

# Forecasting Costs of Apple's Supply Chain

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Catherine Wu



Esther Ko



Yuxiao (Emma) Zhou

# Who are we?



Shi Jie Koh



Sheila Teo

# Agenda

- Problem Statement Overview
- Time-Series Modelling for Cost Prediction
- Desktop User Interface
- Tableau Dashboard: Visualizing Monthly Cost Summaries
- Conclusions

# Problem Overview



Data Entry



Procurement



Managerial Review

Problem Statement

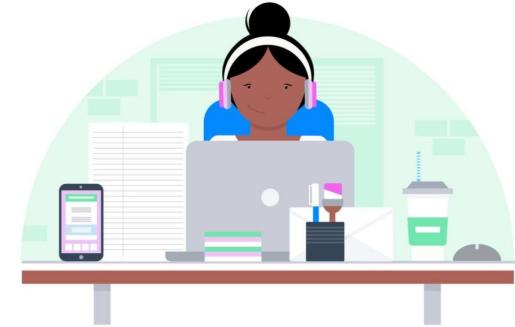
Time-Series Model

Procurement Input UI

Month-End Dashboard

Conclusion &  
Takeaway

# What is at stake?



Data Entry

Sorry boss, I entered \$35 instead of  
\$3.5 for this part ...

Procurement

Why are we spending 900%  
MORE than last month??!!

Managerial Review

# What is at stake?



Cost (per part)	\$0.01
Product produced (annual)	x 200 million
Usage per Product	x 10
<hr/>	
<b>Total overpayment (annual)</b>	<b>\$20 million</b>

Thousands of similar parts...



Managerial Review

# How do we help?



Data Entry

User interface with machine learning algorithm to detect errors and its potential reasons



Procurement



Managerial Review

Tableau dashboard provides visual summary

# The data

1100 rows

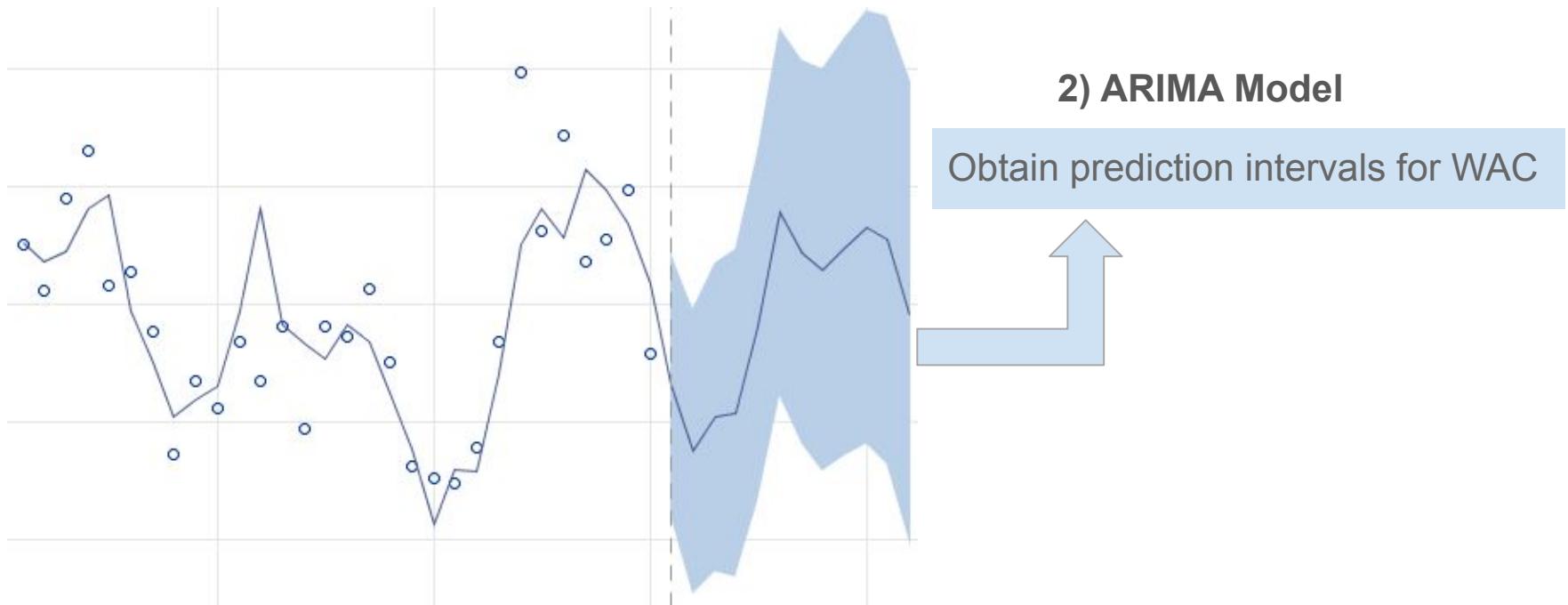
Part	Program	Buy Sell Flag	M Code	Allocation %	Buy \$	Sell (PO) \$	WAC
593-00514	O_J318	N	000049M	40%	\$0.57400	\$0.00000	\$0.52480
593-00514	O_J318	N	005173M	60%	\$0.49200	\$0.00000	\$0.52480

$$\Sigma(\text{Allocation})(\text{Buy Price}) = \text{WAC}$$

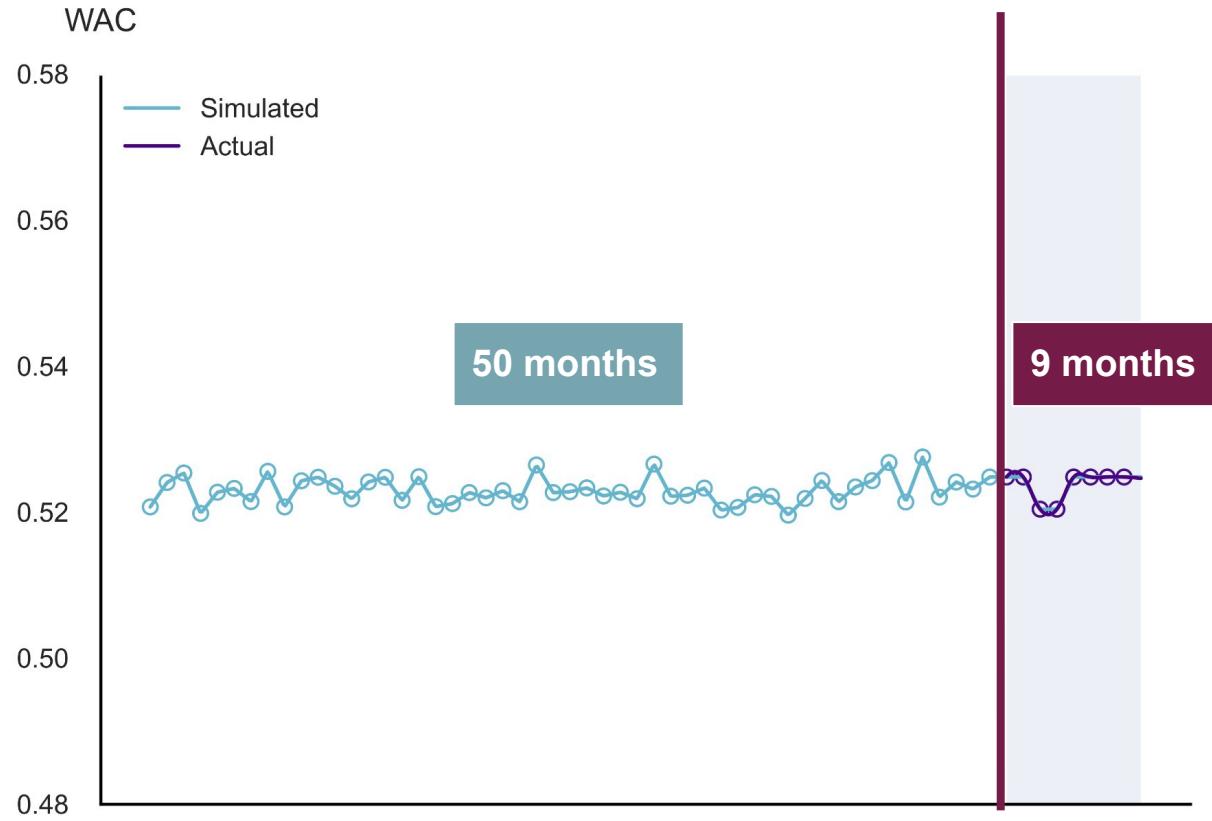
$$40\% * 0.574 + 60\% * 0.492 = 0.5248$$

WAC = Weighted Average Cost

# Time-Series Model: Predicting Monthly WAC



# Simulating Historical Data



Problem Statement

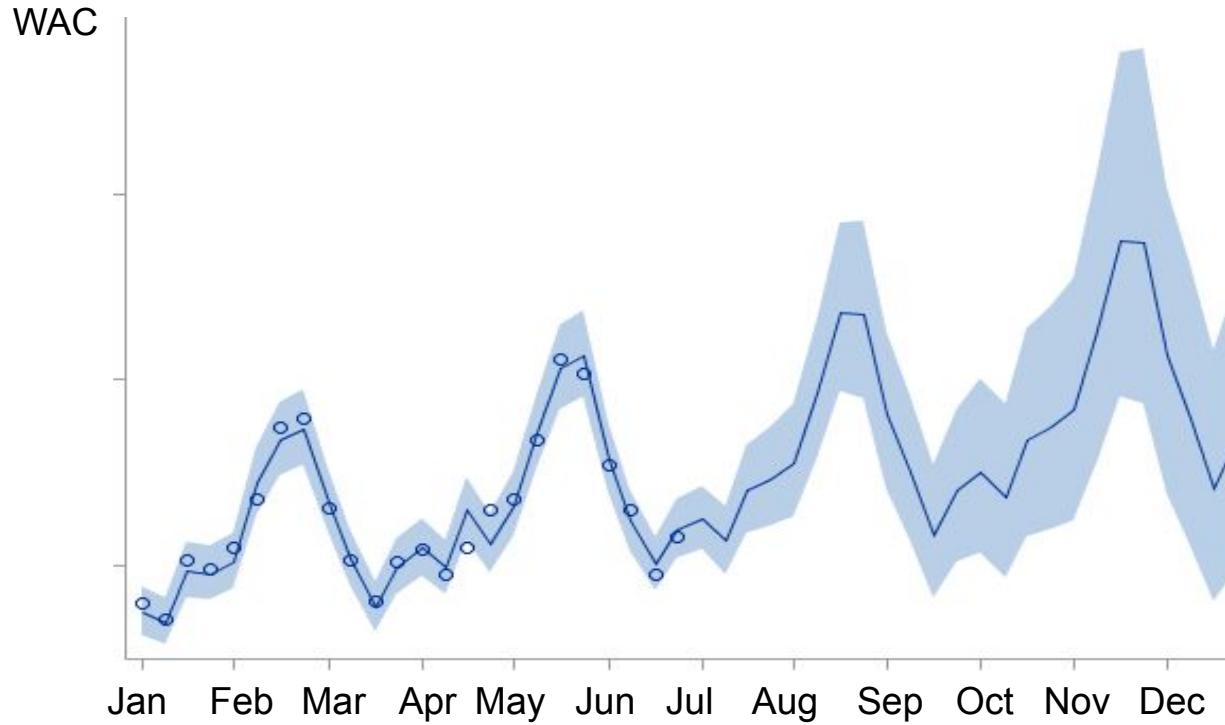
Time-Series Model

Procurement Input UI

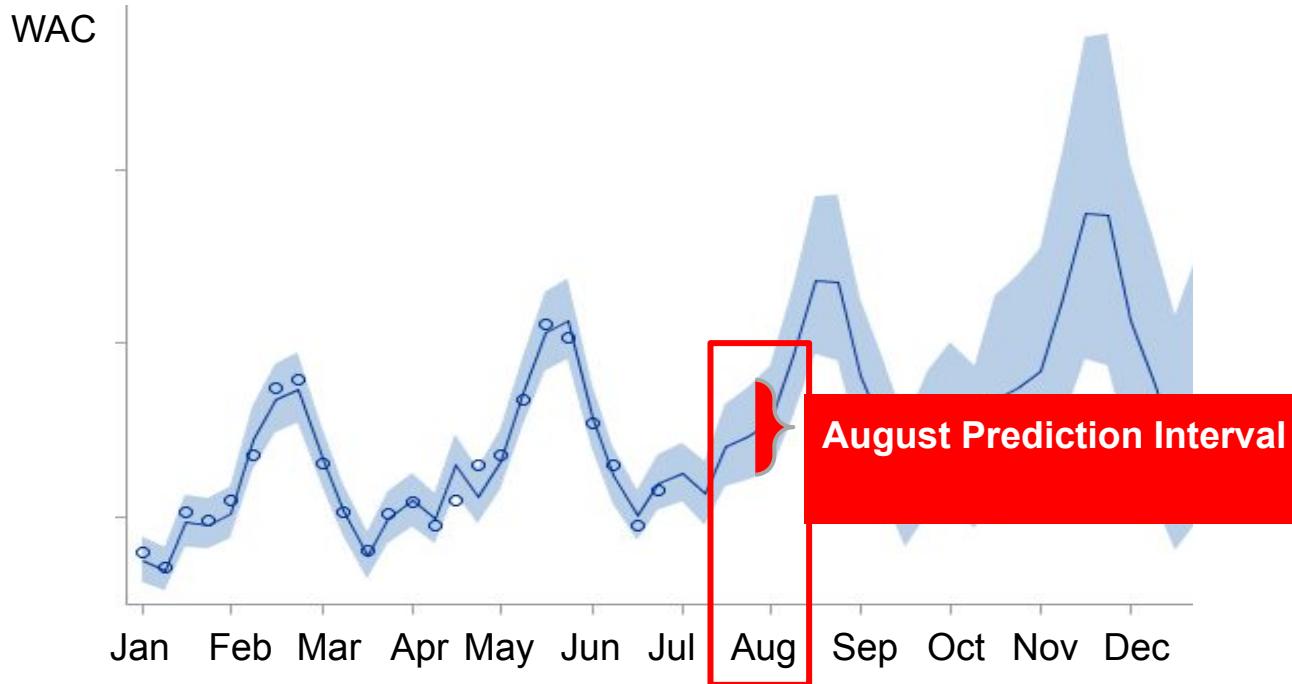
Month-End Dashboard

Conclusion &  
Takeaway

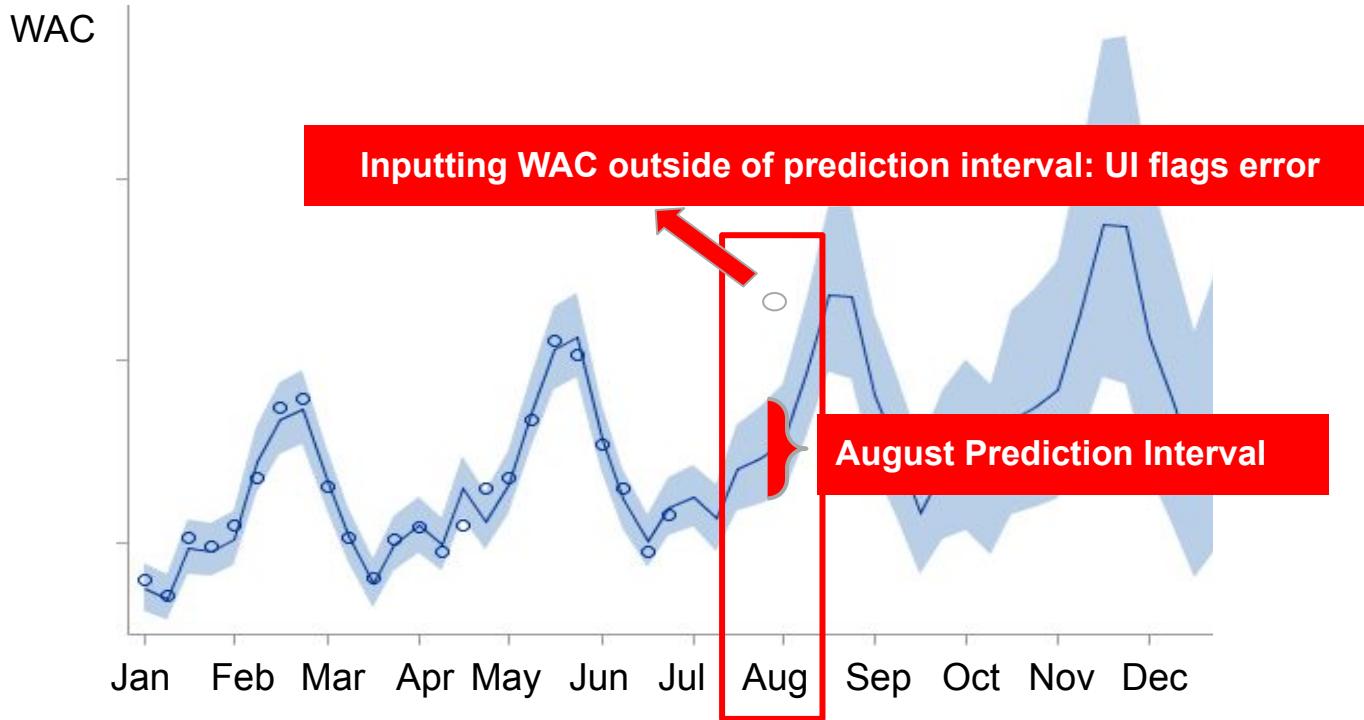
# Time-Series Model: Predicting Monthly WAC



# Time-Series Model: Predicting Monthly WAC



# Time-Series Model: Predicting Monthly WAC



# Why Do Time-Series Modelling?

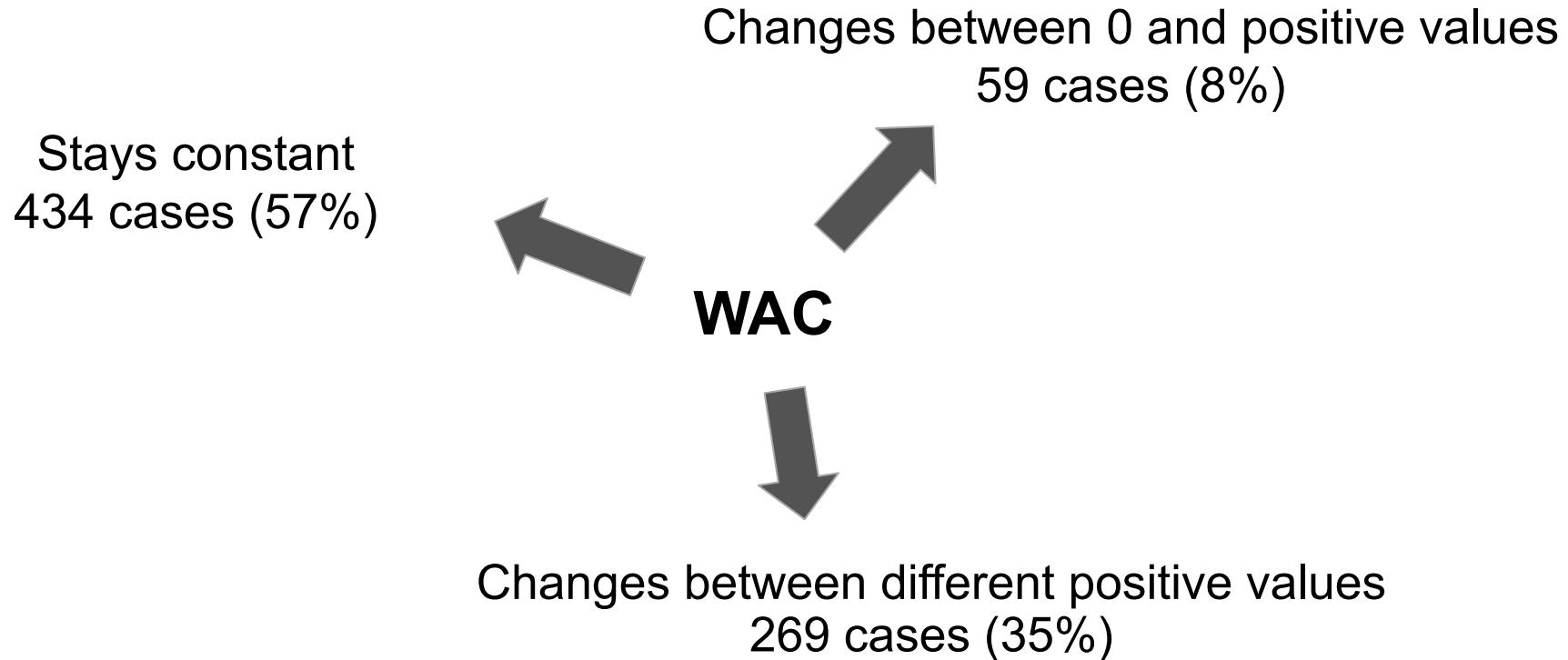
## Current Practice at Apple

Flag if WAC varies more than 5% from last month's WAC

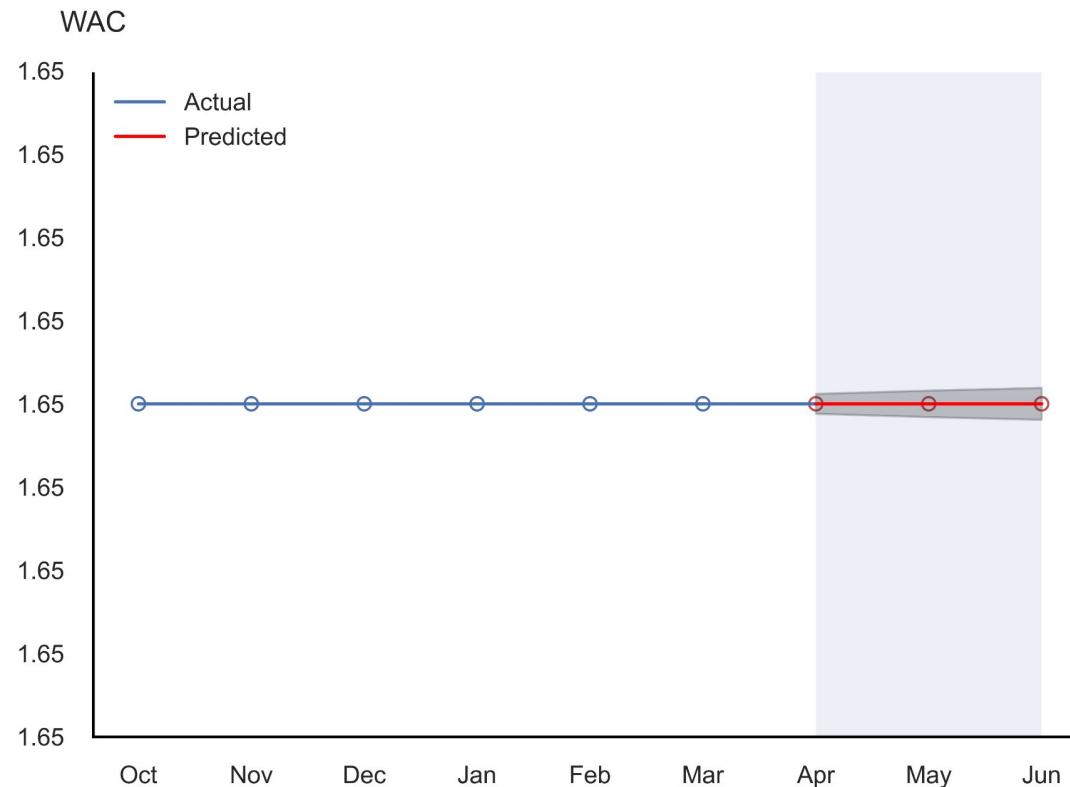


Arbitrary

# How Does WAC Change?

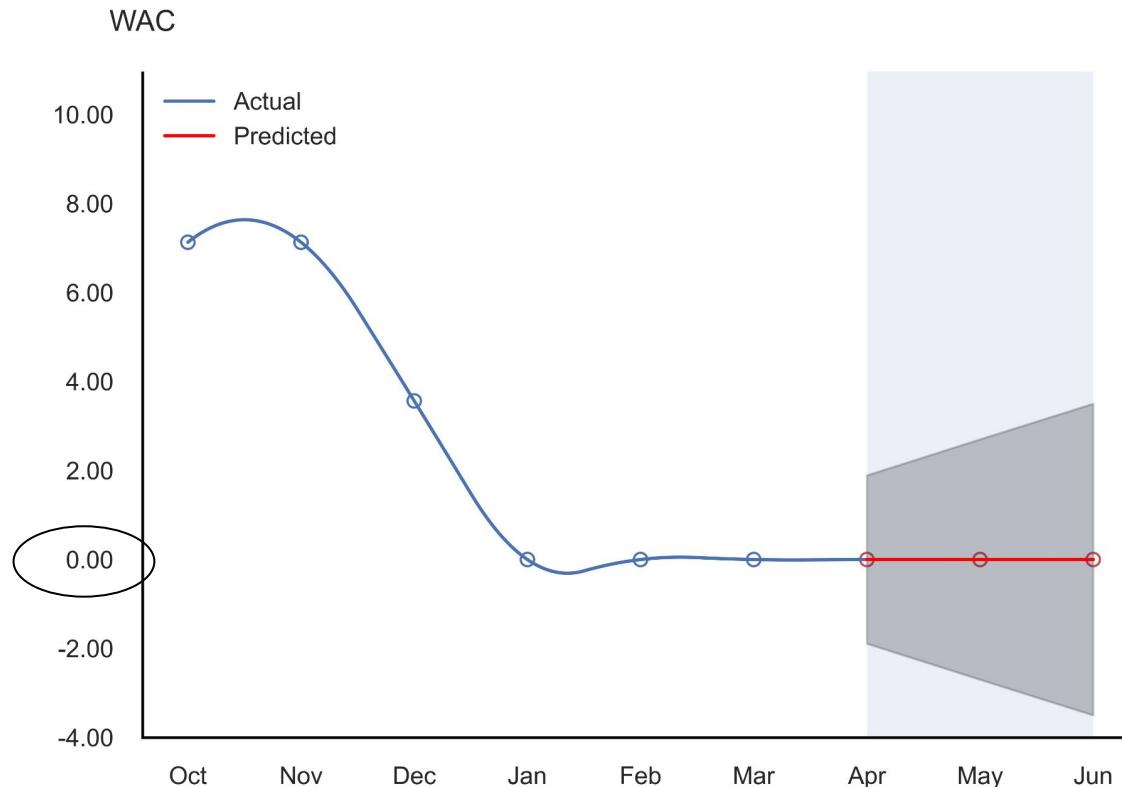


# 1) WAC stays constant → 434 cases (57%)



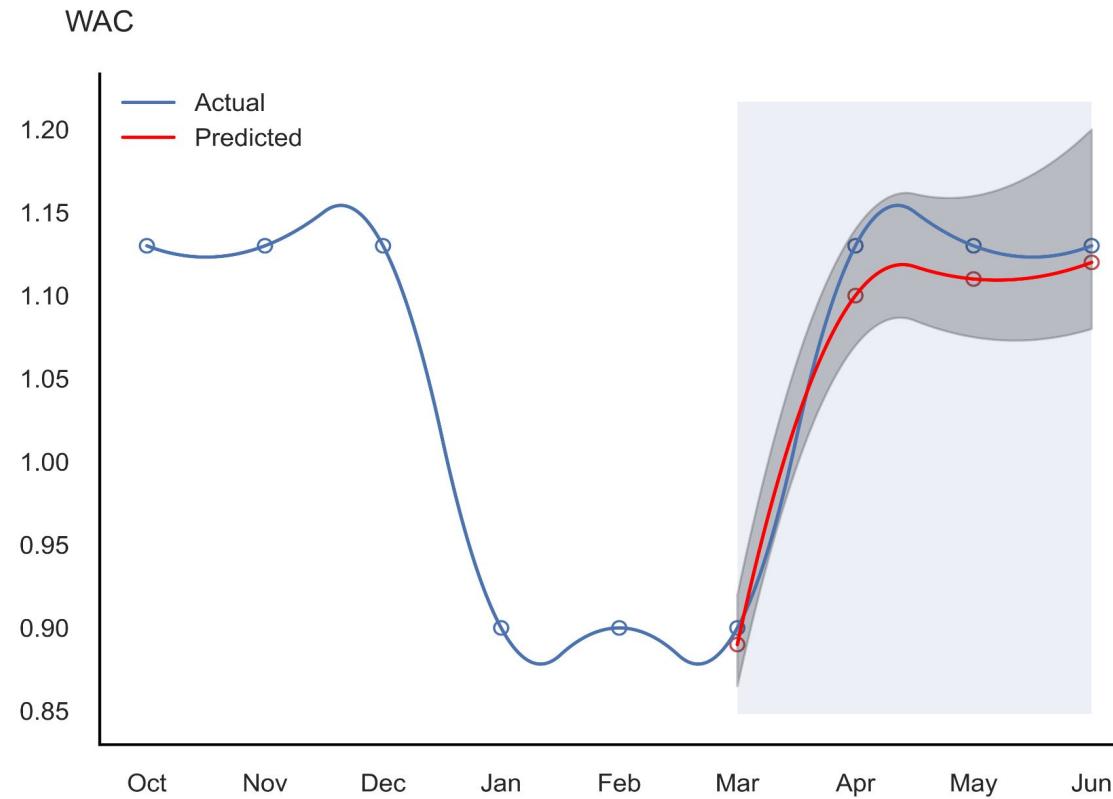
Part: 677-05605  
Program: O\_D10

## 2) WAC changes between 0 and positive values → 59 cases (8%)



Part: 616-00557  
Program: B427

### 3) WAC changes between different positive values → 269 cases (35%)



Part: 741-00019  
Program: B288

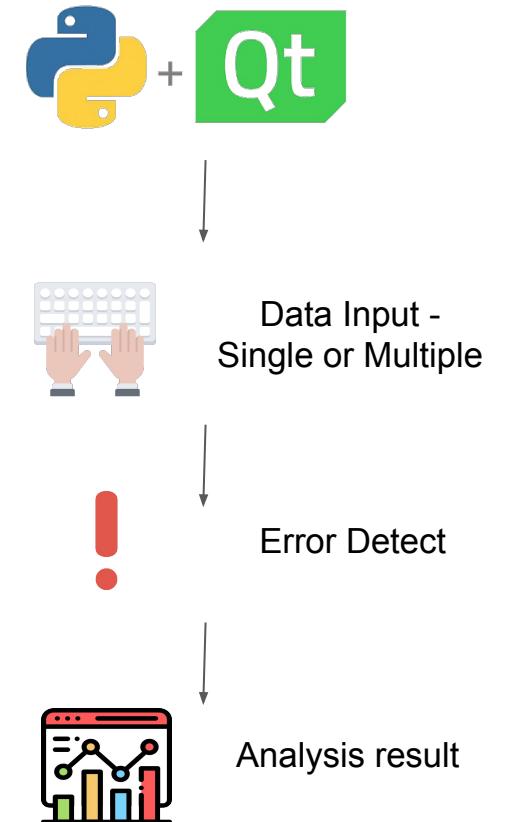
# Model Performance

768 Time-Series Models

Mean Absolute Percentage Error (MAPE): 0.00093%

0% Prediction Error: 72.9% of Models

# UI Demo with PyQt5 - Home Page



Problem Statement

Time-Series Model

Procurement Input UI

Month-End Dashboard

Conclusion &  
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# UI Demo - Single Part & Program Input

## Apple Cost Test

### Date

2021/2/14

**Option 1. Input one Part & Program to get detailed output**

### Part/Program

Part	Program
1 631-05349	B298

### Data Input

Upload

**Option 2. Input multiple Part & Program for brief check**

### Data Input

Upload

Check

# UI Demo - Single Part & Program - Alert

**Apple Cost Test**

Date  
2021/2/14

**Option 1. Input one Part & Program to get detailed output**

Part/Program

Part	Program
1 631-05349	B298

Data Input  
Upload

**Option 2. Input multiple Part & Program for brief check**

Data Input  
Upload

Check

Compare WAC with ARIMA model prediction interval



The UI demo shows a user interface for cost testing. It includes sections for inputting a single part and program (Option 1) and multiple parts and programs (Option 2). A modal dialog is displayed, asking if the WAC is higher than expected and if the user wants to continue checking. The dialog has 'No' and 'Yes' buttons. A red annotation with an arrow points from the text 'Compare WAC with ARIMA model prediction interval' to the 'Yes' button of the dialog.

# UI Demo - Single Part & Program - Analysis Results

Message ←

**Apple Cost Test**

Date  
2021/2/14

Check

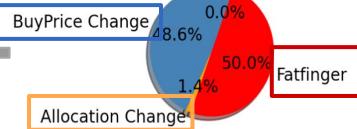
==== Section 1: WAC difference detection =====  
WAC NOT the same as last month. Previous month WAC is 0.5176. This month WAC is 1.8896.

==== Section 2: Potential Reasons Diagnosis =====

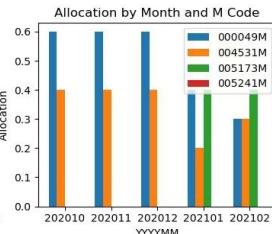
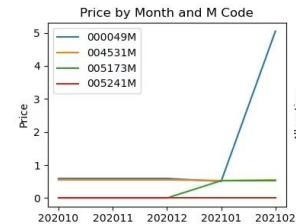
- Check for fat fingers  
For supplier: 000049M, the current buy price and previous month buy price has a 10 times difference. Fat finger?
- Check for allocation issues  
This month, you bought more from a more expensive supplier compared to last month.  
This month, you bought more from a cheaper supplier compared to last month.

==== Section 3: Tables and Visualizations =====

Reason likelihood ←



Price/Allocation Trend ←



# UI Demo - Single Part & Program - Likelihood Pie Chart

- For each supplier (M code), calculate the likelihood of each potential reasons

Valid Likelihood =  $1 - (\text{change in buy price} * \text{allocation})$

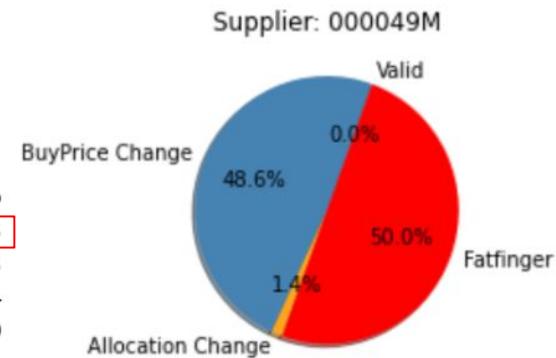
- What is left is distributed among other causes (e.g. buy price change)

$$\text{Buy Price Change} = \frac{|\text{buy price change \%}|}{|\text{buy price change \%}| + |\text{allocation change \%}|}$$

# UI Demo - Single Part & Program - Likelihood Pie Chart

For each supplier (M code), calculate the likelihood of each potential reasons

	M Code	LastMonth Buy	ThisMonth Buy	LastMonth Allo	ThisMonth Allo
0	000049M	0.505	5.050	0.4	0.3
1	004531M	0.530	0.620	0.2	0.3
2	005173M	0.524	0.524	0.4	0.4
3	005241M	0.000	0.000	0.0	0.0

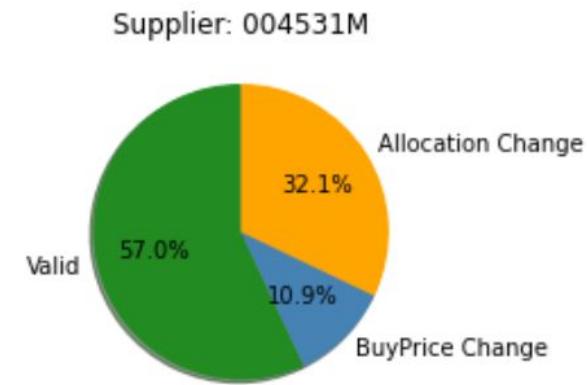


Because there's very likely to be a fat finger issue (there's a shift in decimal), valid likelihood is 0%

# UI Demo - Single Part & Program - Likelihood Pie Chart

For each supplier (M code), calculate the likelihood of each potential reasons

	M Code	LastMonth Buy	ThisMonth Buy	LastMonth Allo	ThisMonth Allo
0	000049M	0.505	5.050	0.4	0.3
1	004531M	0.530	0.620	0.2	0.3
2	005173M	0.524	0.524	0.4	0.4
3	005241M	0.000	0.000	0.0	0.0



No fat finger issue, but price change from 0.53 to 0.62;  
allocation increase from 20% to 30%

# UI Demo - Multiple Part & Program Input

## Apple Cost Test

### Date

2021/2/14

**Option 1. Input one Part & Program to get detailed output**

### Part/Program

Part	Program
1	

### Data Input

Upload

**Option 2. Input multiple Part & Program for brief check**

### Data Input

Upload

### Reason Output

	Part	Program	M Code	Max Reason	WAC	Prev WAC	WAC change %
1	593-00514	O_J318	000049M	fat finger	2.7388	0.5204	426.287
2	593-00514	O_J318	005173M	Allocation Change	2.7388	0.5204	426.287
3	593-00631	O_J418	000049M	Allocation Change	0.522	0.4787	9.045
4	593-00631	O_J418	005173M	Allocation Change	0.522	0.4787	9.045
5	616-00471	O_N84A	004031M	Sell Price	6.98	7.98	-12.531
6	616-00471	O_N84A	004031M	Sell Price	6.98	7.98	-12.531
7							
8							
9							
10							
11							
12							

Check

# Apple Cost Test

Date

2021/4/21

## Option 1. Input one Part & Program

### Part/Program

Part	Program
1	

### Data Input

Upload



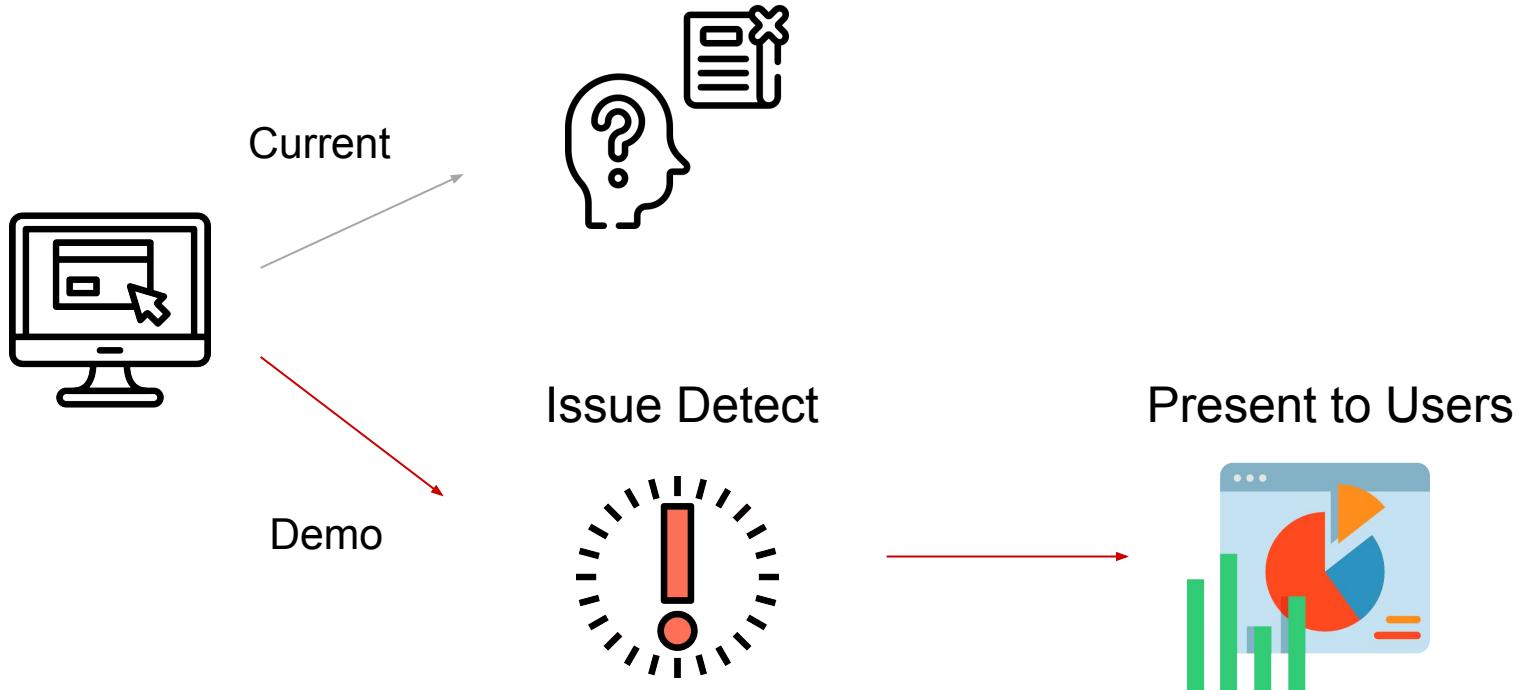
## Option 2. Input multiple Part & Program for brief check

### Data Input

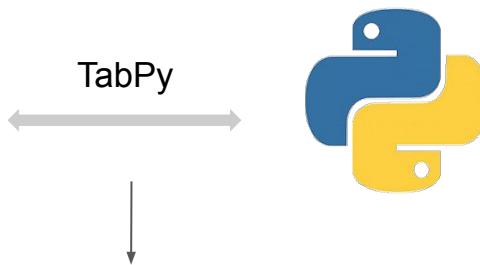
Upload

Check

# How the UI helps



# Tableau Dashboard: Monthly Cost Summaries



Overview



Details



Navigate



# Preprocessing & Prerequisite

- Oct 2020 - Mar 2021
- Calculate weighted average cost (WAC) percentage changes
  - Null: previous WAC is 0
- Focus on changes
- Details:
  - Allocation change
  - Buy price change
  - Sell price change

$$\text{WAC \% change} = \left( \frac{\text{this month WAC}}{\text{previous month WAC}} - 1 \right) \times 100\%$$

Let's go to Tableau!



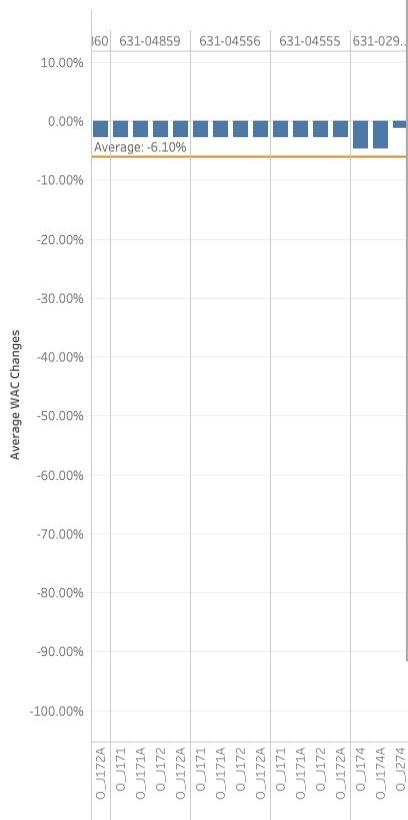
## **Weighted Average Cost Overview**

Las

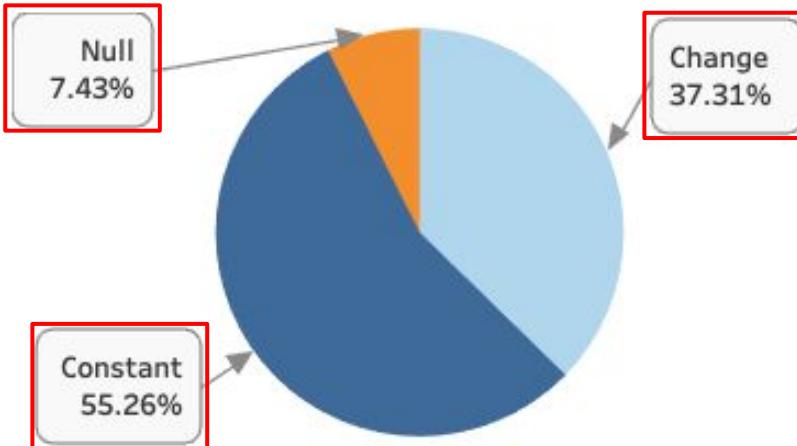
Nex

## **Dec & Jan WAC Changes Table and Details**

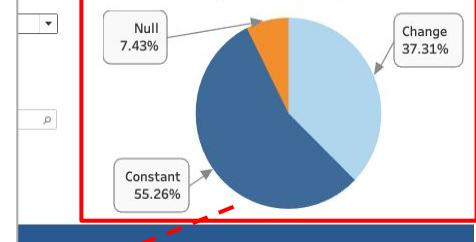
## Average WAC Changes by Part & Program



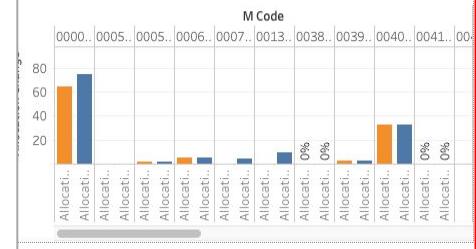
## **WAC Changes Distribution**



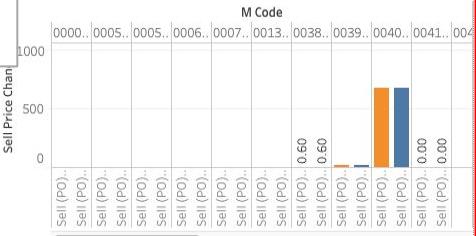
### **WAC Changes Distribution**



**Allocation**



**Sell Price**





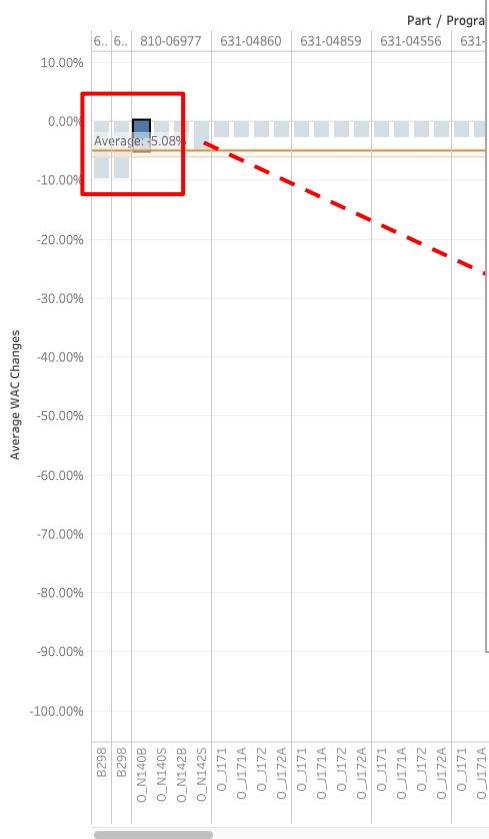
## **Weighted Average Cost Overview**

Last

**Next**

## Dec & Jan WAC Changes Table and Details

## Average WAC Changes by Part & Program





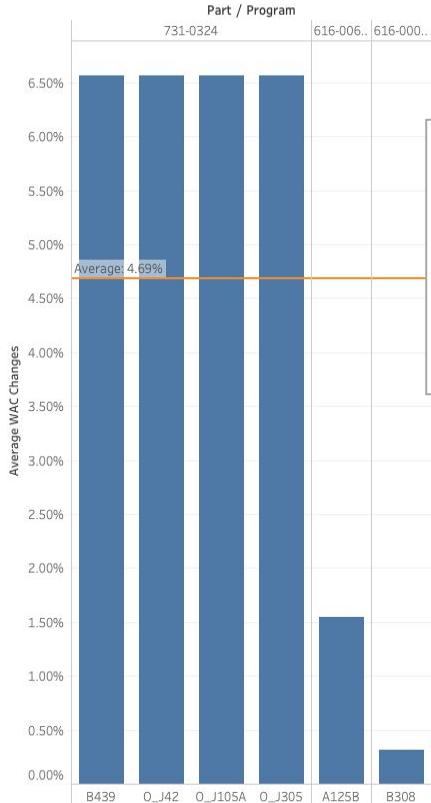
## **Weighted Average Cost Overview**

Las

**Next**

## **Dec & Jan WAC Changes Table and Details**

## Average WAC Changes by Part & Program



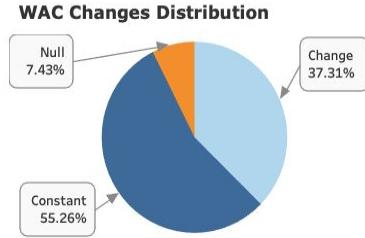
WAC Changes Filter

0.29%  6.56%

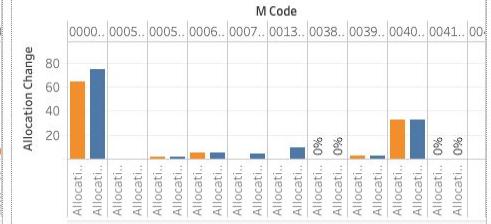
Values in Range

## Highlight Part

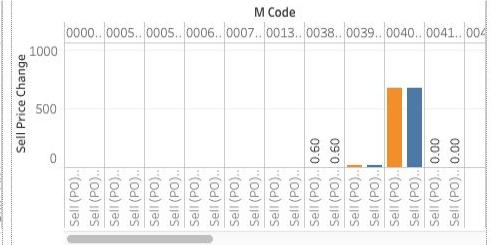
## Highlight Program



## Allocation



Sell Price



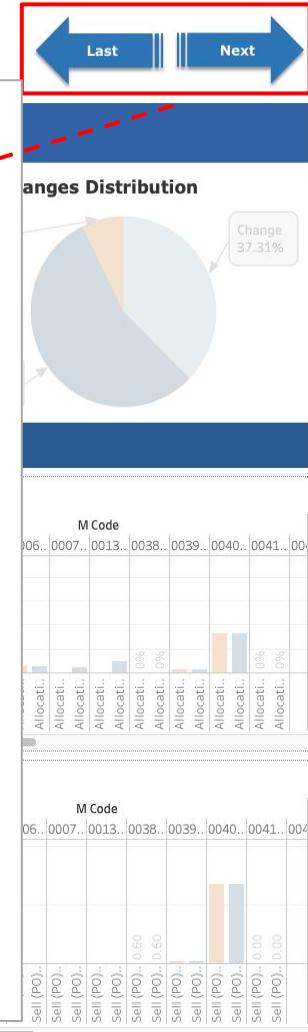
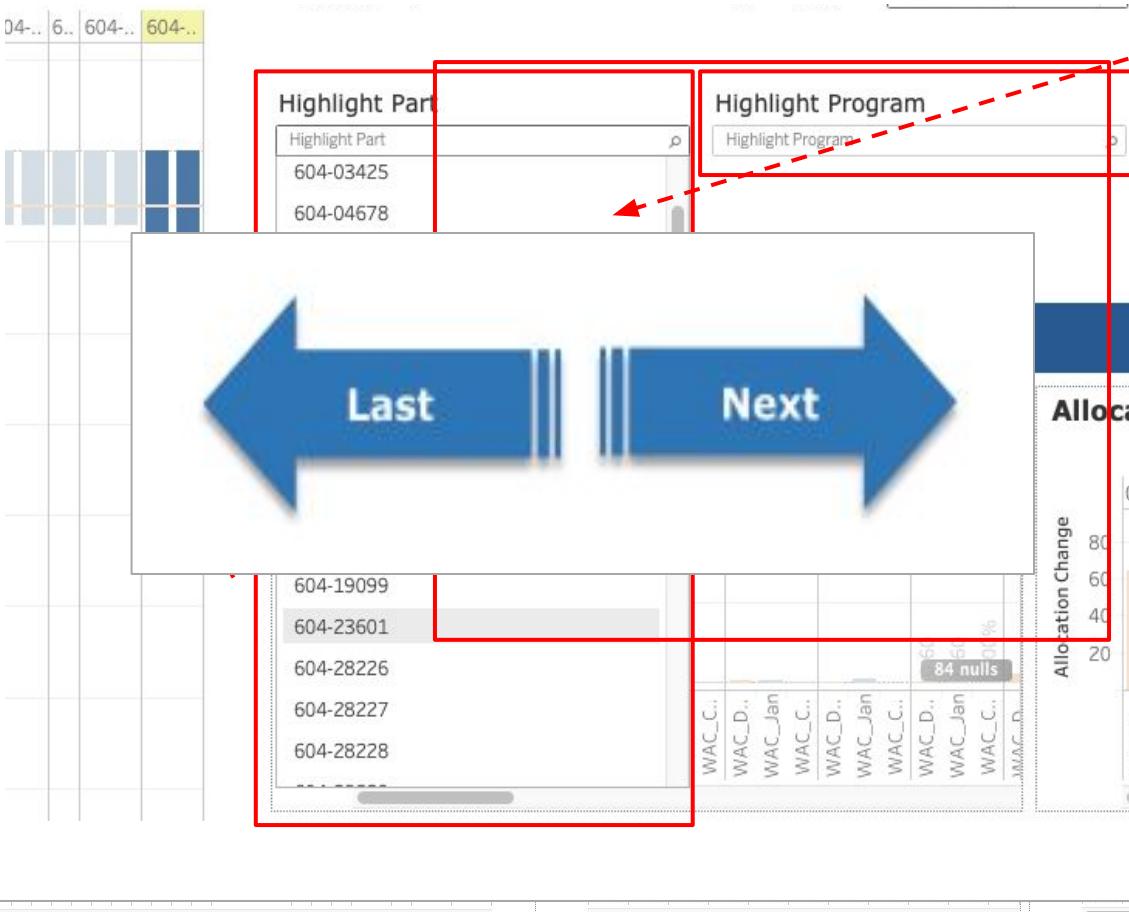
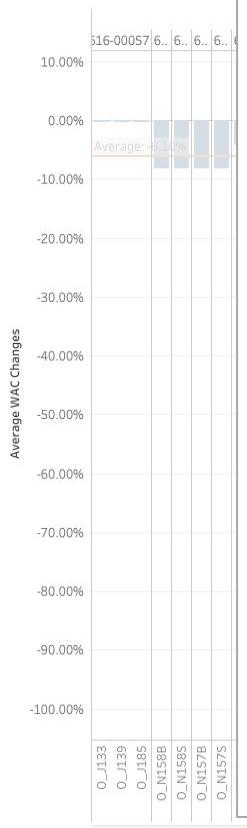




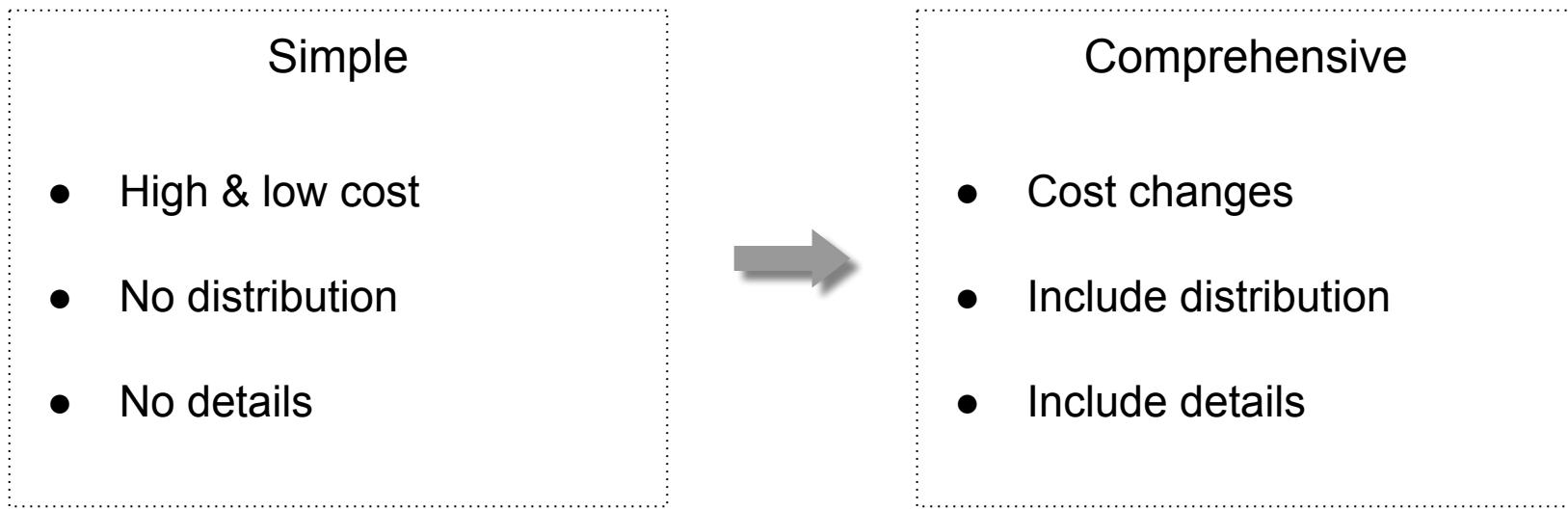
## **Weighted Average Cost Overview**

### **Dec & Jan WAC Cha**

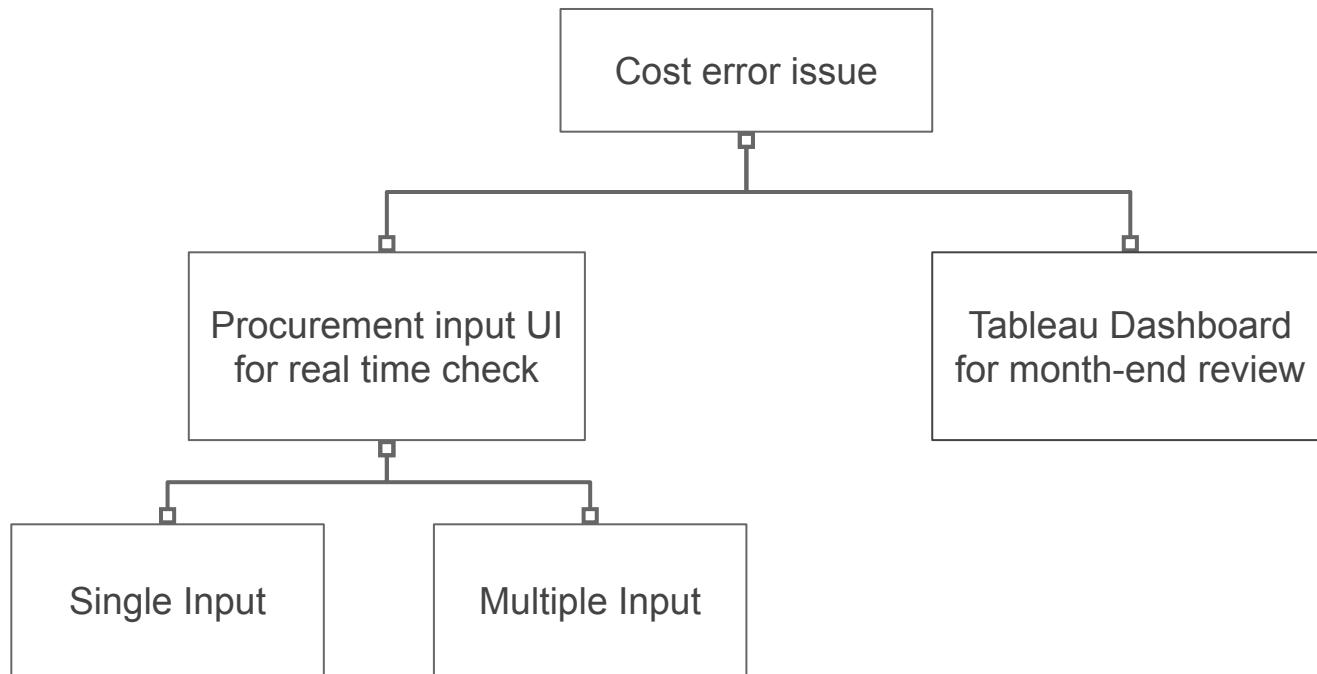
## Average WAC Change



# How the Dashboard helps



# Conclusions



Thank you!

Any Questions?