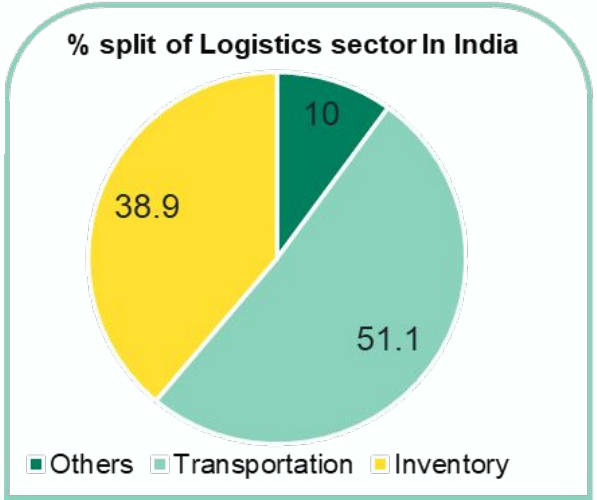
Indian Case Challenge

Final Case |Trucking Industry

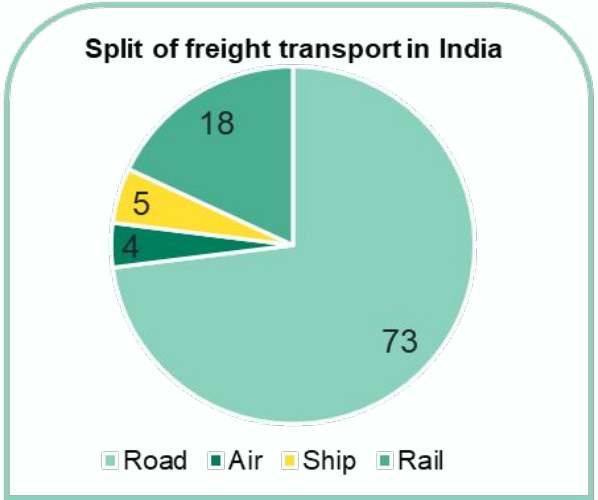
Executive Summary

- The trucking industry is **highly unorganised** in India,even then it plays a significant role in contributing to the GDP(almost 5%)
- There is a huge disparity between the profit margins,fleet of trucks as well as empty truck rates of organised and unorganised sectors thereby opening an opportunity for XYZ logistics to tap into this market.
- Comparing different trucks fuel types, we focused on EV batteries to be better option for long term goals
- **MDTs EV investment has a payback period of 7.05yrs** whereas **HDTs EV investment has approx. 22yrs**
- Diesel trucks have a dominant market share , but a very low market growth (4-5%) as compared to ZET(40-60%)
- India can utilise the **battery swapping technology** to inch ahead in the EV distance race ,
- We recommend **adopting a hybrid mixture of Diesel and E.V based trucks** so as penetrate into the existing market as well as explore future segments
- Solving the supply chain imbalance will be done by **Hub & Spoke model for intra-city by EVs** and **Point to Point model for Inter-city** preferably by conventional trucks.
- Integrating technologies in hands with tapping into the unorganised truck industry will be done by creating a platform for **connecting shippers with truck owners**.
- Using algorithms for connecting supplier requests with truck owners, ensuring smooth payments with escrow system.
- To optimize daily delivery scheduling, implementation of **Genetic Algorithm with variable parameters** depending on the requirements
- **Reinforcement Learning** using Proximal Policy optimisation trained model will have greater speed and accuracy.

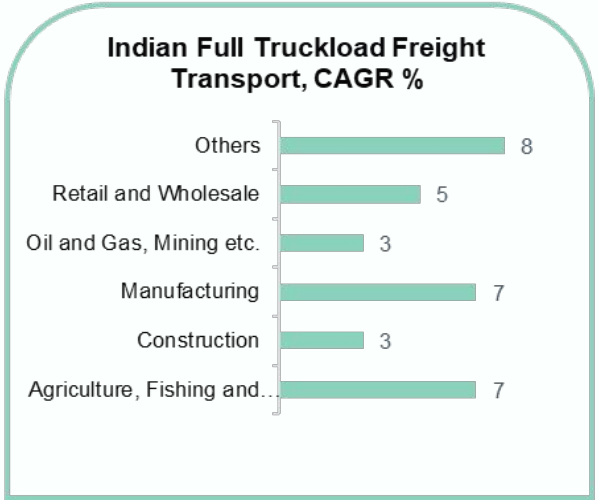
Despite being 86% unorganised, the road freight transport industry plays a significant role in contributing 5% to India's GDP



- Logistics sector contributes 13–14% to India's GDP amounting to INR 44.52L crore.
- Out of this INR 16.2L crore is contributed by the trucking industry



- The Unorganized sector holds an 86% share in road freight transport, contributing to 73% of the total freight transport.
- Increasing regulations in road freight pose challenges for unorganized businesses.



- The surge in e-commerce has boosted the demand for parcel delivery services, contributing to the growth of the logistics industry.
- This has also amplified the demand for long-haul trucking services.

Analyzing Challenges faced by different Stakeholders

Driver

- Work-life imbalance and bad working conditions
- **Low Income** with a lack of Job Security and respect in society
- **Unscheduled working hours** leading to health risks
- Road Related Issues and risk of life.

Truck Owners

- Not able to **optimize efficiency** and thus end up making less profit thereby give lower salary to drivers.
- Make inefficient use of trucks without much association with technology
- **Unable to connect** with a **larger** set of **consumers**
- Increasing Regulations

Shipper

- Not able to **track shipment**
- Trust issues with carrier side
- **Delayed shipments** due to inefficiency
- **Higher brokerage costs** and risk of theft/damage
- No provision for emergency transport at affordable prices
- **Absence of Less than Truckload** (LTL)

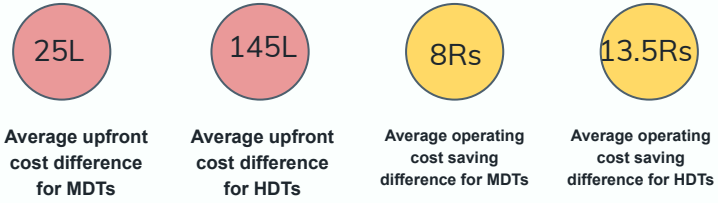
All these factors affect the overall efficiency of the trucking industry, leading to huge economic downturns, disrupting the supply chain network along with loss of lives and capital in road-related issues.

Trucks represent just 3% of the total vehicle fleet (including both passenger and freight) yet are responsible for a staggering 53% of PM emissions

Classification

Parameter	Diesel	Battery EV	Fuel cell
Market Size	99.1%	0.3%	Negligible
Market growth	4-5%	30-50%	50-60%
Cost per km	5 Rs	1 Rs	2 Rs
Payload capacity	30-35 tonnes	10-20 tonnes	15-20 tonnes
Refuelling time	5-10 minutes	60-120 minutes	60-120 minutes
Noise level(dB)	75-85	60-70	50-55
Co2 emissions	1.0-1.5	0	0

Break-Even Point Analysis



Clearly ZETs have a higher upfront cost than diesel trucks but lower operating costs per km .Thus we can recover the initial extra capital cost

Payback Period for ZETs vs. Diesel Trucks in India (assuming a truck travels for 300 km in a day for 300 days in a year)

MDT's

- Annual cost saving: ₹7,20,000
- Adjusted TCO difference: ₹22,00,000
- Payback period: 7.05 years

HDT's

- Annual cost saving: ₹12,15,000
- Adjusted TCO difference: ₹121,20,000
- Payback period: 22 years (approx.)

For complete calculation refer appendix

Unorganised Road Freight sector , marked by modest fleet sizes,high empty running rates, low utilisation,high transaction costs, and lower profit margins

Fleet size	The prevailing characteristic of unorganized road freight businesses is the ownership of relatively modest fleets, typically comprising **3-5 trucks**, reflecting a scale distinct from larger and more structured counterparts.
Cargo Load	Unorganized road freight encounters a significant hurdle with **empty running rates** soaring as high as **40%.** Substantial portion of trucks operates without cargo during return trips, poses a considerable challenge to operational efficiency.
Utilization	The sector grapples with a substantial utilization gap, exhibiting **40–50% lower annual truck utilization** compared to global standards further emphasizing the need for enhanced operational efficiency.
Transaction cost	The 'traditional' marketplace for unorganized road freight bears transaction costs, including brokerage, inventory, and fleet underutilization, totaling **USD 8-16 billion annually**. This represents a substantial **7-14%** of the total marketplace size
Profit Margins	There is distinct profit gaps between unorganized and organized road freight players. Unorganized entities secure **4-5% margins**, while organized counterparts command higher **10-15% margins**

ZET's reduces fuel costs by 46% over the vehicle's lifetime which can lead to 17% save in logistics costs over the vehicle's lifetime

Factor focus during adoption of EV's

Charging infrastructure distribution

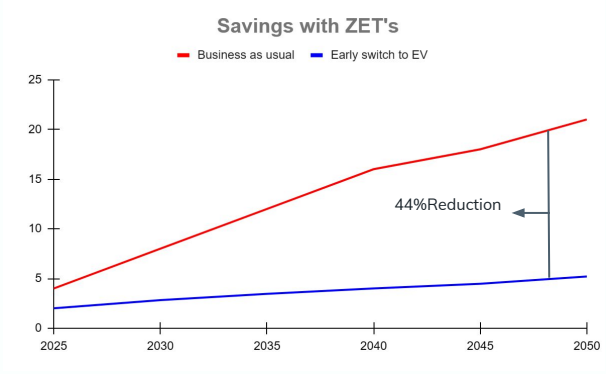
- Establishing a comprehensive charging network strategically placed along major transportation routes and distribution centers.
- Ensuring fast-charging capabilities to minimize downtime for electric trucks.
- Targeting a charging station density that supports the operational needs

Technology improvement

- Research and development efforts to enhance battery technology,
- Integration of advanced telematics and connectivity solutions for real-time monitoring and optimization of electric truck performance.
- Collaborating with technology partners.

Improved cost,speed and efficiency

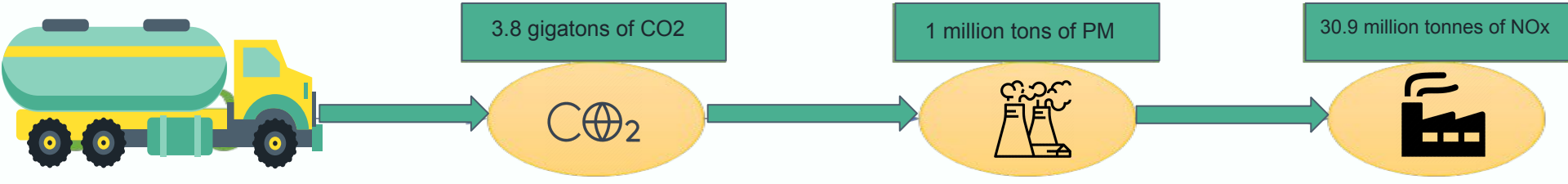
- Achieving economies of scale through bulk purchasing of electric trucks and charging infrastructure components.
- Monitoring and leveraging government incentives, subsidies, and tax credits for electric vehicle adoption.
- Conducting life cycle cost analysis



Possible reduction of 44% on switching to ZET

Shifting to zero-emission technologies (ZETs) will enable India to reduce its reliance on oil imports, fostering energy independence and environmental sustainability..

If 100% ZET sales penetration by 2050



The battery-swapping technology sector has raised an impressive $16,17,61,883 funding underscoring the significant demand and potential within this sector

Solving for lower payload in ZET's

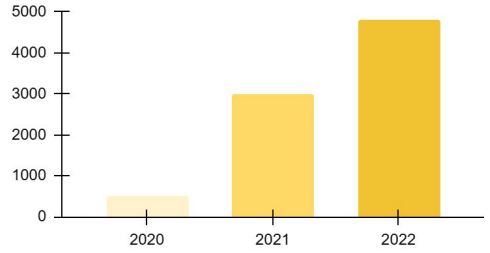
Partnership with Battery swapping companies

This Technology provides an alternative strategy to charging electric vehicles. It allows EV operators to swap their battery near the end of its state of charge with a new battery at battery swapping stations. **China has witnessed a growing momentum of battery swappable HDTs over the past two years**

Reasons for this growth

1. Faster charging times
2. Lower upfront cost
3. Shifted responsibility of battery ownership to swapping operatora

Battery swappable HDT's



Proposed strategy

Synergy: Diesel-Electric Hybrid Model

XYZ Logistics will lead a transformative shift, strategically renting diesel trucks from the unorganized sector initially

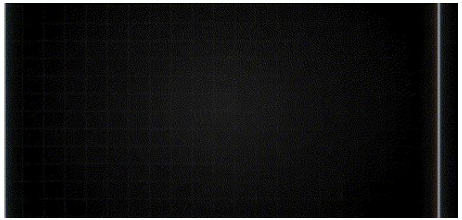
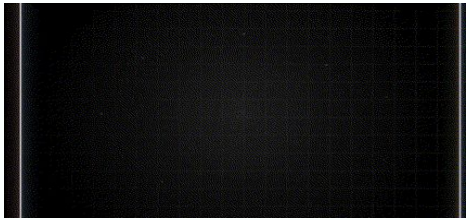
Simultaneously, we will invest in cutting-edge electric vehicles, aligning with industry data projecting a surge in electric truck adoption.

We will use E.V trucks for intra-city operations due to their reduced distance of travelling
Diesel trucks will be used for inter city operations
We will also work on data driven optimization to regulate intercity routes for E.V when charging infrastructure is developed sufficiently

Benefits

- Penetration into existing(diesel) and new(E.V) trucking industry
- Long term investment into Electric Vehicles
- Reduced initial capital cost
- Low operating costs per km(due to electric as well as diesel)

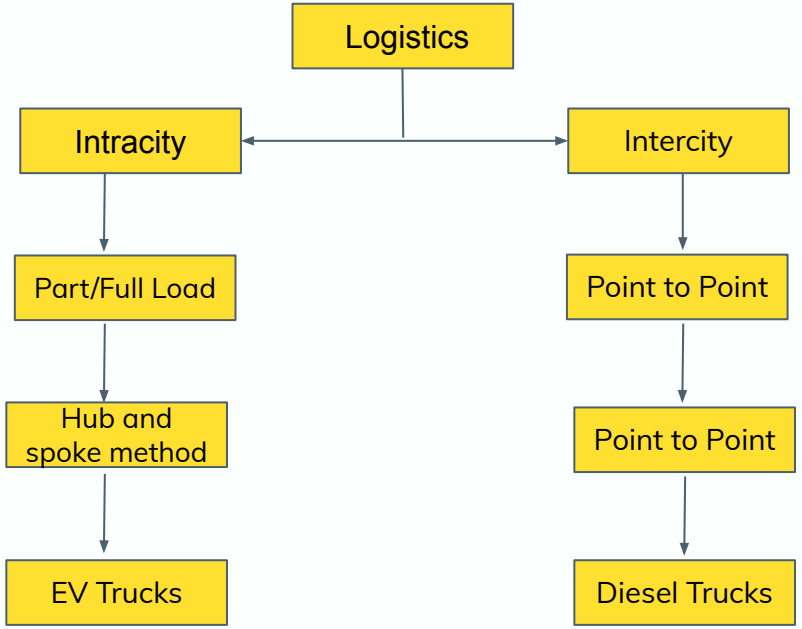
Hub & Spoke and Point to Point are the conventional supply chain models, creating an optimum balance will benefit XYZ Logistics

Feature	Hub and spoke	Point to Point
Video Illustration		
Structure	Central hub connects directly to individual nodes (vehicles, warehouses)	Data can flow across multiple paths, increasing redundancy and resilience
Data Flow	Information routed through the central hub, creating bottlenecks and points of failure	Data can flow across multiple paths, increasing redundancy and resilience
Flexibility	Limited ability to adapt to changes in network conditions (traffic, disruptions)	Highly adaptable to changing conditions as data can reroute around disruptions
Scalability	Expansion requires adding more spokes to the central hub, causing congestion	Can easily expand by adding more nodes without impacting existing connections
Cost	Lower upfront cost, potentially higher operational costs due to inefficiencies	Higher upfront cost for infrastructure, lower operational costs due to increased efficiency
Examples	Airlines , Blackbuck etc	Delhivery

A model using both Hub & Spoke for intra-city logistics and Point to Point for inter-city.

Major points to be followed

- Truck Driver's regulation for intercity and intracity operations to maintain efficiency
- EV trucks have a reduced payload ,and travel less distance
- Diesel trucks pollute the environment and have much low government support



Utilizing Diesel Trucks for Intercity Logistics:

- Since diesel trucks perform better on long routes we will use them for intercity logistics.
- These trucks are the ones that are registered on our platform and are owned by Unorganized Business truck owners.

Leveraging EV Trucks for Shorter Routes:

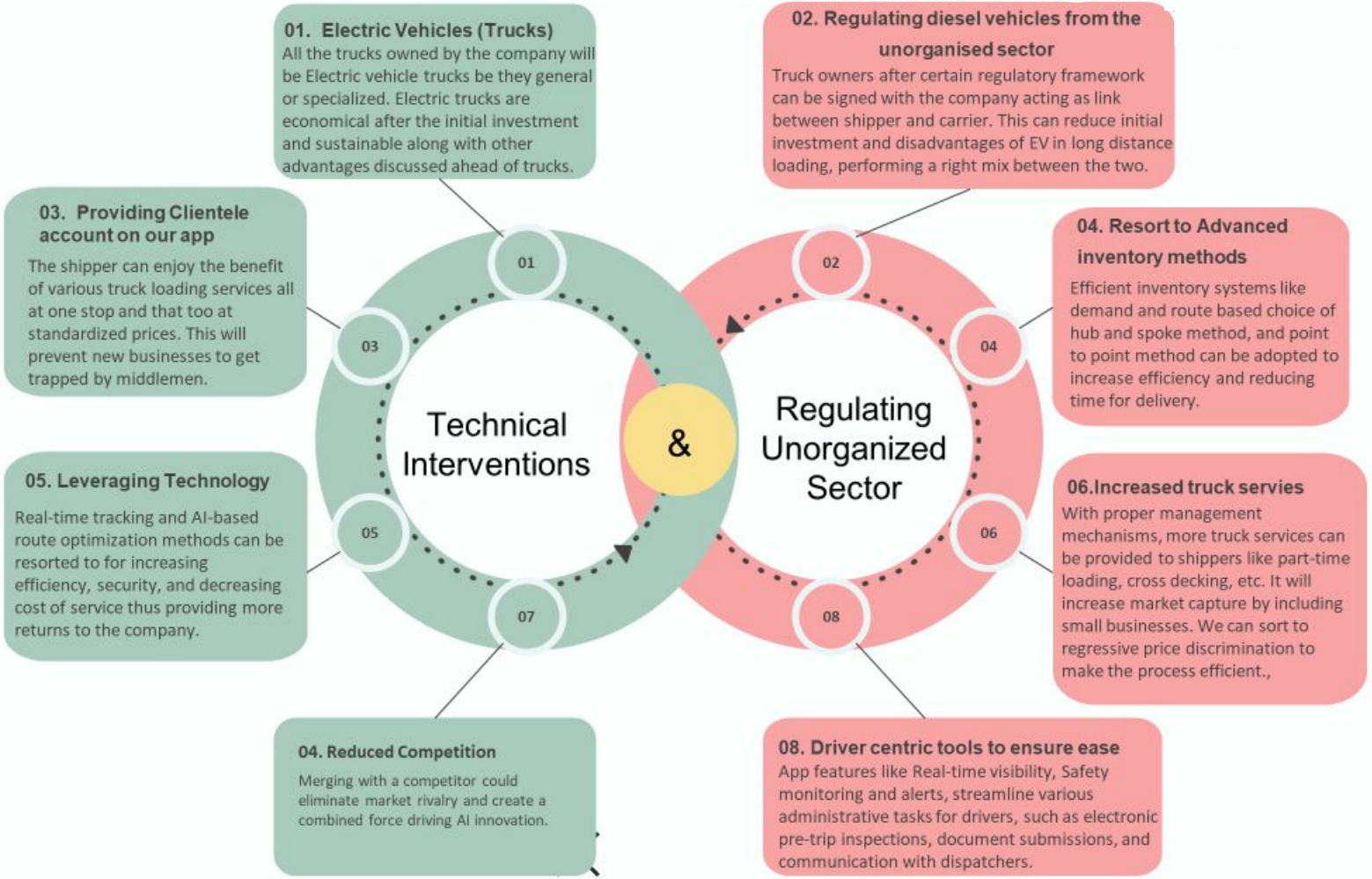
- Enhanced efficiency on shorter routes due to cost-effectiveness, lower load capacity, and advanced technologies like regenerative braking.

Point-to-Point Transport for Decent Capacity Goods:

- Direct transport of goods with capacities comparable to a normal truck's maximum capacity.

Hub-and-Spokes Method for Lesser Capacity Goods:

- Transporting goods from the shipper's location to a central hub using EV trucks.
- Aggregating goods from multiple shippers at the hub.
- Loading consolidated shipments onto a single diesel truck for efficient transportation to the desired destination.


01. Electric Vehicles (Trucks)
All the trucks owned by the company will be Electric vehicle trucks be they general or specialized. Electric trucks are economical after the initial investment and sustainable along with other advantages discussed ahead of trucks.
02. Regulating diesel vehicles from the unorganised sector
Truck owners after certain regulatory framework can be signed with the company acting as link between shipper and carrier. This can reduce initial investment and disadvantages of EV in long distance loading, performing a right mix between the two.
03. Providing Clientele account on our app
The shipper can enjoy the benefit of various truck loading services all at one stop and that too at standardized prices. This will prevent new businesses to get trapped by middlemen.
04. Resort to Advanced inventory methods
Efficient inventory systems like demand and route based choice of hub and spoke method, and point to point method can be adopted to increase efficiency and reducing time for delivery.
05. Leveraging Technology
Real-time tracking and AI-based route optimization methods can be resorted to for increasing efficiency, security, and decreasing cost of service thus providing more returns to the company.
06.Increased truck servies
With proper management mechanisms, more truck services can be provided to shippers like part-time loading, cross decking, etc. It will increase market capture by including small businesses. We can sort to regressive price discrimination to make the process efficient.,
04. Reduced Competition
Merging with a competitor could eliminate market rivalry and create a combined force driving AI innovation.
08. Driver centric tools to ensure ease
App features like Real-time visibility, Safety monitoring and alerts, streamline various administrative tasks for drivers, such as electronic pre-trip inspections, document submissions, and communication with dispatchers.
01
02
03
04
05
06
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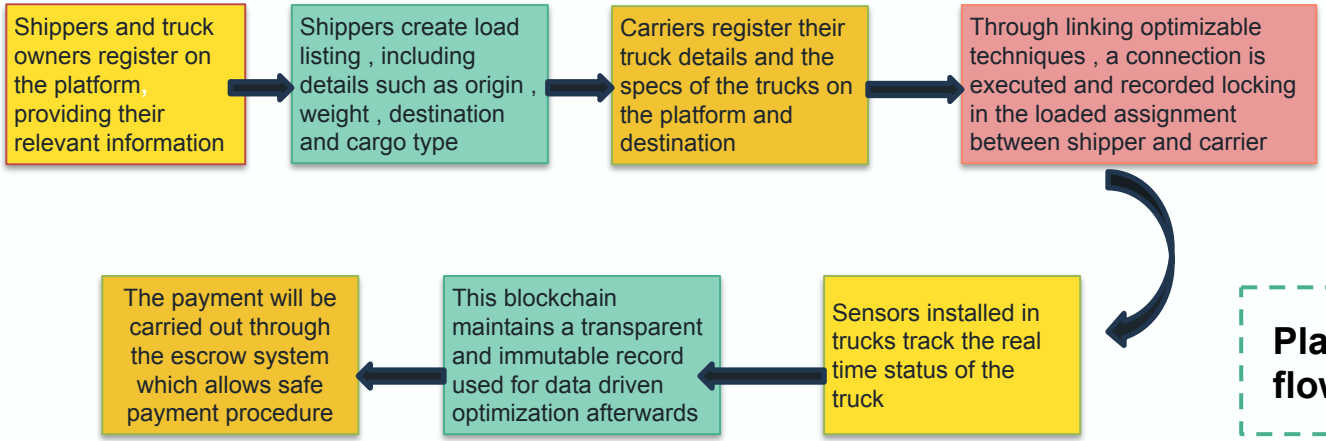
Technical Interventions
&
Regulating Unorganized Sector

XYZ Portal - Shippers and carriers can leverage this platform to seamlessly connect, adhering to specified guidelines, facilitating the efficient and organized onboarding of participants from the unorganized trucking sector



Platform features and user flow

Guidelines to be followed

Shipper	Truck owner
• The shipper must have the insurance of the goods to be transferred along • They should have a membership with the company • **Reason for insurance**- This is to make ourselves sure that we are connected with **a genuine** truck owner for transporting our goods	• The truck owner must be having a minimum of 3 or more trucks • They should have registered caution money • **Reason for "3"**-More than **75%** of the truck owners have less than 3 trucks.Thus tapping into the rest allows us to identify the **potential serious truck owners** who genuinely want to be a part of this .

Digitization of unorganised sector will include features to increase supply chain efficiency

Mobile Apps

integrations with third-party applications and services that are commonly used by drivers. This can include navigation apps, fuel management tools, and other services that contribute to a seamless and efficient workflow

User-Friendly Interface

interface that is intuitive for drivers and truck owners. The platform provides easy access to essential information, allowing drivers to navigate through the system with minimal effort.

GPS Tracking & Route Optimisation

for fleet management,monitoring the location and activity of your entire fleet in real-time, allowing you to optimize routes, reduce downtime, and improve overall efficiency.

Vehicle Inspection

examine the external and internal features of the vehicle for anything that looks damaged or defective. For the driver, inspectors are checking the documentation required for them to be legally operating their truck.

Load Matching

Digital freight matching allows shippers, brokers, and 3PLs to find trucks and drivers with available capacity to transport truckload and less-than-truckload (LTL) freight shipments.

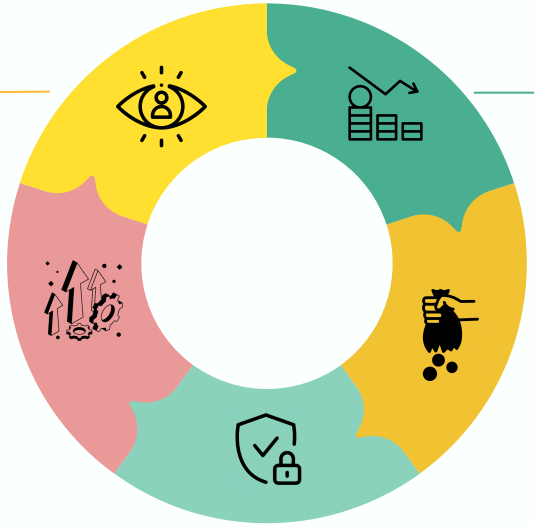
Third party integration

To ensure secure and post delivery payments, integrating with 3rd party softwares will be implemented

How Digitization will help Trucking Industry

Transparency and Visibility

allows for proactive problem-solving, faster load acceptance, and improved allows for problem-solving, faster load acceptance, and improved communication with customers



Cost Reduction(10-15%)

eliminate manual paperwork for invoices thus reduces errors and document storage.This reduces empty miles, fuel consumption, and driver time, leading to lower transportation costs.

Increase in Operational Efficiency

by consolidating the industry, there would be fewer, larger trucking companies. This would make it easier to coordinate shipments and track deliveries

Minimizing Cash Leaks

Using algorithms to find the most efficient routes based on real-time traffic, weather, and vehicle availability.

***Samsara, a fleet management platform, claims their platform can reduce fuel costs by 6% and operational costs by 12%**

Truckbase, a transportation management system, estimates a 30% reduction in administrative costs through automation

Security and decrease in Fuel Theft

Integrated fuel card systems track fuel purchases and consumption in real-time. This helps identify unauthorized usage, fuel theft

Unit Economics for Shippers And Truck Owners

FOR SHIPPERS

Brokerage Corrections:
Standardized brokerage fees leading to lower brokerage cost because of low operation cost due to improved efficiency in system.

Part Load Truck and Specialization:
Providing options of part load leads to increase in profit and resources optimization. While specialization leads to improved safety along with reduced environmental impact.

Tracking and Tracing:
Real time visibility with optimized routes and schedules. It also reduce chance of theft and losses. Improved transparency and customer service.

FOR TRUCK OWNERS

Efficiency of Operations:
Improved logistics management, resources will be utilized, improved route planning contributing to overall operational efficiency.

Compliance with Regulations:
Adhering to rules and regulations helps truck owners avoid penalties, legal issues, and disruptions to their operations.

Tracking and Tracing:
Optimizing routes and increase in efficiency of fleet.Streamlines administrative processes, reduces manual paperwork, and facilitates accurate billing and invoicing.

Addressing the opportunities for different stakeholders

Truck owners will have to sign regulatory framework with the company to register their trucks with us which includes **Caution money/ truck paper** . This is done to ensure age , condition and efficiency , thereby ensuring trust.

Company

- Can initialize with low investment.
- Investment only in EV
. to make it sustainable for long run.

Driver

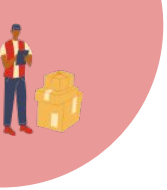
- Provision of safety
- Switching between schedules (intra-inter) to avoid fatigue
Better living conditions as facility of apps ,AC
Better income

Truck Owner

- Increase in efficiency and thus making profit
- Safety
- All time orders
- Increase in unit economics incase of part loading
Proper tracking facility

Shipper

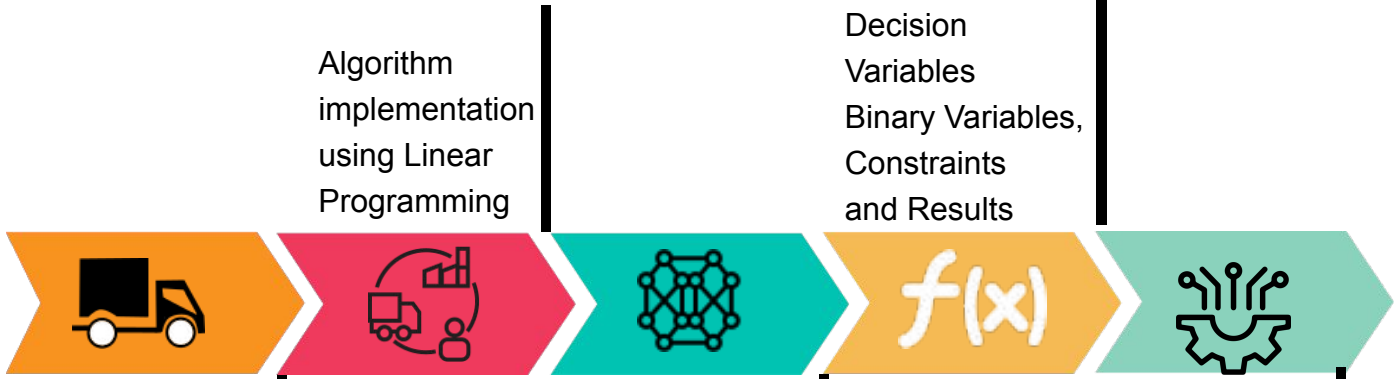
- Urgent delivery options
- Portal membership and offers
- Tracking and tracing facility
- Builds trust



Daily Dynamic Schedule Optimisation

Algorithmic approach to solving key logistics issues

Timeline


Discussion on the problems of inefficient logistics supply chain
Algorithm implementation using Linear Programming
Explanation of Algorithm for Supply chain optimisations
Decision Variables Binary Variables, Constraints and Results
Future Prospects and expansion of our model

Identifying problems and objectives for Real-Time optimisation of supply chain.

Getting maximum revenue from Trucking industry is relatively challenging, owing to the dynamic trends in human resources, machinery and demand

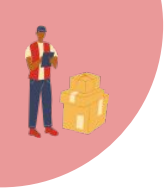
Problems identified

- Age of truck impacts operating cost
- Limitations to human resources
- Compliance of safety norms
- Inefficient goods allocation leads to delay

Algorithmic and Excel approaches solve 4 main objectives

- Maximizing Revenue/hour travelled
- Optimum Truck utilization
- Goods Type allocation to trucks
- Revenue Tiering model for product load

Creating a dynamic daily schedule for each truck to fulfill all safety needs and ensure revenue remains the main purpose of Trucking industry



Genetic Algorithm for creating Dynamic Scheduling of Goods based on product types and constraints on trucks

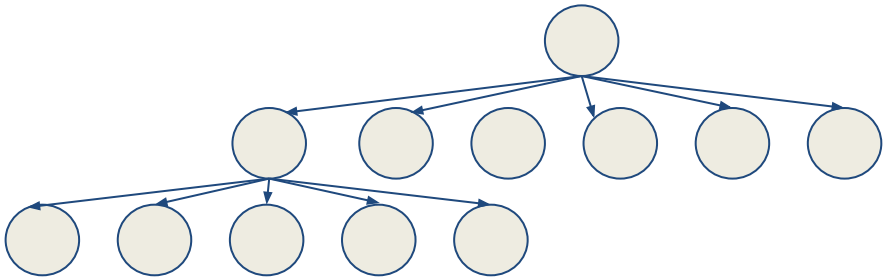
As discussed earlier, **Cross-Docking** as part of our solution for faster delivery and utilization of aged trucks for shorter distance to maximize revenue, to solve the challenge of efficiency decrease and further scheduling of packages further.

We can implement Genetic Algorithm to build on the best solution for scheduling deliveries.

Assumptions made:

- An **average of total 500 delivery** of different products each day (Can be changed as per dynamic demand, in the code)
- As per other truck companies, goods can be divided into --

  30% Perishable Goods, 20% electronics, 40% General Goods, 10% Fragile Goods
- The company has **access to powerful GPU RAMs** to perform iterations to find best solution
- Out of 80 trucks assuming:
  - 25 Refrigerator Trucks
  - 10 Flatbed Trucks
  - 25 Box Trucks
  - 5 Jumbo Trucks
  - 15 Pickup Trucks



Genetic Algorithm with parameters assigns each truck daily with products and allots hours to ensure maximum revenue

Methodology

- Randomly assigning Truck ID to category of Trucks for transport

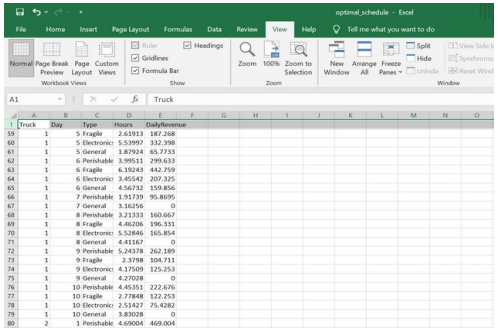
  Population Size: 40x25+80x20+60x25+10x10= 4200

  Generations: 100 (loops to improve scheduling)

  Mutation Rate: 0.1

  Elitism Rate:0.25 (top 25% of soln will be build upon in in next loop)

- These parameters can be varied depending on the no.of goods and computing powers



Daily Schedule for Truck 1 with Revenue/trip using GA

[Click here to view the GA on 100 deliveries for 10 days for 10 trucks]

Constraints and Parameters

Truck ID, Revenue Constraints, Good Types are defined

Population Generation

Number of possible solutions (Permutation Combination)

Genetic Algorithm Loop

Uses elitism to find best performing population

SBX applied to find new generations

Fitness Calculation

For each generation fitness = sum of Total revenue by each truck

Best Solution Selection

[Click here to get Colab File link for GA]

Scheduling approach with Mathematical Constraints and Linear Programming and future scope

Objective : Maximize Z=i∑j∑k∑(Revenueijk⋅xijk)

Where,

- i is ith truck, j is jth good type and k is hours
- x-- Binary Variable, whether truck is occupied or not

Maximize Revenue:

- Maximize $Z = \sum_{i,j,k}(\text{Revenue per hour} \times x_{ijk})$

Constraints:

Truck Daily Limit:

- $\sum_j x_{ijk} \leq 16$ for all i and k

Monthly and Weekly Minimum Running Hours:

- $\sum_j x_{ijk} \geq 200$ for all i and k
- $\sum_{j \text{ in a week}} x_{ijk} \geq 50$ for all i and k

Goods Type-Specific Constraints:

- Perishable: $\sum_j x_{i,j,\text{Perishable}} \geq 3000$ and $\sum_j x_{i,j,\text{Perishable}} \leq 4000$ for all i
- Fragile: $\sum_j x_{i,j,\text{Fragile}} \geq 4000$ and $\sum_j x_{i,j,\text{Fragile}} \leq 6000$ for all i
- Electronics: $\sum_j x_{i,j,\text{Electronics}} \geq 5000$ and $\sum_j x_{i,j,\text{Electronics}} \leq 8000$ for all i
- General Goods: No constraints

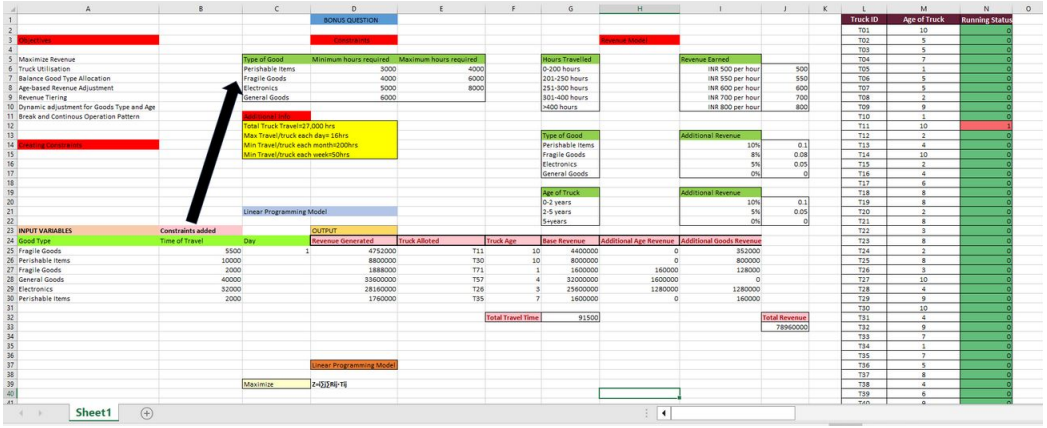
Break Requirements:

- Implement specific break patterns based on the nature of goods.

Overall Monthly Travel Limit:

- $\sum_{i,j,k}(\text{Travel time per hour} \times x_{ij} < 27,000$

Excel sheet for dynamically allocating trucks based on product types and hours .



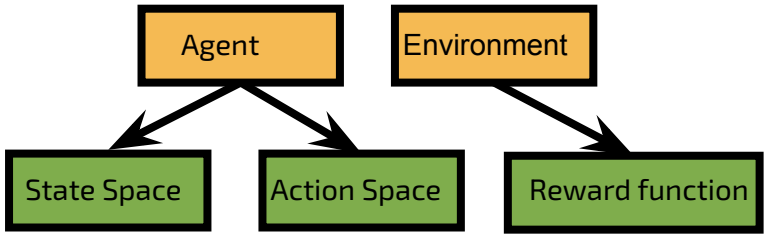
[Excel sheet for Real-Time Truck allotment]

Enhancing approaches with Reinforcement Learning with larger dataset, other approaches and related limitations

The problem of Truck dynamic scheduling can also be solved using Reinforcement Learning

Huge computational requirement, RL involves training an agent to make decisions (herein the daily optimised schedule) by interacting with environment.

Decision Variable : xijk (i,j,k remains same as discussed in slide 06)



State of truck, good type, hours of travel

Binary Decision (which truck will carry what good at what time?)

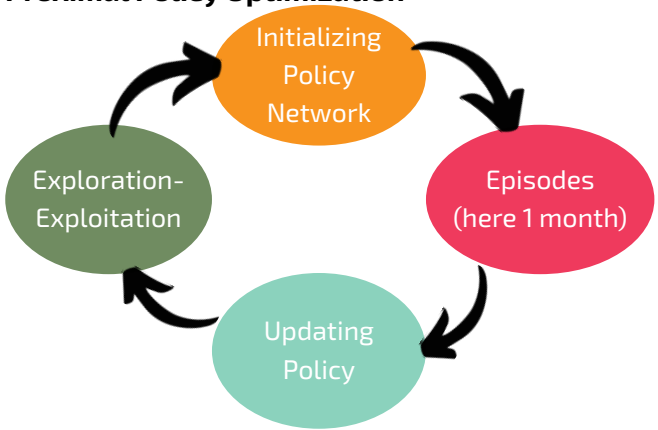
Revenue earned by trucks

Selecting the best RL algorithm

Q-Learning

Deep Q-Learning

Proximal Policy Optimization



Implementing RL would require months of training an agent, if we have access to larger dataset. Also, a colab link to iterative approach using pandas to solve the dynamic scheduling is implemented. LLM chatbot creation for query answering using the real time schedule generated by model

Appendix & References

- ZETs vs. Diesel Trucks in India: Payback Period Analysis

Scenario:

- Daily travel: 300 km
- Annual usage: 300 days (90,000 km)
- Cost differences:
  - MDTs:
    - Upfront cost difference: ₹25 lakh
    - Operating cost difference per km: ₹3.50
  - HDTs:
    - Upfront cost difference: ₹145 lakh
    - Operating cost difference per km: ₹6.00
- TCO Reduction:
- MDTs: 12% lower for ZETs compared to diesel trucks
- HDTs: 16% lower for ZETs compared to diesel trucks

Calculations: MDTs:

Annual cost saving::-

  - Saving = ₹3.50/km * 90,000 km =₹3,15,000
- Adjusted TCO Difference:
  - Upfront cost difference: ₹25,00,000
  - TCO reduction: 12%
  - Adjusted difference = ₹25,00,000 - (12% * ₹25,00,000) = ₹22,00,000
- Payback Period:
  - Payback period = (Adjusted TCO difference / Annual saving = ₹22,00,000 / ₹3,15,000 **= 7 years**

For HDTs:

- Annual cost saving:
  - Operating cost difference: ₹6.00/km
  - Annual distance: 90,000 km
  - Saving = ₹6.00/km * 90,000 km = ₹5,40,000
- Adjusted TCO Difference:
  - Upfront cost difference: ₹145,00,000
  - TCO reduction: 16%
  - Adjusted difference = ₹145,00,000 - (16% * ₹145,00,000) = ₹121,20,000
- Payback Period:
  - Payback period = Adjusted TCO difference / Annual saving = ₹121,20,000 / ₹5,40,000 = **22.4 years**

A Genetic Algorithm Approach for Multi Objective Cross Dock Scheduling in Supply Chains - ScienceDirect

Appendix & References

Dynamic Scheduling Optimisation:

Research Papers read:
Science Direct

https://intapi.sciendo.com/pdf/10.2478/v10238-012-0039-2

Reinforcement Learning :
https://pure.tue.nl/ws/portalfiles/portal/203677931/Master_Thesis_Remco_Coppens.pdf

Excel Solver :
https://www.youtube.com/watch?v=rQt_SWrOktg

Genatic Algorithm:
https://www.poms.org/archive/conferences/Meeting2003/2003A/Papers/PSC-12.1.pdf

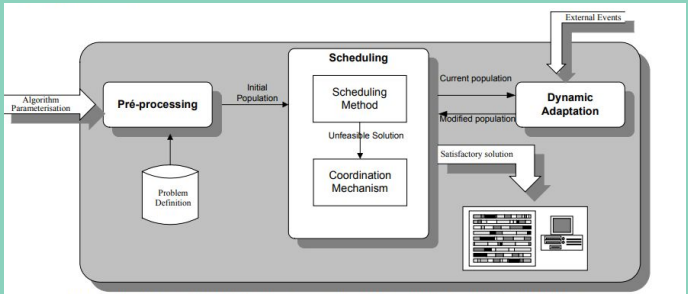


Figure 4 - GA-based Scheduling System for Non-Deterministic Scheduling Problems

https://www.sciencedirect.com/science/article/pii/S2212827120307708

Implementation of dynamic scheduling using RL agent

Classification of trucks used

- Truck movements are typically categorised based on vehicle weight, freight movement, and make
- Gross vehicle weight rating (GVWR) of a truck is the maximum load it can carry plus the weight of the truck itself (curb weight).

- Light-duty trucks: <3.5 tonnes
- Medium-duty trucks: 3.5–12 tonnes
- Heavy-duty trucks: >12 tonnes

Niti aayog report .pdf (niti.gov.in)

https://www.sciencedirect.com/science/article/pii/S2351978920304261#:~:text=In%20this%20paper%2C%20Genetic%20Algorithm,traveling%20distance%20of%20material%20handling