BURRITO OPTIMIZATION GAME - GUROBI

BAN 630 OPTIMIZATION FOR ANALYTICS

TEAM MEMBERS:

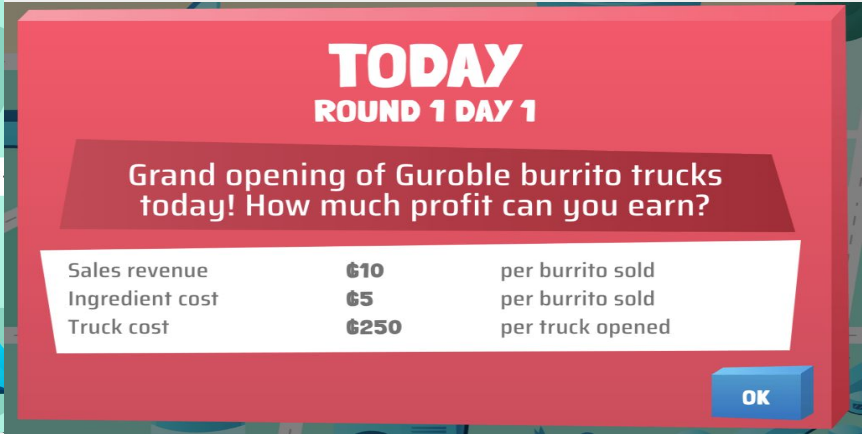
Khush Domadiya

Dharmi Kanth Cigiri

Mohanasundaram Murugesan

Amisha Farhana Shaik

Game Overview



Problem definition

Decision Variables:

- **Zi:** Binary variable, 1 if truck is open, 0 otherwise
- **Xij:** Binary variable, 1 if truck demand node, 0 otherwise

Objective Function: Maximize profit

- Maximize profit = (Revenue from burrito sales) - (Cost of opening trucks)

Constraints:

- Each demand node must be served exactly once.
- A truck must be open if it serves any demand node.
- Profit is affected by ingredient costs and truck setup costs.

Data Overview

1. Demand Node Data
(round1-day2_demand_node_data.csv)

- Customer locations & burrito demand
- Includes: ID, Name, (X, Y) Coordinates, Demand

2. Truck Node Data
(round1-day2_truck_node_data.csv)

- Potential truck deployment locations
- Includes: ID, (X, Y) Coordinates

3. Demand-Truck Relationship Data
(round1-day2_demand_truck_data.csv)

- Feasibility between trucks & demand nodes
- Includes: Demand ID, Truck ID, Distance, Scaled Demand

4. Problem Parameters
(round1-day2_problem_data.csv)

- Global parameters like pricing & costs
- Includes: Burrito Price, Ingredient Cost, Truck Setup Cost

Model Implementation

- The optimization model was implemented in Python using Gurobi.
- Data Preprocessing: CSV files loaded into Pandas DataFrames; dictionaries created for demand, truck locations, and feasibility constraints.
- Building Scaled Demand and Valid Pairs: Iterated through demand-truck data, adding valid pairs (i,j) to the scaled_demand dictionary and valid_pairs list if scaled_demand i,j is positive. This filtering improves model efficiency by considering only feasible truck-demand assignments.
- Defining Decision Variables: Binary decision variables xi,j created for each valid pair (i,j), ensuring only feasible truck-demand assignments are modeled. xi,j = 1 means truck i is assigned to demand node j, serving the exact number of burritos as per scaled_demand i,j.
- Key Takeaway: This two-step approach first identifies feasible assignments and then builds the optimization model using only those assignments.

Constraint Summary & Importance

- Scenario: Burrito truck business with three customer locations: demand1, demand2, and demand3.
- Valid Assignments:
  - demand1: truckA, truckB
  - demand2: truckA only
  - demand3: truckC, truckD
- Constraints:
  - demand1: x{truckA,demand1} + x{truckB,demand1} = 1 (Either truckA or truckB serves demand1)
  - demand2: x{truckA,demand2} = 1 (TruckA must serve demand2)
  - demand3: x{truckC,demand3} + x{truckD,demand3} = 1 (Either truckC or truckD serves demand3)
- Why This Is Critical:
  - Ensures Full Coverage: Every demand node gets exactly one truck serving it.
  - Simplifies Decision Making: The solver doesn't have to choose between conflicting options—each customer location gets one clear assignment.

Case 1: Base case

- Burrito truck cost: $250
- Ingredient cost : $5
- Price of burrito : $10 , Thus profit from each burrito is $5
- Optimal profit is $3710 from 6 trucks

Truck	**Demand Nodes Served**	**Total Scaled Burritos**
Truck8	demand0, demand1, demand2, demand15, demand16, demand52, demand53	149
Truck16	demand8, demand11, demand12, demand13, demand14, demand18, demand20, demand21, demand51	214
Truck26	demand17, demand19, demand28, demand29, demand30, demand31, demand45	188
Truck37	demand27, demand33, demand41	170
Truck45	demand37, demand38, demand40	117
Truck56	demand22, demand23, demand25, demand26, demand35	204


YOUR SOLUTION
OPTIMAL SOLUTION
LEGEND
Truck location
Fewer customers
More customers
<25% of demand captured
25%-50% of demand captured
>50% of demand captured
Tip
Sales revenue: ₲3,240
Ingredient cost: ₲1,620
Truck cost: ₲250
TOTAL PROFIT: ₲1,370 (63% worse than optimal)
Sales revenue: ₲10,420
Ingredient cost: ₲5,210
Truck cost: ₲1,500
TOTAL PROFIT: ₲3,710
Gurobi found an optimal solution in 0.235 seconds
TRY AGAIN
NEXT DAY

Case 2: Supply chain issue

- Burrito truck cost: $250
- Ingredient cost shoots up: $7
- Price of burrito : $10 , Thus profit from each burrito is $3
- Optimal profit is $1714 from 5 trucks

Truck	Demand Nodes Served	Total Scaled Burritos
Truck14	demand0, demand1, demand2, demand12, demand14, demand15, demand16, demand17, demand18, demand19, demand20, demand52	215
Truck18	demand8, demand11, demand13, demand21, demand22, demand23, demand51, demand53	247
Truck26	demand28, demand29, demand30, demand31, demand45	162
Truck33	demand25, demand26, demand35, demand37, demand38, demand40	194
Truck37	demand27, demand32, demand33, demand41	170

Case 3: We the fast-food chain

- Burrito truck cost: $250
- Reduce ingredient cost by a dollar: $4
- Price of burrito : $10, Thus profit from each burrito is $3
- Optimal profit is $4752 from 6 trucks

Truck	Demand Nodes Served	Total Scaled Burritos
Truck8	demand0, demand1, demand2, demand15, demand16, demand52, demand53	149
Truck16	demand8, demand11, demand12, demand13, demand14, demand18, demand20, demand21, demand51	214
Truck26	demand17, demand28, demand29, demand30, demand31, demand45	188
Truck37	demand27, demand32, demand33, demand41	170
Truck45	demand37, demand38, demand40	117
Truck56	demand22, demand23, demand25, demand26, demand35	204

Case 4: Worst case supply chain crisis

- Burrito truck cost: $250
- Ingredient cost: $9
- Price of burrito : $10, Thus profit from each burrito is $1
- Optimal profit is $27 from 3 trucks

Truck	Demand Nodes Served	Total Scaled Burritos
Truck15	demand0, demand1, demand2, demand8, demand11, demand12, demand13, demand14, demand15, demand16, demand18, demand19, demand20, demand21, demand51, demand52, demand53	294
Truck26	demand17, demand27, demand28, demand29, demand30, demand31, demand32, demand33, demand41, demand45	250
Truck33	demand22, demand23, demand25, demand26, demand35, demand37, demand38, demand40	233

Case 5: Minimum possible loss

- Burrito truck cost: $250
- Ingredient cost: $9.1
- Price of burrito : $10, Thus profit from each burrito is $0.99
- Optimal profit is $-50 or $50 loss

Truck	Demand Nodes Served	Total Scaled Burritos
Truck15	demand0, demand1, demand2, demand8, demand11, demand12, demand13, demand14, demand15, demand16, demand18, demand20, demand21, demand51, demand52, demand53	279
Truck26	demand17, demand19, demand27, demand28, demand29, demand30, demand31, demand32, demand33, demand41, demand45	265
Truck33	demand22, demand23, demand25, demand26, demand35, demand37, demand38, demand40	233

Key Observations & Insights

Break-even Truck Utilization:

- Higher ingredient costs reduce per-burrito profit, requiring more sales to break even.
- At $5 profit per burrito: A truck must sell 50 burritos to cover setup costs.
- At $3 profit per burrito: A truck must sell 84 burritos to break even.
- At $1 profit per burrito: The model minimizes trucks to 3 to reduce costs.

Impact of Ingredient Cost Reduction:

- Lower ingredient costs increase profit margins but do not significantly change truck assignments.
- A $1 drop in ingredient cost increases optimal profit while keeping the same truck locations.

Key Observations & Insights

Worse Case Scenario - Near Break-even:

- At $9 ingredient cost, the company makes a small profit ($27) by reducing trucks to 3.
- At $9.1 ingredient cost, the company enters a loss-making zone.

Recommendations & Future Considerations

- Cheap or smaller trucks: trucks costing $150 or below to setup (with limited scaling capacity i.e. ability to serve demand) can be setup get more profit. Analysis by simulation needed before setting up
- Value meals: priced at $7 with a profit of $4 can be introduced which could gain more popularity. Analysis by simulation needed before setting up
- Kids meals: This code make the problem nonlinear as kid meals might boost sales of normal burritos and gain more profit .