The Unsolvable Equation of Fleet Management

How Data Optimisation Delivers a Definitive Answer

Presentation By Medha Saha, Nadia González Guarner, Gema Lozano Soto

Introduction

"Our project slide sets the stage for the 'Travel Startup Paradox.' We operate in a space where booking too early is a financial risk, but booking too late is a service risk. As our graphics show, we are caught between the 'Ghost Bus'—where we pay for empty seats—and the 'Stranded Customer.'

This project moves away from intuition and toward a mathematical resolution. By the end of this presentation, you will see how we use a specific total cost of €15,800 as our benchmark for efficiency and how seasonal data from Barcelona dictates our daily operations."

Every Logistics Manager Faces a Fundamental Conflict

We are tasked with achieving maximum cost efficiency, yet we must serve a customer base with highly volatile & unpredictable demand.

THE GOAL: COST EFFICIENCY

Larger groups & full vehicles drive down per-passenger costs.

THE REALITY: DEMAND VOLATILITY

Demand fluctuates wildly, peaking seasonally & on weekends.

The Financial Penalty for Mismatched capacity is Severe

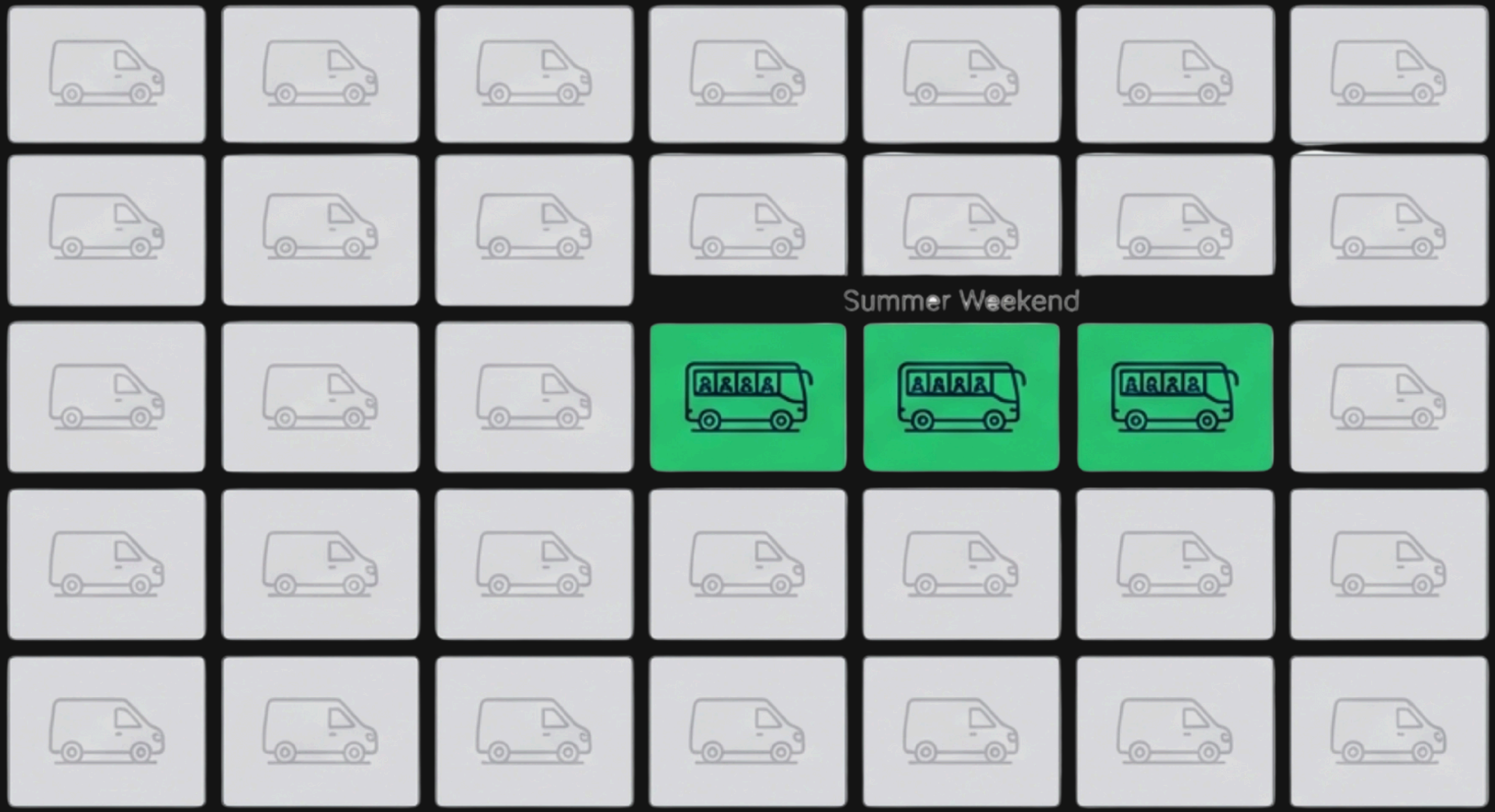
Nearly 45% reduction

in per-passenger cost from small to large groups .

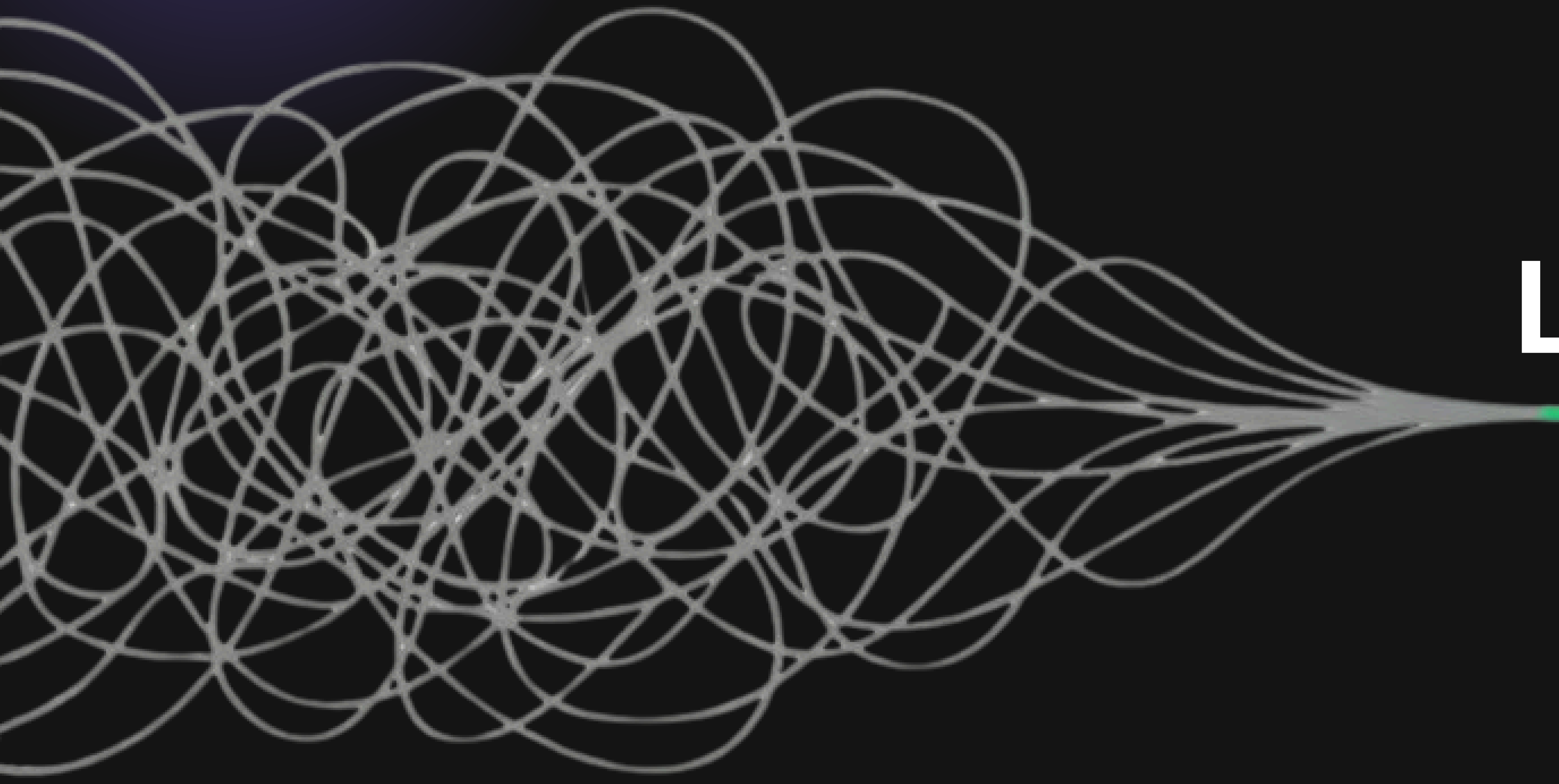
This gap highlights a strong mathematical incentive to maximize vehicle occupancy.
Every trip that falls short of the benchmark average cost of €30.83 represents lost profit.

The Inefficiency Trap: A Fleet Built for Peak Demand Guarantees Off-peak Waste

The conventional approach of maintaining a fleet large enough
to handle maximum potential demand is a direct route to poor
utilisation. For the majority of the year, expensive vehicles sit idle,
depreciating in value while contributing nothing to the bottom line.



This isn't a people problem; It's a Maths problem with a Definitive Solution



Linear Programming

Instead of relying intuition or historical precedent to solve this complex equation, we can use a proven mathematical method to find the single best outcome. This method is called Linear programming.

Deconstructing Linear Programming: A Framework for Optimal Decisions

LP provides a structure to define your goal, your opinions, and your limitations in purely mathematical terms.

Objective Function

What is your ultimate goal?

This isthe mathematical expression of what we want to achieve. (e.g., Minimise total cost).

Decision Variables

What choices can we make?

These are the levers we can pull. (e.g., The numbers and type of vehicles to deploy).

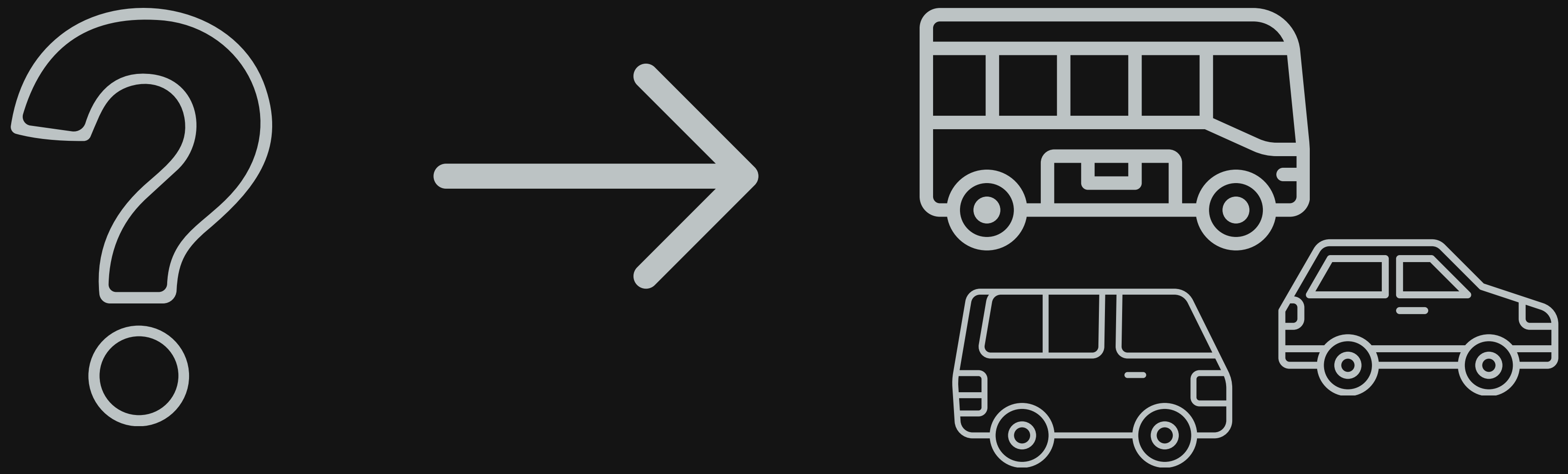
Constraints

What are the rules we must follow?

These are the real-world limits on our choices. (e.g., We must meet passenger demand; we can't use half a bus).

Let's make it real: A practical case Study

The Mission: Find the most cost-effective vehicle combination to transport exactly 40 passengers.



Translating the business Problem into a mathematical Model

VAN

Capacity: 8 Passangers
Cost per Trip: €200
Cost per seat: €25.00

MINIBUS

Capacity: 20 Passangers
Cost per Trip: €350
Cost per seat: €17.50

BUS

Capacity: 50 Passangers
Cost per Trip: €600
Cost per seat: €12.00

Translating the Business Problem into a Mathematical Model

We can now express our mission using the LP framework

// Decision Variables

Let v = number of Vans deployed

Let m = number of Minibuses deployed

Let b = number of Buses deployed

// Objective Function: MINIMISE TOTAL COST

Minimise C = 200v + 350m + 600b

// Constraints: THE RULES OF THE ROAD

8v + 20m + 50b ≥ 40 (The Demand Constraint: We must accommodate at least 40 people) v, m, b must be whole numbers (The Integer Constraint: We cannot deploy fractions of vehicles)

The Model's Verdict is Unambiguous & Optimal

Optimal Solution: v=0, m=0, b=1

Total Passangers accomodatied: 50

Total Cost: €600

Deploy 1 Bus

Why One Bus? The Logic of Per-seat Optimization

While other combinations might seem cheaper at first glance (e.g. two minibuses for €700). The LP model correctly identifies that the Bus offers the lowest cost per required seat. It fulfills the 40 passengers constraint at the most efficient rate.

2 X Minibus

Cost: €700 | Capacity: 40

1 X Bus

Cost: €600 | Capacity: 50

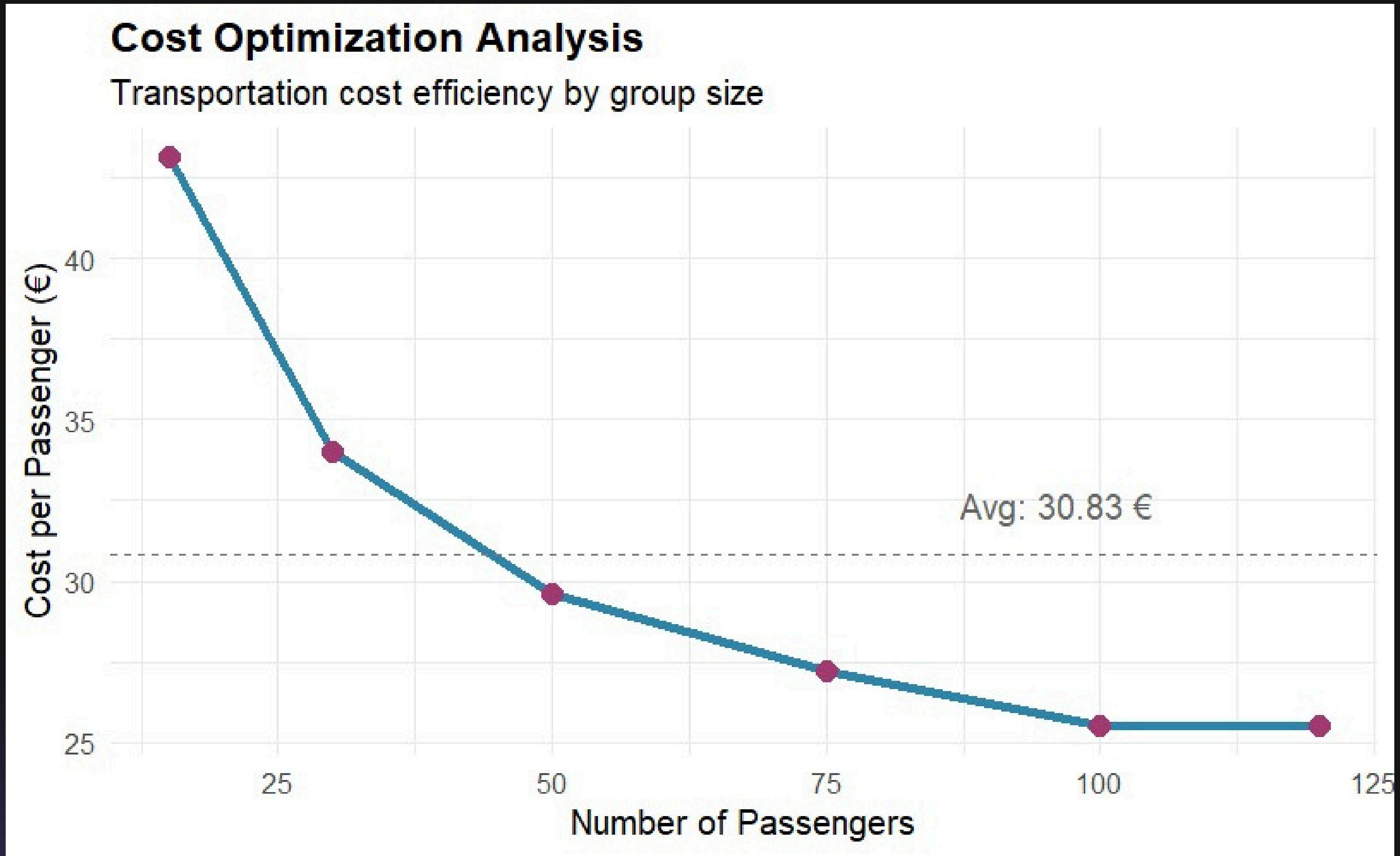
Prioritises the asset with the lowest per-seat cost (€12.00) capable of meeting the demand

Cost Optimization Analysis

Fixed Cost Dilution: Expenses like driver wages, insurance, and fuel are spread across more people, making larger groups much more profitable or cost-effective.

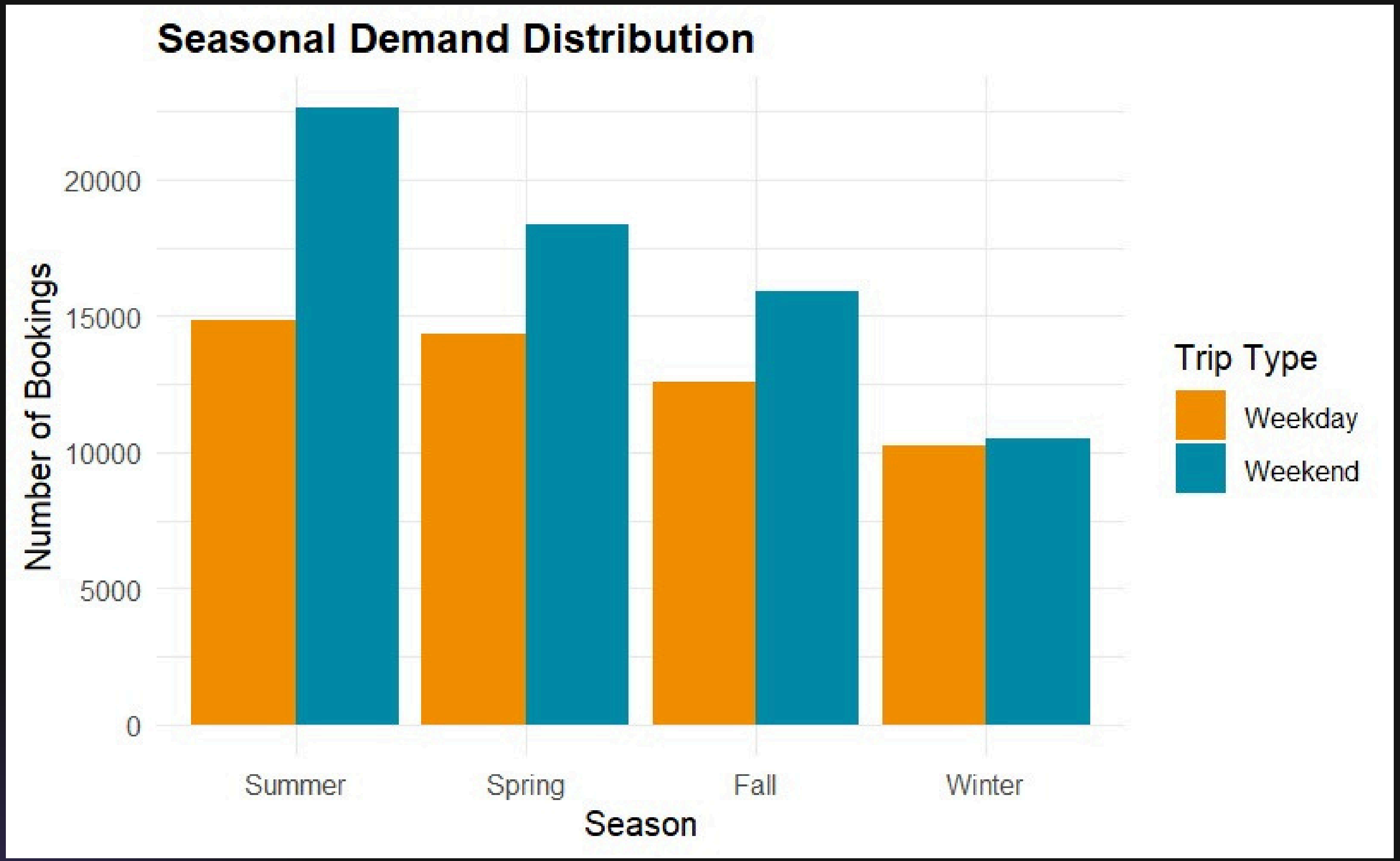
The "Efficiency Elbow": The steepest savings occur when moving from 1 to 5 passengers. After a certain point, the curve flattens, meaning adding more passengers yields "diminishing returns" on cost savings.

Strategic Goal: For a fleet manager, the goal is to maximize vehicle utilization to move as far to the right of the curve as possible, avoiding the high-cost "small group" zone.



Seasonal Demand Distribution

The Breakdown:
The Wave : Your daily demand. It fluctuates based on peaks (busy days) and valleys (slow days).
The Flat Line: Your Owned Fleet Capacity.
The "Make" Area (Below the line): Demand met by your own vehicles. You want this area to be high so your assets aren't sitting idle.
The "Buy" Area (Above the line): Peak demand that exceeds your capacity. This is when you rent vehicles or hire subcontractors to fill the gap.



The Strategy:
A fleet manager's goal is to set the flat line at a level where you own enough vehicles to handle steady work, but not so many that you have "idle iron" during slow periods. You "buy" (outsource) the peaks to stay flexible and keep costs down.

Vehicle Fleet Economics

Seasonal Demand (The "When")

Peak Time: Summer weekends are your busiest periods, exceeding 20,000 bookings.

The Weekend Gap: Weekends consistently outperform weekdays across all seasons.

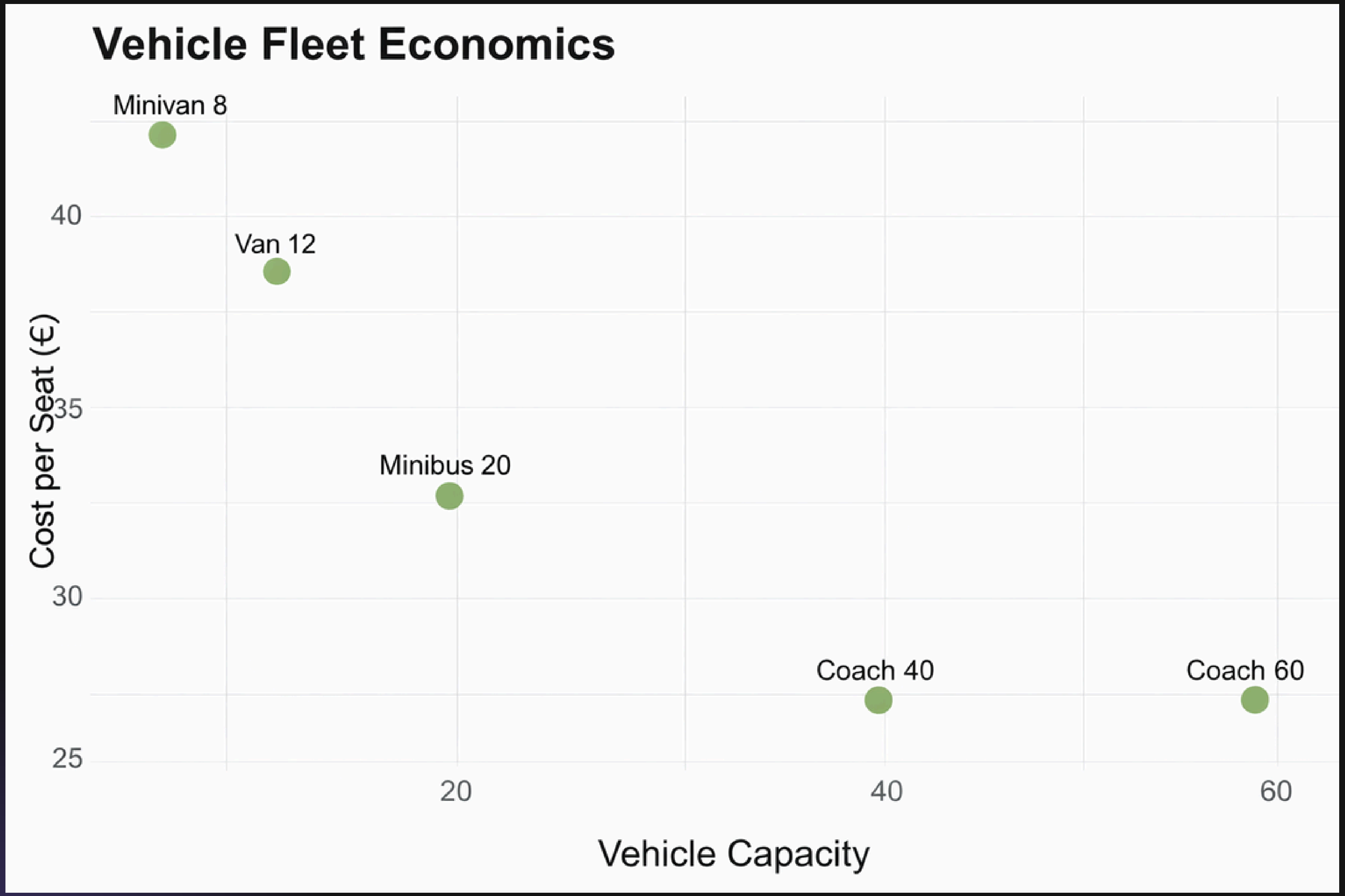
Maintenance Window: Winter is the ideal time for fleet servicing due to the lowest overall demand.

Fleet Economics (The "What")

Scale Efficiency: Cost per seat drops as vehicle size increases; a Minivan 8 is nearly twice as expensive per seat as a Coach.

The Sweet Spot: The Coach 40 offers the best value. Moving to a Coach 60 provides no additional cost-per-seat savings.

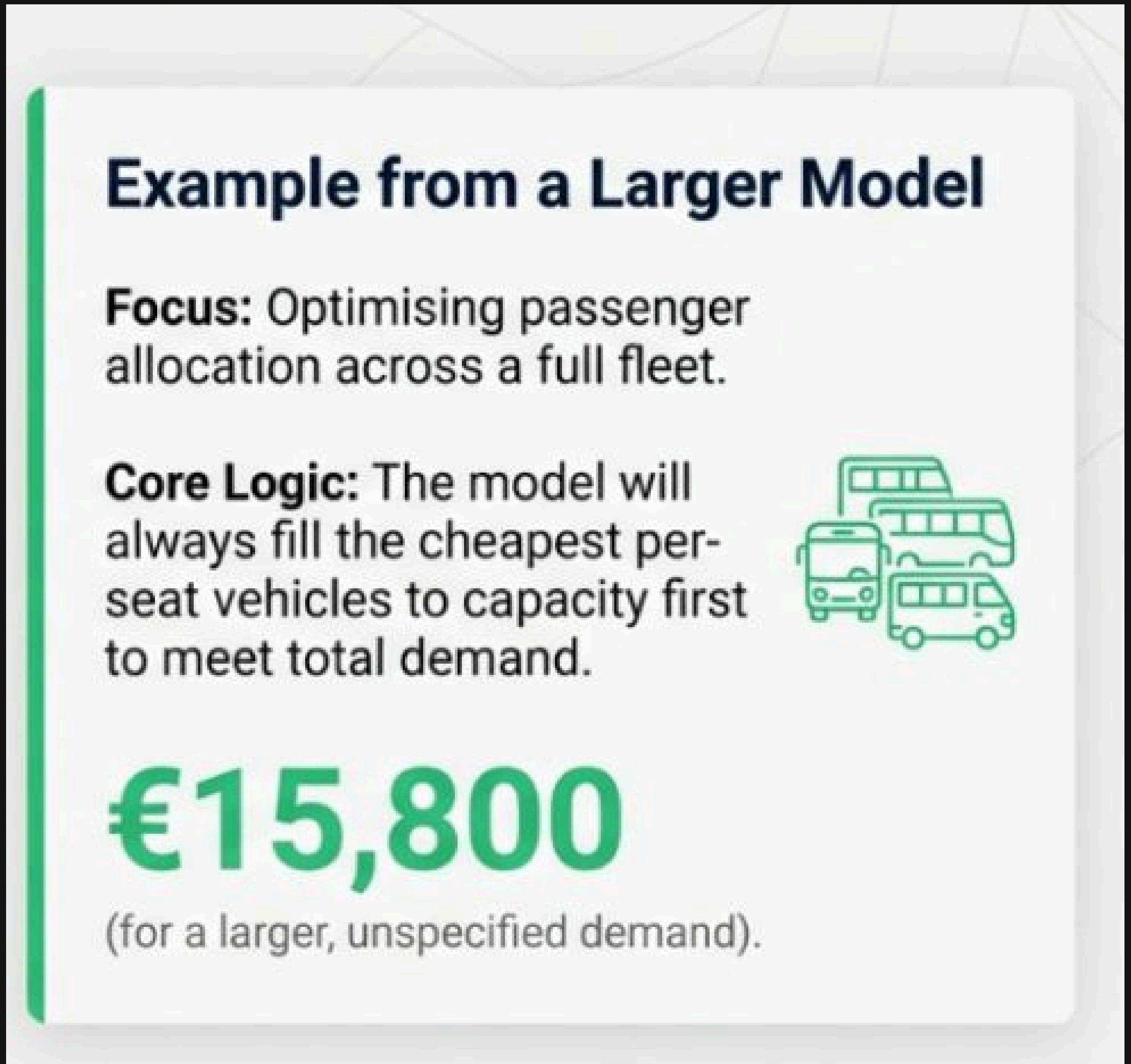
Action Plan: Use smaller vans for low-demand weekdays and prioritize large coaches for those high-volume summer weekends to maximize margins.



The Model is Versatile: It can Optimise for Occupancy First

An alternative LP model can be constructed to prioritise filling the most cost-effective vehicles to capacity before deploying others. This is crucial for larger, more complex scenarios.

For larger scale operations, this logic of prioritising the cheapest per-unit capacity first can lead to significant savings.



An Optimisation Model Is Only as Reliable as Its Input Data

The accuracy of the LP model's output is directly dependent on the quality of the data we provide. Garbage in, garbage out applies absolutely.

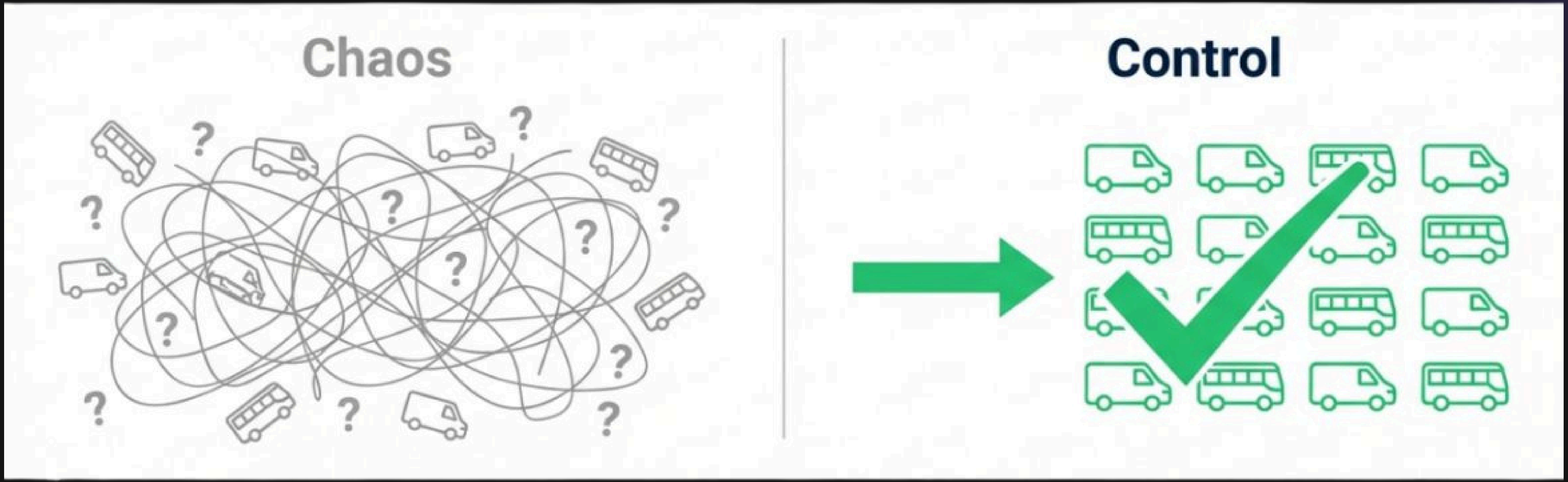
Actionable Requirement: To build an effective optimisation tool, organisations must commit to gathering precise, real-world data.

Key Data Points to Collect:

- ☑ Actual fuel costs per vehicle type
- ☑ True driver costs (salary, benefits, overtime)
- ☑ Vehicle rental or leasing fees
- ☑ Maintenance and depreciation schedules
- ☑ Accurate vehicle capacities

The Ultimate Advantage: Moving from Guesswork to Data-Backed - Data-Backed Certainty

Linear Programming is more than a calculation tool; it's a strategic framework. It transforms the complex, chaotic variables of fleet management into an unambiguous, lowest-cost solution. It replaces gut feeling with a reliable foundation for critical business decisions.



Sources

All data has been taken from Kaggle (an online platform where people analyze data, compete in data science challenges, and learn machine learning using real-world datasets):
https://www.kaggle.com/datasets/jessemostipak/hotel-booking-demand

Thank You So Much