d \in \text{Depots}$$

- **Depot capacity**: Flow into a depot must respect depot capacity.

$$\sum_{s\in \text{Cities}} \text{flow}_{s,d} \leq \text{through}_d \quad \forall d \in \text{Depots}$$

Notebook

CODE WALKTHROUGH

Q & A