

# Unlocking Hidden Value: Data Science + Optimization

**ODSC EAST 2024**

APRIL 24, 2024



# Types of Analytics



## Machine Learning

- Finds patterns in data
- Makes predictions based on previous observations
- Usually involves the solution of a mathematical optimization problem
- User has to:
  - Collect necessary data
  - Decide on the structure of the model
  - Decide how to measure the quality of a model

## Mathematical Optimization

- Makes optimal decisions based on a mathematical model
- Can accurately measure the quality of a solution
- Is a mathematical tool that can be used to solve many different problems
- User has to define:
  - Decision variables
  - Constraints
  - Objectives

# Machine Learning



Known:

- Input
  - Output
- } **Data**

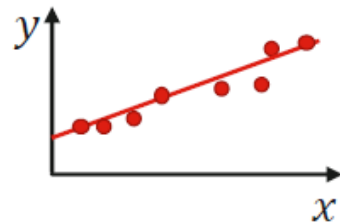
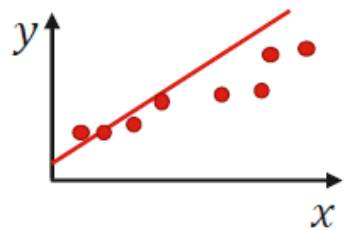
Unknown:

- Model

Question to be answered:

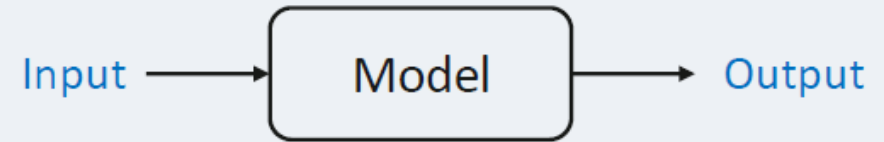
*Which **model** best describes my data?*

Example: Fitting a linear model to data point



- Which one is "better"?
- Why?

# Mathematical Optimization



Known:

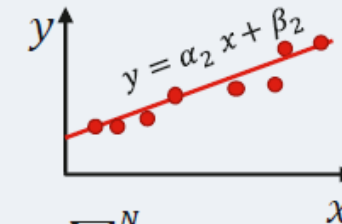
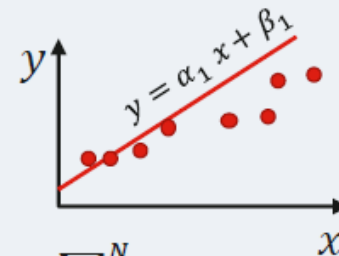
- Possible Decisions
  - Constraints
- } **Model**

Unknown:

- Input/Output

Question to be answered:

*Which **input** yields the best possible **output** for a given model?*



$$\sum_{i=1}^N (y_i - \alpha_1 x_i - \beta_1)^2 > \sum_{i=1}^N (y_i - \alpha_2 x_i - \beta_2)^2$$

- Data points  $\{(x_1, y_1), \dots, (x_N, y_N)\}$
- **Minimize** distance between data and model

# Examples

# Price Optimization

(quick serve restaurants and gas stations)

**AND USING EXCEL FOR PROTOTYPING**

# Elements of Menu Price Optimization

## OBJECTIVE

What you want to maximize

- Profit?
- Volume?

## ITEM PRICE

“DECISION VARIABLES”

- Items whose prices can be changed

## CUSTOMER RESPONSE MODEL

How customers respond to price changes

- Price elasticity
- Typically by product and segment

## RULES & CONSTRAINTS

Rules that should not be broken

- Menu Inflation
- Small < Large; Combo Meal < Sum of individual items; round to nearest 9 cents, etc.
- Relationship to specific competitor items



# “Toy”-scale Prototyping using Excel Solver

| Product          | Cost    | Competitor Price | Original Price | Previous Quantity Sold | Previous Profit     | Optimized Price     | New Quantity Estimate | New Profit Estimate |
|------------------|---------|------------------|----------------|------------------------|---------------------|---------------------|-----------------------|---------------------|
| Sandwich (large) | \$ 2.80 | \$ 3.90          | \$ 4.00        | 1,700                  | \$ 2,040            | \$ 3.92             | 1,723                 | 1,938               |
| Sandwich (small) | \$ 2.20 | \$ 2.80          | \$ 3.00        | 1,850                  | \$ 1,480            | \$ 3.36             | 1,760                 | 2,042               |
| Fries (large)    | \$ 0.90 | \$ 1.80          | \$ 2.00        | 1,300                  | \$ 1,430            | \$ 1.23             | 1,531                 | 506                 |
| Fries (small)    | \$ 0.60 | \$ 1.40          | \$ 1.50        | 1,400                  | \$ 1,260            | \$ 1.00             | 1,499                 | 604                 |
| Drink (large)    | \$ 0.60 | \$ 1.30          | \$ 1.60        | 2,320                  | \$ 2,320            | \$ 1.56             | 2,332                 | 2,239               |
| Drink (small)    | \$ 0.50 | \$ 1.00          | \$ 1.10        | 2,393                  | \$ 1,436            | \$ 1.20             | 2,356                 | 1,649               |
| Salad (A)        | \$ 1.20 | \$ 2.10          | \$ 2.10        | 1,901                  | \$ 1,711            | \$ 2.52             | 1,821                 | 2,404               |
| Salad (B)        | \$ 1.30 | \$ 2.20          | \$ 2.00        | 1,800                  | \$ 1,260            | \$ 2.32             | 1,704                 | 1,741               |
| Salad (C)        | \$ 1.00 | \$ 1.40          | \$ 1.50        | 1,800                  | \$ 900              | \$ 1.68             | 1,692                 | 1,151               |
|                  |         |                  | <b>\$ 2.09</b> | <b>16,464</b>          | <b>\$ 13,837</b>    | <b>\$ 2.09</b>      | <b>16,418</b>         | <b>\$ 14,273</b>    |
|                  |         |                  |                |                        | <b>Total Profit</b> | <b>Total Profit</b> |                       |                     |

| Actual Products |           |
|-----------------|-----------|
| Classics        | 9         |
| Wraps           | 3         |
| Salads          | 8         |
| Side Items      | 7         |
| Breakfast items | 14        |
| Desserts        | 9         |
| Drinks          | 13        |
| Trays           | 10        |
|                 | <b>73</b> |

*Excludes combo's and sizes.*

Can't go more than 20% over competitor price

Average Price held constant in model

From Elasticity Models



# “Toy”-scale Prototyping using Excel Solver

The image shows the 'Solver Parameters' dialog box in Excel. The 'Set Target Cell' is '\$L\$12' with a callout box labeled 'Total Profit'. The 'Equal To' section has 'Max' selected, and the 'Value Of' is '0'. The 'By Changing Cells' is '\$J\$3:\$J\$11' with a callout box labeled 'Prices'. The 'Subject to the Constraints' list includes: '\$J\$3 <= 1.2 \* \$D\$3', '\$J\$4 <= 1.2\*\$D\$4', '\$J\$5 <= 1.2\*\$D\$5', '\$J\$7 <= 1.2 \*\$D\$7', '\$J\$12 <= \$F\$12', and '\$I\$8 <= 1.2\*\$D\$8'. A callout box points to the first four constraints, stating: 'Competitiveness Constraints: Each row says a particular item's price can't exceed 1.2 x competitor price'. Another callout box points to the '\$J\$12 <= \$F\$12' constraint, stating: 'Menu Inflation Constraint: Can't increase the current average menu price'. On the right side of the dialog, there are buttons for 'Solve', 'Close', 'Options...', 'Reset All', and 'Help'.

# Business Impact of Menu Price Optimization

- Depending on the market area, the results showed an increase in sales ranging from **1.43%** to **3.33%**.
- Profit showed increases of **1.25%** to **2.55%**.
- These were achieved without changing the weighted price of current offerings, so as to maintain the perception of value in the mind of the consumer
- Ancillary benefits include insights that were uncovered which helped the company understand the impact that business rules have on productivity.

# Fuel Price Optimization

- An operator of about 1700 gas stations needed to set fuel sales volume and profit targets at the corporate level.
- Both in pilot and in real-world evaluations of the optimization model, the system was shown to increase profits by 10%.



# Excel Solver Prototyping

| Fuel Price Optimization |       |         |           |           |                |             |                   |                |              | Original Retail Price & Profits |          |           |        |             |          |              |
|-------------------------|-------|---------|-----------|-----------|----------------|-------------|-------------------|----------------|--------------|---------------------------------|----------|-----------|--------|-------------|----------|--------------|
| Store                   | State | Date    | Fuel Cost | MM retail | Optimum Retail | Diff vs. MM | Vol = f(diff,...) | Profit per gal | Total Profit | Min diff                        | Max diff | Fuel Cost | Retail | Diff vs. MM | Gal      | Total Profit |
| 105                     | NC    | 4/24/11 | 3.644     | 3.699     | 3.737          | 0.038       | 1,330.02          | 0.093          | 124.25       | 0                               | 0.04     | 3.644     | 3.699  | -           | 1,360.16 | 74.81        |
| 445                     | SC    | 4/24/11 | 3.499     | 3.579     | 3.579          | 0.000       | 1,554.98          | 0.080          | 124.40       | 0                               | 0.04     | 3.499     | 3.589  | 0.01        | 1,525.60 | 137.30       |
|                         |       |         |           |           |                |             | 2,885.00          |                | 248.64       |                                 |          |           |        |             | 2,885.76 | 212.11       |
|                         |       |         |           |           |                |             | 2,885.00          |                |              |                                 |          |           |        |             |          | 17.2%        |

Find the difference vs. MM that maximizes Total Profit

2,885.00  
Min Gallons

Constraints

Profit increase

# Excel versus Serious Optimization



- **Accessibility:** Solver is integrated into Excel, making it widely accessible and easy to use for those familiar with spreadsheet software.
- **Ease of Use:** It provides a user-friendly interface ideal for those who are not experts in programming, allowing quick setup and testing of optimization models.
- **Prototyping:** Solver is suitable for building and testing small-scale models quickly, which helps in validating concepts before implementing them on a more advanced platform.
- **Educational Tool:** Excellent for educational purposes and for learning the basics of optimization without the need for complex coding.



- **Performance:** Gurobi is designed for large-scale optimization and offers superior performance and speed, which is crucial for handling complex and large data sets.
- **Advanced Algorithms:** It includes more sophisticated algorithms and more extensive capabilities for solving integer, linear, and non-linear problems more efficiently.
- **Scalability:** Gurobi can efficiently solve problems of much larger scale than Excel Solver, making it suitable for industrial-level applications.
- **Integration Capabilities:** Offers better options for integration with other software and programming languages like Python, C++, Java, etc
- **Support and Updates:** Provides professional support and regular updates

# Drug Dispenser Cabinet Optimization

**Simplist<sup>®</sup>**

# Simplist<sup>®</sup>

ready-to-administer  
prefilled syringes



## No assembly required\*

Simplist is a single unit dose prefilled syringe requiring no assembly at the point of care. Designed for efficient medication delivery and ease of use, Simplist helps reduce waste potential and eliminate steps where errors can occur.<sup>1,2</sup>

Less preparation. Less waste. It's that simple.

[Learn more](#)





**Simplist<sup>®</sup>**

# Pharmacy Storage Optimization





**Simplist<sup>®</sup>**

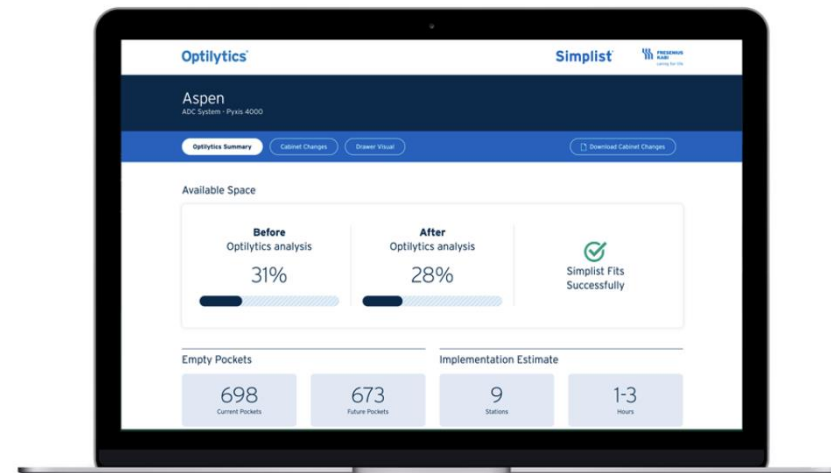
## Analytics for streamlining the storage of Simplist<sup>®</sup>

Optilytics<sup>®</sup> analyzes existing data from automated dispensing cabinets (ADCs) and provides a succinct road map for reorganization. Utilizing a few standard reports from your ADC, Optilytics from Fresenius Kabi can make the storage of Simplist simple, time-effective, and efficient.



### Optilytics<sup>®</sup>

- Automated cabinet analysis for Simplist prefilled syringes
- For customers considering Simplist, implementation roadmap provided
- For customers with Simplist, optimizations provided
- All Optilytics Simplist reports are complimentary
- Easy to get started, with little time commitment to view results





# Simplist<sup>®</sup>

## How it works

Optilytics analyzes your ADC data and provides step-by-step instructions for selective enhancements, giving you time estimates and allowing you to optimize for Simplist quickly and easily.

### 1. Data collection

We request a few standard ADC inventory reports. No patient information is required, and no data will be shared.

### 2. Analysis

Optilytics will also look to improve the storage of Simplist already loaded in the cabinet. Par levels will be adjusted as needed to optimize space for Simplist.

### 3. Reporting

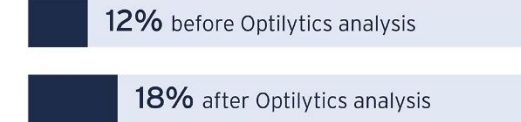
Optilytics provides instructions for the selective optimization of Simplist. Reporting includes the tool's overall impact, including time estimates and inventory changes.

#### Sample reporting based on a network of 50 ADCs

##### Effort summary

**57** total stations  
**9.12** hours for completion  
**9.6** minutes per station

##### Available capacity



##### Fill quantity summary

|  | Vials (before)  | → | Simplist (after) |
|--|-----------------|---|------------------|
| <b>Morphine</b> Sulfate Injection, USP                         | <b>527</b> qty. | → | <b>527</b> qty.  |
| <b>Dilaudid<sup>®</sup></b> (HYDROMORPHONE HCl) Injection, USP | <b>530</b> qty. | → | <b>530</b> qty.  |
| <b>Ketorolac</b> Tromethamine Injection, USP                   | <b>343</b> qty. | → | <b>341</b> qty.* |

\*Par adjusted based on usage.



# Hospital floor drug storage units



# Drawers have locked modular “cubies”





# The problem

## Our client

- Millions invested in product development.
- Built a new factory just for this.
- Nurses love the product.
- But it's not selling.

## Hospital pharmacy operations

- Will these things even fit?
- How? Figuring this out for one med station is 50 times harder than a Rubik's cube.
- Won't we have to buy more med-stations?



Optilytics Summary

**Cabinet Changes**

Drawer Visual

Download Cabinet Changes

Station ▶

*Search for medication*



UHLMC\_DENTAL

1.0% increase in available space



| STEP ≡ | ACTION ≡             | MEDICATION ≡                                 | DRAWER ≡   | POCKET [SIZE] ≡     | QTY |         |
|--------|----------------------|--|------------|---------------------|-----|---------|
| 1.     | REMOVE               | fentaNYL (fentaNYL Citrate) 100 mcg (2 mL) v | drawer 2.1 | pocket C3 [HHC:1x2] | 15  | Preview |
| 2.     | MOVE THIS<br>TO HERE | Sodium Chloride 0.9% (Normal Saline) (20 mL) | drawer 4   | pocket C1 [FHC:2x2] | 4   | Preview |
|        |                      | Sodium Chloride 0.9% (Normal Saline) (20 mL) | drawer 2.1 | pocket C3 [HHC:1x2] | 4   |         |
| 3.     | ADD THIS             | Simplist® Fentanyl MV 50 MCG                 | drawer 2.2 | pocket E1 [HHC:1x3] | 15  | Preview |

Note: The suggested fill quantity of 15 is 1 less than the pocket capacity of 16

# Move-by-move

## A Visual Guide To Solving A Rubik's Cube

**Notation**

**Sides**

**Moves**

F, F', L, L', R, R', U, U', D, D'

**Bright green squares indicate blocks in the correct spot, but not the correct orientation.**

**Examples**

would indicate...

**Goal**

**Starting Position & Algorithms**

**End Result**

**Cross on U**  
Top-center matching on sides  
Top-centers in correct spots

**Getting top-centers to match quickly**  
available for the corner pieces with the same color as the cross. (See the cross to be solved to you refer to the corner pieces as Italy, Mexico, The Netherlands, and Iceland. If you know your national flag!

**Top-centers matching on sides**  
Place top-center to solve in upper right corner of F.  
Flip the cube upside-down.

**Middle layer all matching**  
Use other algorithm to reorientize squares to their starting position.

**Cross on U**  
Any two top-centers matching  
Complete algorithm to get to starting position.  
Rotate U until two top-centers match.

**All top-centers matching on sides**

**All top-centers in correct spots**  
If no top-centers are in a correct spot, but do, the algorithm from any side repeat for each top-center that needs to be corrected.

**All top-centers matching**  
Place top-center to solve in upper right corner of U.  
Rotate **ONLY** U until unsolved square is in correct position (overweight of U).  
The side will look messy but just leave following the algorithm and **have faith**.

**Solve the Rubik's cube and feel awesome**

## Station UHLMC\_ED1

0.7% increase in available space

Optilytics™

Medical Center  
Cabinet Changes

| ACTION   | MEDICATION  | DRAWER                                      | POCKET [SIZE]   | QTY            |
|--|---|---|---|----------------|
| 1. REMOVE  | fentaNYL (fentaNYL Citrate) 100 mcg (   | from drawer 2                               | pocket D3 [HHC:1x2]   | 25             |
| 2. REMOVE  | fentaNYL (fentaNYL Citrate) 100 mcg (   | from drawer 3                               | pocket D5 [HHC:1x2]   | 25             |
| 3. MOVE THIS TO HERE   | HYDRomorphone (Dilaudid) 0.5 mg (0.5<br>HYDRomorphone (Dilaudid) 0.5 mg (0.5  | from drawer 6<br>to drawer 7                | pocket B3 [FHC:2x3]<br>pocket A3 [FHC:2x1]                        | 10<br>10       |
| 4. MOVE THIS TO HERE AND HERE  | OXYcodone-APAP 5-325mg (Percocet) tab<br>OXYcodone-APAP 5-325mg (Percocet) tab<br>OXYcodone-APAP 5-325mg (Percocet) tab | from drawer 3<br>to drawer 3<br>to drawer 4 | pocket E4 [HHC:1x3]<br>pocket B5 [HHC:1x1]<br>pocket B3 [HHC:1x1] | 31<br>15<br>16 |
| Note: The suggested fill quantity of 16 is 8 less than the pocket capacity of 24 |   |   |   |                |
| 5. MOVE THIS TO HERE   | albuterol HFA (OR & SP) (ProAir HFA)<br>albuterol HFA (OR & SP) (ProAir HFA)  | from drawer 6<br>to drawer 6                | pocket D1 [FHC:2x5]<br>pocket B3 [FHC:2x3]                        | 9<br>9         |
| 6. MOVE THIS TO HERE   | lidocaine 1% MPF (Xylocaine) (5 mL) v<br>lidocaine 1% MPF (Xylocaine) (5 mL) v  | from drawer 7<br>to drawer 2                | pocket C1 [FHC:2x2]<br>pocket D3 [HHC:1x2]                        | 10<br>10       |
| Note: The suggested fill quantity of 10 is 2 less than the pocket capacity of 12 |   |   |   |                |
| 7. MOVE THIS TO HERE AND HERE  | diazepam (Valium) 10 mg (2 mL) syring<br>diazepam (Valium) 10 mg (2 mL) syring<br>diazepam (Valium) 10 mg (2 mL) syring | from drawer 7<br>to drawer 3<br>to drawer 4 | pocket E1 [FHC:2x5]<br>pocket E4 [HHC:1x3]<br>pocket E4 [HHC:1x3] | 14<br>5<br>9   |
| Note: The suggested fill quantity of 9 is 1 less than the pocket capacity of 10  |   |   |   |                |
| 8. ADD THIS  | Simplist® Fentanyl MV 50 MCG  | to drawer 1                                 | pocket A3 [FHC:2x1]   | 10             |
| Note: The suggested fill quantity of 10 is 1 less than the pocket capacity of 11 |   |   |   |                |
| 9. ADD THIS  | Simplist® Fentanyl MV 50 MCG  | to drawer 7                                 | pocket C1 [FHC:2x2]   | 23             |
| 10. ADD THIS   | Simplist® Fentanyl MV 50 MCG  | to drawer 7                                 | pocket E1 [FHC:2x5]   | 67             |

# Other Examples



# Some Typical ML/Optimization Use Cases

| Use Case                              | Machine Learning Role   | Optimization Details  |
|---------------------------------------|---|---|
| <b>Supply Chain Management</b>        | Predicting demand and supply chain risks                        | Minimizing costs and maximizing efficiency, considering constraints such as delivery times and resource availability                    |
| <b>Manufacturing Scheduling</b>       | Predicting machine failures and maintenance needs               | Scheduling of jobs to maximize throughput and minimize downtime, using constraints like machine availability and maintenance schedules  |
| <b>Financial Portfolio Management</b> | Predicting future price movements and risks                     | Optimizing portfolio allocation to maximize returns and minimize risk, with constraints on risk tolerance and liquidity requirements    |
| <b>Customer Marketing</b>             | Predicting customer behavior and preferences                    | Maximizing campaign effectiveness by targeting optimal customer segments, with budget constraints and expected ROI                      |
| <b>Energy Grid Management</b>         | Forecasting energy demand and production from renewable sources | Optimizing energy distribution and storage to balance supply and demand, considering factors like weather predictions and energy prices |

# Some Typical ML/Optimization Use Cases

| Use Case                               | Machine Learning Role                                      | Optimization Details   |
|--|--|--|
| <b>Traffic Flow Optimization</b>       | Predicting traffic patterns and congestion                 | Optimizing traffic signal timings to reduce congestion and improve flow, using data on traffic volumes and speeds  |
| <b>Agricultural Yield Optimization</b> | Predicting crop yields based on environmental data         | Optimizing planting schedules and resource allocation (like water and fertilizers) to maximize crop yields, with constraints such as climatic conditions and soil health   |
| <b>Healthcare Staff Scheduling</b>     | Predicting patient admissions and care requirements        | Optimizing staff shifts to ensure adequate coverage and minimize overtime, considering patient needs and staff availability  |
| <b>Retail Inventory Management</b>     | Forecasting sales and product demand trends                | Optimizing inventory levels to balance stock availability against holding costs, using sales forecasts and seasonal trends   |
| <b>Freight Load Optimization</b>       | Predicting optimal load configurations and delivery routes | Optimizing the distribution of cargo within vehicles and the selection of delivery routes to minimize fuel consumption and travel time, with constraints on vehicle capacity, delivery windows, and route restrictions |

# Some Typical ML/Optimization Use Cases

| Use Case                                    | Machine Learning Role                                     | Optimization Details  |
|---|---|---|
| <b>Warehouse Layout Optimization</b>        | Analyzing patterns of item retrieval and storage          | Optimizing the placement of goods in a warehouse to minimize retrieval time, with constraints on space and accessibility  |
| <b>Airline Crew Scheduling</b>              | Forecasting staff availability and flight demands         | Optimizing crew assignments to ensure coverage for all flights while minimizing costs and adhering to labor laws  |
| <b>Public Transport Fleet Management</b>    | Predicting passenger loads and transit patterns           | Optimizing the number and timing of vehicles on routes to balance service frequency with operational costs, considering passenger comfort and vehicle capacity            |
| <b>Intermodal Transportation Management</b> | Estimating delays and efficiencies across transport modes | Optimizing the use of different transport modes (rail, ship, truck) to minimize overall transit time and costs, with constraints related to transfer points and schedules |
| <b>Autonomous Vehicle Routing</b>           | Predicting traffic conditions and obstacle data           | Optimizing routes for autonomous vehicles to minimize travel time and maximize safety, considering real-time traffic data, road conditions, and regulatory constraints    |

# Software Tools

**HINT: IT'S VERY FAMILIAR**

# Optimization in Code

**Let's have  
ChatGPT 4  
write it for us**

RS

**You**

A company makes two products (X and Y) using two machines (A and B). Each unit of X that is produced requires 50 minutes processing time on machine A and 30 minutes processing time on machine B. Each unit of Y that is produced requires 24 minutes processing time on machine A and 33 minutes processing time on machine B.

At the start of the current week there are 30 units of X and 90 units of Y in stock. Available processing time on machine A is forecast to be 40 hours and on machine B is forecast to be 35 hours.

The demand for X in the current week is forecast to be 75 units and for Y is forecast to be 95 units. Company policy is to maximise the combined sum of the units of X and the units of Y in stock at the end of the week.

Formulate the problem of deciding how much of each product to make in the current week as a linear program.

Write a program using Python and Gurobi to solve this problem.

# Variables and Objective Function



## ChatGPT

To solve this optimization problem using a linear program, we need to formulate our variables, objective function, and constraints based on the given information.

### Variables

Let's define:

- $x$ : the number of units of Product X to be produced this week.
- $y$ : the number of units of Product Y to be produced this week.

### Objective Function

We aim to maximize the combined sum of the units of X and Y in stock at the end of the week. Initially, there are 30 units of X and 90 units of Y in stock. The demand for X is 75 units, and for Y is 95 units.

Therefore, our objective function, which we want to maximize, can be represented as:

$$\text{Maximize : } (30 + x - 75) + (90 + y - 95)$$

Simplified, this becomes:

$$\text{Maximize : } x + y - 50$$

# Constraints

## Constraints

1. **Machine A Time Limitation:** Each unit of X requires 50 minutes on machine A, and each unit of Y requires 24 minutes on machine A. Machine A has 40 hours available, which is 2400 minutes. Hence, the constraint is:

$$50x + 24y \leq 2400$$

2. **Machine B Time Limitation:** Each unit of X requires 30 minutes on machine B, and each unit of Y requires 33 minutes on machine B. Machine B has 35 hours available, which is 2100 minutes. Thus, the constraint is:

$$30x + 33y \leq 2100$$

3. **Production Non-Negativity:** We cannot produce a negative quantity of products. Therefore:

$$x \geq 0, y \geq 0$$

# Python Code

Gurobi API

Variables

Objective Function

Constraints

Do the math

python

Copy code

```
from gurobipy import Model, GRB

# Create a new model
m = Model("production_optimization")

# Define variables
x = m.addVar(vtype=GRB.INTEGER, name="x")
y = m.addVar(vtype=GRB.INTEGER, name="y")

# Set objective: Maximize combined sum of units of X and Y in stock at the end of the
m.setObjective(x + y - 50, GRB.MAXIMIZE)

# Add constraint: Machine A time limit
m.addConstr(50*x + 24*y <= 2400, "Machine_A")

# Add constraint: Machine B time limit
m.addConstr(30*x + 33*y <= 2100, "Machine_B")

# Optimize model
m.optimize()

# Print results
if m.status == GRB.OPTIMAL:
    print(f"Optimal number of X to produce: {x.X}")
    print(f"Optimal number of Y to produce: {y.X}")
else:
    print("An optimal solution was not found.")
```



# Experience Sharing

**INTERACTIVE DISCUSSION**

# Your Turn (pick some questions to discuss)

- 1. Current Use of Optimization:** In what areas of your current projects are you already using optimization techniques?
- 2. Identifying Opportunities:** Where do you see potential for optimization to improve efficiency or reduce costs in your existing projects?
- 3. Integration Challenges:** What are the main challenges you face in integrating optimization techniques with existing machine learning models?
- 4. Resource Management:** How might optimization help in better resource allocation your team company?
- 5. Strategic Decisions:** How could optimization techniques support strategic planning and decision-making in your organization?
- 6. Innovative Applications:** Can you think of a recent problem you encountered that could have been approached differently with optimization?
- 7. Skill Development:** What skills or knowledge do you think would be necessary to better leverage optimization in your work?
- 8. Tools and Technologies:** What tools or software are you currently using that involve optimization, and are there tools you wish you had access to?
- 9. Collaboration and Interdisciplinary Work:** What opportunities do you see for interdisciplinary collaboration using optimization techniques in your company?
- 10. Measuring Impact:** How might you measure the success or impact of optimization in your projects?

# Thank You

Rob Stevens | [rstevens@firstanalytics.com](mailto:rstevens@firstanalytics.com)



- PDF of the slides
- More information about Gurobi
  - Insights for data scientists
  - Case studies in Jupyter notebooks
- More information from First Analytics