FOOD STORAGE OPTIMIZATION TO MINIMIZE COSTS AND FOOD WASTE

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Optimization and Simulation Methods for Analytics

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Background

- According to the USDA, the restaurant industry loses **$162 billion** annually due to wasted food
- In 2015, the USDA joined with the EPA to set a goal to reduce our nation's food waste by 50% by the 2030
- Causes of food waste
  - Improper food storage
  - Over-ordering
  - Cooking too much without saving the leftovers
  - *And many more*

(https://www.usda.gov/foodwaste/faqs)

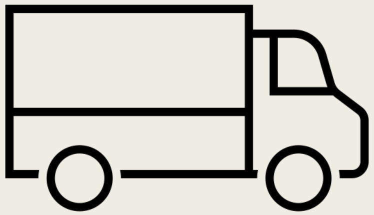
Business Problem

- The environmental impacts of food waste are unprecedented.
- Reducing and preventing food waste can increase food security, foster productivity and economic efficiency, promote resource and energy conservation, and address climate change
- This project will help us address food waste and increase sustainability within the restaurant industry.

(https://www.epa.gov/land-research/farm-kitchen-environmental-impacts-us-food-waste)

Business Problem

- Our goal is to optimize food storage and transportation across the restaurant industry
- Will minimize food waste and the costs associated with it and maximize the utility and therefore profits of restaurants
- We will focus on a restaurant with a specified menu to suggest shipment quantities that will minimize food waste of perishable ingredients
  - *Still be able to* satisfy customer needs and keeping within the constraints of inventory space of the restaurant



Data

- Generated dummy data using wholesale retail prices for each of the ingredients from two different retailers
- Each suppliers' costs vary by item
- In our example, identical, standard size box trucks used for food transport (1200 ft^3 capacity)

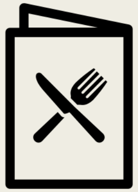
Truck A	Truck B
300	200

Cost of a delivery from each supplier

Ingredient	Supplier A	Supplier B	Type
Flour	27.1	28	Perishable
Cheese	62.91	59.99	Perishable
Salt	8.41	0	Nonperishable
Tomato Sauce	0	26	Nonperishable
Yeast	79.85	0	Nonperishable
Pepperoni	120.51	118	Perishable
Ground Beef	93.4	96	Perishable
Hamburger Buns	44.52	44.99	Perishable
Hoagie Roll	43.55	47.1	Perishable
Ham	134.54	131.33	Perishable
Salami	83.72	89.49	Perishable
Lettuce	37.74	37.99	Perishable
Tomato	0	33.87	Perishable
Ketchup	0	72.11	Nonperishable
Mustard	55.65	53.35	Nonperishable
Pepper	24.19	0	Nonperishable
Oil	24.68	24.69	Nonperishable
Sugar	32.05	32.95	Nonperishable

Cost of ingredients (per cubic foot) from each supplier, with the type of item it is.
0 indicates supplier does not sell item.

Our menu and how much of each ingredient we need in feet^3 to make it for quantity of 1 and quantity of 100



Menu Item	Ingredient	Quantity - 1	Quantity -100	type
Cheese Pizza	Cheese	0.00313314	0.313314	Perishable
Cheese Pizza	Flour	0.026798651	2.6798651	Perishable
Cheese Pizza	Tomato Sauce	0.00208876	0.208876	Nonperishable
Cheese Pizza	Yeast	0.000870316	0.0870316	Nonperishable
Cheese Pizza	Salt	0.00104438	0.104438	Nonperishable
Cheese Pizza	Oil	0.00156657	0.156657	Nonperishable
Cheese Pizza	Sugar	0.000348126	0.0348126	Nonperishable
Pepperoni Pizza	Cheese	0.00313314	0.313314	Perishable
Pepperoni Pizza	Flour	0.026798651	2.6798651	Perishable
Pepperoni Pizza	Tomato Sauce	0.00208876	0.208876	Nonperishable
Pepperoni Pizza	Yeast	0.000870316	0.0870316	Nonperishable
Pepperoni Pizza	Salt	0.00104438	0.104438	Nonperishable
Pepperoni Pizza	Oil	0.00156657	0.156657	Nonperishable
Pepperoni Pizza	Sugar	0.000348126	0.0348126	Nonperishable
Pepperoni Pizza	Pepperoni	0.00313314	0.313314	Nonperishable
Cheeseburger	Hamburger Bun	0.00416667	0.416667	Perishable
Cheeseburger	Burger	0.00416667	0.416667	Perishable
Cheeseburger	Cheese	0.00313314	0.313314	Perishable
Cheeseburger	Lettuce	0.002513314	0.2513314	Perishable
Cheeseburger	Tomato	0.002013314	0.2013314	Perishable
Cheeseburger	Ketchup	0.00156657	0.156657	Nonperishable
Cheeseburger	Mustard	0.00156657	0.156657	Nonperishable
Italian Hoagie	Hoagie Roll	0.026042	2.6042	Perishable
Italian Hoagie	Ham	0.00416667	0.416667	Perishable
Italian Hoagie	Salami	0.00416667	0.416667	Perishable
Italian Hoagie	Cheese	0.00313314	0.313314	Perishable
Italian Hoagie	Lettuce	0.002513314	0.2513314	Perishable
Italian Hoagie	Tomato	0.002013314	0.2013314	Perishable
Italian Hoagie	Oil	0.00156657	0.156657	Nonperishable

Constraints

- Storage and moving capacity of delivery trucks: Sum of $x_{i,j}$ (from each supplier) <= capacity of truck*y_i
- Storage capacity of restaurant – for perishable and non-perishable food items: Sum of $x_{i,j}$ <= storage
- Perishable food constraint
  - *Shelf life of food items*
    - Sum $x_{i,j}$ = demand
  - *We can stock up on nonperishable ingredients*
    - Demand <= sum of $x_{i,j}$ <= 3*demand
- Minimum amount of ingredients needed to prepare menu items
  - $x_{i,j}$, y_i *>= 0, and integers*
- $x_{i,j}$ is the ingredients (i = 1 … N, j = 1 … n) , y_i is the # of trucks (i = 1 … n)
  - *where N is the number of ingredients and n is the number of supplier*

Modeling and Analysis

- Approach: Mixed-Integer and Linear Programming
- Found demand for each ingredient (in $feet^3$) to meet demand of each menu item

	1	2	3	4	5	6	7	8	9
Ingredient	Cheese	Flour	Ground Beef	Ham	Hamburger Bun	Hoagie Roll	Ketchup	Lettuce	Mustard
Demand	31.3314	267.987	41.6667	41.6667	41.6667	260.42	15.6657	25.1331	15.6657

	10	11	12	13	14	15	16	17	18
Ingredient	Oil	Pepper	Pepperoni	Salami	Salt	Sugar	Tomato	Tomato Sauce	Yeast
Demand	15.6657	0	31.3314	41.6667	10.4438	3.48126	20.1331	20.8876	8.70316

2 Supplier Problem

$$\begin{aligned}\min_{x} \quad & 62.91x_{1,1} + 59.99x_{1,2} + 27.1x_{2,1} + 28x_{2,2} + 93.4x_{3,1} + 96x_{3,2} + 134.54x_{4,1} + 131.33x_{4,2} + 44.52x_{5,1} + 44.99x_{5,2} + 43.55x_{6,1} + 47.1x_{6,2} \\ & + 72.11x_{7,2} + 37.74x_{8,1} + 37.99x_{8,2} + 55.65x_{9,1} + 53.35x_{9,2} + 24.68x_{10,1} + 24.69x_{10,2} + 24.19x_{11,1} + 120.51x_{12,1} + 118x_{12,2} + 83.72x_{13,1} \\ & + 89.49x_{13,2} + 8.41x_{14,1} + 32.05x_{15,1} + 32.95x_{15,2} + 33.87x_{16,2} + 26x_{17,2} + 79.85x_{18,1} + 300y_1 + 200y_2\end{aligned}$$

Min sum cost*$x_{i,j}$ + sum cost*y_i

2 Supplier Problem

$$x_{1,A} + x_{1,B} = 32$$
$$\vdots$$
$$x_{16,A} + x_{16,B} = 21$$

Demand of ingredients rounded up, cannot buy partial units

$$x_{7,A} = 0$$
$$\vdots$$
$$X_{18,B} = 0$$

Set ingredients not offered by certain supplier to zero

$$x_{1,A} + \ldots + x_{18,A} + x_{1,B} + \ldots + x_{18,B} \leq 7000$$

$$x_{1,A} + \ldots + x_{18,A} - 1200y_A \leq 0$$
$$x_{1,B} + \ldots + x_{18,B} - 1200y_B \leq 0$$

Restaurant Storage and Truck Space

$$15.667 \leq x_{7,A} + x_{7,B} \leq 46.997$$
$$\vdots$$
$$8.703 \leq x_{18,A} + x_{18,B} \leq 26.109$$

We can buy and store up to 3x our demand of nonperishable ingredients

2 Supplier Problem

$$x_{m,n} \in \mathbb{Z}$$
$$y_1 \in \mathbb{Z}$$
$$y_2 \in \mathbb{Z}$$

Numbers are integers

$$y_1 \geq 0$$
$$y_2 \geq 0$$

Cannot have negative number of trucks

$$x_{\text{ingredient, supplier}} \geq 0$$

Cannot have negative ingredients

2 Supplier Solution

Objective value: $45,229.88

1 Truck from Supplier A,

1 Truck from Supplier B

Ingredient	Supplier A	Supplier B
Cheese	0	32
Flour	268	0
Ground Beef	42	0
Ham	0	42
Hamburger Bun	42	0
Hoagie Roll	261	0
Ketchup	0	16
Lettuce	26	0
Mustard	0	16
Oil	16	0
Pepper	0	0
Pepperoni	0	32
Salami	42	0
Salt	11	0
Sugar	4	0
Tomato	0	21
Tomato Sauce	0	21
Yeast	9	0

A New Suburb-Based Supplier Enters Market

- Significantly lower ingredient costs, if they sell the item
- Significantly higher delivery fee
- How does this affect our current solution?

Truck A	Truck B	Truck C
300	200	800

Ingredient	Supplier A	Supplier B	Supplier C	Type
Flour	27.1	28	20.05	Perishable
Cheese	62.91	59.99	54.99	Perishable
Salt	8.41	0	6.88	Nonperishable
Tomato Sauce	0	26	18.76	Nonperishable
Yeast	79.85	0	72	Nonperishable
Pepperoni	120.51	118	105	Perishable
Ground Beef	93.4	96	85	Perishable
Hamburger Bun	44.52	44.99	0	Perishable
Hoagie Roll	43.55	47.1	0	Perishable
Ham	134.54	131.33	115	Perishable
Salami	83.72	89.49	76	Perishable
Lettuce	37.74	37.99	0	Perishable
Tomato	0	33.87	27.89	Perishable
Ketchup	0	72.11	68.42	Nonperishable
Mustard	55.65	53.35	0	Nonperishable
Pepper	24.19	0	19.98	Nonperishable
Oil	24.68	24.69	19.87	Nonperishable
Sugar	32.05	32.95	26.07	Nonperishable

3 Supplier Problem

$$\min_x \; 62.91x_{1,1} + 59.99x_{1,2} + 54.99x_{1,3} + 27.1x_{2,1} + 28x_{2,2} + 20.05x_{2,3} + 93.4x_{3,1} + 96x_{3,2} + 85x_{3,3} + 134.54x_{4,1} + 131.33x_{4,2} + 115x_{4,3} + 44.52x_{5,1} + 44.99x_{5,2} + 43.55x_{6,1} + 47.1x_{6,2} + 72.11x_{7,2} + 68.42x_{7,3} + 37.74x_{8,1} + 37.99x_{8,2} + 55.65x_{9,1} + 53.35x_{9,2} + 24.68x_{10,1} + 24.69x_{10,2} + 19.87x_{10,3} + 24.19x_{11,1} + 19.98x_{11,3} + 120.51x_{12,1} + 118x_{12,2} + 105x_{12,3} + 83.72x_{13,1} + 89.49x_{13,2} + 76x_{13,3} + 8.41x_{14,1} + 6.88x_{14,3} + 32.05x_{15,1} + 32.95x_{15,2} + 26.07x_{15,3} + 33.87x_{16,2} + 27.89x_{16,3} + 26x_{17,2} + 18.76x_{17,3} + 79.85x_{18,1} + 72x_{18,3} + 300y_1 + 200y_2 + 800y_3$$

Min sum cost*$x_{i,j}$ + sum cost*y_i

3 Supplier Problem

$$x_{1,A} + x_{1,B} + x_{1,C} = 32$$
$$\vdots$$
$$x_{16,A} + x_{16,B} + x_{16,C} = 21$$

Demand of perishable ingredients rounded up, cannot buy partial units

$$x_{7,\,1} = 0$$
$$\vdots$$
$$x_{5,\,3} = 0$$

Set ingredients not offered by certain supplier to zero

$$x_{1,A} + \ldots + x_{18,A} + x_{1,B} + \ldots + x_{18,B} + x_{1,C} + \ldots + x_{18,C} \leq 7000$$

$$x_{1,A} + \ldots + x_{18,A} - 1200y_A \leq 0$$
$$x_{1,B} + \ldots + x_{18,B} - 1200y_B \leq 0$$
$$x_{1,C} + \ldots + x_{18,C} - 1200y_C \leq 0$$

Restaurant Storage and Truck Space

$$15.667 \leq x_{7,A} + x_{7,B} + x_{7,C} \leq 46.997$$
$$\vdots$$
$$8.703 \leq x_{18,A} + x_{18,B} + x_{18,C} \leq 26.109$$

We can buy and store up to 3x our demand of nonperishable ingredients

3 Supplier Problem

$x_{m,n} \in \mathbb{Z}$
$y_1 \in \mathbb{Z}$
$y_2 \in \mathbb{Z}$
$y_3 \in \mathbb{Z}$

Numbers are integers

$y_1 \geq 0$
$y_2 \geq 0$
$y_3 \geq 0$

Cannot have negative number of trucks

$x_{\text{ingredient, supplier}} \geq 0$

Cannot have negative ingredients

3 Supplier Solution

Objective value: $41,513.36

1 Truck from Supplier A,

0 Trucks from Supplier B,

1 Truck from Supplier C

Ingredient	Supplier A	Supplier B	Supplier C
Cheese	0	0	32
Flour	0	0	268
Ground Beef	0	0	42
Ham	0	0	42
Hamburger Bun	42	0	0
Hoagie Roll	261	0	0
Ketchup	0	0	16
Lettuce	26	0	0
Mustard	16	0	0
Oil	0	0	16
Pepper	0	0	0
Pepperoni	0	0	32
Salami	0	0	42
Salt	0	0	11
Sugar	0	0	4
Tomato	0	0	21
Tomato Sauce	0	0	21
Yeast	0	0	9

Applications

- Any restaurant can use this to fill the demands of their customers and minimize their weekly spending on ingredients
- Minimize food waste by managing inventory
- Inform restaurants which supplier fits their needs the best

Future Opportunities

Scaling up

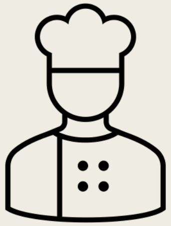
- Adding more menu items
- Across more restaurants or among widespread industry

What about next week's shipments?

- Utilize Stochastic Programming to determine our week-over-week purchasing decisions

Let's Cook!

- Find the optimal type and number of dishes to serve in our restaurant to maximize revenue



Bon Appétit!

Appendix

2 Supplier Problem

```
newModel = Model(GLPK.Optimizer)
n = length(sup_cost[:,1])
x_lb = zeros(n, 1);
@variable(newModel, x[i=1:n, j=1:2] >=x_lb[i], Int)
@variable(newModel, y[i=1:2] >=x_lb[i], Int)

@constraint(newModel, sum(x[i,j] for i=1:n for j=1:2) <= inventory_space[1,1])
for j=1:2
    @constraint(newModel, sum(x[i,j] for i=1:n) - truck_space*y[j] <= 0)
end

for i=1:n
    if demand[i,1] in perish_list
        @constraint(newModel, sum(x[i,j] for j=1:2) == ceil(demand[i,2]))
    else
        @constraint(newModel, sum(x[i,j] for j=1:2) >= demand[i,2])
        @constraint(newModel, sum(x[i,j] for j=1:2) <= abs(demand[i,2] * 3))
    end

end

for i=1:n
    for j=1:2
        if sup_cost[i,j+1] == 0
            @constraint(newModel, x[i,j] == 0)
        end
    end
end

@objective(newModel, Min, sum(c[i,j] * x[i,j] for i=1:n for j=1:2) + sum(truck_cost[1,i] * y[i] for i=1:2))

print(newModel)
```

```
status = optimize!(newModel)
println("Objective value: ", JuMP.objective_value(newModel))
println("Optimal solution is x = \n", JuMP.value.(x))
sol = JuMP.value.(x)
num_shipments = JuMP.value.(y)
for i=1:n
    println(demand[i,1], "    ", sol[i,1], "    ", sol[i,2])
end

println("Number of trucks ", num_shipments)
```

2 Supplier Problem

$$
\begin{aligned}
x_{1,1} + x_{1,2} &= 32.0 \\
x_{2,1} + x_{2,2} &= 268.0 \\
x_{3,1} + x_{3,2} &= 42.0 \\
x_{4,1} + x_{4,2} &= 42.0 \\
x_{5,1} + x_{5,2} &= 42.0 \\
x_{6,1} + x_{6,2} &= 261.0 \\
x_{8,1} + x_{8,2} &= 26.0 \\
x_{12,1} + x_{12,2} &= 32.0 \\
x_{13,1} + x_{13,2} &= 42.0 \\
x_{16,1} + x_{16,2} &= 21.0 \\
x_{7,1} &= 0.0 \\
x_{11,2} &= 0.0 \\
x_{14,2} &= 0.0 \\
x_{16,1} &= 0.0 \\
x_{17,1} &= 0.0 \\
x_{18,2} &= 0.0
\end{aligned}
$$

Demand of perishable ingredients rounded up, cannot buy partial units

$$
\begin{gathered}
x_{1,1} + x_{2,1} + x_{3,1} + x_{4,1} + x_{5,1} + x_{6,1} + x_{7,1} + x_{8,1} + x_{9,1} + x_{10,1} + x_{11,1} + x_{12,1} + x_{13,1} + x_{14,1} + x_{15,1} + x_{16,1} + x_{17,1} + x_{18,1} + x_{1,2} + x_{2,2} + x_{3,2} \\
+ x_{4,2} + x_{5,2} + x_{6,2} + x_{7,2} + x_{8,2} + x_{9,2} + x_{10,2} + x_{11,2} + x_{12,2} + x_{13,2} + x_{14,2} + x_{15,2} + x_{16,2} + x_{17,2} + x_{18,2} \leq 7000.0 \\
x_{1,1} + x_{2,1} + x_{3,1} + x_{4,1} + x_{5,1} + x_{6,1} + x_{7,1} + x_{8,1} + x_{9,1} + x_{10,1} + x_{11,1} + x_{12,1} + x_{13,1} + x_{14,1} + x_{15,1} + x_{16,1} + x_{17,1} + x_{18,1} - 1200y_1 \leq 0.0 \\
x_{1,2} + x_{2,2} + x_{3,2} + x_{4,2} + x_{5,2} + x_{6,2} + x_{7,2} + x_{8,2} + x_{9,2} + x_{10,2} + x_{11,2} + x_{12,2} + x_{13,2} + x_{14,2} + x_{15,2} + x_{16,2} + x_{17,2} + x_{18,2} - 1200y_2 \leq 0.0
\end{gathered}
$$

Restaurant Storage and Truck Space

$$
\begin{aligned}
x_{7,1} + x_{7,2} &\geq 15.6657 \\
x_{9,1} + x_{9,2} &\geq 15.6657 \\
x_{10,1} + x_{10,2} &\geq 15.6657 \\
x_{11,1} + x_{11,2} &\geq 0.0 \\
x_{14,1} + x_{14,2} &\geq 10.4438 \\
x_{15,1} + x_{15,2} &\geq 3.48126 \\
x_{17,1} + x_{17,2} &\geq 20.8876 \\
x_{18,1} + x_{18,2} &\geq 8.70316
\end{aligned}
$$

$$
\begin{aligned}
x_{7,1} + x_{7,2} &\leq 46.997099999999996 \\
x_{9,1} + x_{9,2} &\leq 46.997099999999996 \\
x_{10,1} + x_{10,2} &\leq 46.997099999999996 \\
x_{11,1} + x_{11,2} &\leq 0.0 \\
x_{14,1} + x_{14,2} &\leq 31.3314 \\
x_{15,1} + x_{15,2} &\leq 10.44378 \\
x_{17,1} + x_{17,2} &\leq 62.6628 \\
x_{18,1} + x_{18,2} &\leq 26.10948
\end{aligned}
$$

We can buy and store up to 3x our demand of nonperishable ingredients

3 Supplier Problem

```
newModel2 = Model(GLPK.Optimizer)
n = length(sup_cost[:,1])
x_lb = zeros(n, 1);
@variable(newModel2, x[i=1:n, j=1:3] >=x_lb[i], Int)
@variable(newModel2, y[i=1:3] >=x_lb[i], Int)

@constraint(newModel2, sum(x[i,j] for i=1:n for j=1:3) <= inventory_space[1,1])
for j=1:3
    @constraint(newModel2, sum(x[i,j] for i=1:n) - truck_space*y[j] <= 0)
end

for i=1:n
    if demand[i,1] in perish_list
        @constraint(newModel2, sum(x[i,j] for j=1:3) == ceil(demand[i,2]))
    else
        @constraint(newModel2, sum(x[i,j] for j=1:3) >= demand[i,2])
        @constraint(newModel2, sum(x[i,j] for j=1:3) <= abs(demand[i,2] * 3))
    end

end

for i=1:n
    for j=1:3
        if sup_cost[i,j+1] == 0
            @constraint(newModel2, x[i,j] == 0)
        end
    end
end

@objective(newModel2, Min, sum(c[i,j] * x[i,j] for i=1:n for j=1:3) + sum(truck_cost[1,i] * y[i] for i=1:3))

print(newModel2)
```

```
status = optimize!(newModel2)
println("Objective value: ", JuMP.objective_value(newModel2))
println("Optimal solution is x = \n", JuMP.value.(x))
sol = JuMP.value.(x)
num_shipments = JuMP.value.(y)
for i=1:n
    println(demand[i,1], "    ", sol[i,1], "    ", sol[i,2], "    ", sol[i,3])
end

println("Number of trucks ", num_shipments)
```

3 Supplier Problem

$$
\begin{aligned}
x_{1,1} + x_{1,2} + x_{1,3} &= 32.0 \\
x_{2,1} + x_{2,2} + x_{2,3} &= 268.0 \\
x_{3,1} + x_{3,2} + x_{3,3} &= 42.0 \\
x_{4,1} + x_{4,2} + x_{4,3} &= 42.0 \\
x_{5,1} + x_{5,2} + x_{5,3} &= 42.0 \\
x_{6,1} + x_{6,2} + x_{6,3} &= 261.0 \\
x_{8,1} + x_{8,2} + x_{8,3} &= 26.0 \\
x_{12,1} + x_{12,2} + x_{12,3} &= 32.0 \\
x_{13,1} + x_{13,2} + x_{13,3} &= 42.0 \\
x_{16,1} + x_{16,2} + x_{16,3} &= 21.0 \\
x_{5,3} &= 0.0 \\
x_{6,3} &= 0.0 \\
x_{7,1} &= 0.0 \\
x_{8,3} &= 0.0 \\
x_{9,3} &= 0.0 \\
x_{11,2} &= 0.0 \\
x_{14,2} &= 0.0 \\
x_{16,1} &= 0.0 \\
x_{17,1} &= 0.0 \\
x_{18,2} &= 0.0
\end{aligned}
$$

Demand of perishable ingredients rounded up, cannot buy partial units

$$
\begin{gathered}
x_{1,1} + x_{2,1} + x_{3,1} + x_{4,1} + x_{5,1} + x_{6,1} + x_{7,1} + x_{8,1} + x_{9,1} + x_{10,1} + x_{11,1} + x_{12,1} + x_{13,1} + x_{14,1} + x_{15,1} + x_{16,1} + x_{17,1} + x_{18,1} + x_{1,2} + \\
+ x_{4,2} + x_{5,2} + x_{6,2} + x_{7,2} + x_{8,2} + x_{9,2} + x_{10,2} + x_{11,2} + x_{12,2} + x_{13,2} + x_{14,2} + x_{15,2} + x_{16,2} + x_{17,2} + x_{18,2} + x_{1,3} + x_{2,3} + x_{3,3} + x \\
+ x_{6,3} + x_{7,3} + x_{8,3} + x_{9,3} + x_{10,3} + x_{11,3} + x_{12,3} + x_{13,3} + x_{14,3} + x_{15,3} + x_{16,3} + x_{17,3} + x_{18,3} \leq 7000.0 \\
x_{1,1} + x_{2,1} + x_{3,1} + x_{4,1} + x_{5,1} + x_{6,1} + x_{7,1} + x_{8,1} + x_{9,1} + x_{10,1} + x_{11,1} + x_{12,1} + x_{13,1} + x_{14,1} + x_{15,1} + x_{16,1} + x_{17,1} + x_{18,1} - 1200y \\
x_{1,2} + x_{2,2} + x_{3,2} + x_{4,2} + x_{5,2} + x_{6,2} + x_{7,2} + x_{8,2} + x_{9,2} + x_{10,2} + x_{11,2} + x_{12,2} + x_{13,2} + x_{14,2} + x_{15,2} + x_{16,2} + x_{17,2} + x_{18,2} - 1200y \\
x_{1,3} + x_{2,3} + x_{3,3} + x_{4,3} + x_{5,3} + x_{6,3} + x_{7,3} + x_{8,3} + x_{9,3} + x_{10,3} + x_{11,3} + x_{12,3} + x_{13,3} + x_{14,3} + x_{15,3} + x_{16,3} + x_{17,3} + x_{18,3} - 1200y
\end{gathered}
$$

Restaurant Storage and Truck Space

$$
\begin{aligned}
x_{7,1} + x_{7,2} + x_{7,3} &\geq 15.6657 \\
x_{9,1} + x_{9,2} + x_{9,3} &\geq 15.6657 \\
x_{10,1} + x_{10,2} + x_{10,3} &\geq 15.6657 \\
x_{11,1} + x_{11,2} + x_{11,3} &\geq 0.0 \\
x_{14,1} + x_{14,2} + x_{14,3} &\geq 10.4438 \\
x_{15,1} + x_{15,2} + x_{15,3} &\geq 3.48126 \\
x_{17,1} + x_{17,2} + x_{17,3} &\geq 20.8876 \\
x_{18,1} + x_{18,2} + x_{18,3} &\geq 8.70316
\end{aligned}
$$

$$
\begin{aligned}
x_{7,1} + x_{7,2} + x_{7,3} &\leq 46.997099999999996 \\
x_{9,1} + x_{9,2} + x_{9,3} &\leq 46.997099999999996 \\
x_{10,1} + x_{10,2} + x_{10,3} &\leq 46.997099999999996 \\
x_{11,1} + x_{11,2} + x_{11,3} &\leq 0.0 \\
x_{14,1} + x_{14,2} + x_{14,3} &\leq 31.3314 \\
x_{15,1} + x_{15,2} + x_{15,3} &\leq 10.44378 \\
x_{17,1} + x_{17,2} + x_{17,3} &\leq 62.6628 \\
x_{18,1} + x_{18,2} + x_{18,3} &\leq 26.10948
\end{aligned}
$$

We can buy and store up to 3x our demand of nonperishable ingredients