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

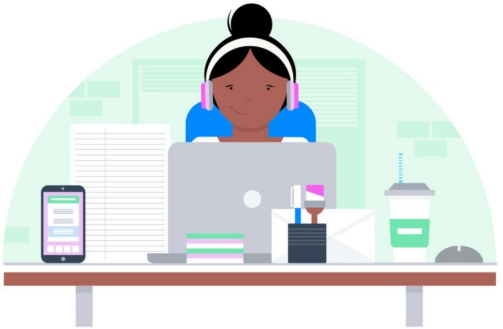
Agenda

- 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

What is at stake?

Data Entry

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

Procurement

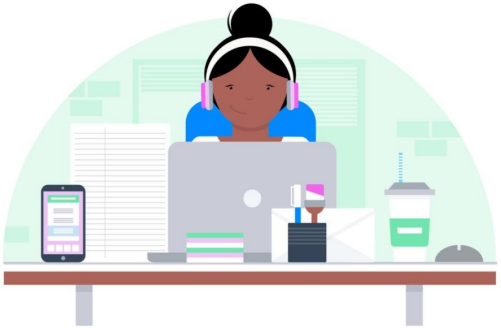
Managerial Review

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

What is at stake?

Cost (per part)		$0.01
Product produced (annual)	x	200 million
Usage per Product	x	10
Total overpayment (annual)		**$20 million**

Thousands of similar parts...



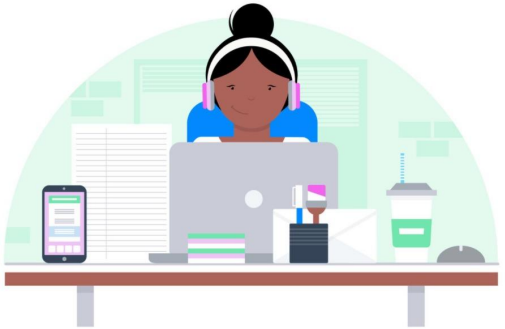
Managerial Review

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

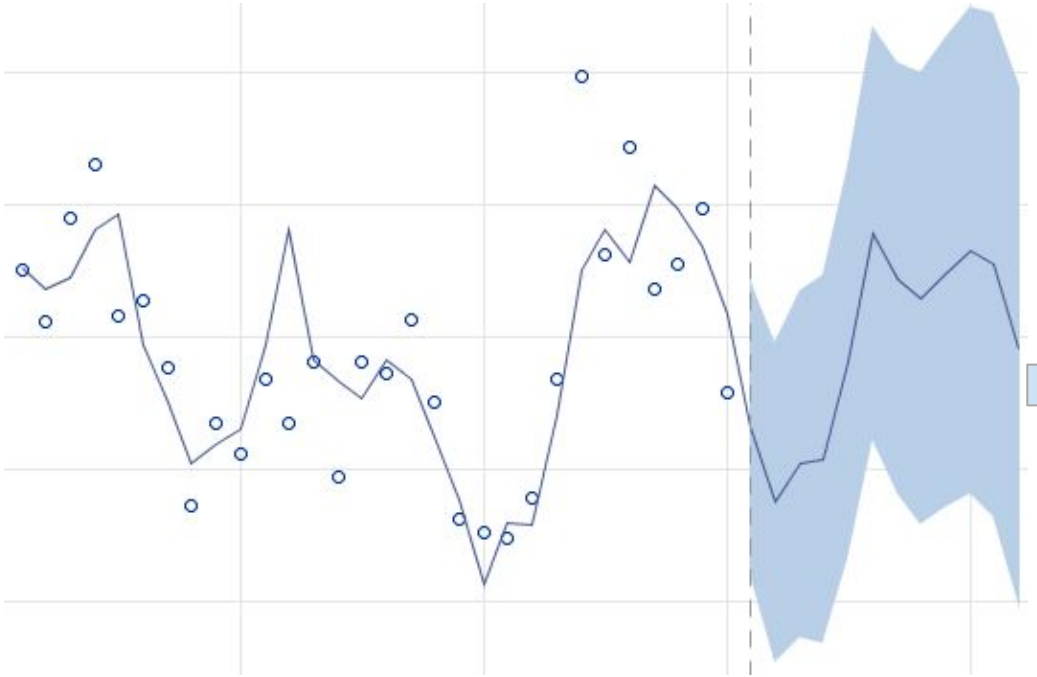
				October FY'21			
Part	Program	Buy Sell Flag	M Code	Allocation %	Buy $	Sell (PO) $	WAC
593-00514	O_J318	N	000049M	40%	$0.57400	$0.00000	$0.52480
593-00514	O_J318	N	005173M	60%	$0.49200	$0.00000	$0.52480

Σ(Allocation)(Buy Price) = WAC

40% * 0.574 + 60% * 0.492 = 0.5248

WAC = Weighted Average Cost

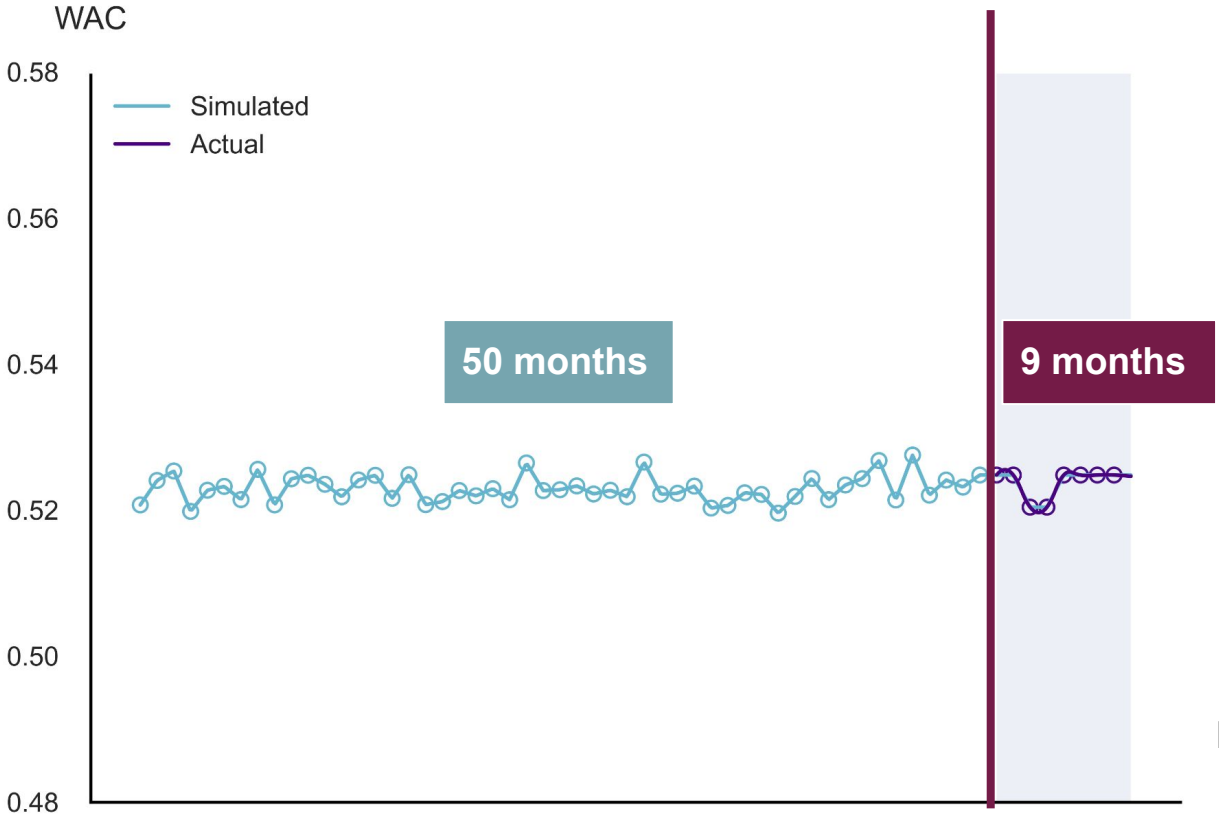
Time-Series Model: Predicting Monthly WAC



2) ARIMA Model

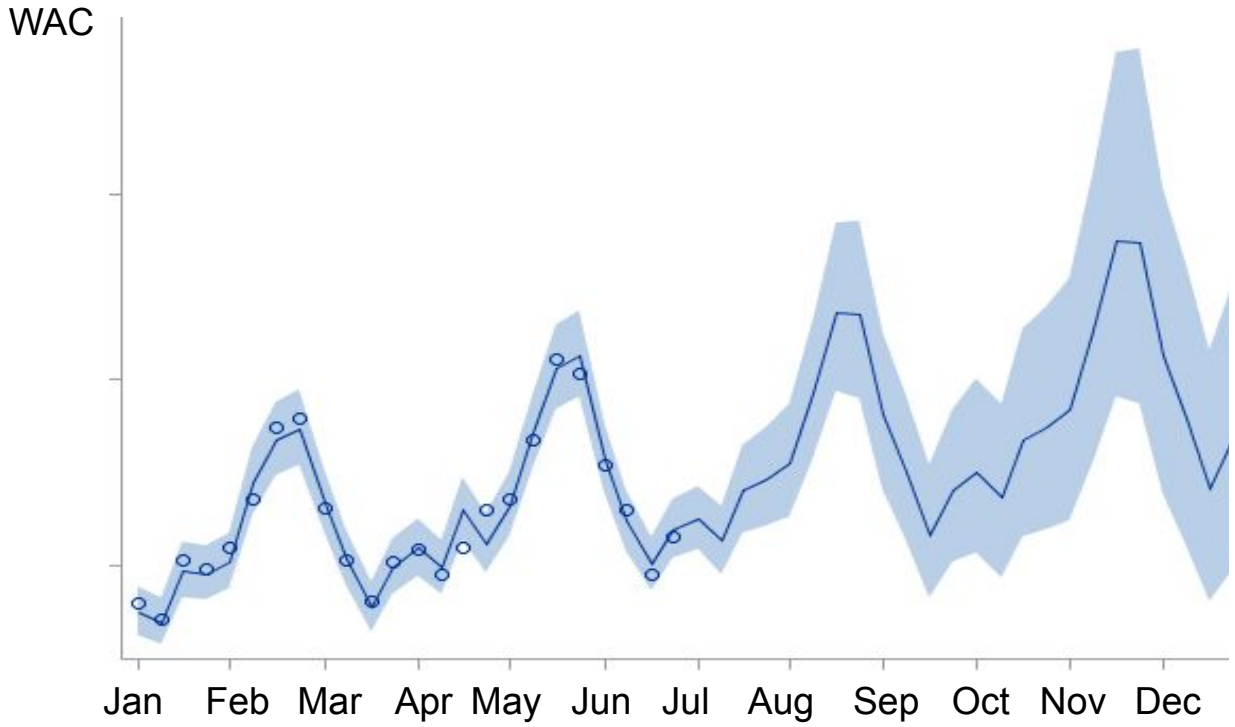
Obtain prediction intervals for WAC

Simulating Historical Data

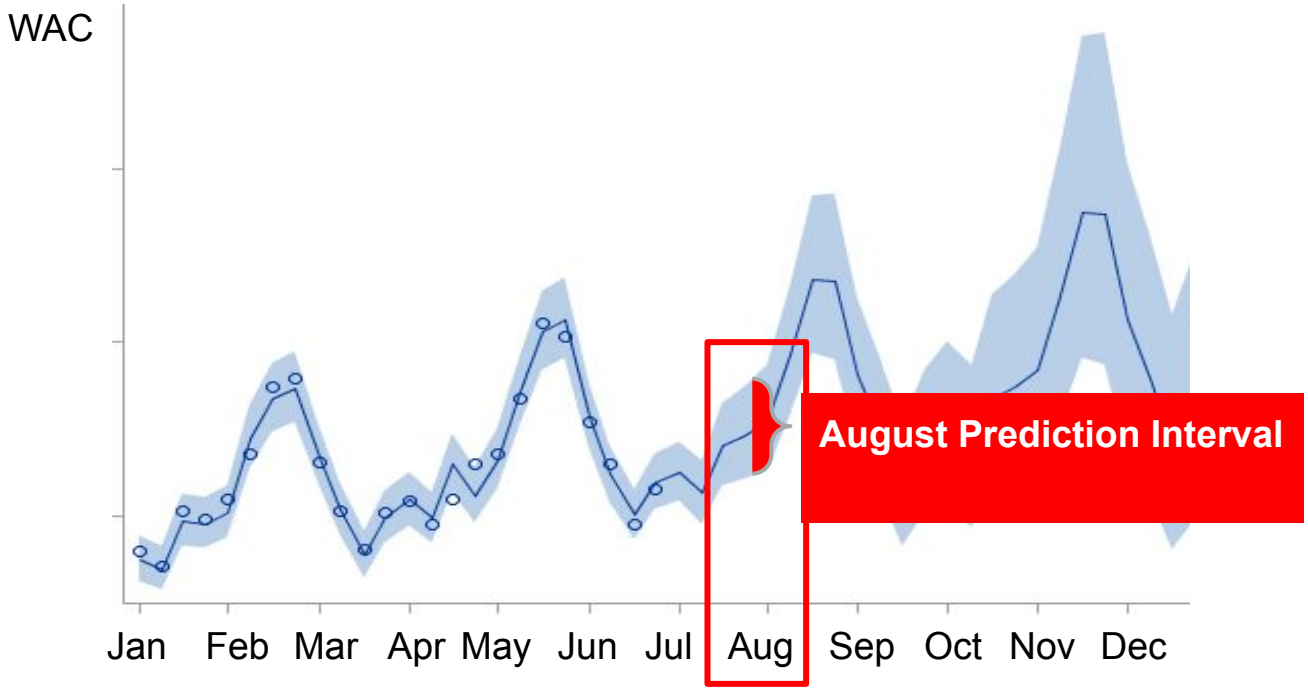


Part: 593-00514
Program: O_J318

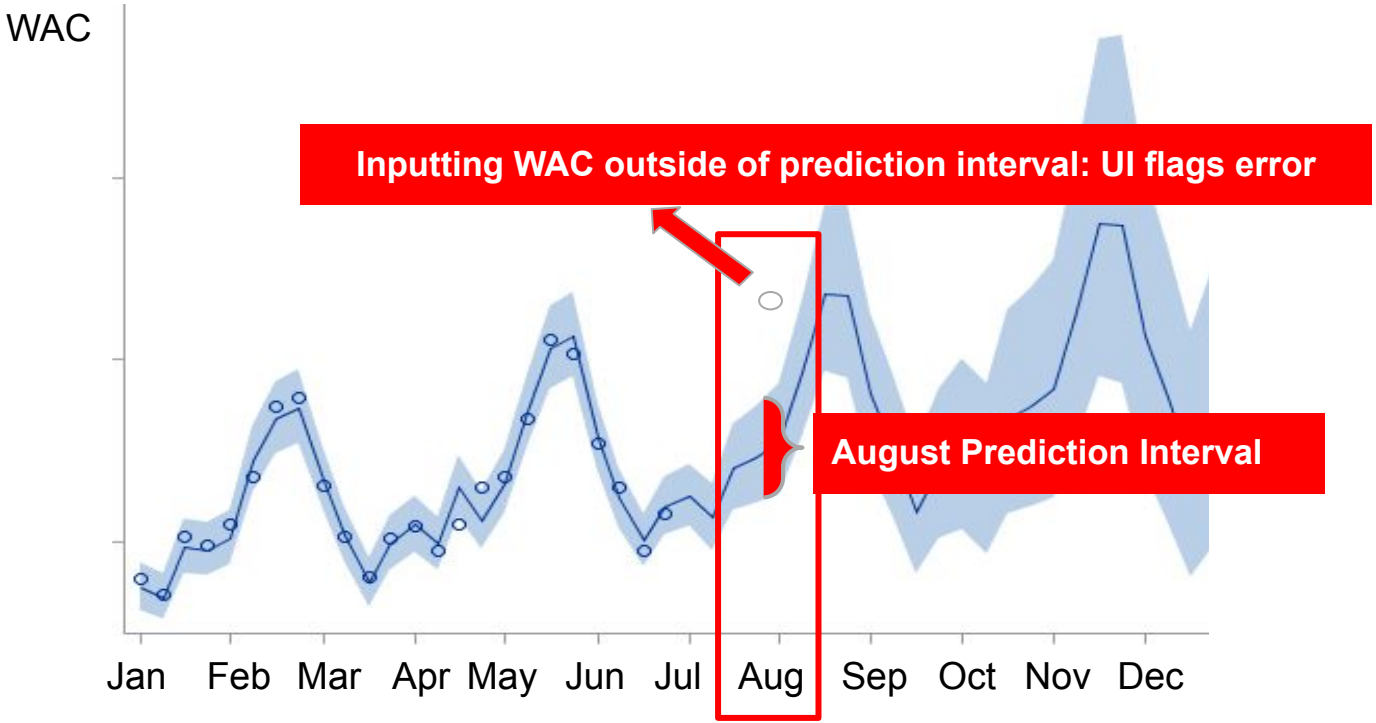
Time-Series Model: Predicting Monthly WAC



Time-Series Model: Predicting Monthly WAC



Time-Series Model: Predicting Monthly WAC



Why Do Time-Series Modelling?

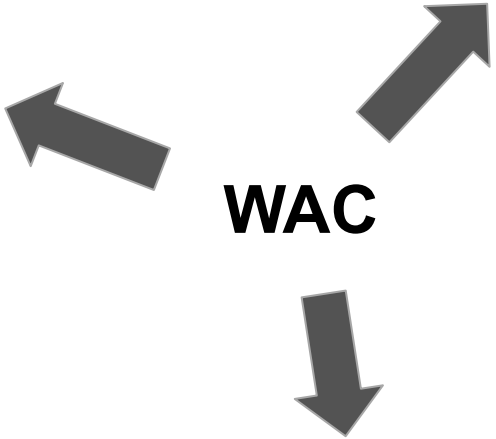
Current Practice at Apple

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

How Does WAC Change?

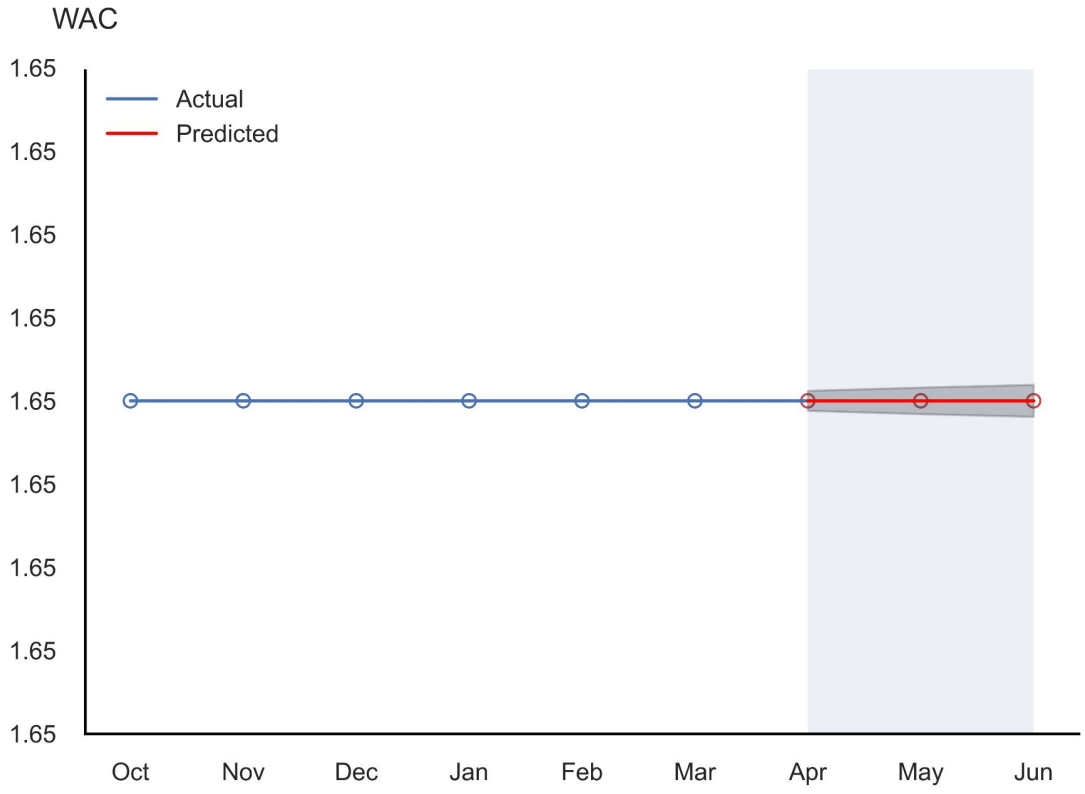
Changes between 0 and positive values
59 cases (8%)

Stays constant
434 cases (57%)



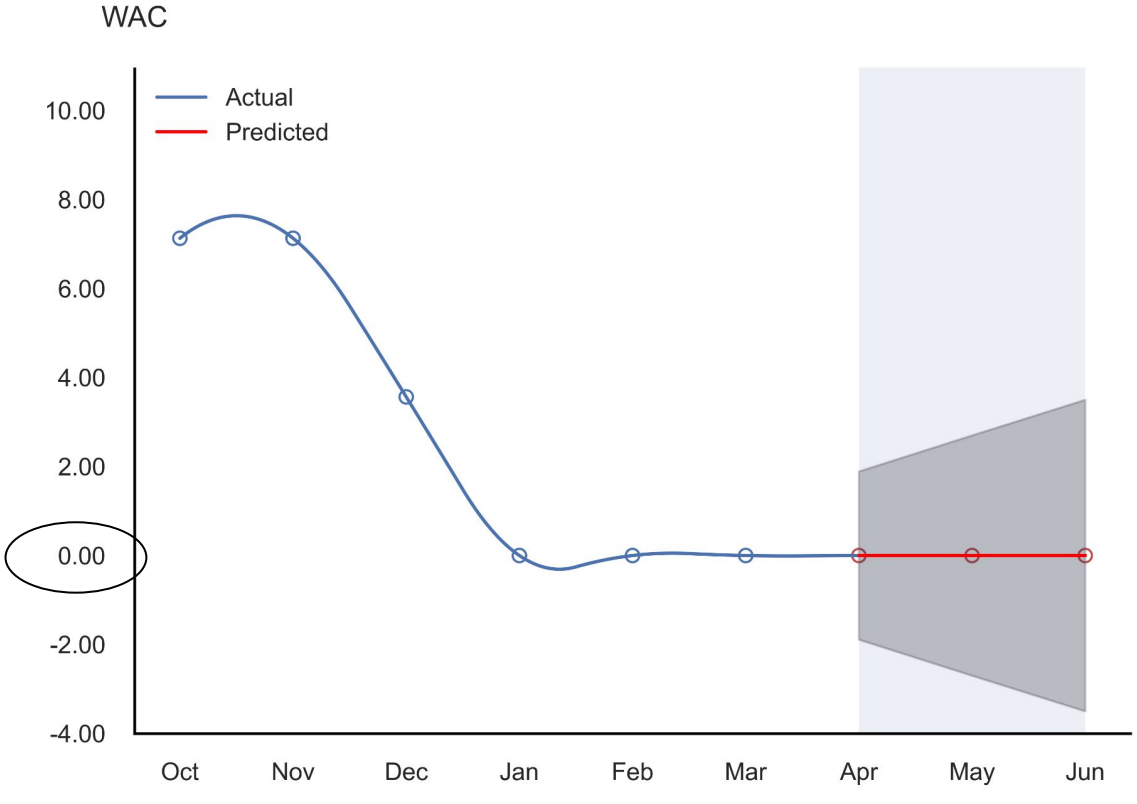
Changes between different positive values
269 cases (35%)

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



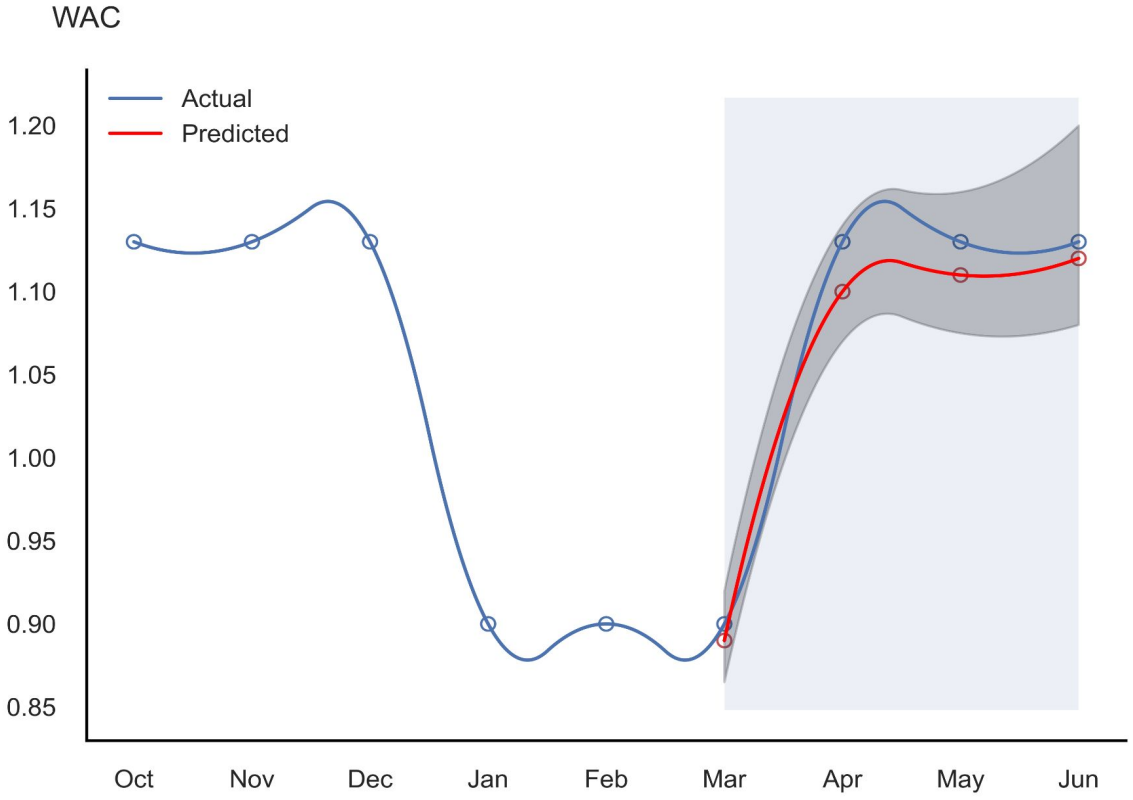
Part: 677-05605
Program: O_D10

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

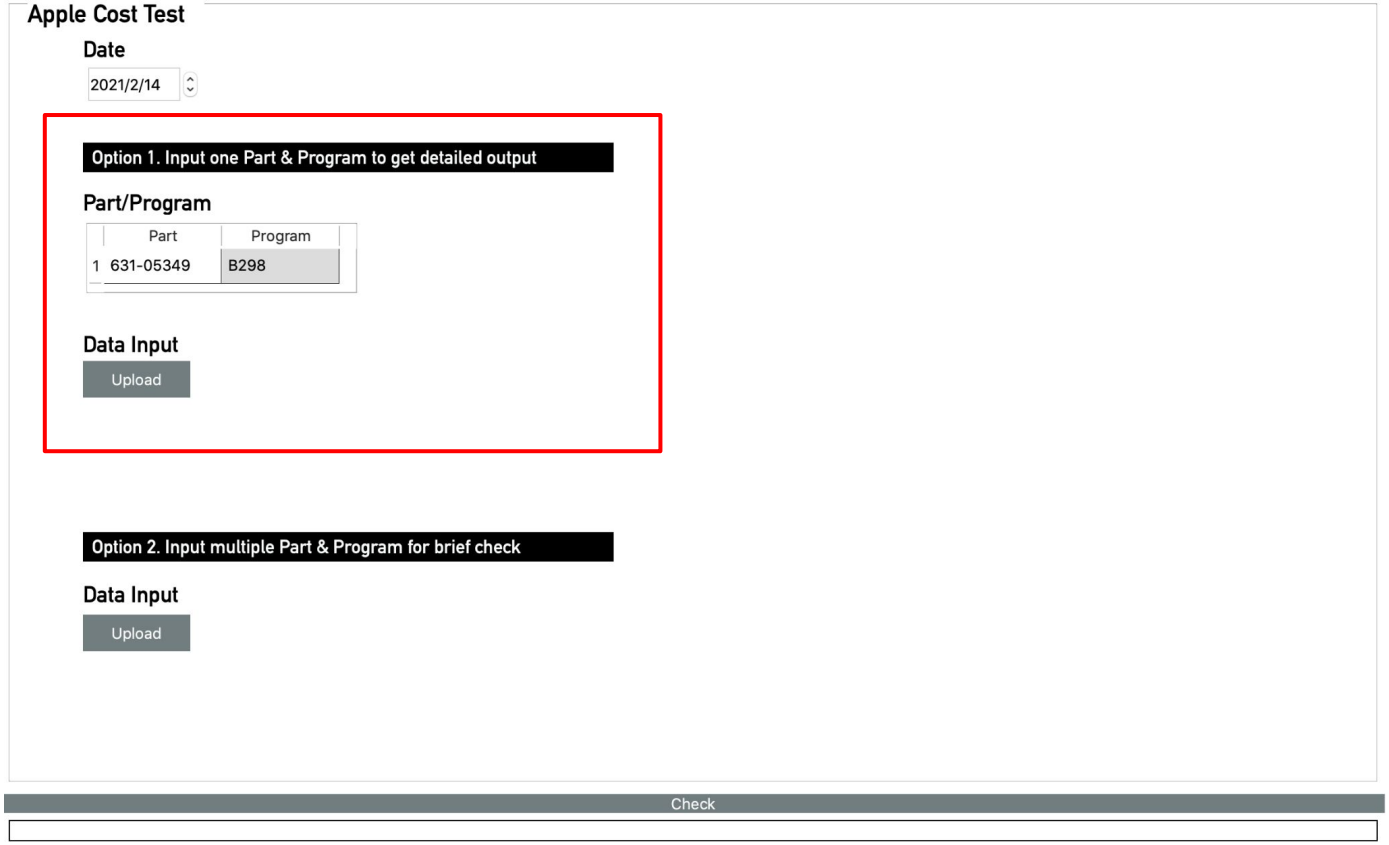
UI Demo with PyQt5 - Home Page

Data Input - Single or Multiple

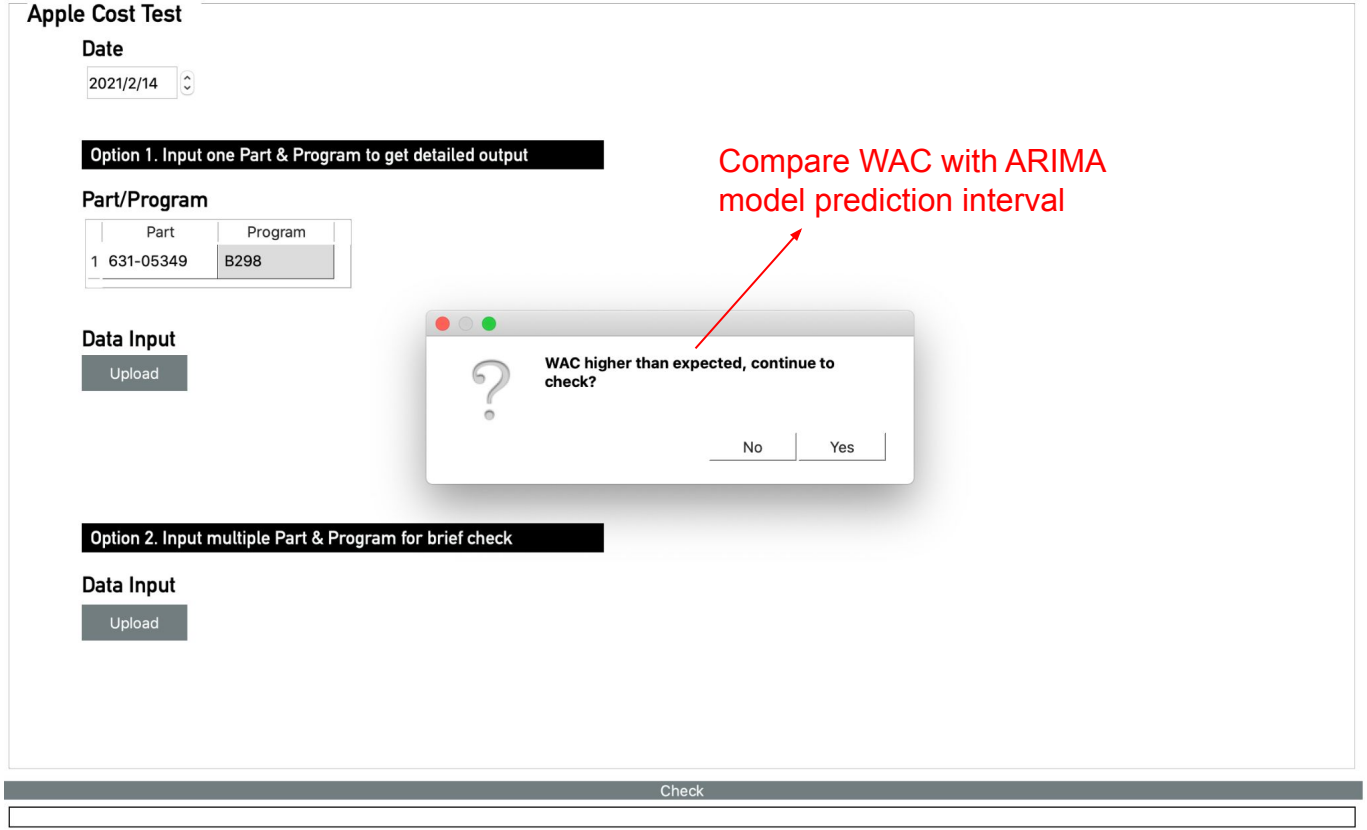
Error Detect

Analysis result

UI Demo - Single Part & Program Input



UI Demo - Single Part & Program - Alert

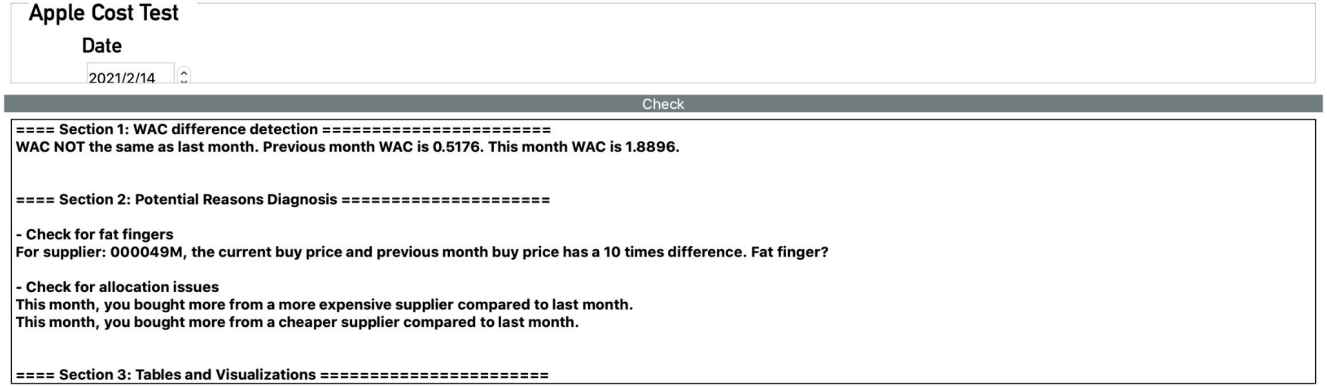


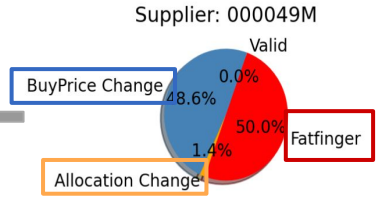
UI Demo - Single Part & Program - Analysis Results

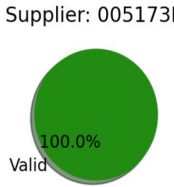
Message

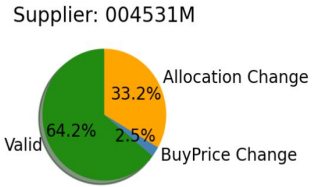
Reason likelihood

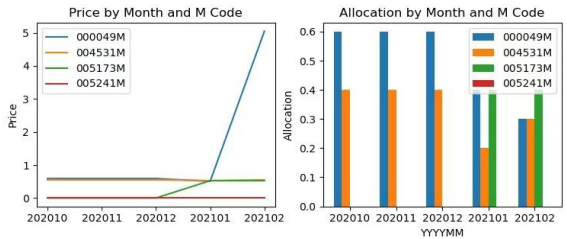
Price/Allocation Trend











UI Demo - Single Part & Program - Likelihood Pie Chart

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

Valid Likelihood = 1 - % change in (buy price * allocation)

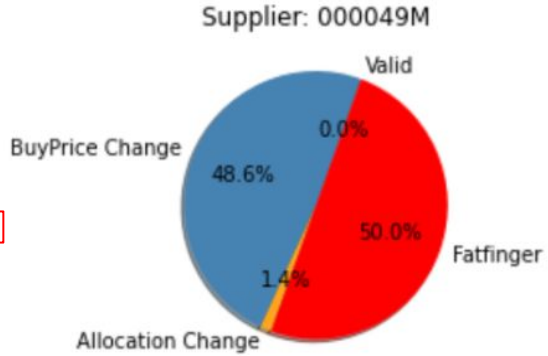
- **What is left is distributed among other causes (e.g. buy price change)**

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

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
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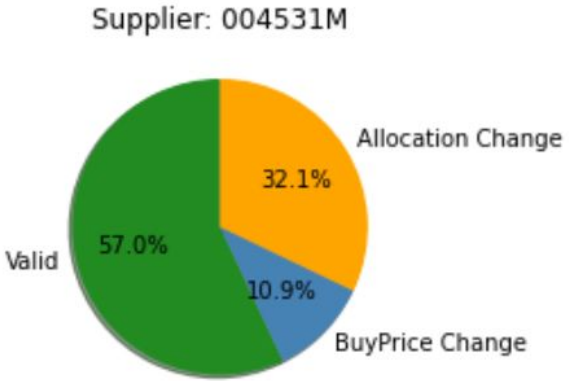
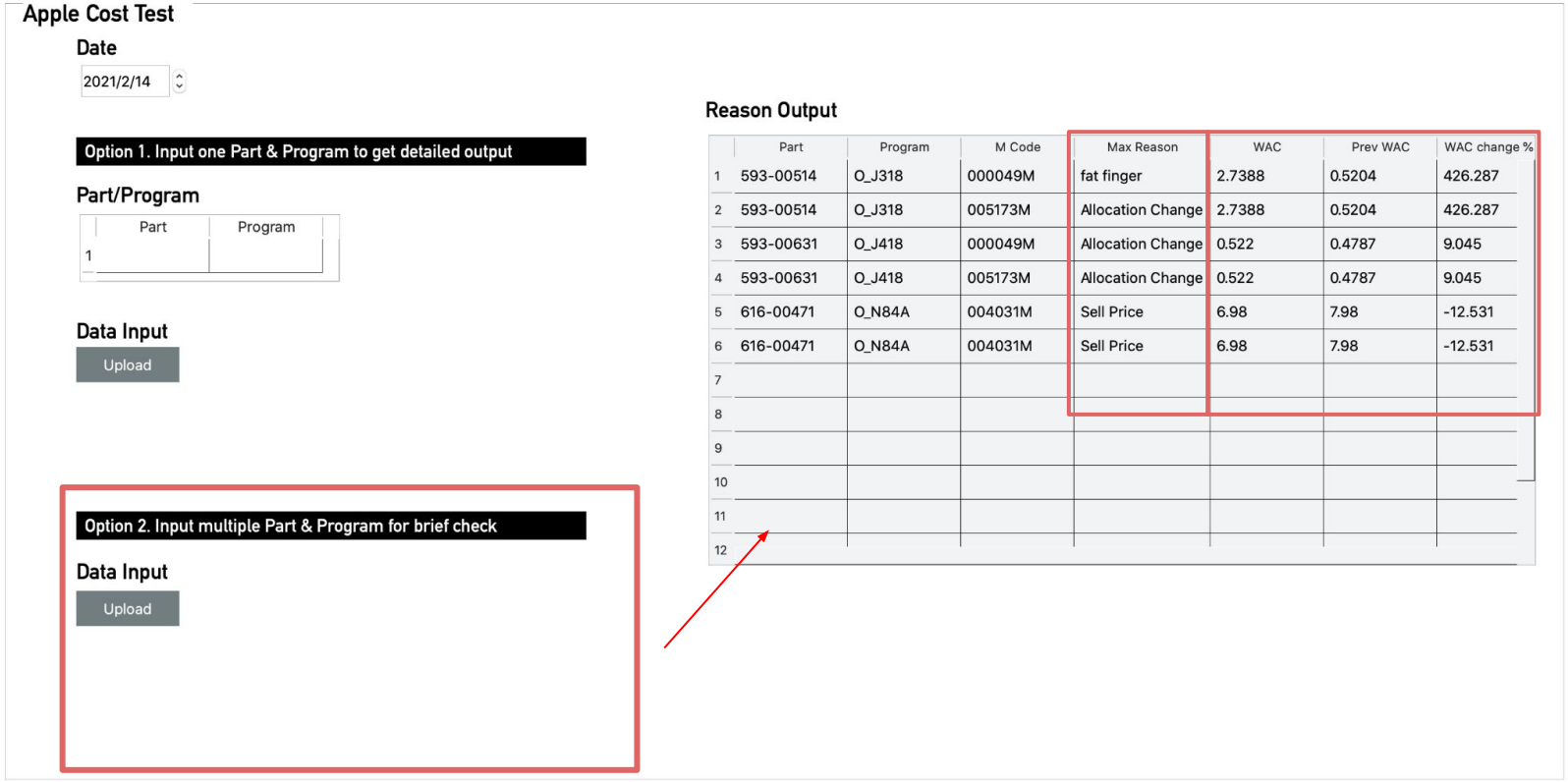


No fat finger issue, but price change from 0.53 to 0.62; allocation increase from 20% to 30%

UI Demo - Multiple Part & Program Input



Apple Cost Test

Date

2021/4/21

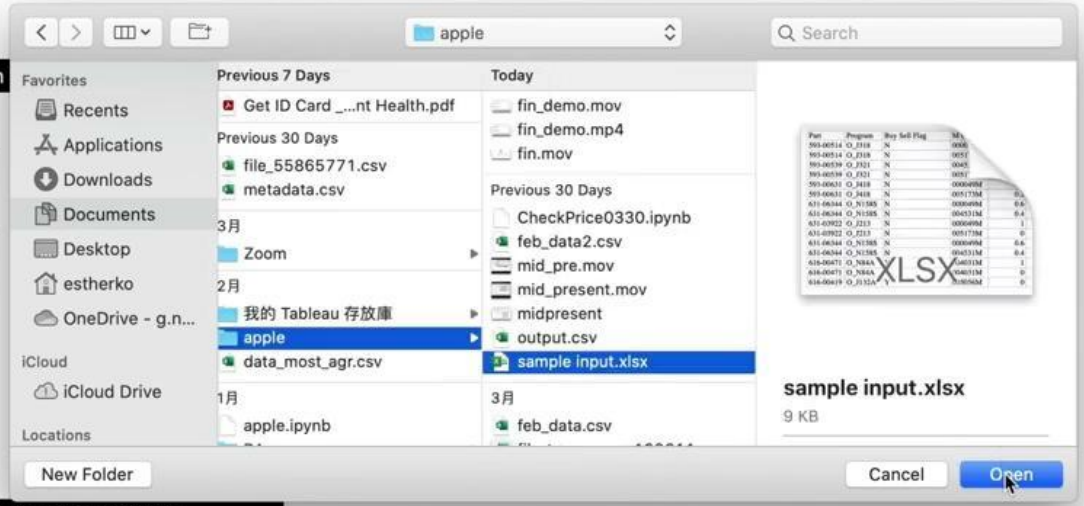
Option 1. Input one Part & Program

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

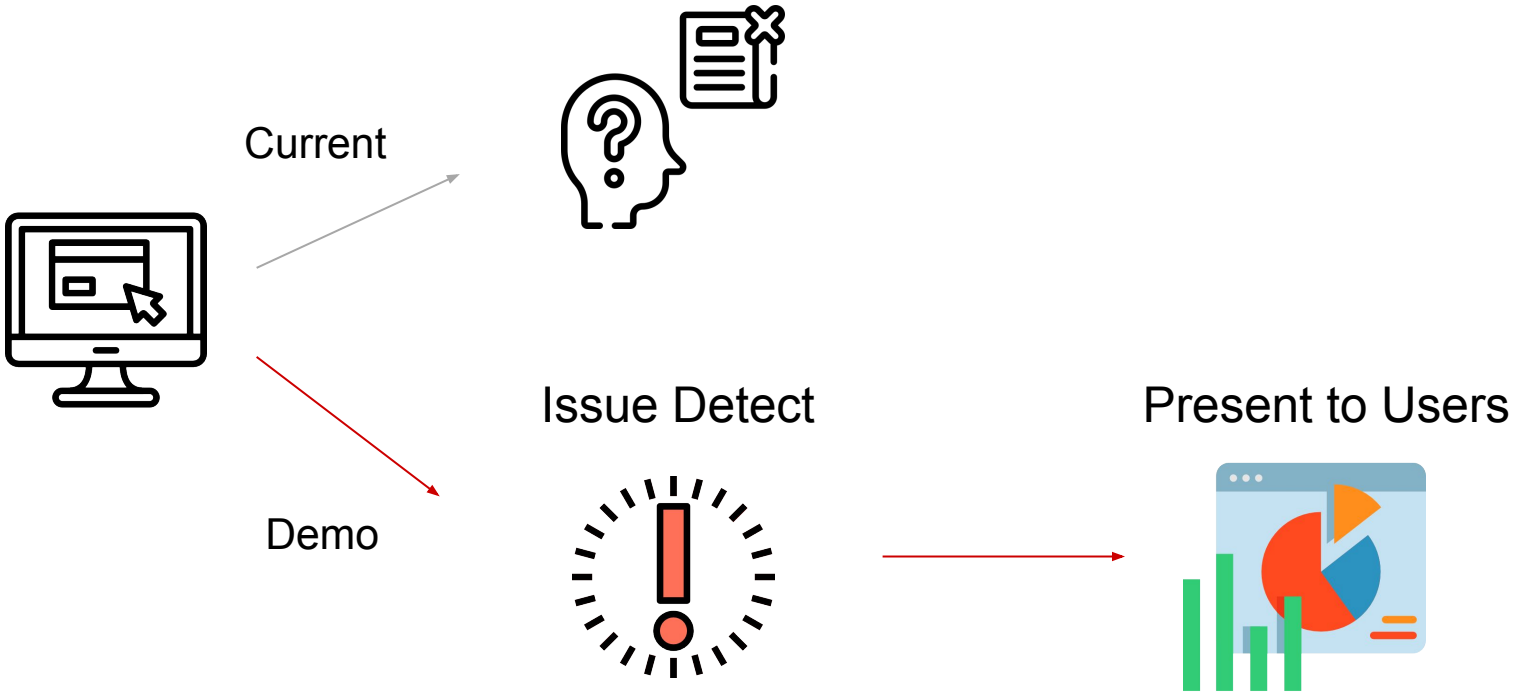
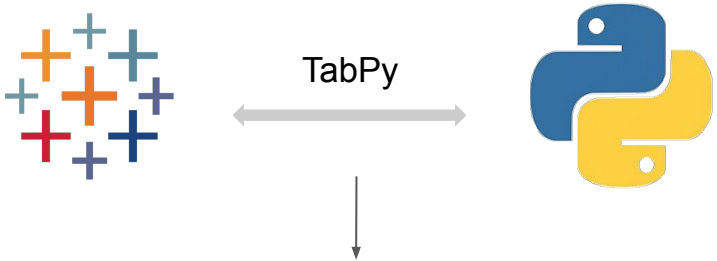


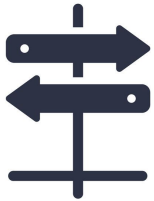
Tableau Dashboard: Monthly Cost Summaries



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

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

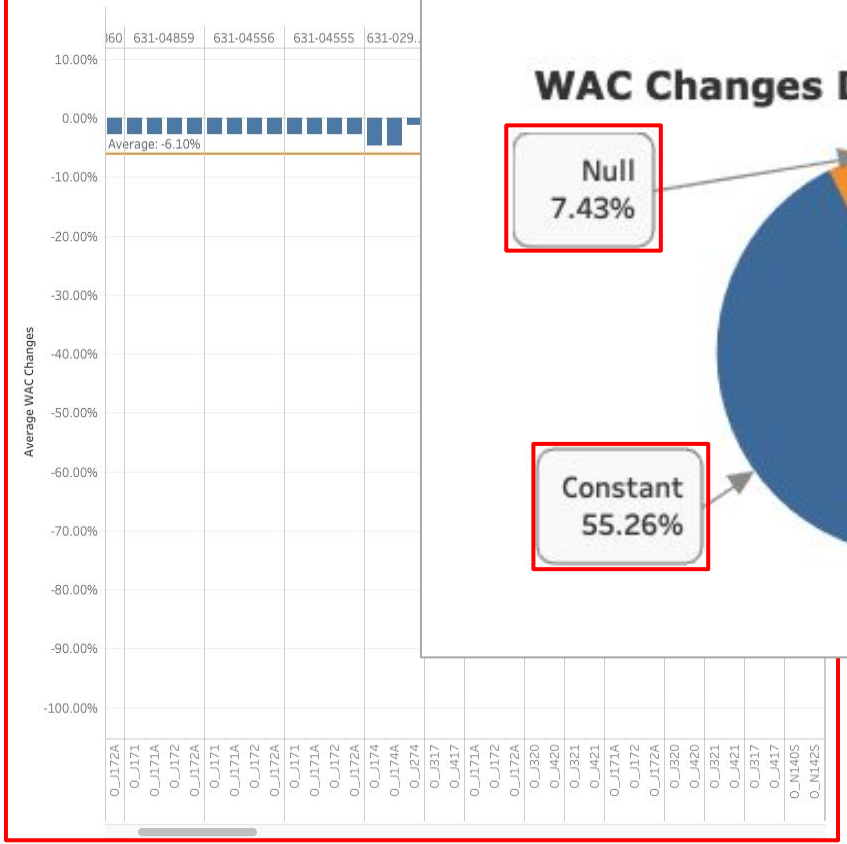
Let’s go to Tableau!

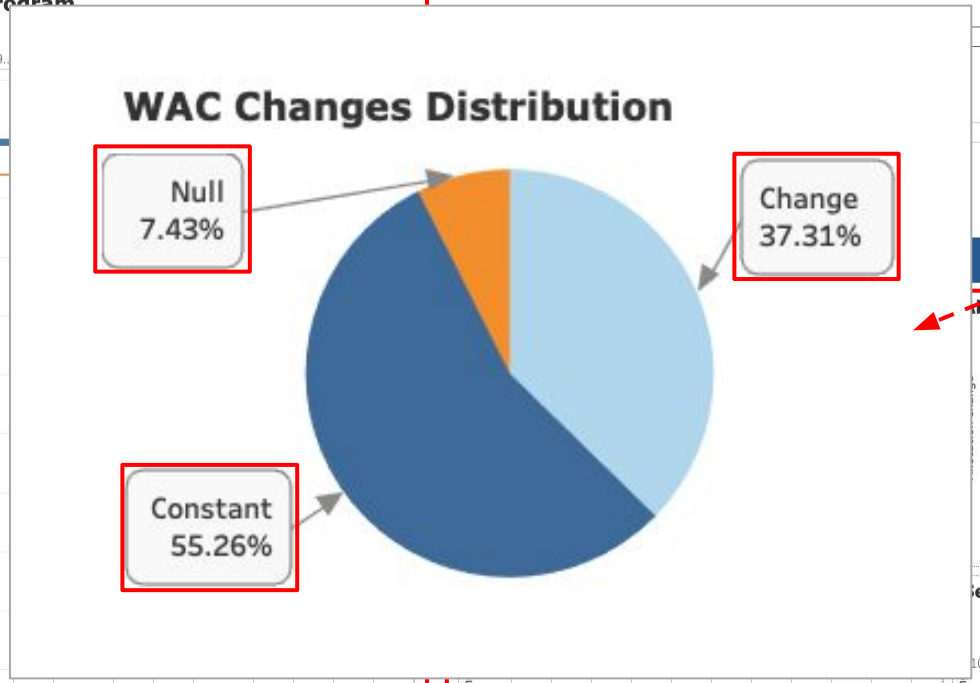
Weighted Average Cost Overview

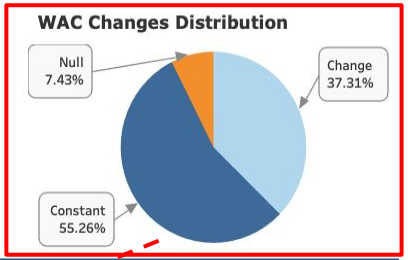
Last Next

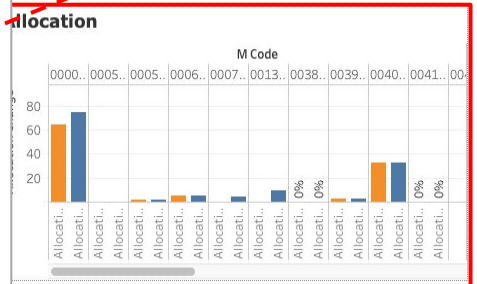
Dec & Jan WAC Changes Table and Details

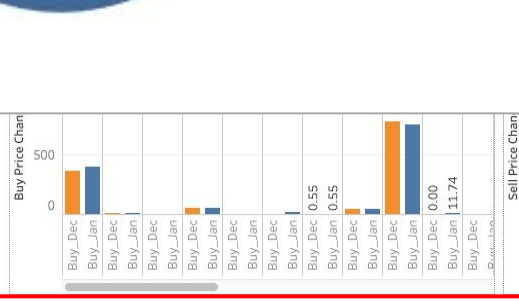
Average WAC Changes by Part & Program

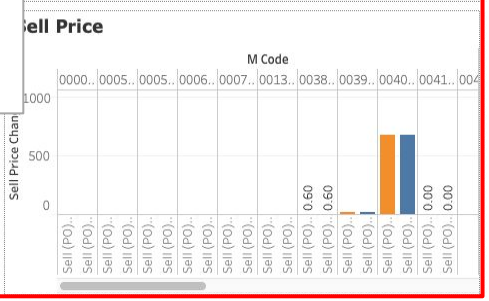












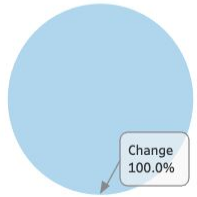
Weighted Average Cost Overview

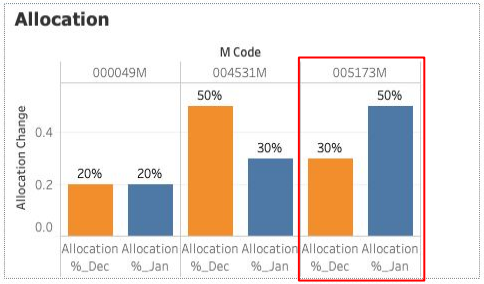
Last Next

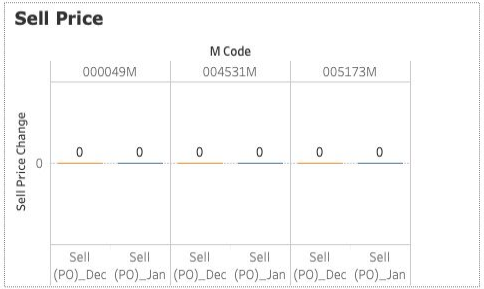
Dec & Jan WAC Changes Table and Details

Average WAC Changes by Part & Program

WAC Changes Distribution





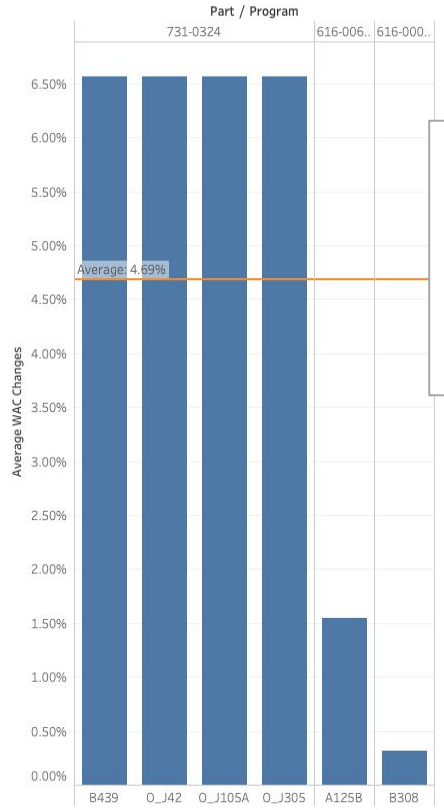


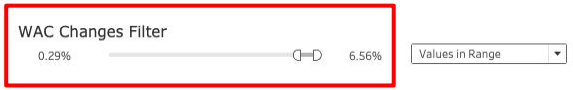
Weighted Average Cost Overview

Last Next

Dec & Jan WAC Changes Table and Details

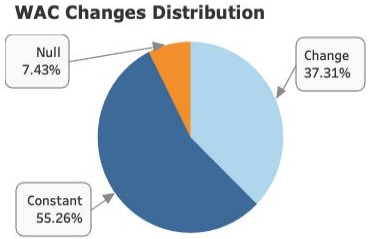
Average WAC Changes by Part & Program

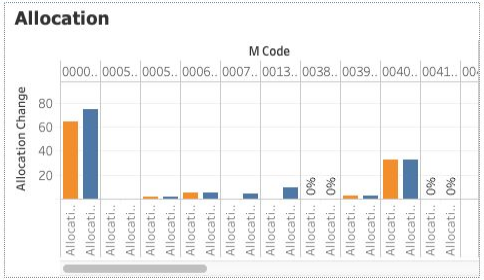


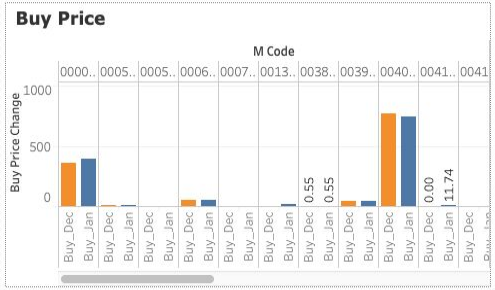


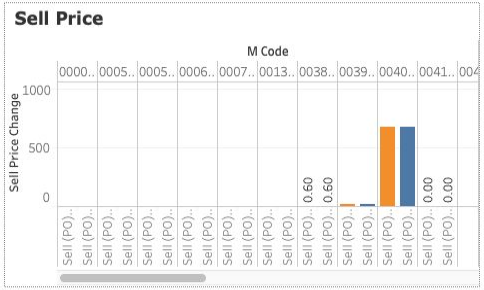
Highlight Part

Highlight Program







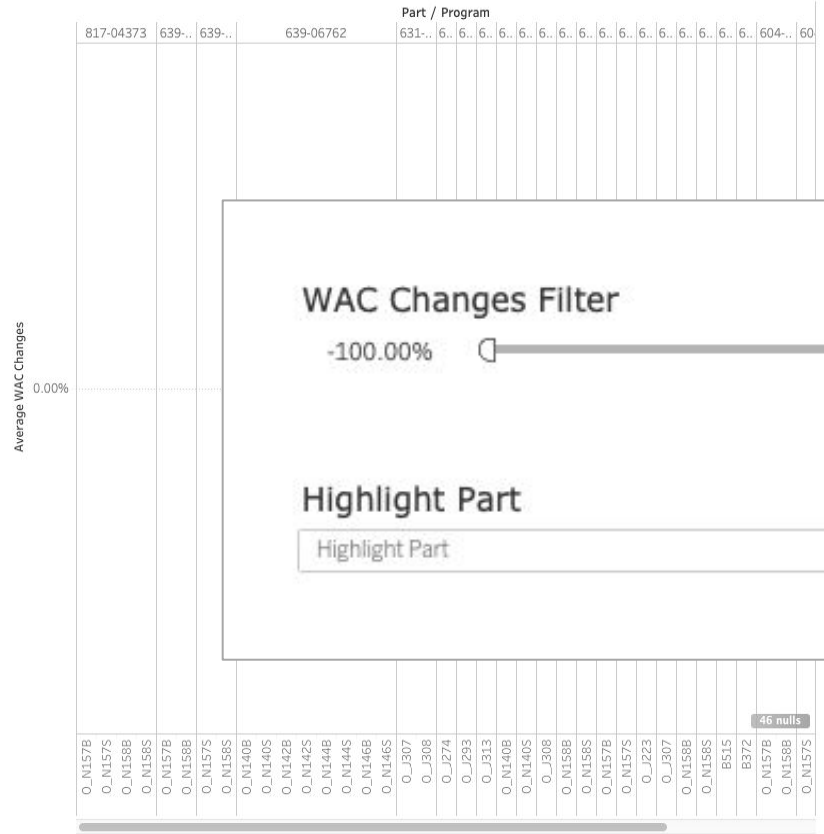


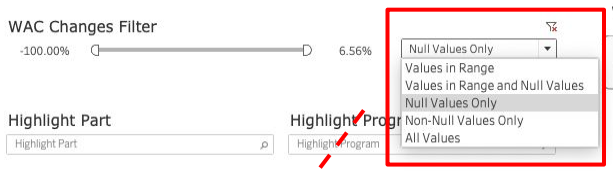
Weighted Average Cost Overview

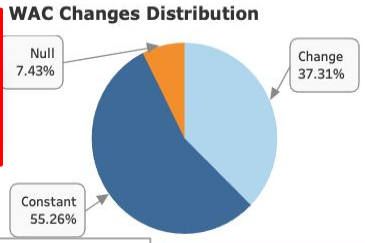
Last Next

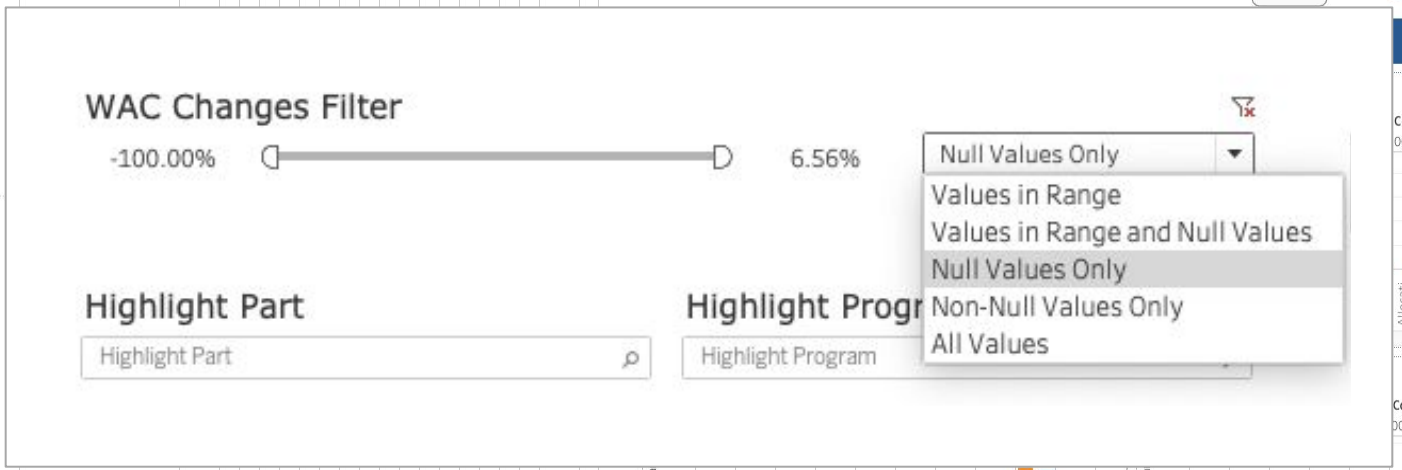
Dec & Jan WAC Changes Table and Details

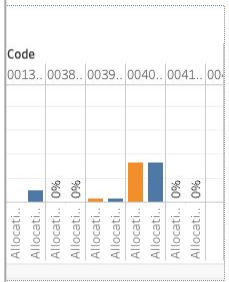
Average WAC Changes by Part & Program

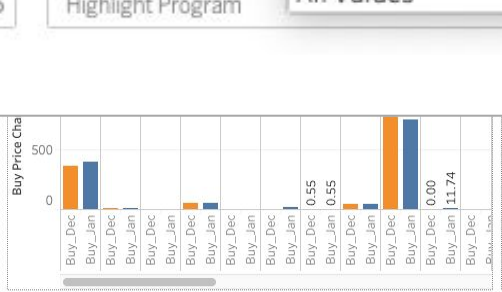


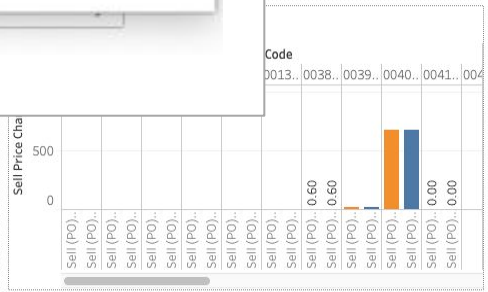




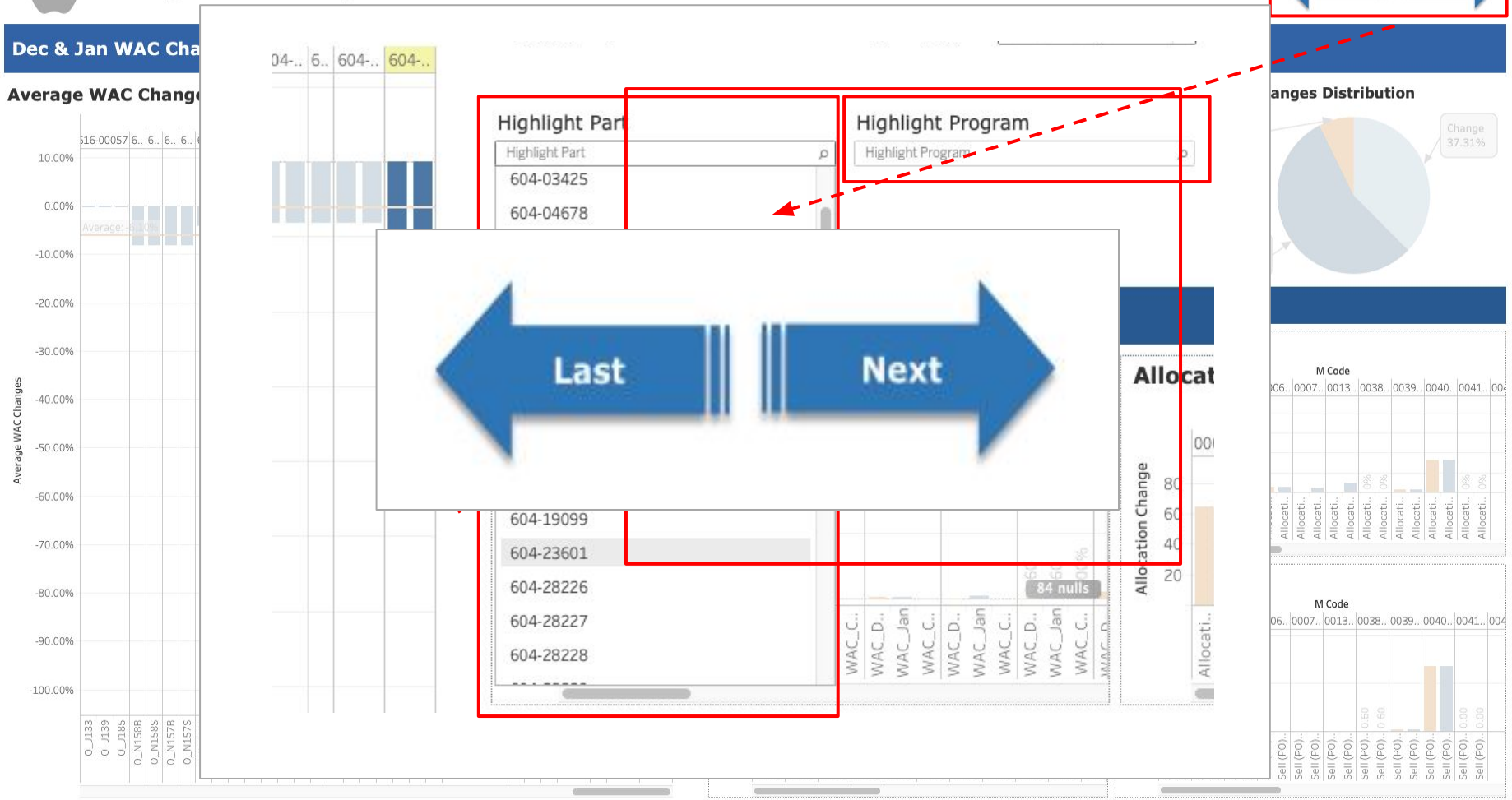








Weighted Average Cost Overview



How the Dashboard helps

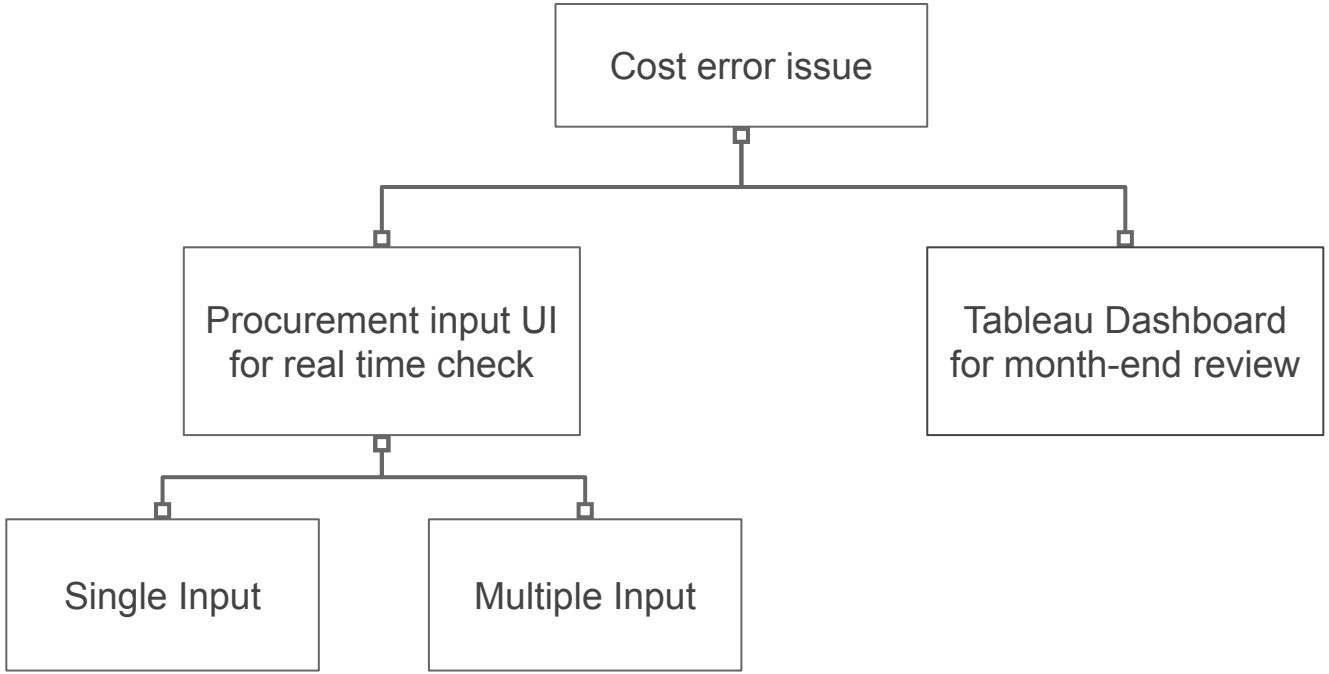
Simple

- High & low cost
- No distribution
- No details

Comprehensive

- Cost changes
- Include distribution
- Include details

Conclusions



Thank you!

Any Questions?