Microsoft

Cortana Analytics Workshop

Sept 10 – 11, 2015 • MSCC

Triple Mac	$28.00
ANGUS Tasty	$35.00
ANGUS Premium Deluxe	$35.00
Big Mac	$20.00

THE BIG MAC INDEX

How many burgers you get for $50 USD?

30

India*	$1.62

23

Ukraine	$2.11
Hong Kong	$2.12

21

Malaysia	$2.34

20

China	$2.44
South Africa	$2.45
Indonesia	$2.46
Thailand	$2.46
Taiwan	$2.5

19

Russia	$2.55
Sri Lanka	$2.55
Egypt	$2.57
Poland	$2.58
Hungary	$2.63

18

Saudi Arabia	$2.67
Philippines	$2.68
Mexico	$2.7

17

Lithuania	$2.87
Pakistan	$2.89

16

Latvia	$3.0

15

South Korea	$3.19
UAE	$3.27

14

Czech Rep.	$3.45
Turkey	$3.54

13

Peru	$3.71
Singapore	$3.75
Britain	$3.82

12

Costa Rica	$4.02
Chile	$4.05
New Zealand	$4.05
Israel	$4.13
Japan	$4.16

11

USA	$4.2
Euro area	$4.43
Colombia	$4.54

10

Canada	$4.63
Uruguay	$4.63
Argentina	$4.64
Australia	$4.94

9

Denmark	$5.37

8

Brazil	$5.68
Sweden	$5.91

7

Norway	$6.79
Switzerland	$6.81

Source: The Economist (Jan 2012)

* Chicken burger

Souce: https://en.wikipedia.org/wiki/Big_Mac_Index#/media/File:Big_Mac_index_50USD_2columns.png
Use under CC BY-SA license: https://en.wikipedia.org/wiki/Wikipedia:Text_of_Creative_Commons_Attribution-ShareAlike_3.0_Unported_License

Cortana Analytics for Retail

Xueshan Zhang
Data Scientist, Microsoft

Microsoft

Cortana Analytics Suite

Transform data into intelligent action

A Brief History …

The Origin of Price and Revenue Optimization

PEOPLExpress

American Airlines

PEOPLExpress Picture: Source: https://commons.wikimedia.org/wiki/File:People_Express_Boeing_747_at_London_Gatwick_in_June_1983.jpg

American Airlines Picture: Source: https://commons.wikimedia.org/wiki/File:American_Airlines.Airline_meal.CDG-JFK.2010.JPG

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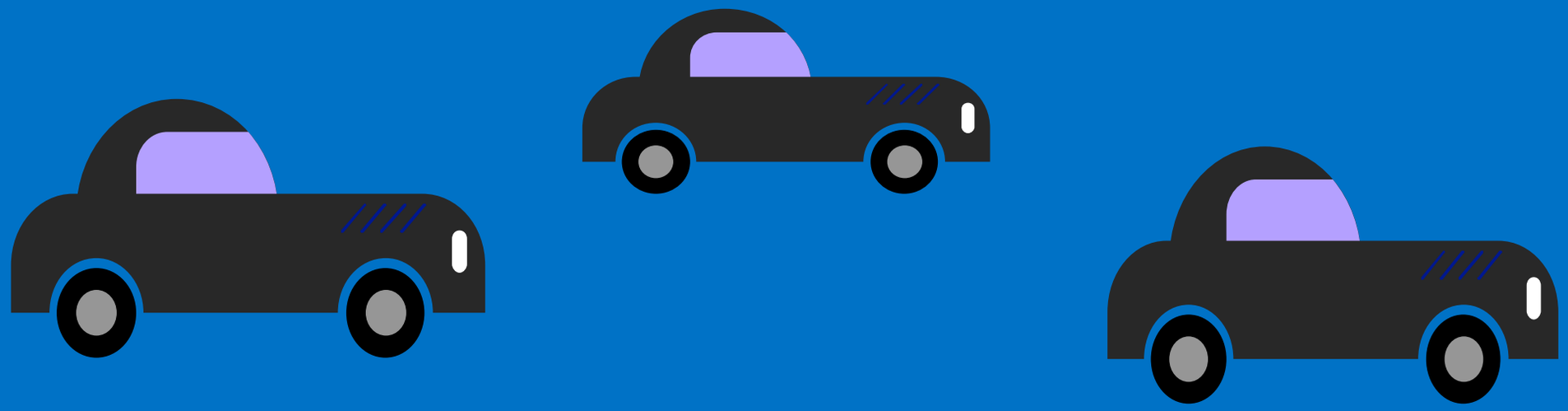
Retail – Why not then?

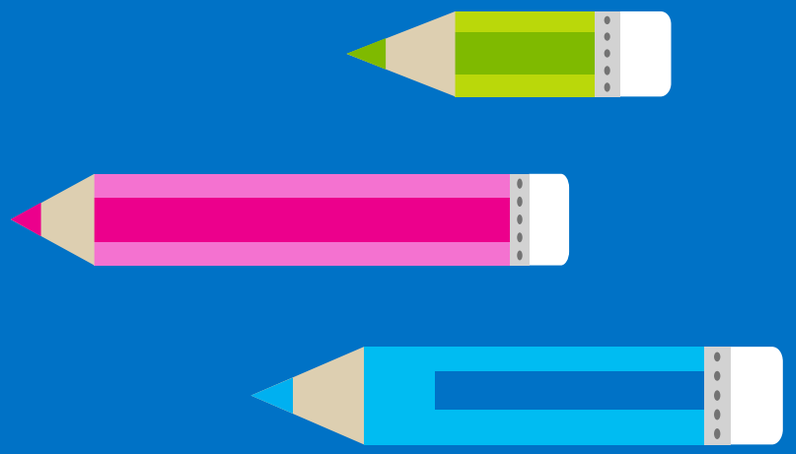
- "You can have any color as long as it is black"

  – Henry Ford, 1920

- Cost-Plus Pricing



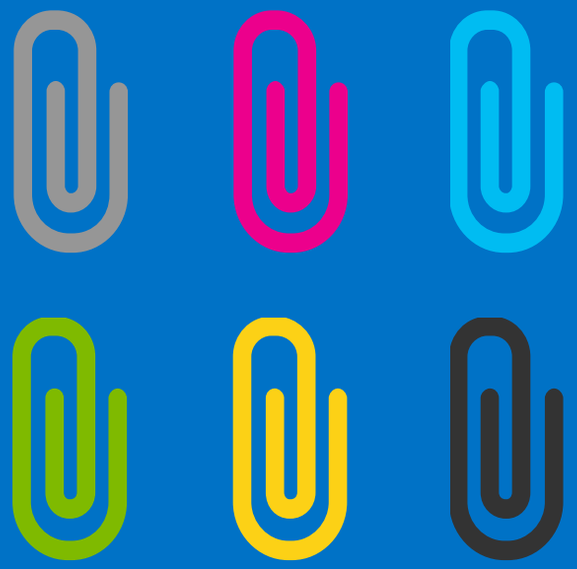
Retail – Why now?



Product variation. Channel variation -> Competition from everywhere

Traditional Pricing

Experience-based
Rely on human



Hard to drill down to
all SKUs, all channels, …

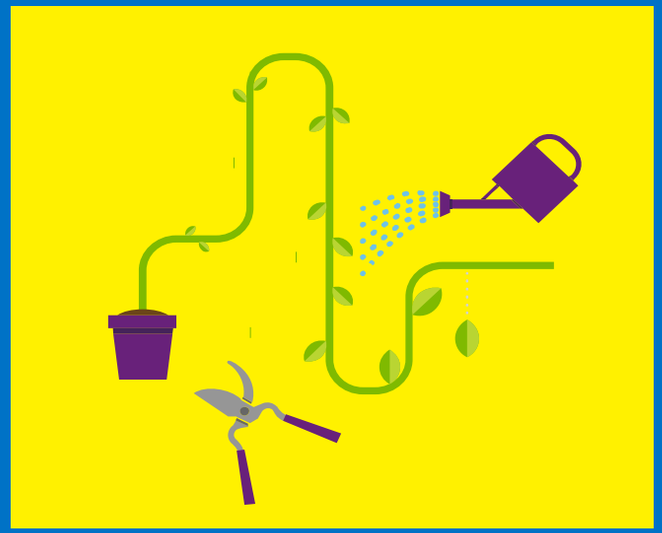
Retail – Why now?

We have the data!

Data-Driven Pricing

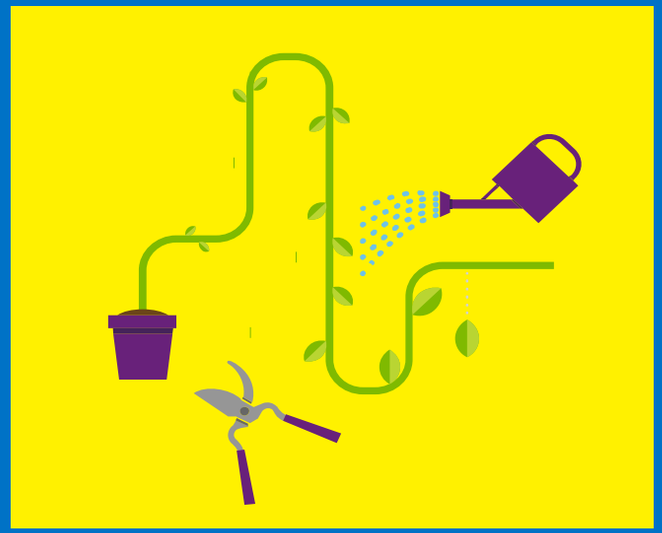
Data is the primary source

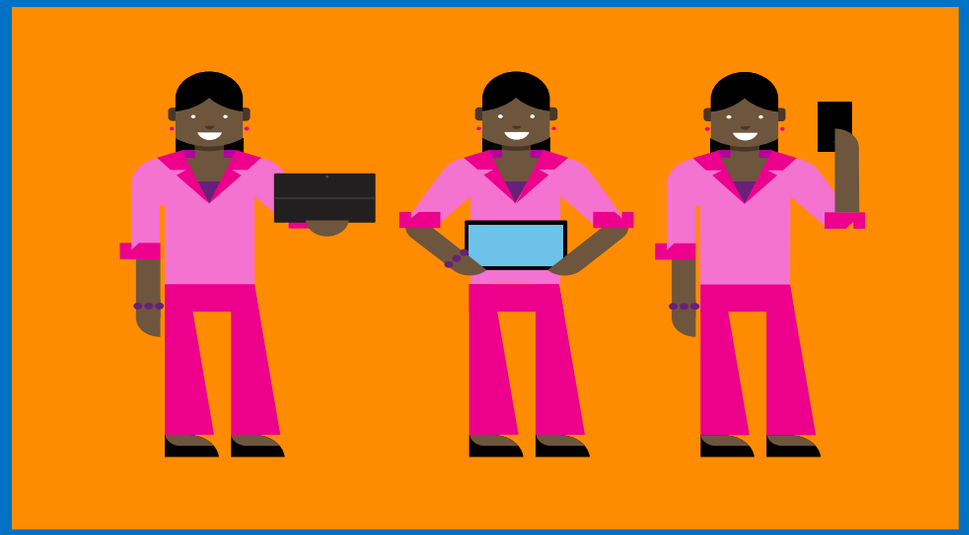
Data-Driven Pricing



Data is the primary source
Validated at each stage of the process

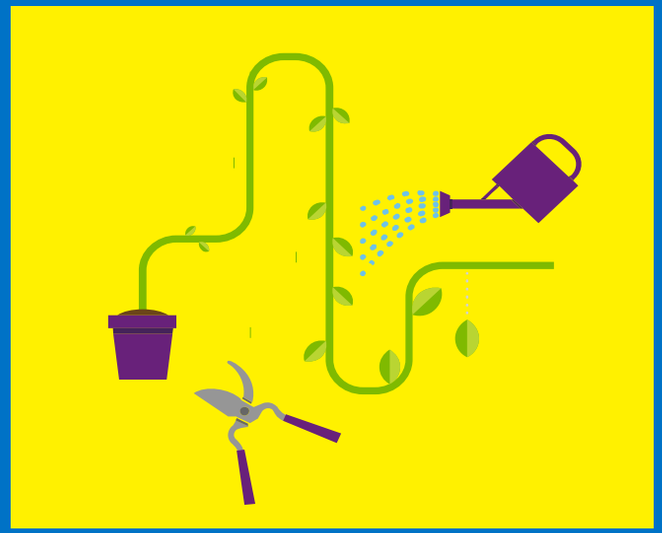
Data-Driven Pricing

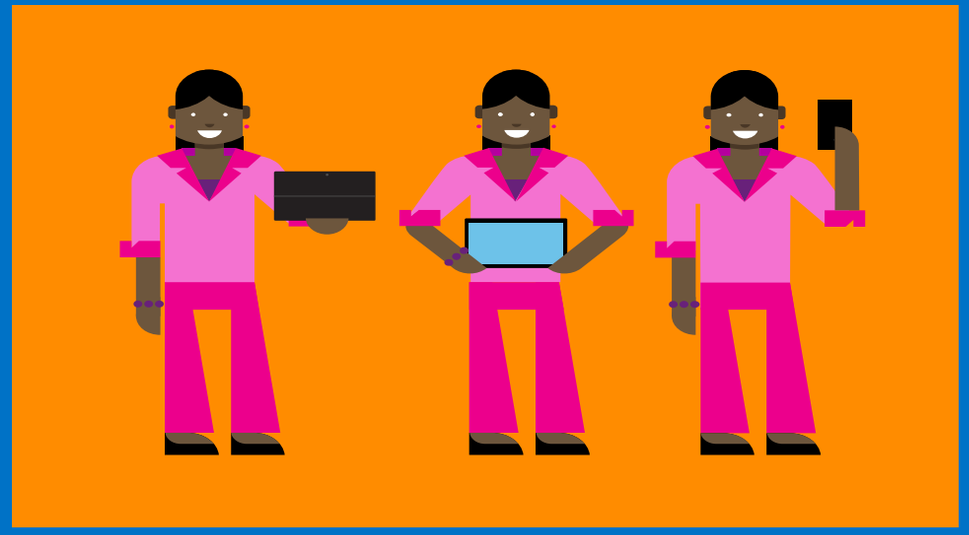


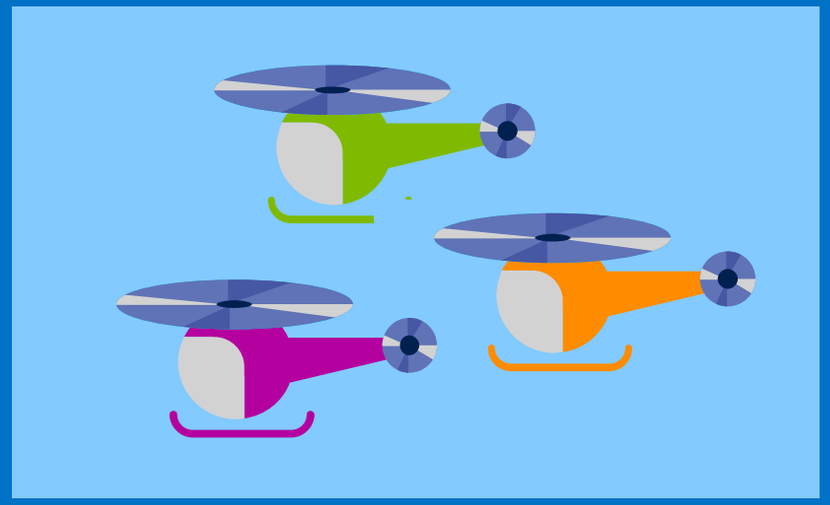


Data is the primary source
Validated at each stage of the process
Democratize pricing decisions

Data-Driven Pricing

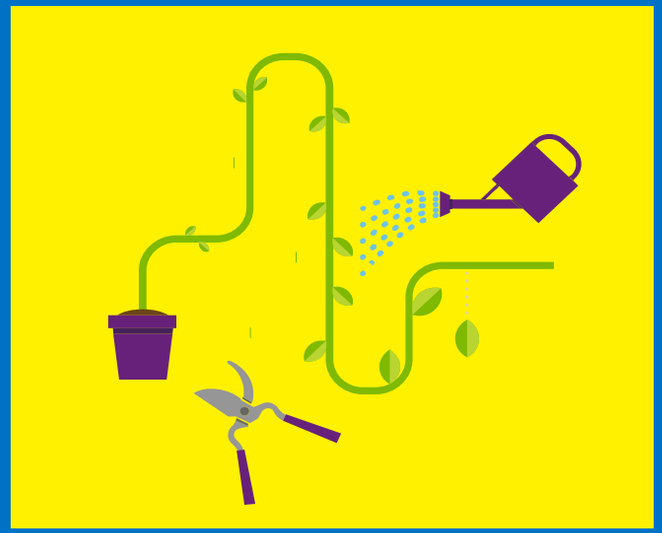


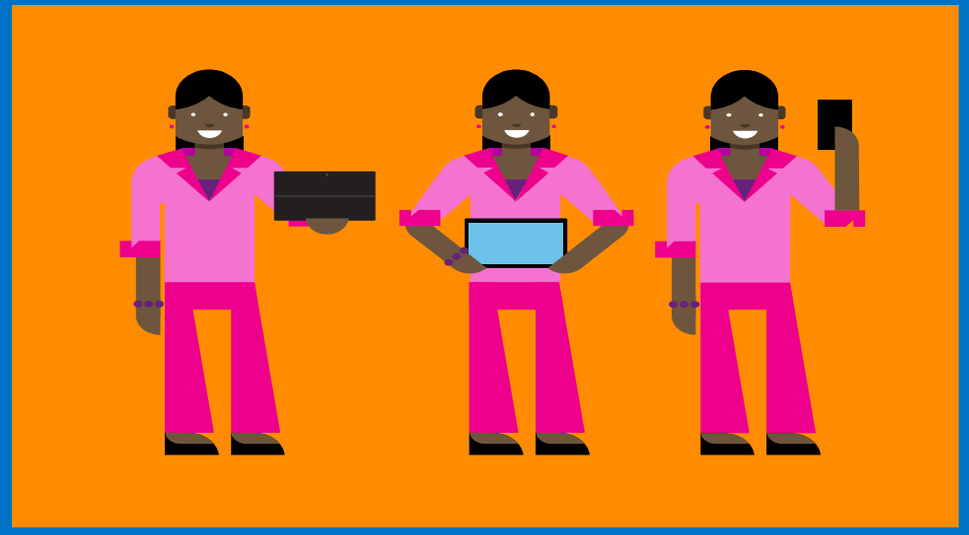


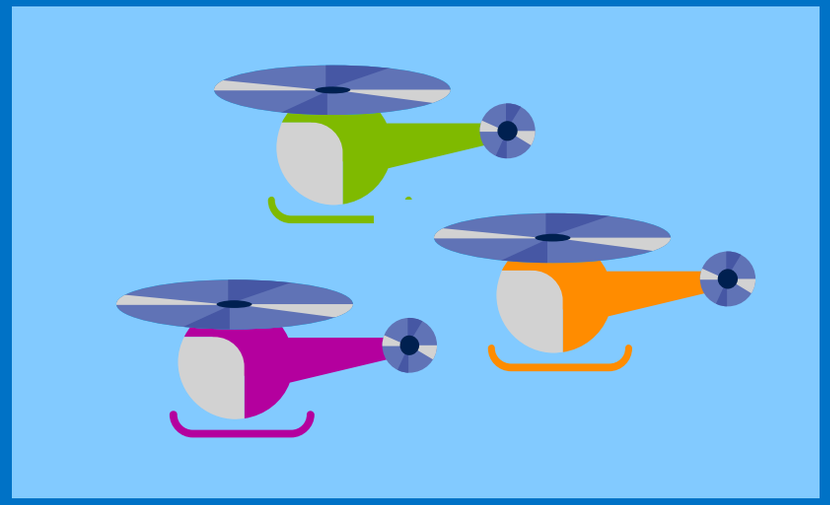


Data is the primary source
Validated at each stage of the process
Democratize pricing decisions
Better granularity. Easy to scale

Data-Driven Pricing

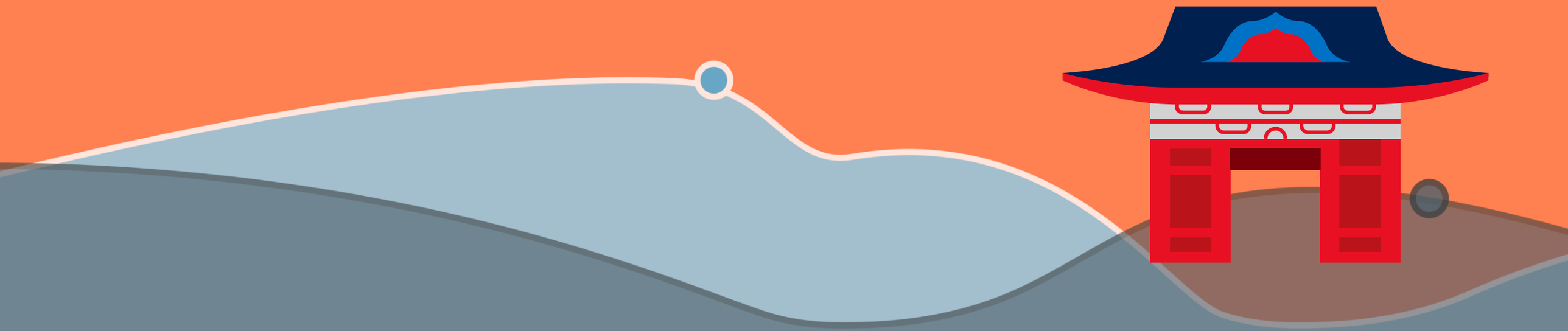






Data is the primary source
Validated at each stage of the process
Democratize pricing decisions
Better granularity. Easy to scale
Facilitates “value-based pricing”

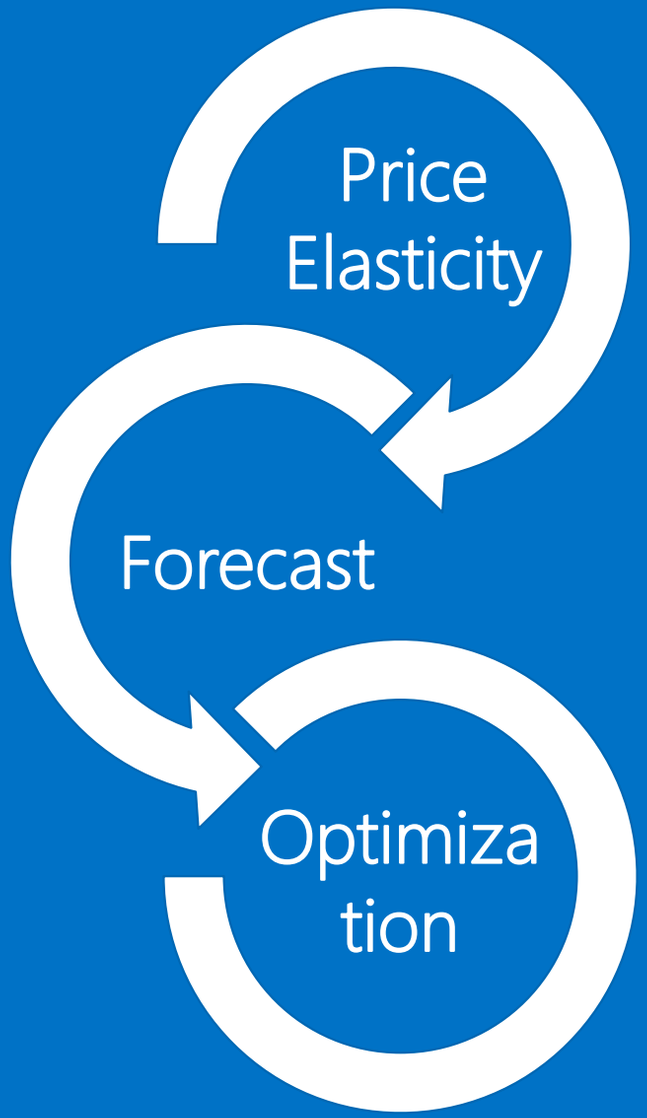
Example:
Xueshan's Burger Cafes



Problem

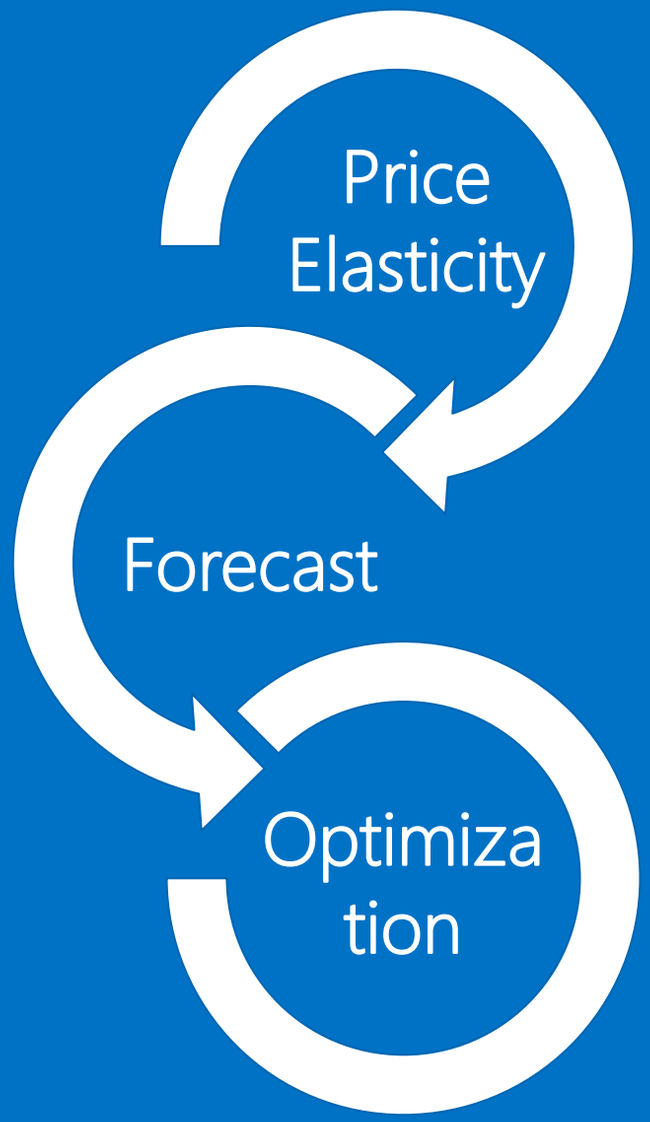
What are the best prices for my stores?

Price Optimization in 3 Steps



Definition

- Estimate Price Elasticity in Business
  Identify sensitive stores and items
- Forecast Demand and Revenue
- Optimize Prices



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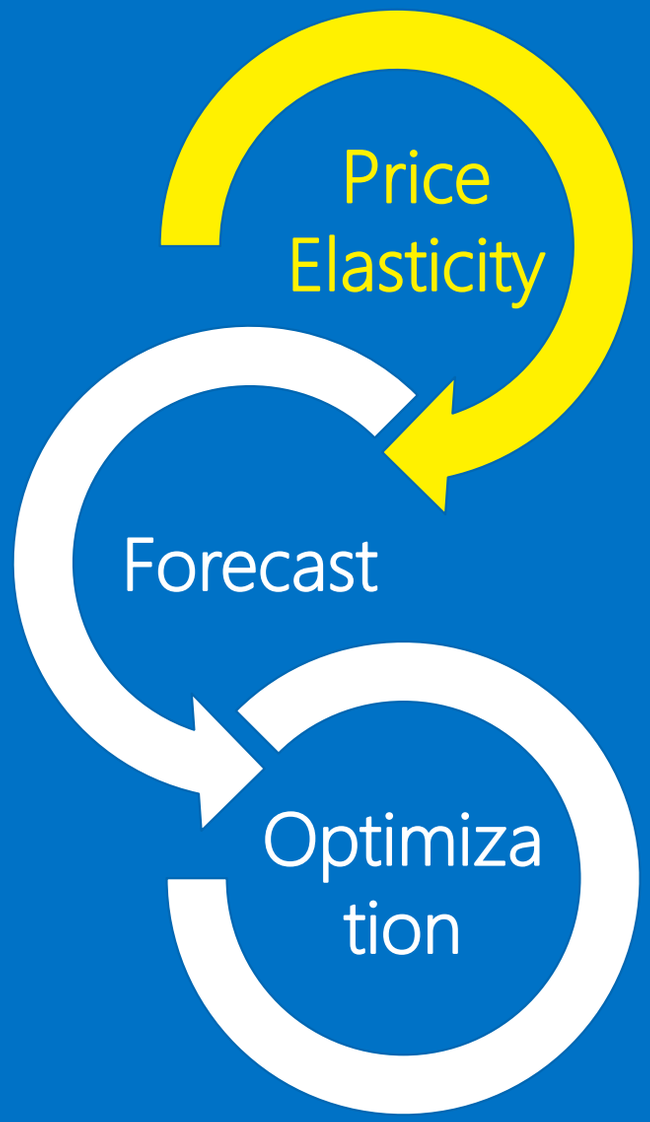
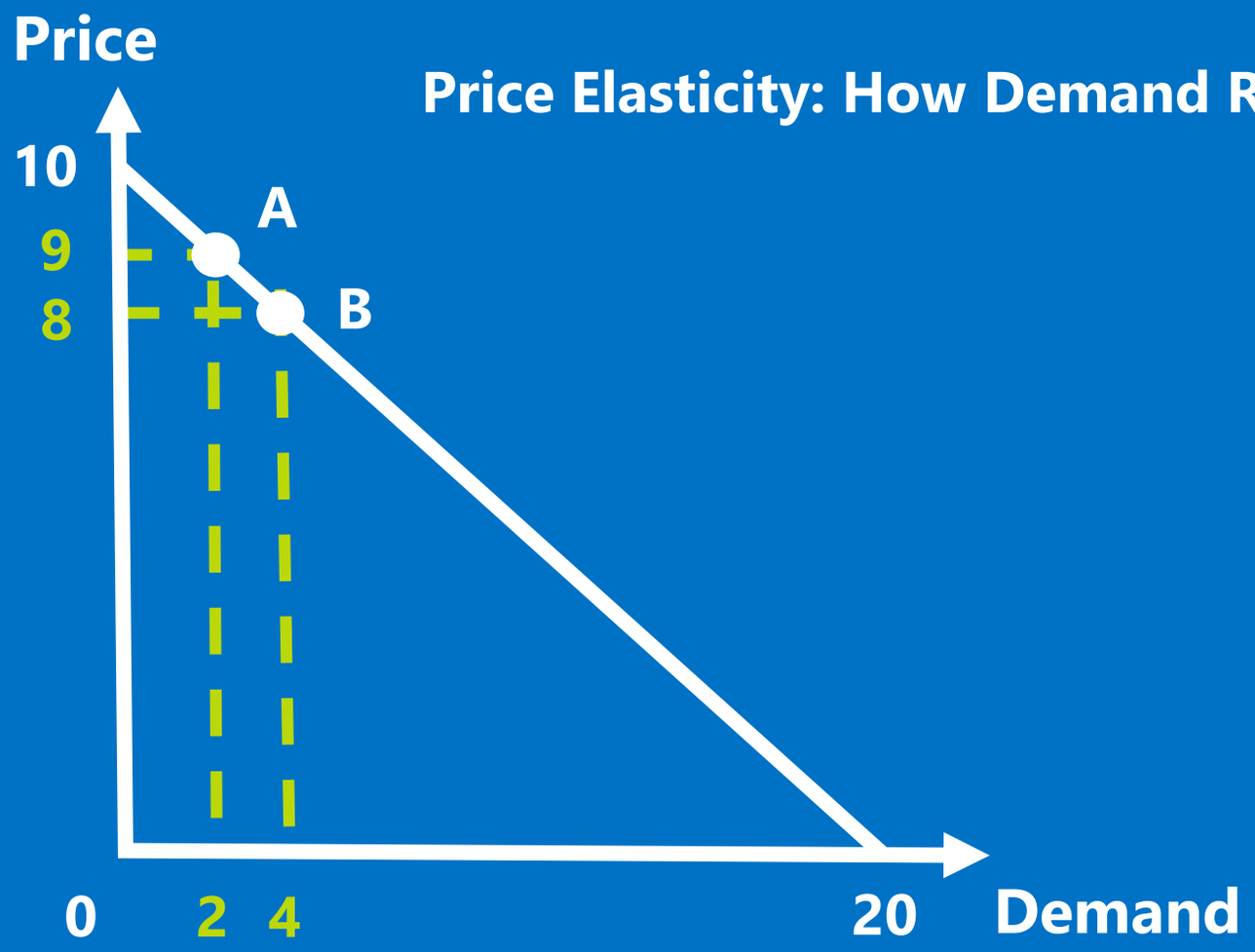


Price Elasticity

Price Elasticity: How Demand React to a Change in Price

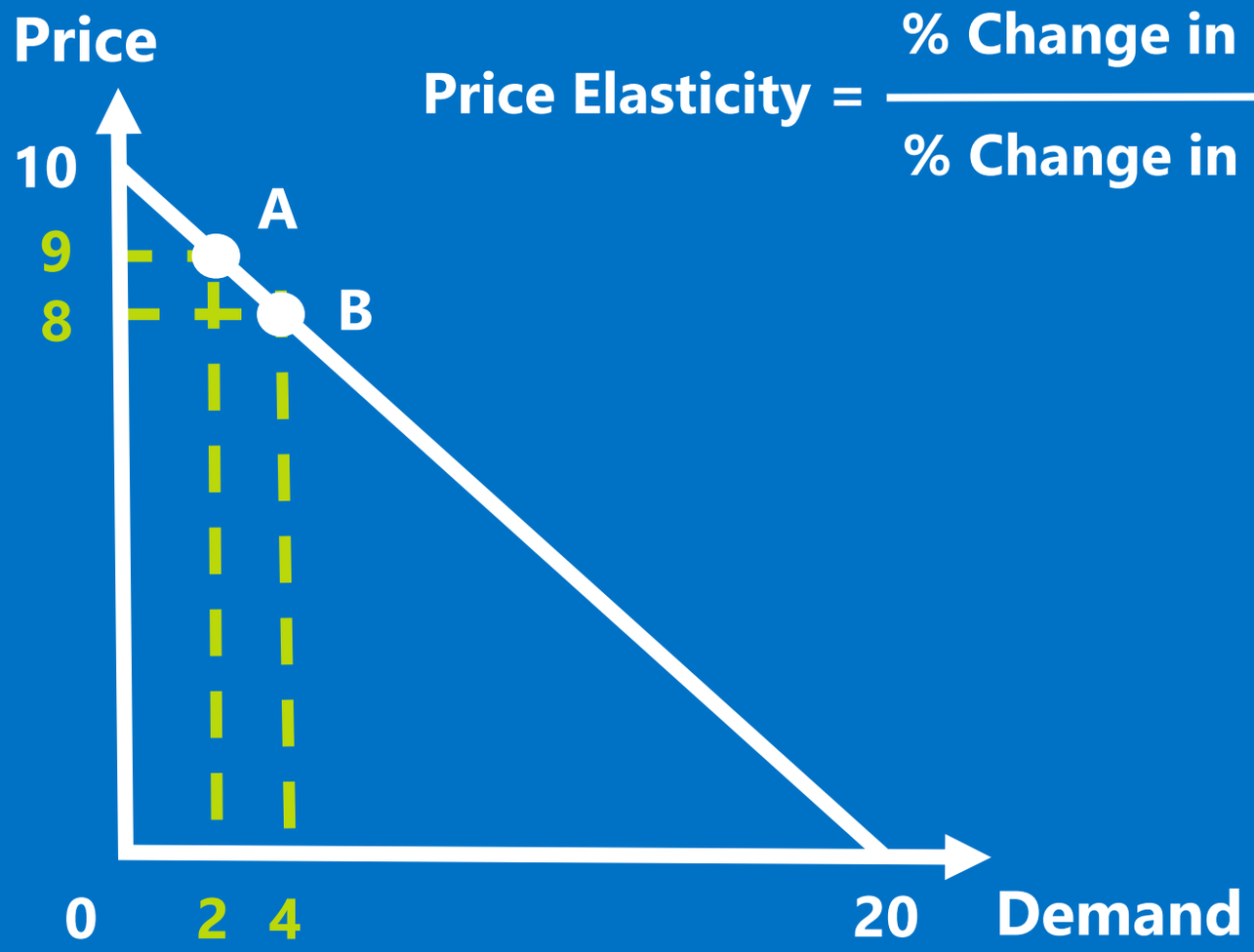
Price Elasticity – Coffee Example

Price Elasticity: How Demand React to a Change in Price



Price Elasticity - Coffee Example

$$\text{Price Elasticity} = \frac{\text{\% Change in Demand}}{\text{\% Change in Price}}$$



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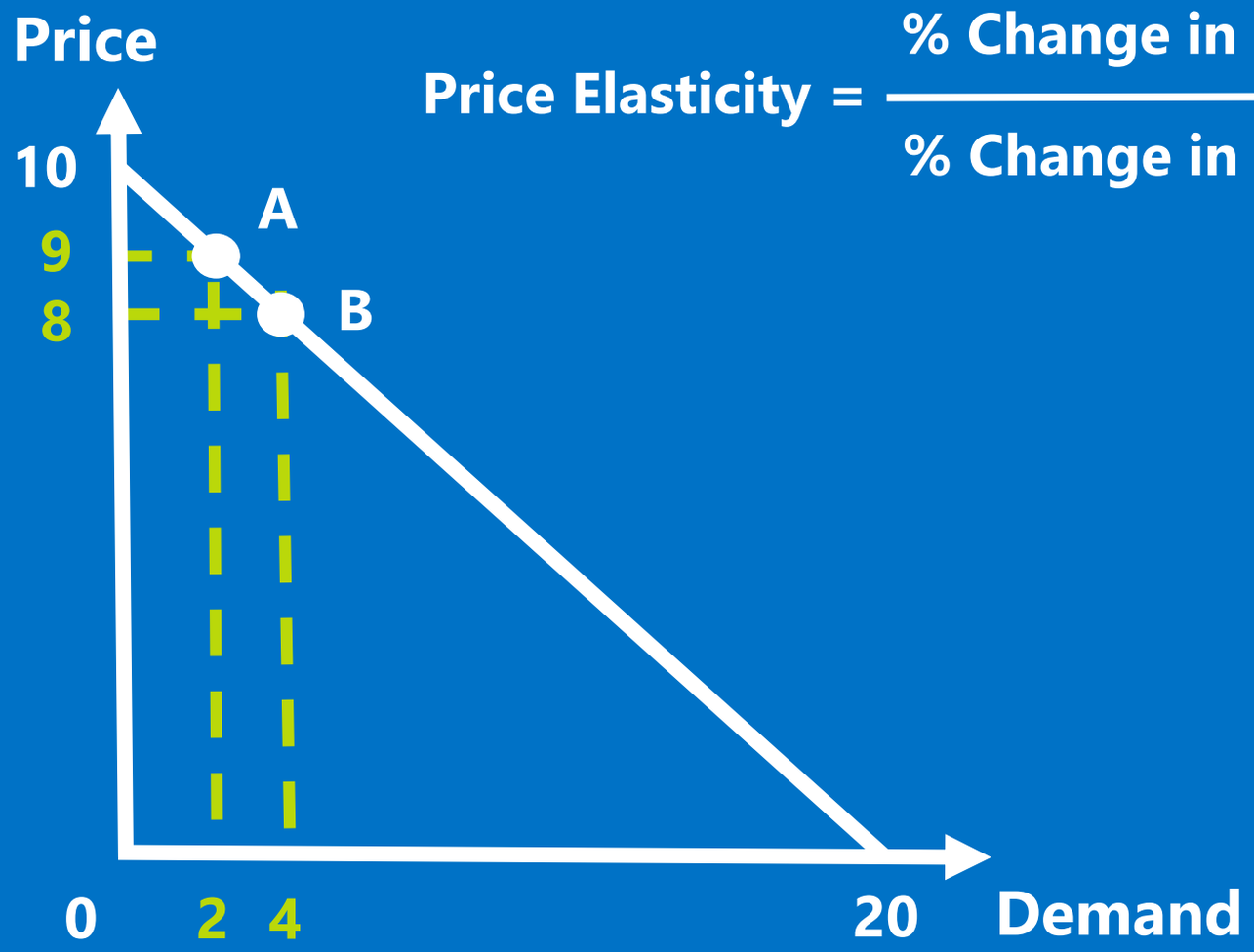
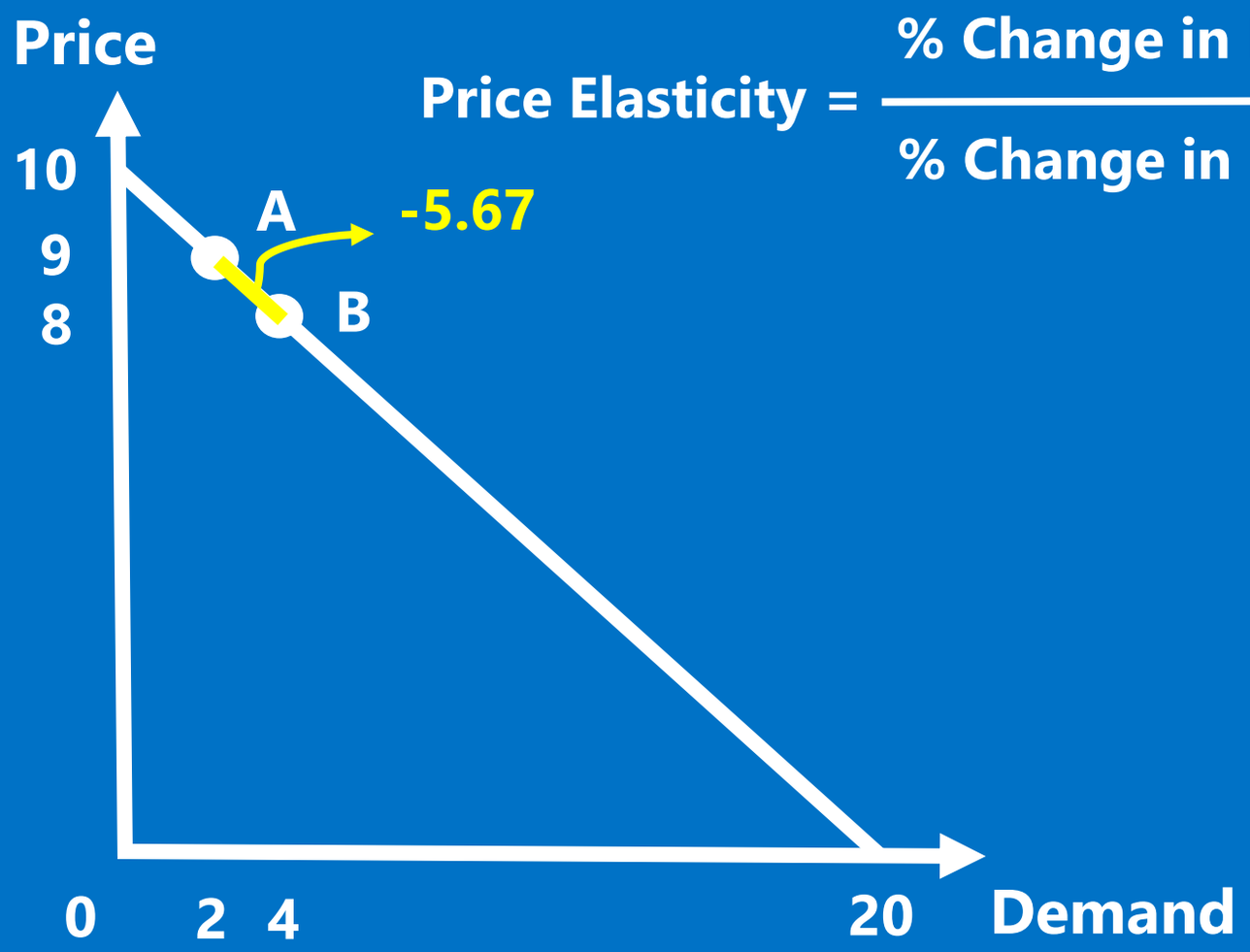


$$\text{Price Elasticity} = \frac{\text{\% Change in Demand}}{\text{\% Change in Price}} = \frac{(2 - 4) \,/\, \left(\frac{2 + 4}{2}\right)}{(9 - 8) \,/\, \left(\frac{9 + 8}{2}\right)} = -5.67$$

Price Elasticity - Coffee Example



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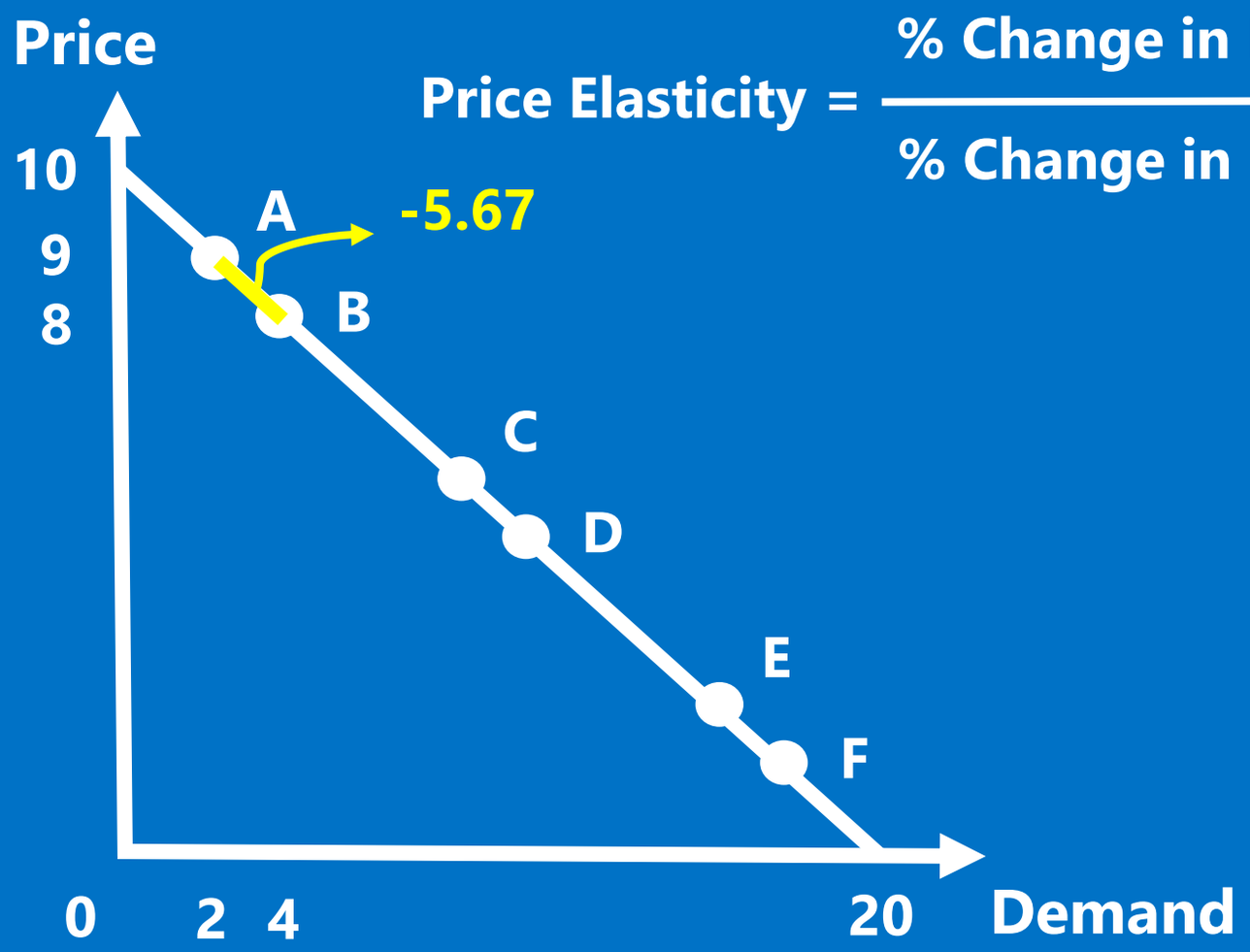

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$$\text{Price Elasticity} = \frac{(9-11)/\left(\frac{9+11}{2}\right)}{(5.5-4.5)/\left(\frac{5.5+4.5}{2}\right)} = -1$$

Price Elasticity - Coffee Example

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$$\text{Price Elasticity} = \frac{(16-18)/(\frac{16+18}{2})}{(2-1)/(\frac{2+1}{2})} = -0.18$$

Price Elasticity - Coffee Example

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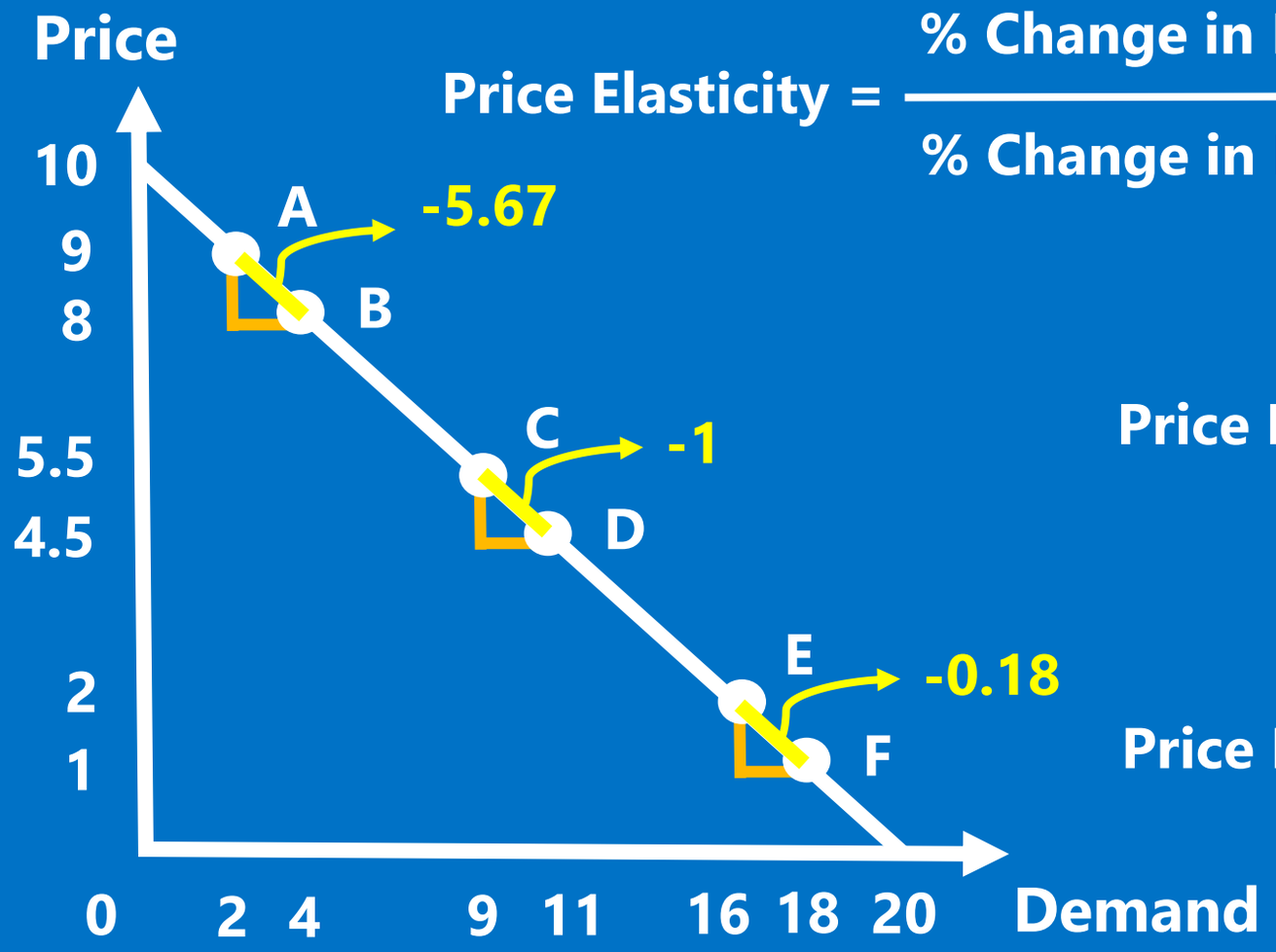

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Price Elasticity <= -1: ELASTIC

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  Identify sensitive stores and items
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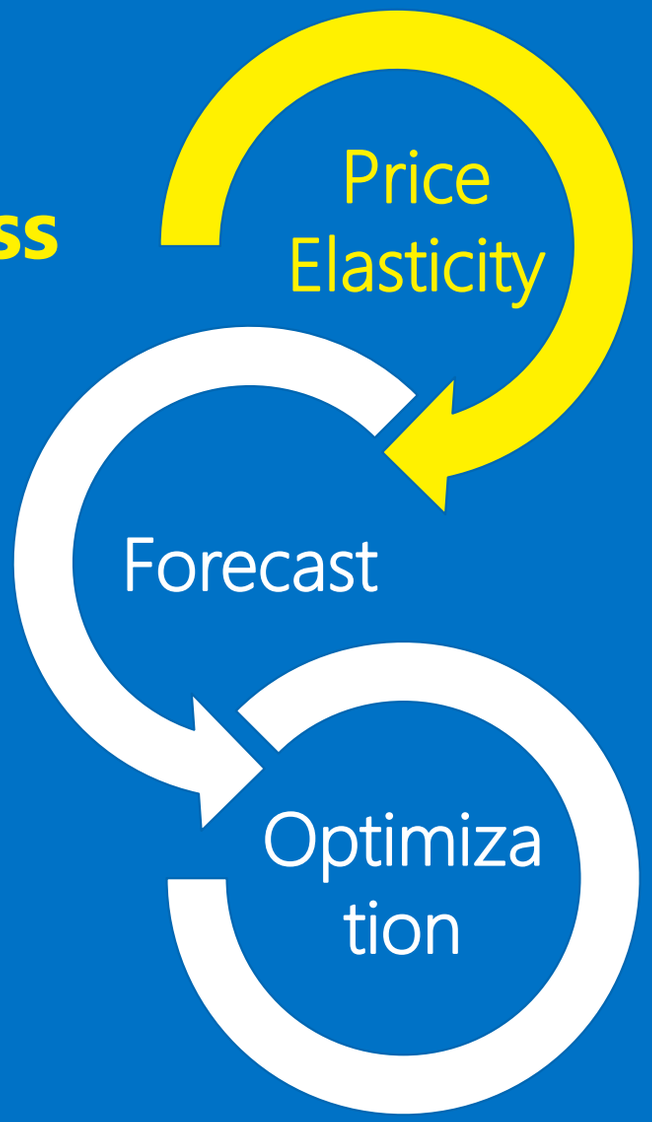
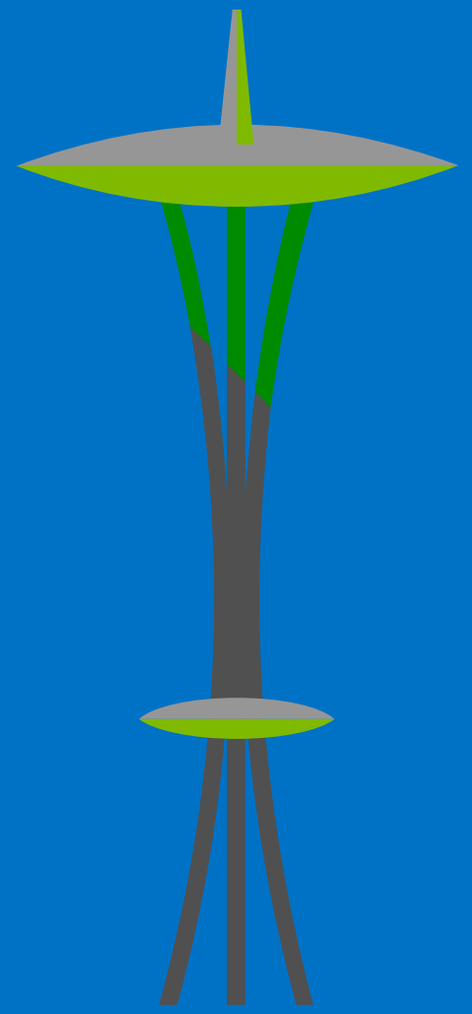
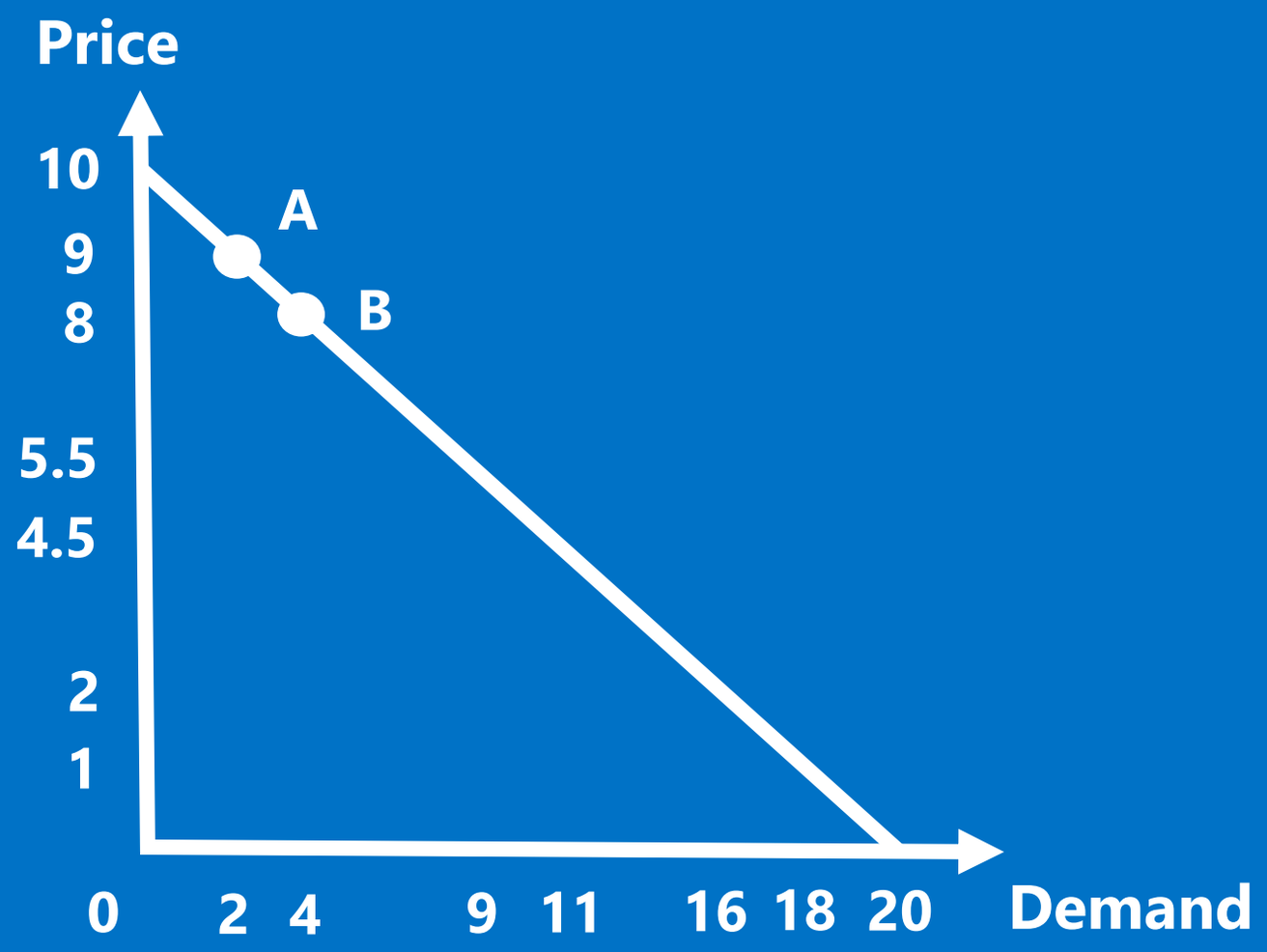


Estimate Price Elasticity with Business Data



Chowder Sales	Chowder Price
102	6.24
59	7.19
49	7.42
59	7.56
76	6.9
80	7.5
69	6.7
113	5.54
59	7.42
66	7.19

Estimate Price Elasticity with Business Data



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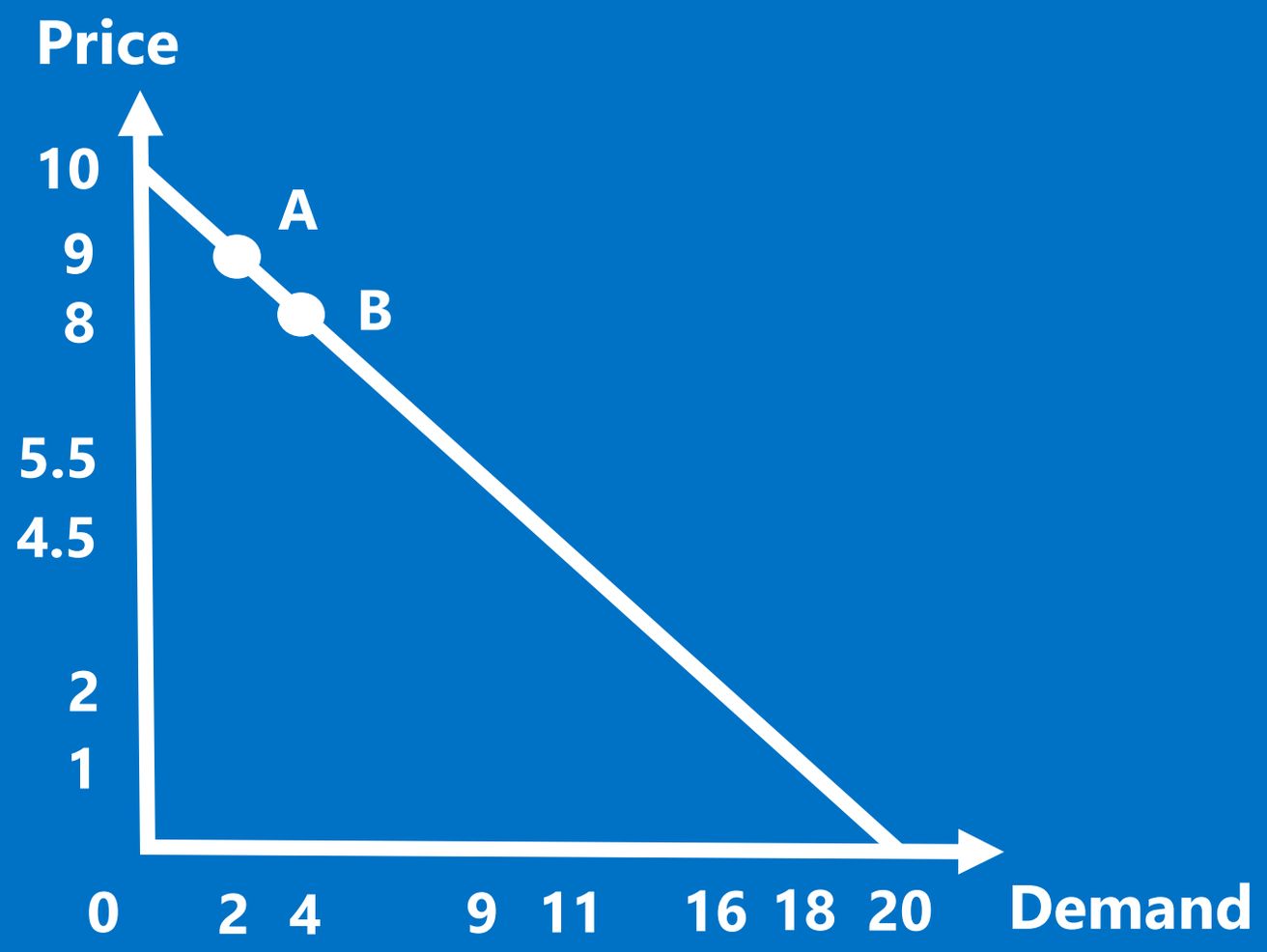

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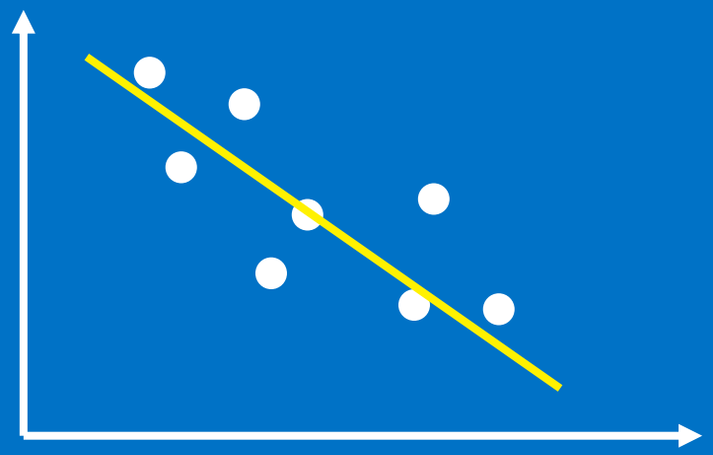
Estimate Price Elasticity with Business Data

- Regression Model



log(Demand) = a + b x log(Price)

=> Elasticity = b

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102	6.24
59	7.19
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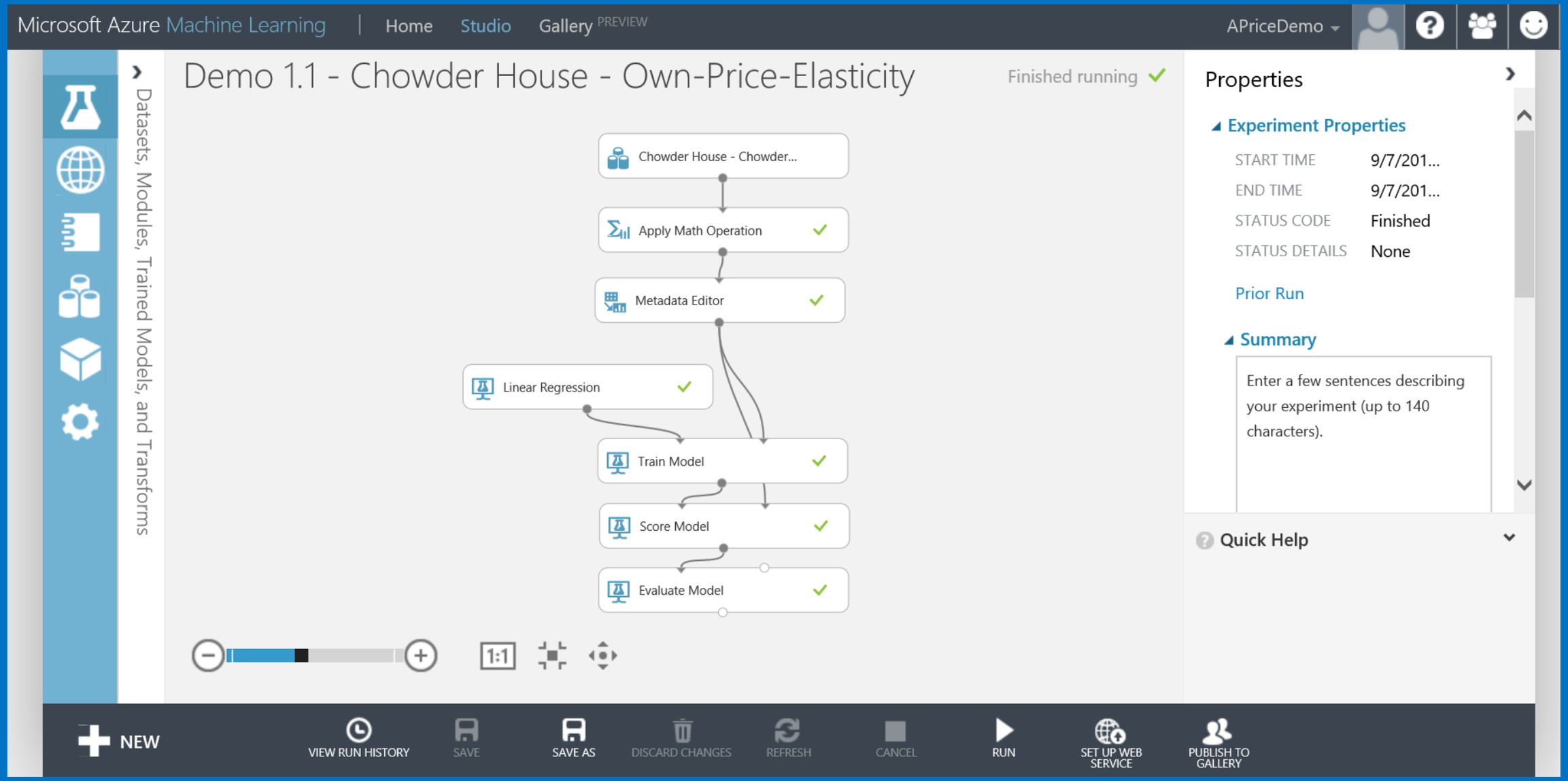
59	7.56
76	6.9
80	7.5
69	6.7
113	5.54
59	7.33
66	7.58

[Next]

Chowder House Demo



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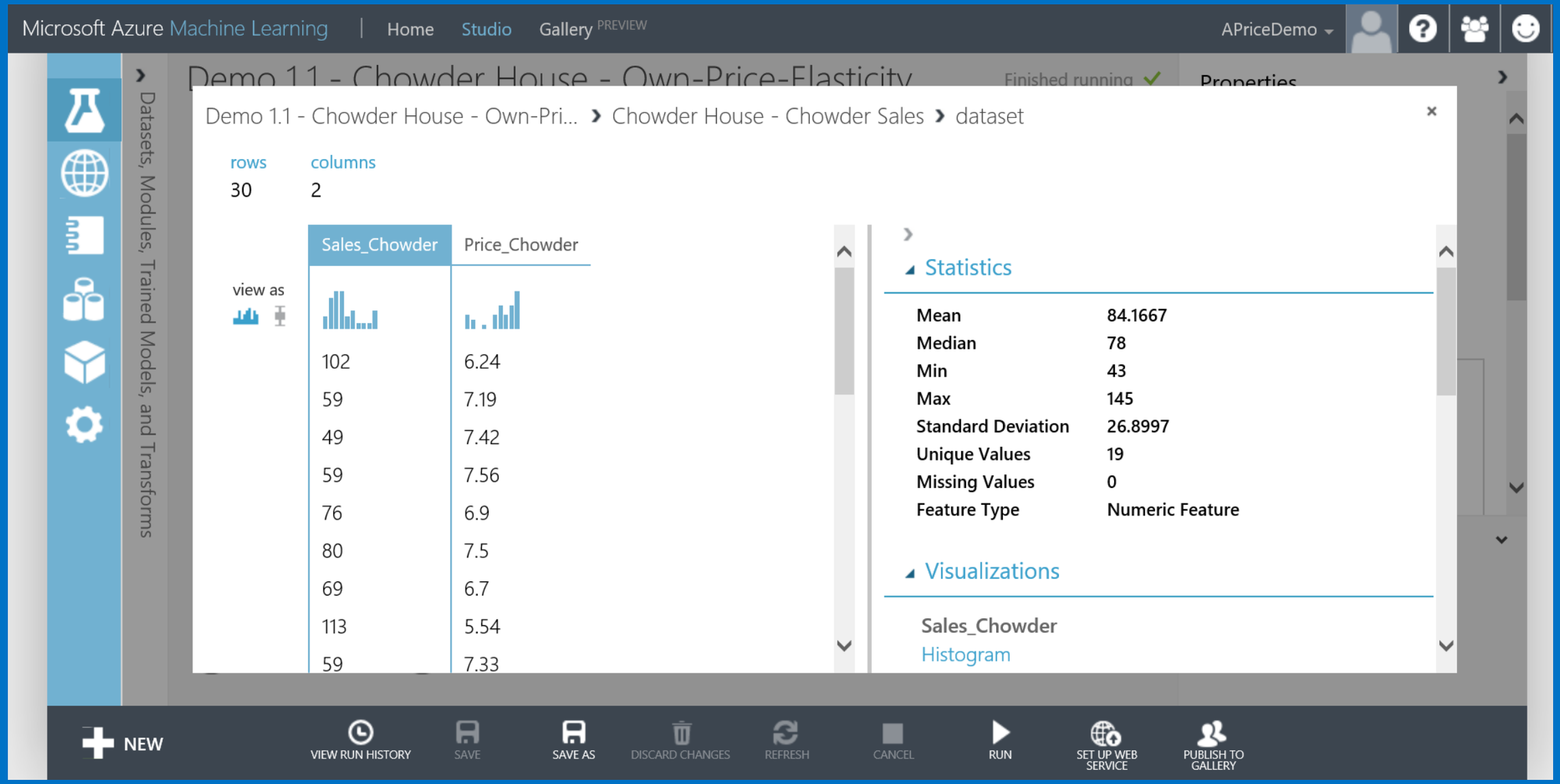

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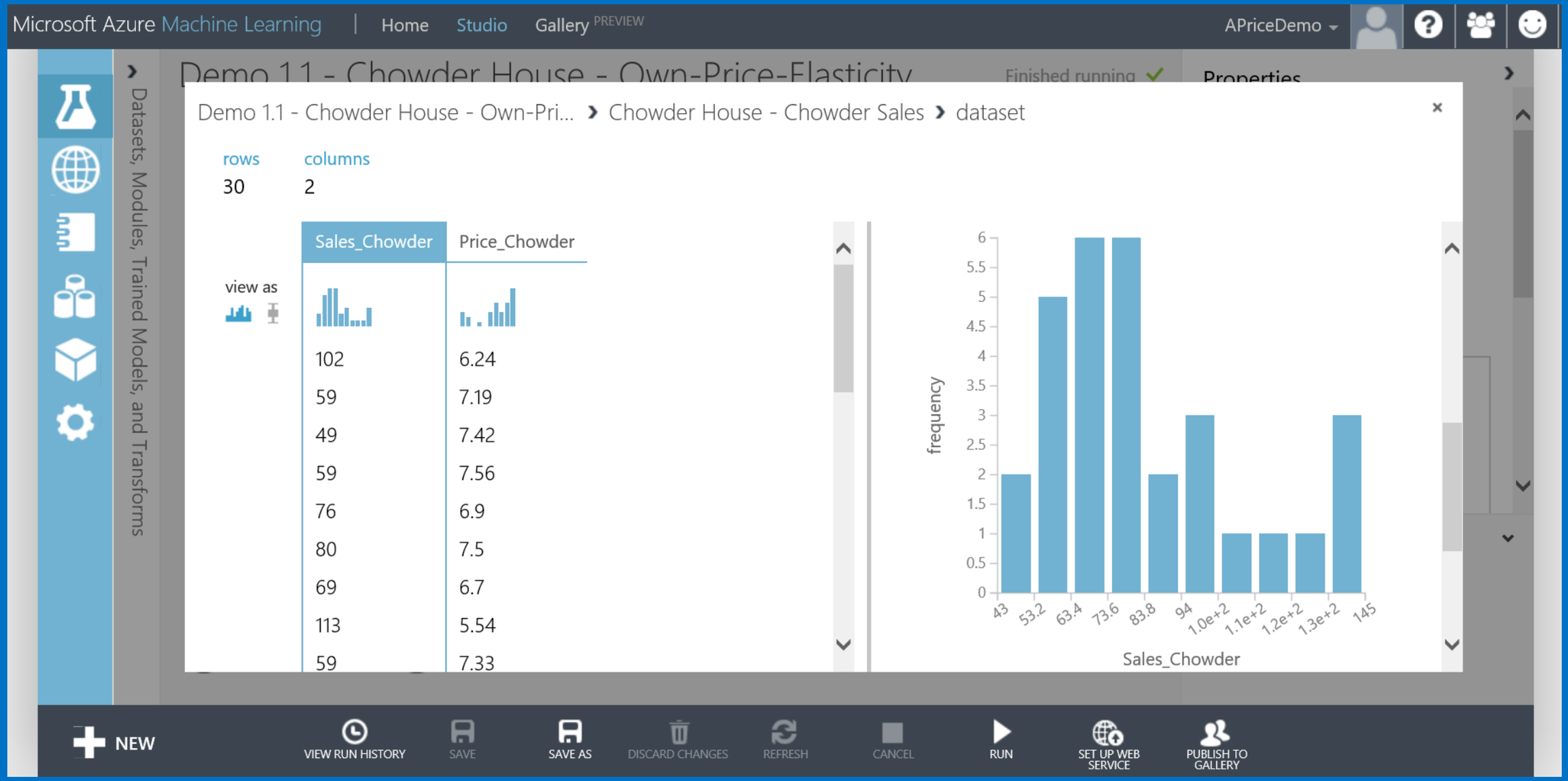

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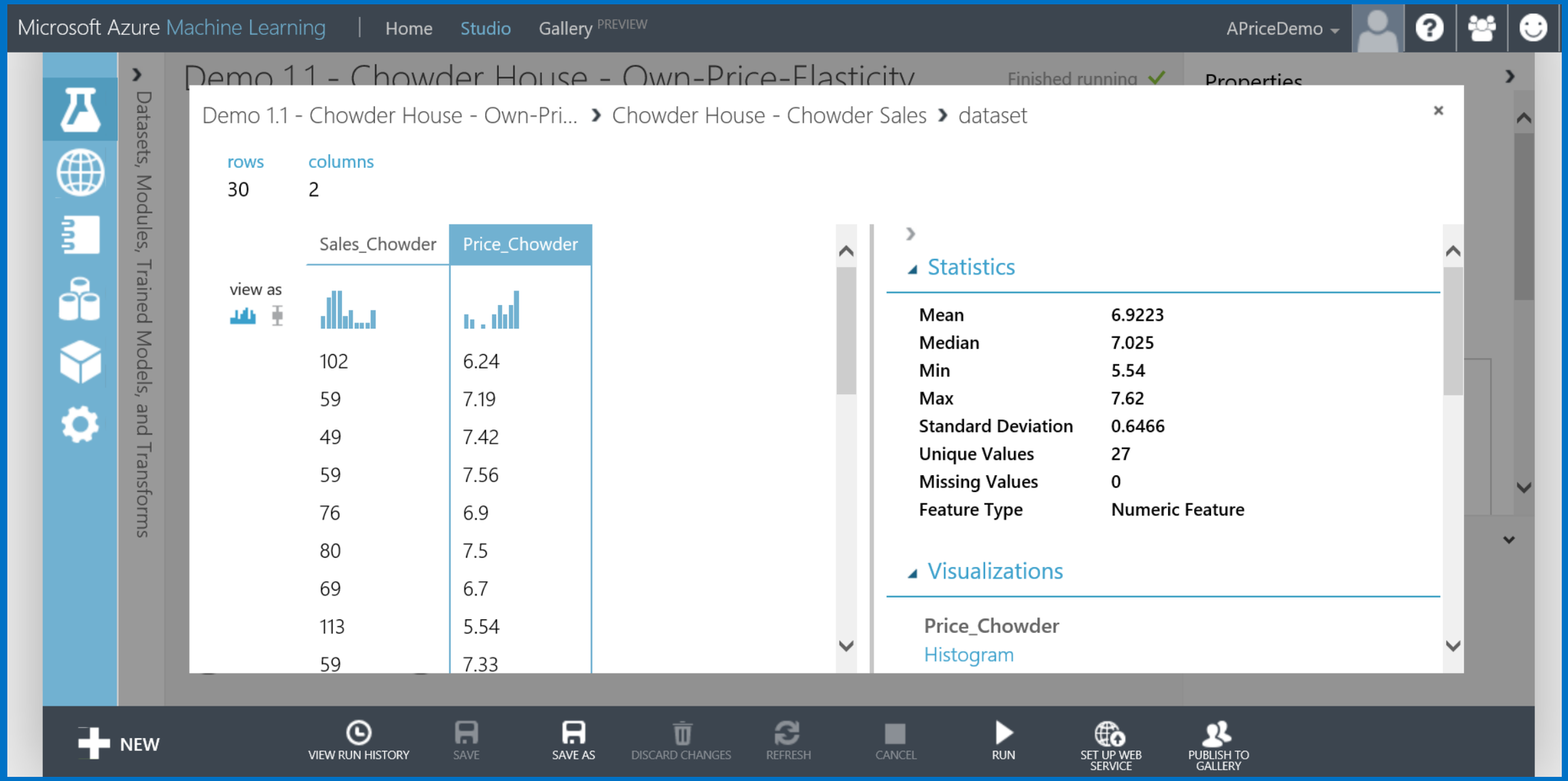

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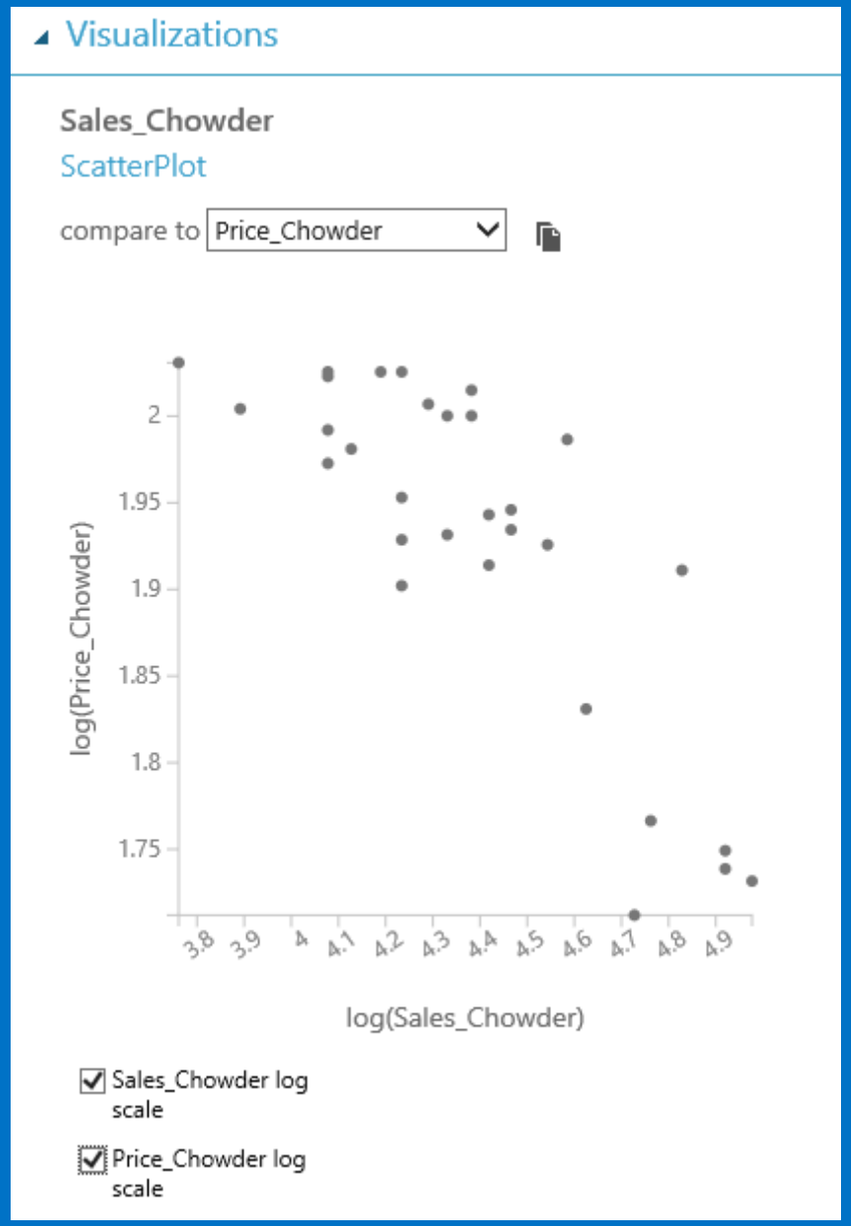

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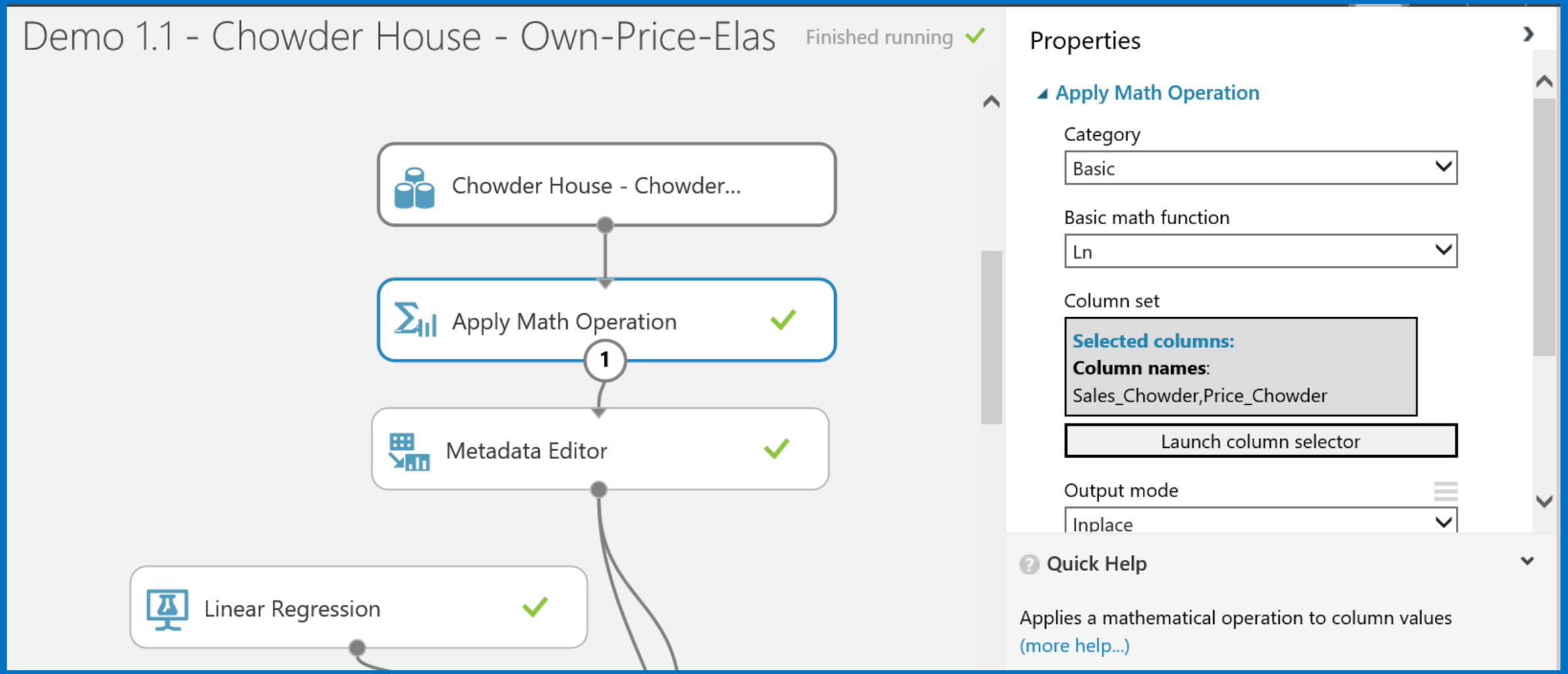

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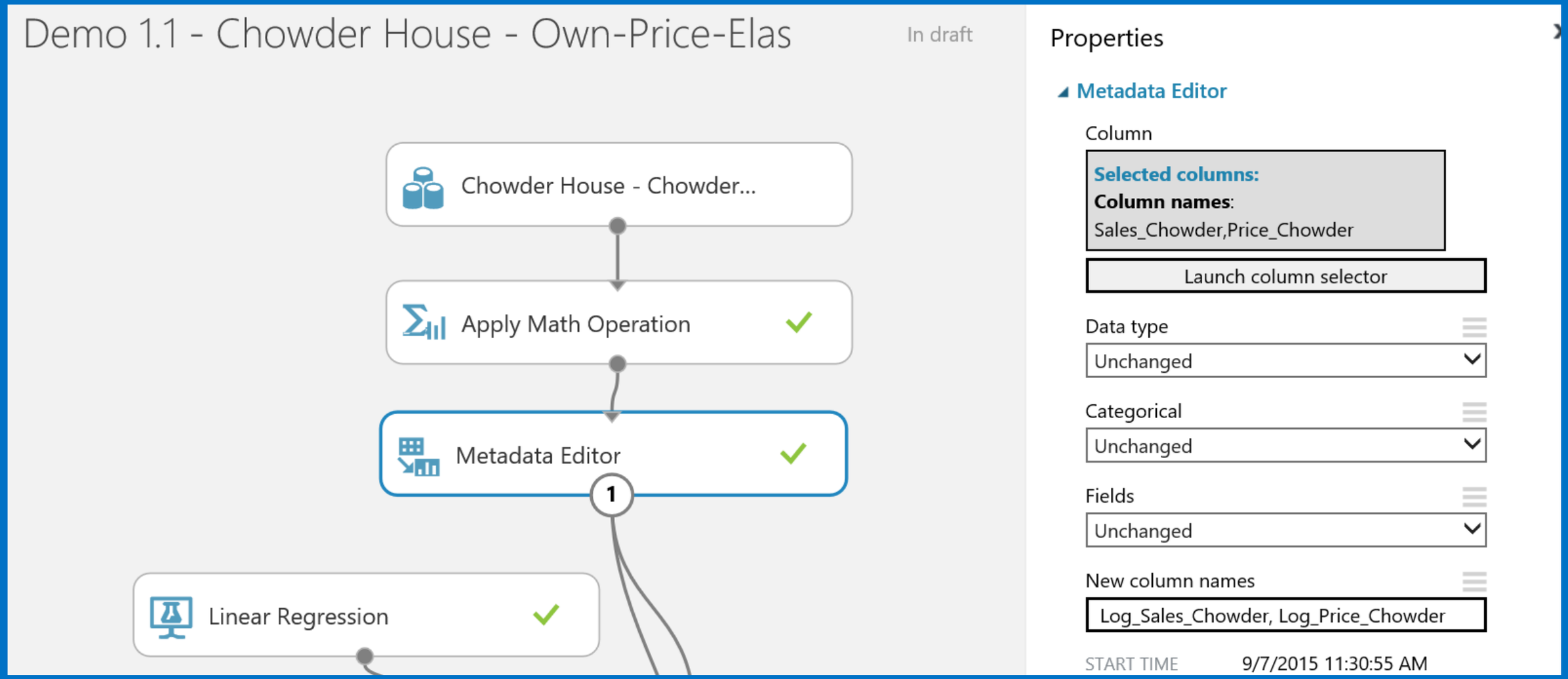

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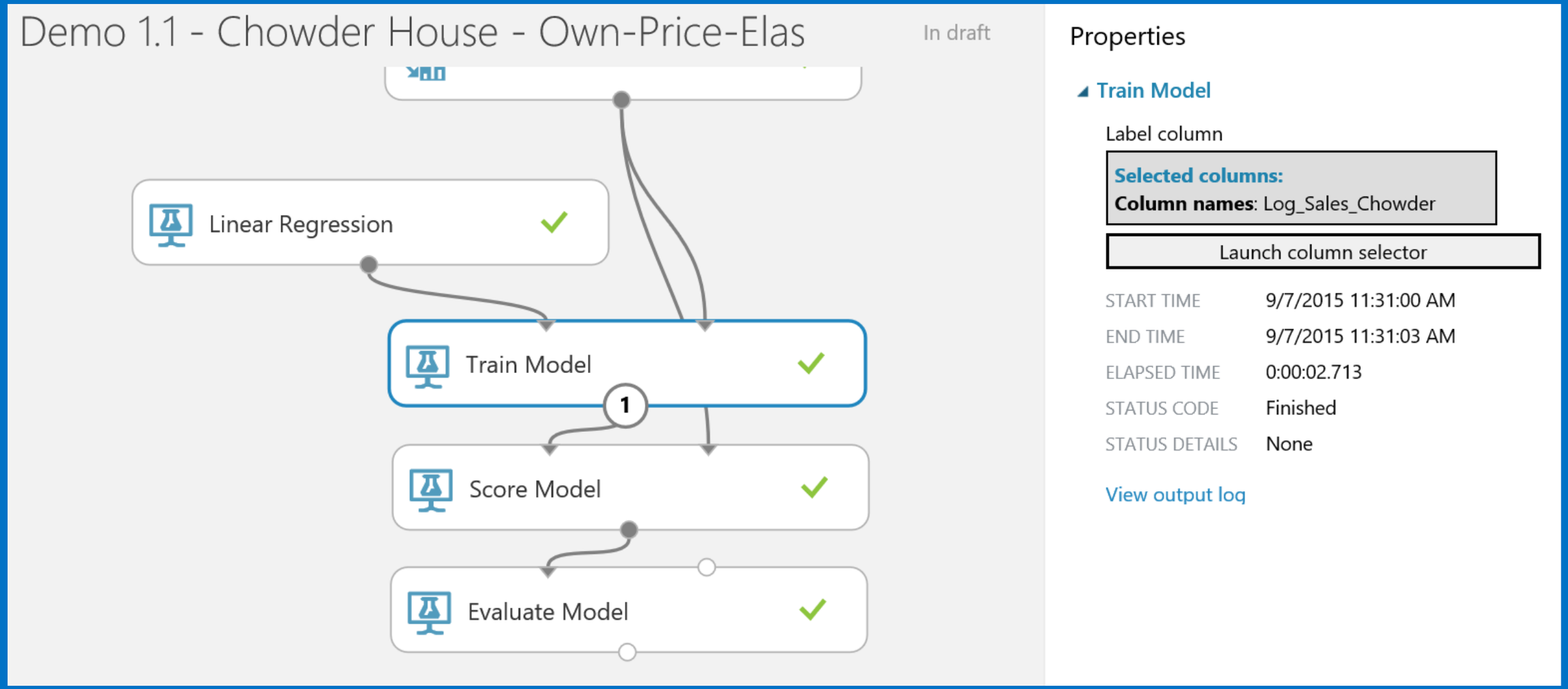


Chowder House Demo

Demo 1.1 - Chowder House - Own-Pri... › Train Model › Trained model

Batch Linear Regressor

Settings

Setting	Value
Bias	True
Regularization	0.001
Allow Unknown Levels	True
Random Number Seed	

Feature Weights

Feature	Weight
Bias	9.18498
Log_Price_Chowder	-2.48621

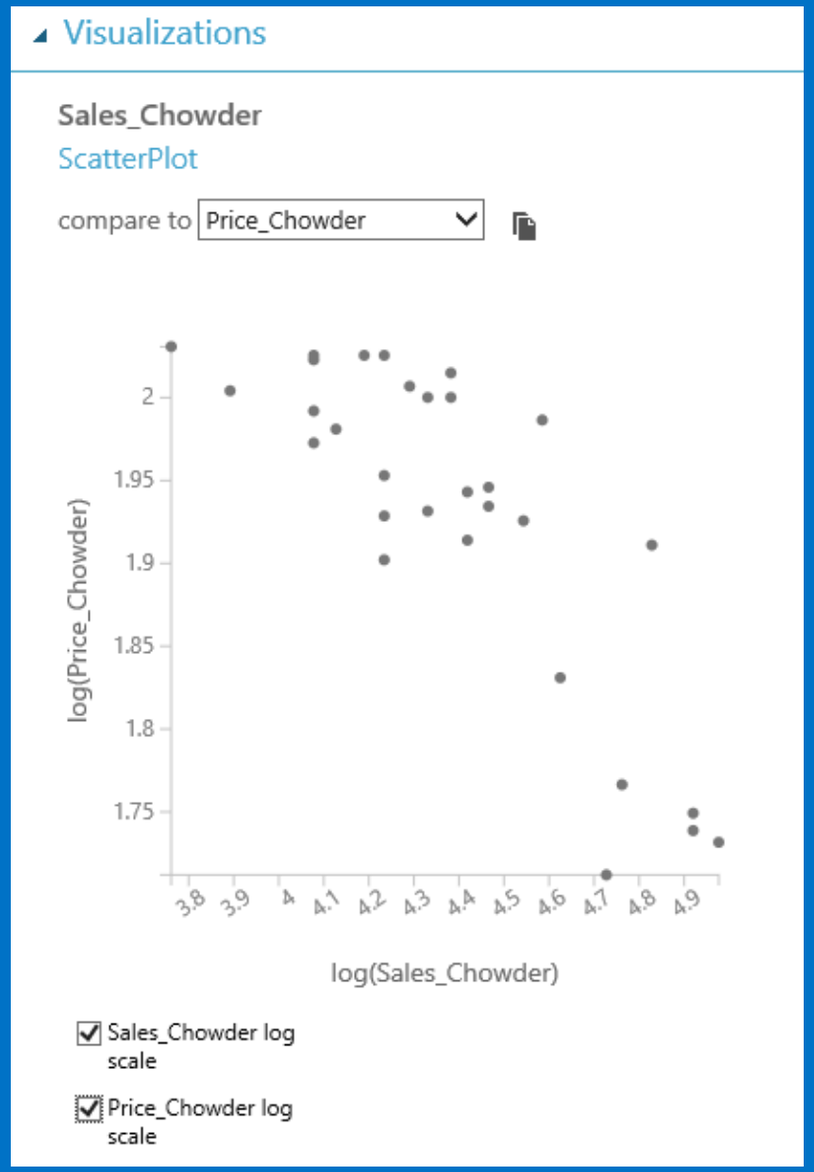
Chowder House Demo

Demo 1.1 - Chowder House - Own-Pri... › Evaluate Model › Evaluatic

rows	columns
1	5

	Mean Absolute Error	Root Mean Squared Error	Relative Absolute Error	Relative Squared Error	Coefficient of Determination
view as	0.140183	0.173127	0.578452	0.328459	0.671541

Chowder House Demo



Sales_Chowder	Price_Chowder
102	6.24
59	7.19
49	7.42
59	7.56

Chowder House Demo

Sales_Chowder	Price_Chowder	Price_Salad
102	6.24	4.73
59	7.19	4.66
49	7.42	4.81
59	7.56	4.29

Cross-Price Elasticity

- How product A's demand react to Product B's price change.

$$\textbf{Cross} - \textbf{Price elasticity} = \frac{\textbf{\% Change in A's Demand}}{\textbf{\% Change in B's Price}}$$

- Estimation

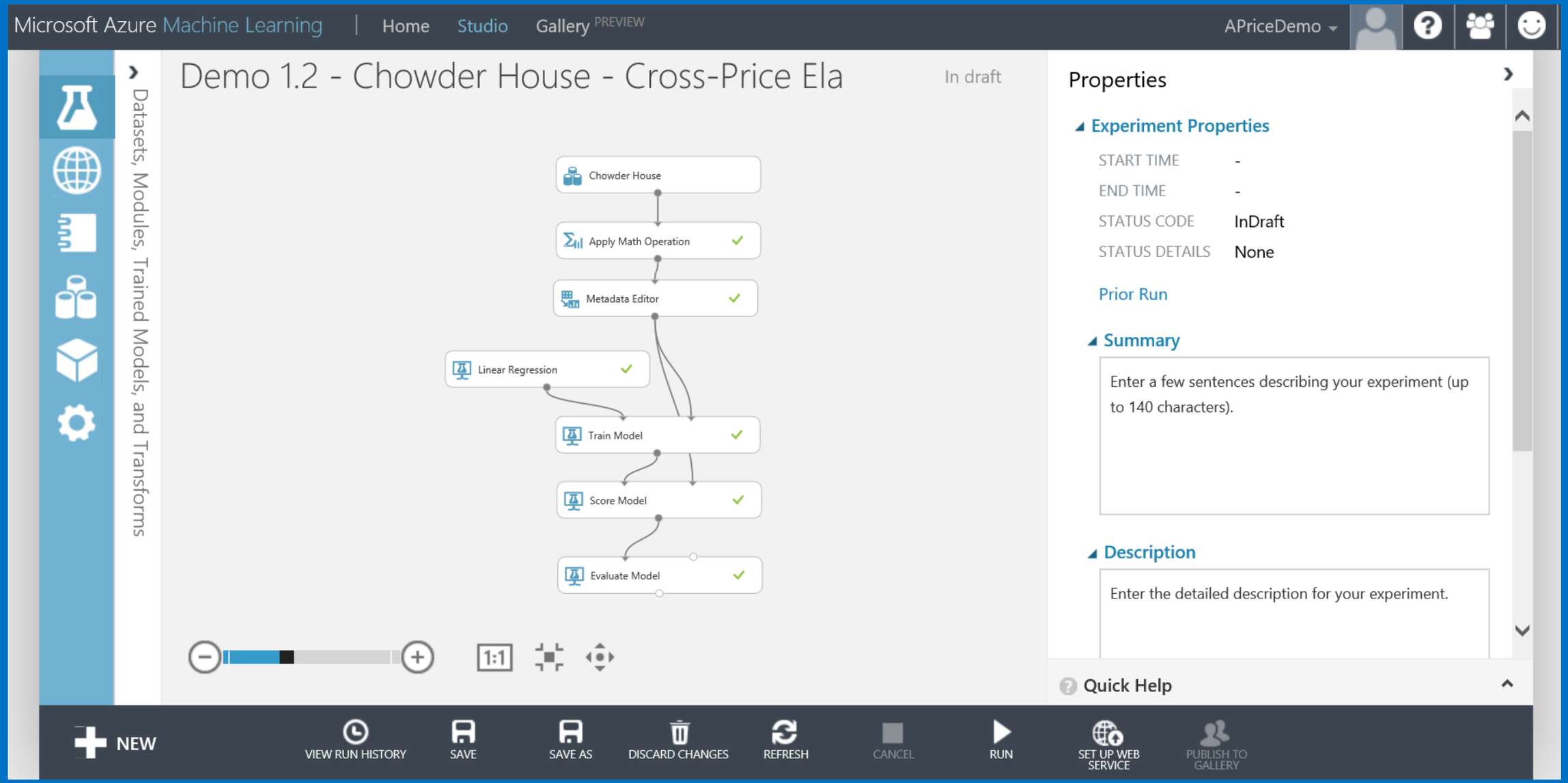
log(A's Demand) = a + b x log(A's Price) + c x log(B's Price)

$\Rightarrow$ Own-Price Elasticity = b

Cross-Price Elasticity = c

[Next]

Chowder House Demo



Chowder House Demo

Demo 1.2 - Chowder House - Cross-P... › Train Model

Settings

Setting	Value
Bias	True
Regularization	0.001
Allow Unknown Levels	True
Random Number Seed	

Feature Weights

Feature	Weight
Bias	11.2979
Log_Price_Chowder	-2.38914
Log_Price_Salad	-1.56069

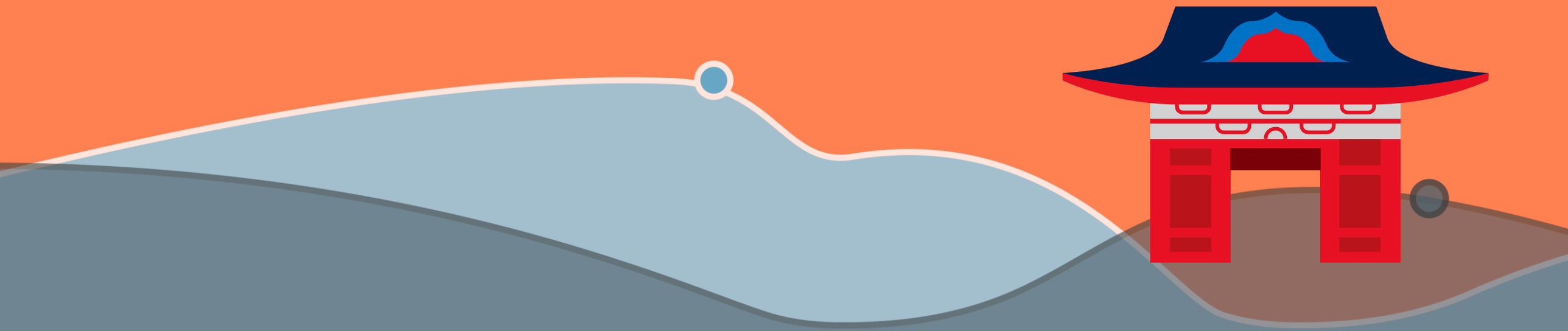
Demo 1.2 - Chowder House - Cross-P... › Evaluate Model › Evaluat

rows	columns
1	5

view as

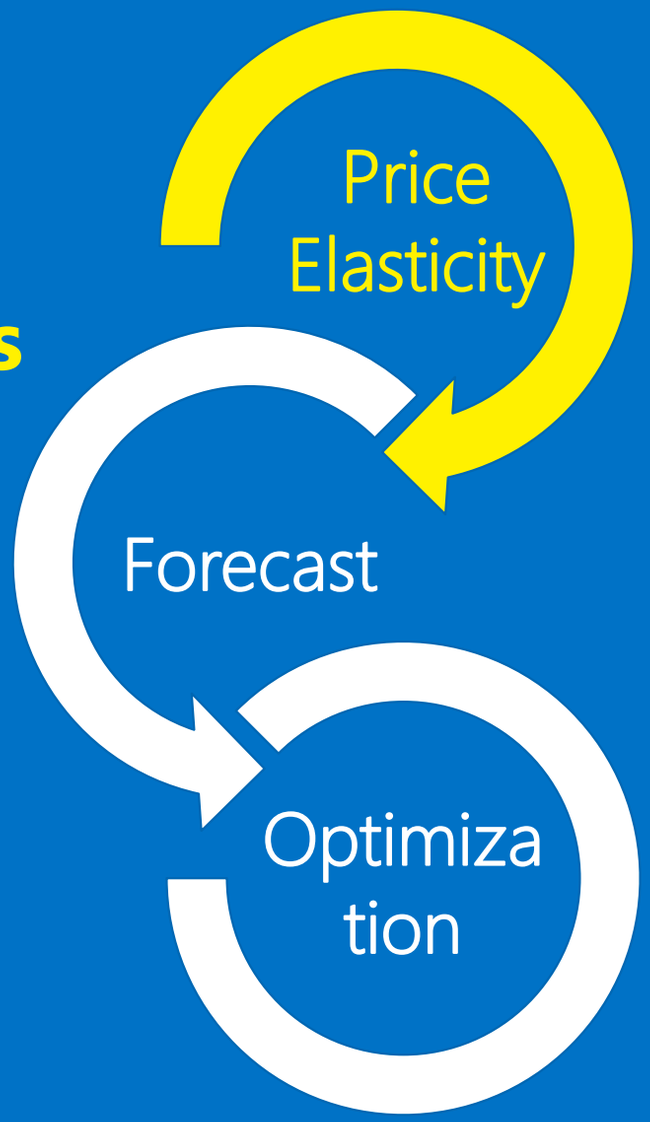
Mean Absolute Error	Root Mean Squared Error	Relative Absolute Error	Relative Squared Error	Coefficient of Determination
0.117948	0.142674	0.486701	0.223071	0.776929

Example:
Xueshan's Burger Cafes



Definition

- Estimate Price Elasticity in Business
  Identify sensitive stores and items
- Forecast Demand and Revenue
- Optimize Prices



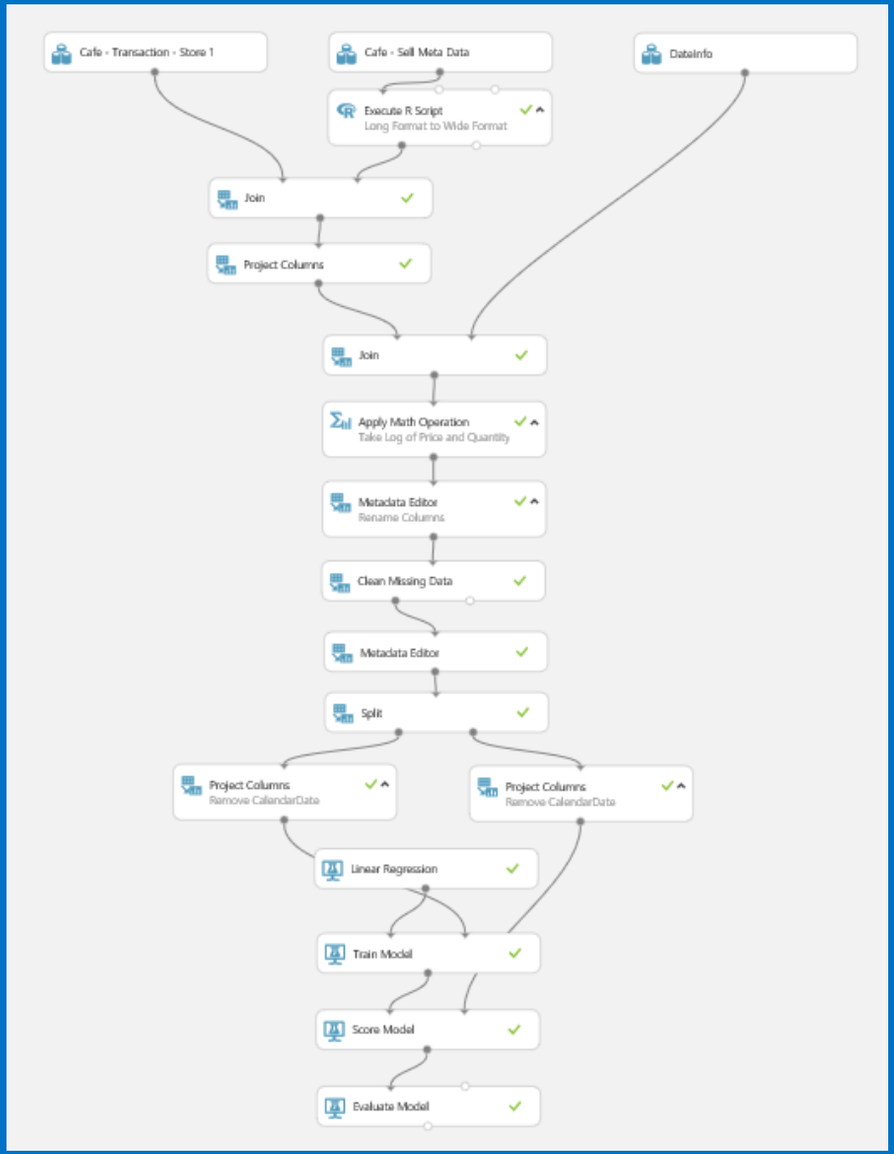
Problem 1: Whose Price to Increase?

Background:

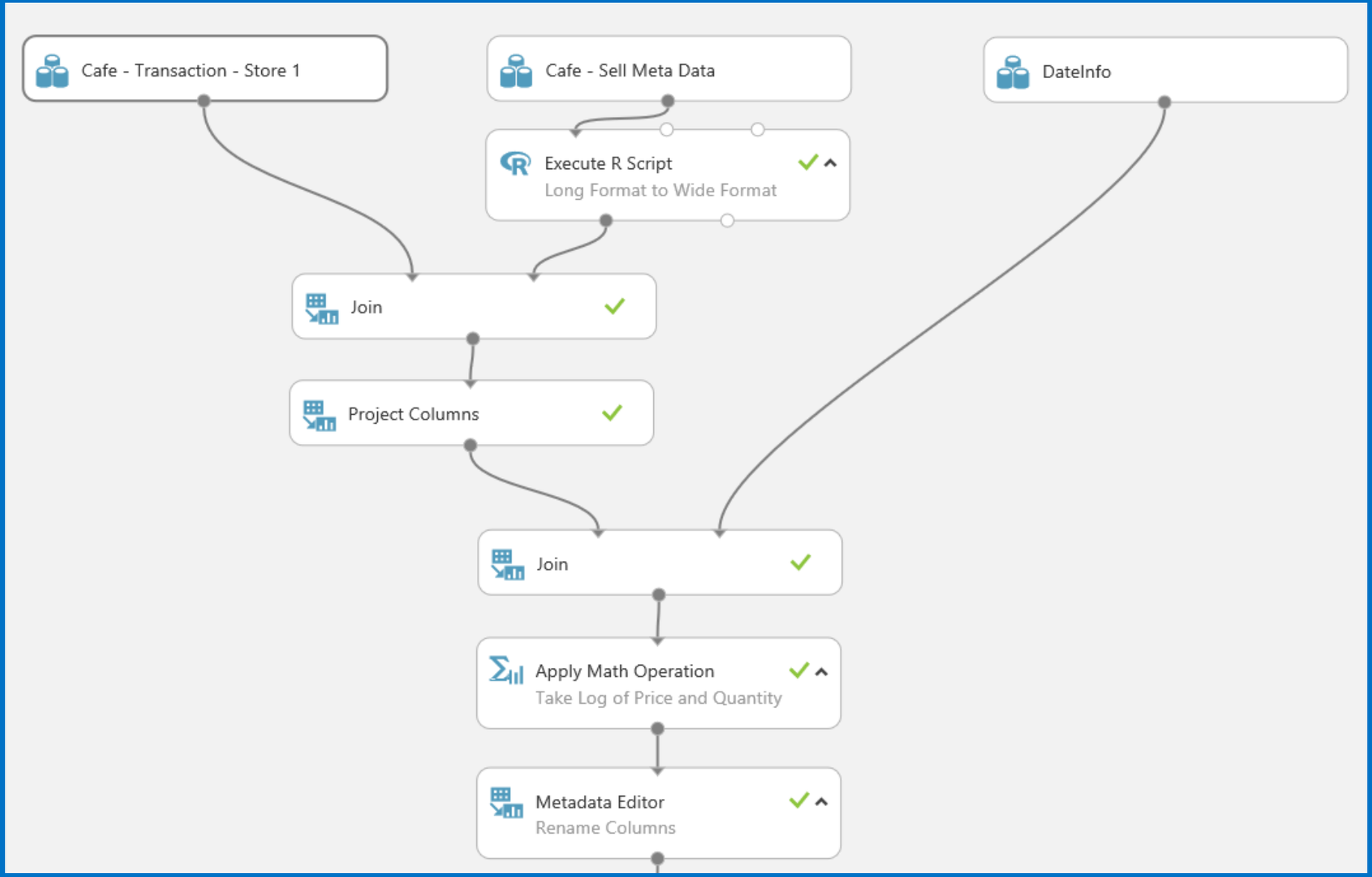
- Increase the price of burger due to cost pressure
- Increment fixed: 0.5 RMB
- Stores have different sensitivity
- Select the least sensitive store

[Next]

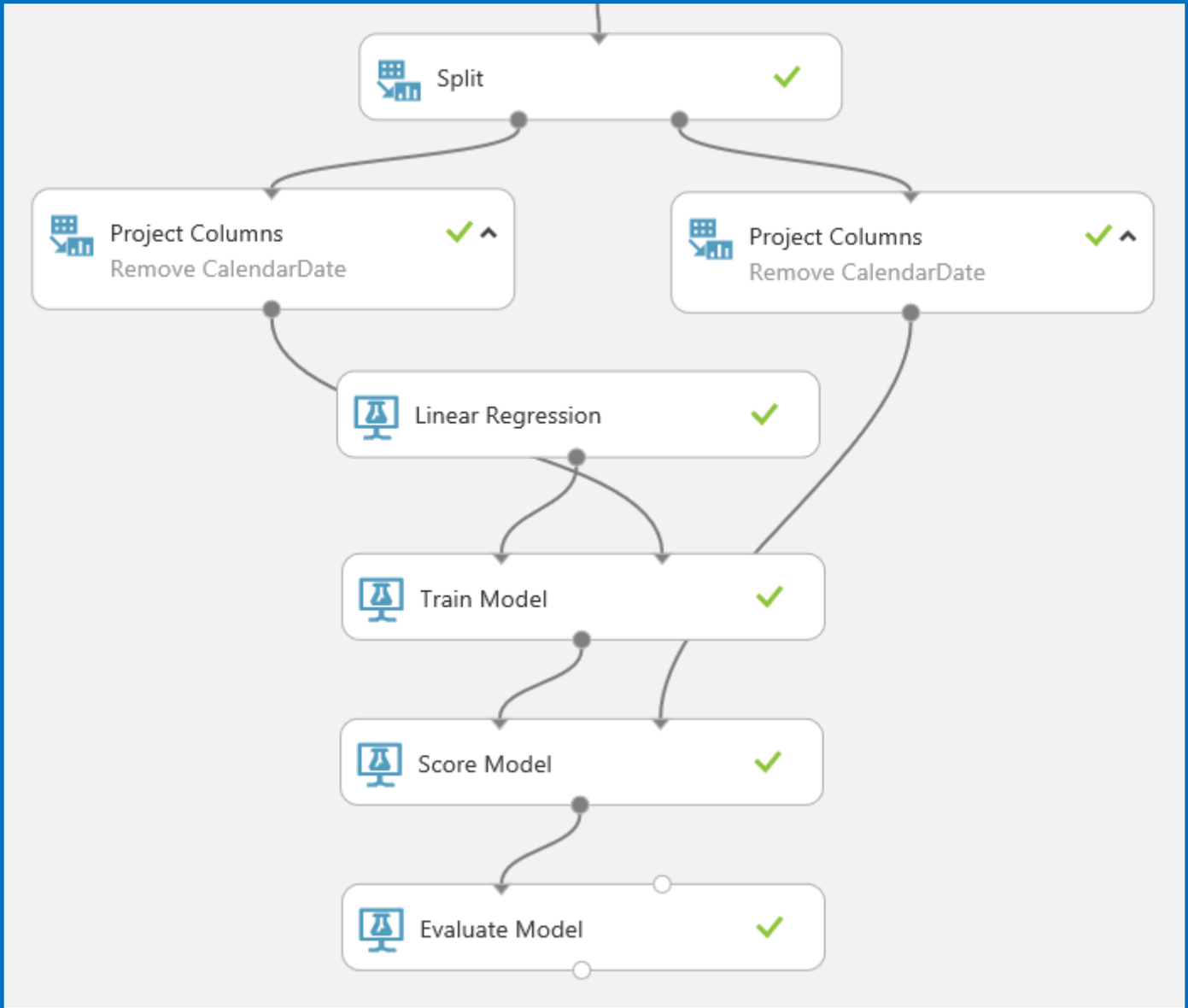
Problem 1: Whose Price to Increase?



Problem 1: Whose Price to Increase?



Problem 1: Whose Price to Increase?



Problem 1: Whose Price to Increase?

Demo 2.1 - Cafe - Elasticity › Cafe - Transaction - Store 1 › dataset

rows 5404

columns 6

view as

STORE	CALENDAR_DATE	PRICE	QUANTITY	SELL_ID	SELL_CATEGORY
1	2012-01-01T00:00:00	15.5	46	1070	0
1	2012-01-01T00:00:00	12.73	22	2051	2
1	2012-01-01T00:00:00	12.75	18	2052	2
1	2012-01-01T00:00:00	12.6	30	2053	2
1	2012-01-02T00:00:00	15.5	70	1070	0
1	2012-01-02T00:00:00	12.73	22	2051	2
1	2012-01-02T00:00:00	12.75	16	2052	2
1	2012-01-02T00:00:00	12.6	34	2053	2

Problem 1: Whose Price to Increase?

Demo 2.1 - Cafe - Elasticity › Cafe - Sell Meta Data › dataset

rows 11

columns 4

view as

SELL_ID	SELL_CATEGORY	ITEM_ID	ITEM_NAME
1070	0	7821	BURGER
3055	0	3052	COFFEE
3067	0	5030	COKE
3028	0	6249	LEMONADE
2051	2	7821	BURGER
2051	2	5030	COKE
2052	2	7821	BURGER
2052	2	6249	LEMONADE
2053	2	7821	BURGER
2053	2	5030	COKE
2053	2	3052	COFFEE

Problem 1: Whose Price to Increase?

Demo 2.1 - Cafe - Elasticity › Project Columns › Results dataset

rows	columns
5404	6

view as

CALENDAR_DATE	PRICE	QUANTITY	COFFEE	COKE	LEMONADE
2012-01-01T00:00:00	15.5	46	0	0	0
2012-01-01T00:00:00	12.73	22	0	1	0
2012-01-01T00:00:00	12.75	18	0	0	1
2012-01-01T00:00:00	12.6	30	1	1	0

Problem 1: Whose Price to Increase?

Demo 2.1 - Cafe - Elasticity › Project Columns › Results dataset

rows	columns
5404	6

view as

CALENDAR_DATE	PRICE	QUANTITY	COFFEE	COKE	LEMONADE
2012-01-01T00:00:00	15.5	46	0	0	0
2012-01-01T00:00:00	12.73	22	0	1	0
2012-01-01T00:00:00	12.75	18	0	0	1
2012-01-01T00:00:00	12.6	30	1	1	0

Problem 1: Whose Price to Increase?

Demo 2.1 - Cafe - Elasticity › DateInfo › dataset

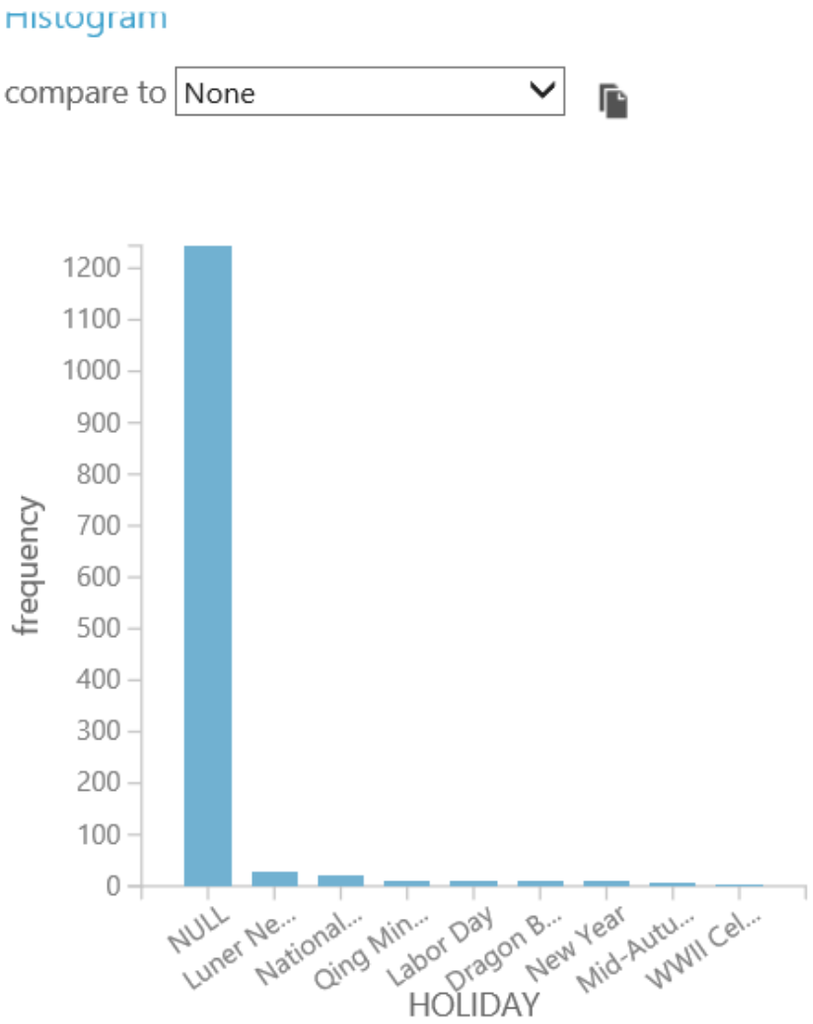
rows	columns
1349	7

view as

CALENDAR_DATE	YEAR	HOLIDAY	IS_WEEKEND	IS_SCHOOLBREAK	AVERAGE_TEMPERATURE	IS_OUTDOOR
2012-01-01T00:00:00	2012	New Year	1	0	24.8	0
2012-01-02T00:00:00	2012	New Year	0	0	24.8	0
2012-01-03T00:00:00	2012	New Year	0	0	32	1
2012-01-04T00:00:00	2012	NULL	0	0	32	1

Problem 1: Whose Price to Increase?

CALENDAR_DATE	YEAR	HOLIDAY	IS_WEEKEND	IS_SCHOOLBREAK	AVERAGE_TEMPERAT
2012-01-01T00:00:00	2012	New Year	1	0	24.8
2012-01-02T00:00:00	2012	New Year	0	0	24.8
2012-01-03T00:00:00	2012	New Year	0	0	32
2012-01-04T00:00:00	2012	NULL	0	0	32
2012-01-05T00:00:00	2012	NULL	0	0	24.8
2012-01-06T00:00:00	2012	NULL	0	0	23
2012-01-07T00:00:00	2012	NULL	1	0	26.6
2012-01-08T00:00:00	2012	NULL	1	0	26.6



Problem 1: Whose Price to Increase?

Demo 2.1 - Cafe - Elasticity › Metadata Editor › Results dataset

rows 5420 columns 12

view as

CALENDAR_DATE	LOG_PRICE	LOG_QUANTITY	COFFEE	COKE	LEMONADE	YEAR	HOLIDAY	IS_WEEKEND	IS_SCHOOLBREAK	AVERAGE_TEMPERATURE	IS_OUTDOOR
2012-01-01T00:00:00	2.74084	3.828641	0	0	0	2012	New Year	1	0	24.8	0
2012-01-01T00:00:00	2.543961	3.091042	0	1	0	2012	New Year	1	0	24.8	0
2012-01-01T00:00:00	2.545531	2.890372	0	0	1	2012	New Year	1	0	24.8	0
2012-01-01T00:00:00	2.533697	3.401197	1	1	0	2012	New Year	1	0	24.8	0
2012-01-02T00:00:00	2.74084	4.248495	0	0	0	2012	New Year	0	0	24.8	0
2012-01-02T00:00:00	2.543961	3.091042	0	1	0	2012	New Year	0	0	24.8	0
2012-01-02T00:00:00	2.545531	2.772589	0	0	1	2012	New Year	0	0	24.8	0
2012-01-02T00:00:00	2.533697	3.526361	1	1	0	2012	New Year	0	0	24.8	0
2012-01-03T00:00:00	2.74084	4.127134	0	0	0	2012	New Year	0	0	32	1
2012-01-03T00:00:00	2.543961	3.258097	0	1	0	2012	New Year	0	0	32	1

Problem 1: Whose Price to Increase?

Demo 2.1 - Cafe - Elasticity › Metadata Editor › Results dataset

rows 5420 columns 12

view as

CALENDAR_DATE	LOG_PRICE	LOG_QUANTITY	COFFEE	COKE	LEMONADE	YEAR	HOLIDAY	IS_WEEKEND	IS_SCHOOLBREAK	AVERAGE_TEMPERATURE	IS_OUTDOOR
2012-01-01T00:00:00	2.74084	3.828641	0	0	0	2012	New Year	1	0	24.8	0
2012-01-01T00:00:00	2.543961	3.091042	0	1	0	2012	New Year	1	0	24.8	0
2012-01-01T00:00:00	2.545531	2.890372	0	0	1	2012	New Year	1	0	24.8	0
2012-01-01T00:00:00	2.533697	3.401197	1	1	0	2012	New Year	1	0	24.8	0
2012-01-02T00:00:00	2.74084	4.248495	0	0	0	2012	New Year	0	0	24.8	0
2012-01-02T00:00:00	2.543961	3.091042	0	1	0	2012	New Year	0	0	24.8	0
2012-01-02T00:00:00	2.545531	2.772589	0	0	1	2012	New Year	0	0	24.8	0
2012-01-02T00:00:00	2.533697	3.526361	1	1	0	2012	New Year	0	0	24.8	0
2012-01-03T00:00:00	2.74084	4.127134	0	0	0	2012	New Year	0	0	32	1
2012-01-03T00:00:00	2.543961	3.258097	0	1	0	2012	New Year	0	0	32	1

Problem 1: Whose Price to Increase?

Feature Weights

Feature	Weight
Bias	5.47738
LEMONADE	-1.64464
YEAR_2014_2	1.37464
YEAR_2015_3	1.37134
YEAR_2012_0	1.36744
YEAR_2013_1	1.36397
COKE	-1.26259
LOG_PRICE	-1.17087

Mean Absolute Error	Root Mean Squared Error	Relative Absolute Error	Relative Squared Error	Coefficient of Determination
0.102659	0.180571	0.22169	0.111322	0.888678

Problem 1: Whose Price to Increase?

Test Demo 2.2 - Cafe - Web Service for Elasticity Service

Enter Web Service Parameters

DATABASE QUERY

```
SELECT STORE, CALENDAR_DATE, PRICE,
QUANTITY, COKE, LEMONADE, COFFEE
FROM salesdata
WHERE STORE = 2
```

✔ 'Demo 2.2 - Cafe - Web Service for Elasticity' test returned ["-2.260","0.000","0.950"]...

Problem 1: Whose Price to Increase?

Price Elasticity:

- Store 1: -1.17
- Store 2: -2.26

⇒Increase the price of burger in Store 1.

Justifies empirical knowledge on store locations.

THE BIG MAC INDEX

How many burgers you get for $50 USD?

30

India*	$1.62

23

Ukraine	$2.11
Hong Kong	$2.12

21

Malaysia	$2.34

20

China	$2.44
South Africa	$2.45
Indonesia	$2.46
Thailand	$2.46
Taiwan	$2.5

19

Russia	$2.55
Sri Lanka	$2.55
Egypt	$2.57
Poland	$2.58
Hungary	$2.63

18

Saudi Arabia	$2.67
Philippines	$2.68
Mexico	$2.7

17

Lithuania	$2.87
Pakistan	$2.89

16

Latvia	$3.0

15

South Korea	$3.19
UAE	$3.27

14

Czech Rep.	$3.45
Turkey	$3.54

13

Peru	$3.71
Singapore	$3.75
Britain	$3.82

12

Costa Rica	$4.02
Chile	$4.05
New Zealand	$4.05
Israel	$4.13
Japan	$4.16

11

USA	$4.2
Euro area	$4.43
Colombia	$4.54

10

Canada	$4.63
Uruguay	$4.63
Argentina	$4.64
Australia	$4.94

9

Denmark	$5.37

8

Brazil	$5.68
Sweden	$5.91

7

Norway	$6.79
Switzerland	$6.81

Source: The Economist (Jan 2012)

* Chicken burger

Souce: https://en.wikipedia.org/wiki/Big_Mac_Index#/media/File:Big_Mac_index_50USD_2columns.png
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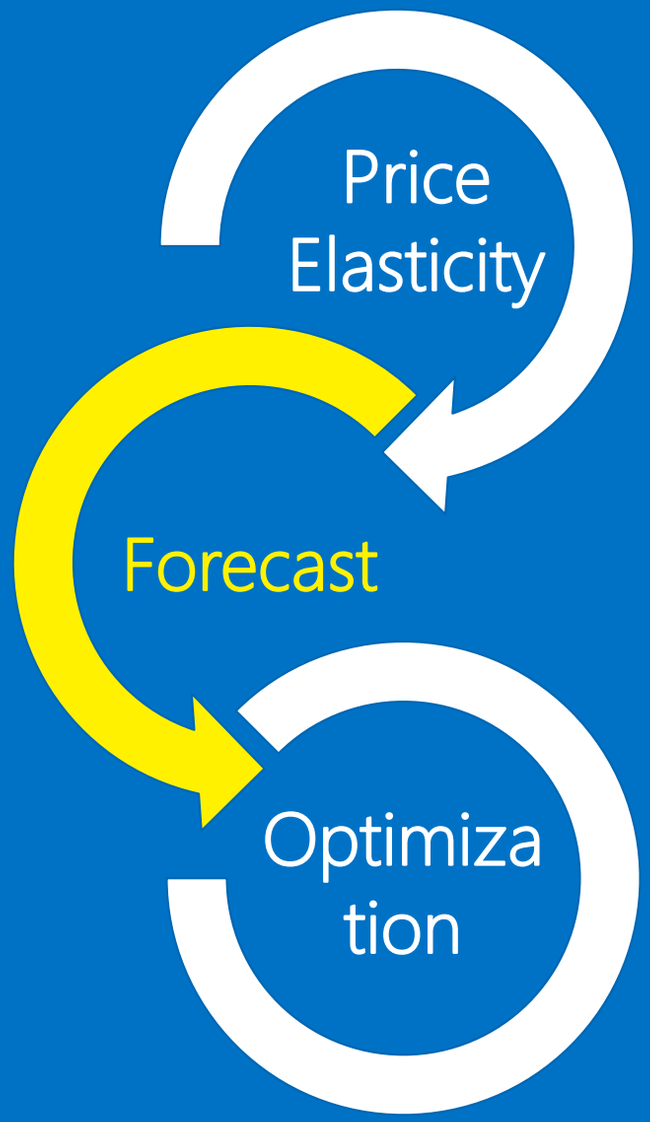
Definition

- Estimate Price Elasticity in Business
  Identify sensitive stores and items
- Forecast Demand and Revenue
- Optimize Prices



Problem 2: How many burgers should I make?

- Increase burger price in store 1 by 0.5 RMB from Sep 11
- Demand forecast from Sep 11 to Sep 17

Problem 2: How many burgers should I make?

- Regression Model

  log(Demand) = a + b x log(Price) + c x Temperature +
  d x Is_Weekend + e x Is_Holiday

- Actually a Demand Forecasting Model

[Next]

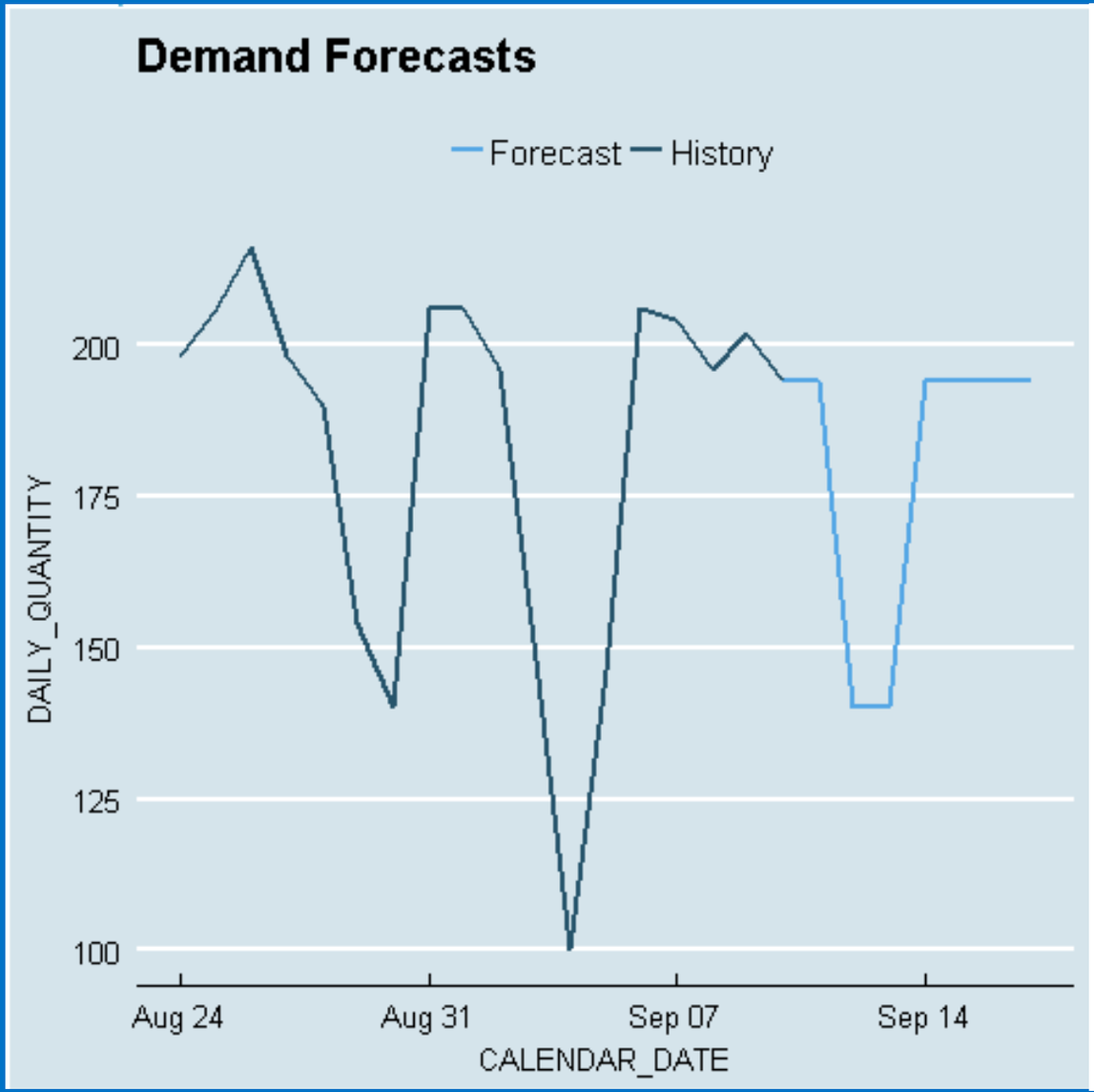
Problem 2: How many burgers should I make?

STORE	CALENDAR_DATE	PRICE	COKE	LEMONADE	COFFEE	YEAR	HOLIDAY	IS_WEEKEND
1	2015-09-11T00:00:00	15	0	0	0	2015	NULL	0
1	2015-09-11T00:00:00	12.46	1	0	0	2015	NULL	0
1	2015-09-11T00:00:00	11.09	0	1	0	2015	NULL	0
1	2015-09-11T00:00:00	11.86	1	0	1	2015	NULL	0
1	2015-09-12T00:00:00	15	0	0	0	2015	NULL	1
1	2015-09-12T00:00:00	12.46	1	0	0	2015	NULL	1
1	2015-09-12T00:00:00	11.09	0	1	0	2015	NULL	1
1	2015-09-12T00:00:00	11.86	1	0	1	2015	NULL	1

Problem 2: How many burgers should I make?

STORE	CALENDAR_DATE	PRICE	COKE	LEMONADE	COFFEE	YEAR	HOLIDAY	IS_WEEKEND	QUANTITY_FORECAST
1	2015-09-11T00:00:00	15	0	0	0	2015	NULL	0	89
1	2015-09-11T00:00:00	12.46	1	0	0	2015	NULL	0	31
1	2015-09-11T00:00:00	11.09	0	1	0	2015	NULL	0	24
1	2015-09-11T00:00:00	11.86	1	0	1	2015	NULL	0	50
1	2015-09-12T00:00:00	15	0	0	0	2015	NULL	1	64
1	2015-09-12T00:00:00	12.46	1	0	0	2015	NULL	1	22
1	2015-09-12T00:00:00	11.09	0	1	0	2015	NULL	1	18
1	2015-09-12T00:00:00	11.86	1	0	1	2015	NULL	1	36

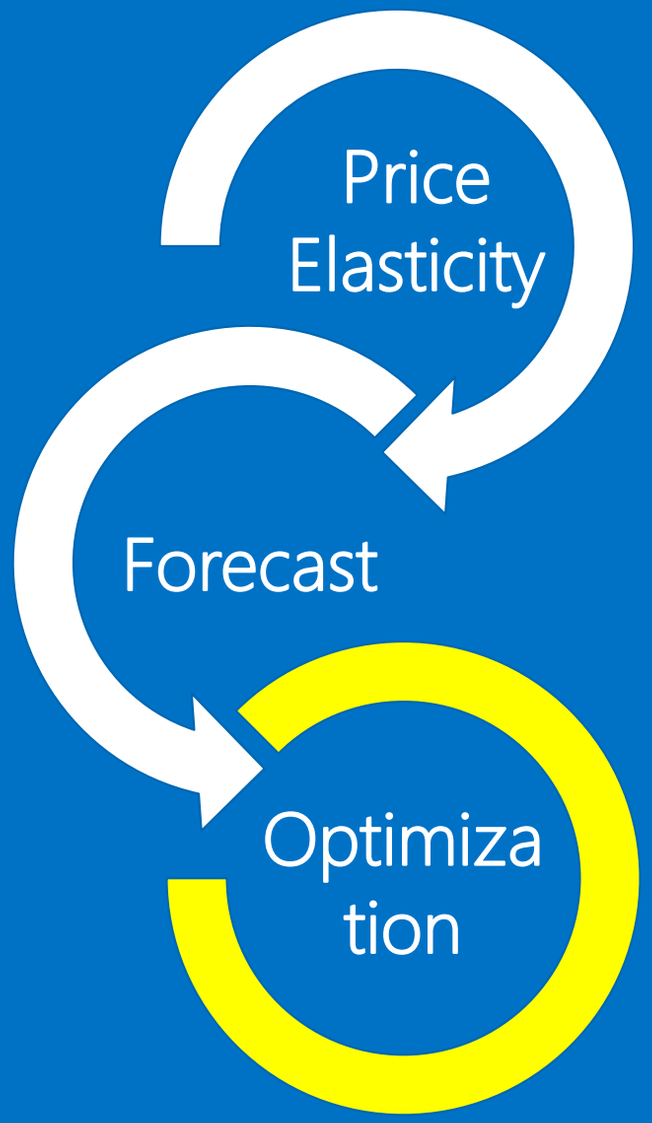
Problem 2: How many burgers should I make?



CALENDAR_DATE	DAILY_QUANTITY	TYPE
2015-09-11T00:00:00	194	Forecast
2015-09-12T00:00:00	140	Forecast
2015-09-13T00:00:00	140	Forecast
2015-09-14T00:00:00	194	Forecast
2015-09-15T00:00:00	194	Forecast
2015-09-16T00:00:00	194	Forecast
2015-09-17T00:00:00	194	Forecast

Definition

- Estimate Price Elasticity in Business
  Identify sensitive stores and items
- Forecast Demand and Revenue
- **Optimize Prices**



Problem 3: Do I have the right price?

- Instead of price increase, plan to maximize revenue for the next month by optimizing both stores' prices

- Constraints:

  |Current Price – New Price| < 1

  |Price in Store 1 – Price in Store 2| <= 1

  Price differs by 0.5. Price >= 14.

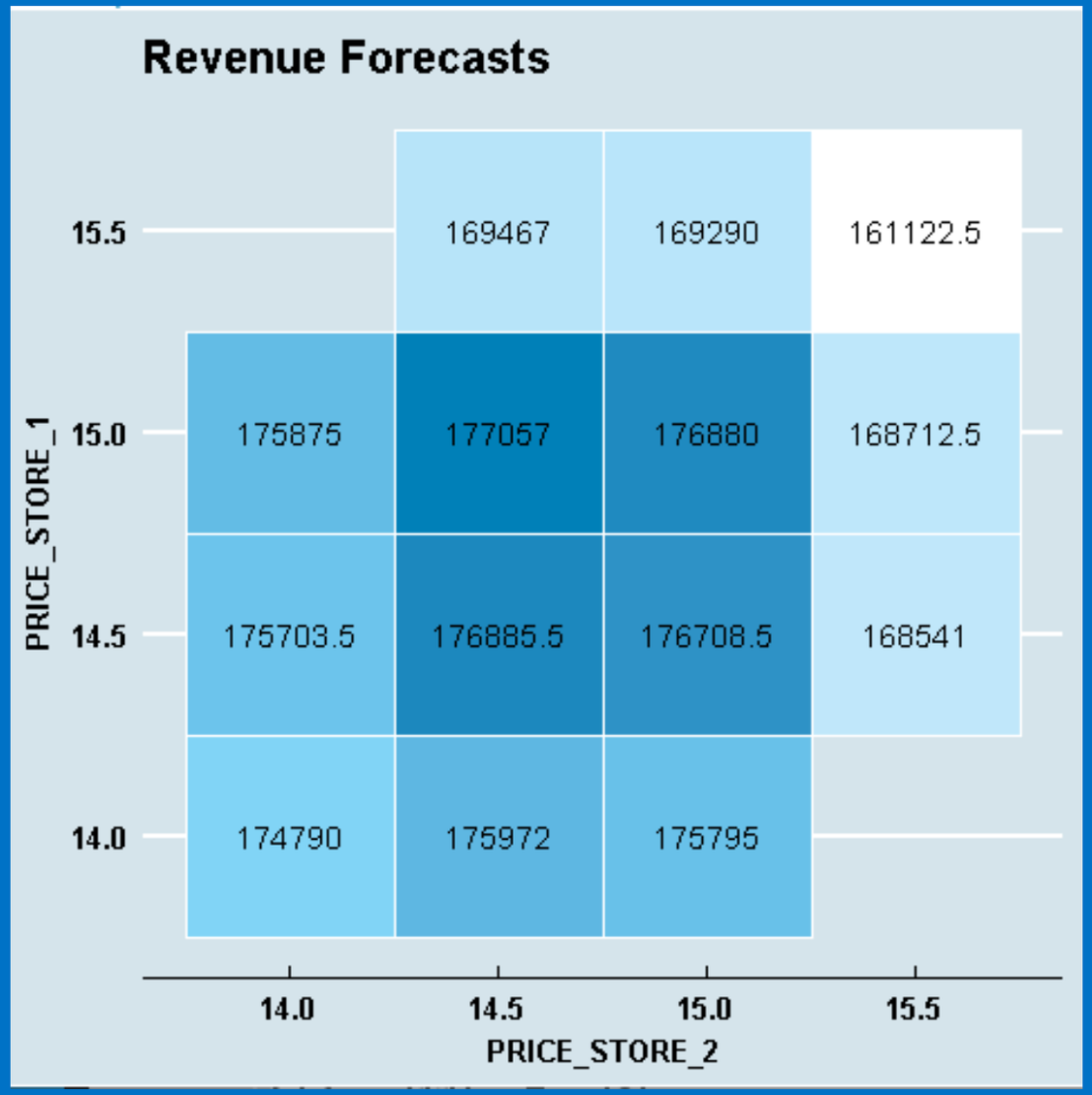
  (Current Price in Store 1 and 2: 14.5 RMB)

Problem 3: Do I have the right price?

- Number of eligible price combinations is limited.

Store 1 \ 2	14	14.5	15	15.5
15.5		Y	Y	Y
15	Y	Y	Y	Y
14.5	Y	Y	Y	Y
14	Y	Y	Y	

Problem 3: Do I have the right price?



PRICE_STORE_1	PRICE_STORE_2	QUANTITY_FORECAST_1	REVENUE_FORECAST_1
15	14.5	5621	84315

QUANTITY_FORECAST_2	REVENUE_FORECAST_2	TOTAL_REVENUE
6396	92742	177057

Problem 3: Do I have the right price?

Optimization Toolbox:

- Grid
- R / Python Packages in AML
- Customized codes in AML
- Optimization engine installed on Azure VM
- Call Public Optimization API from Azure

Definition

- Estimate Price Elasticity in Business
  Identify sensitive stores and items
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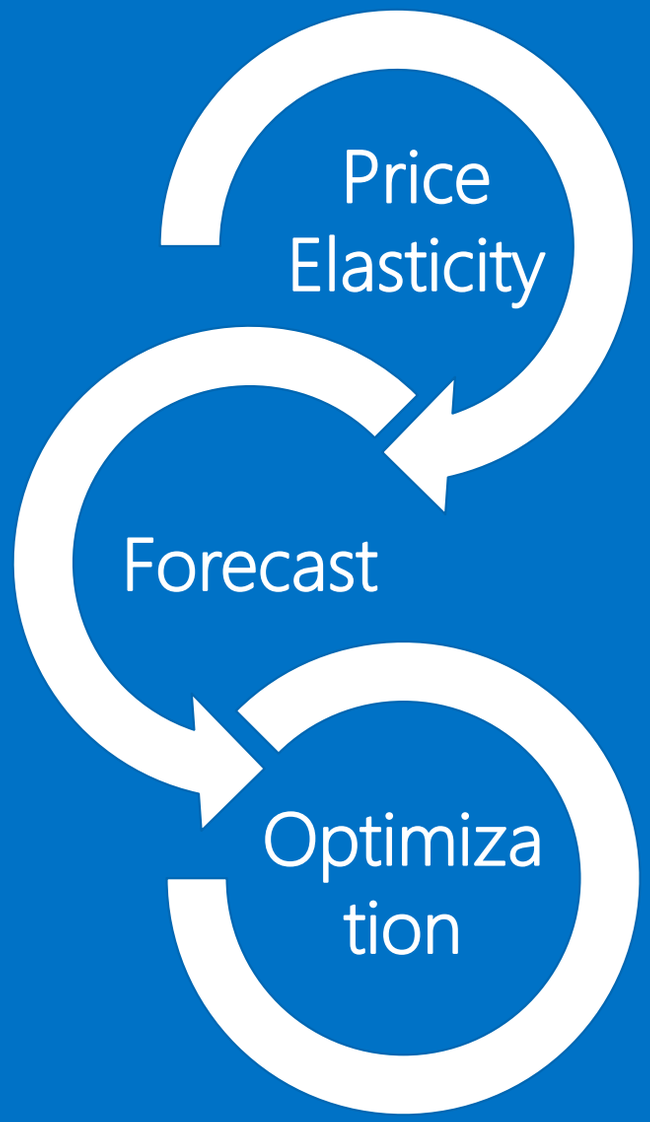


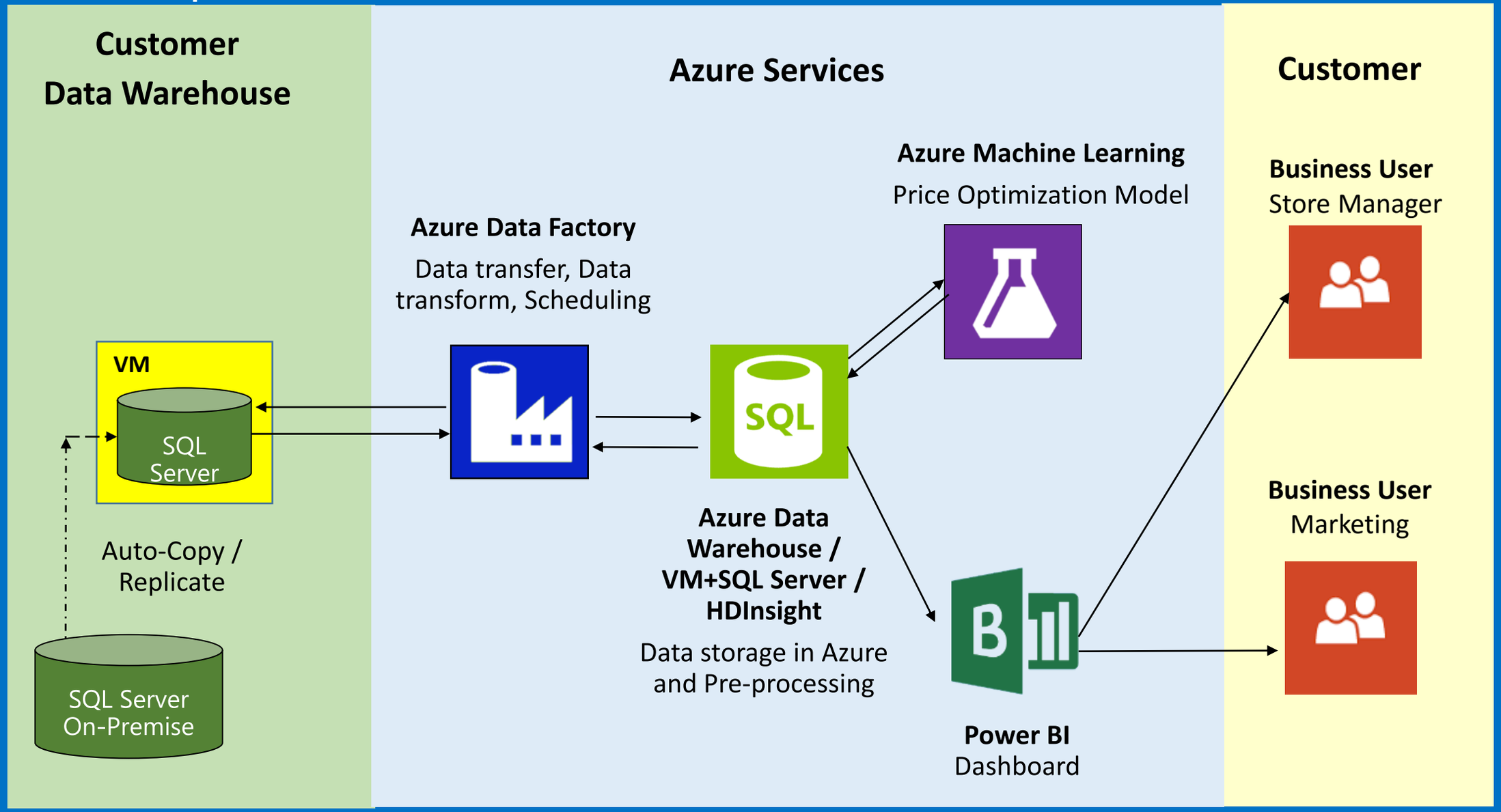
Before I Apply …

Required Data

- Historical Transaction Records
- Price, Sales Quantity, External Factors (Weather, etc.)
- Enough Different Price Points

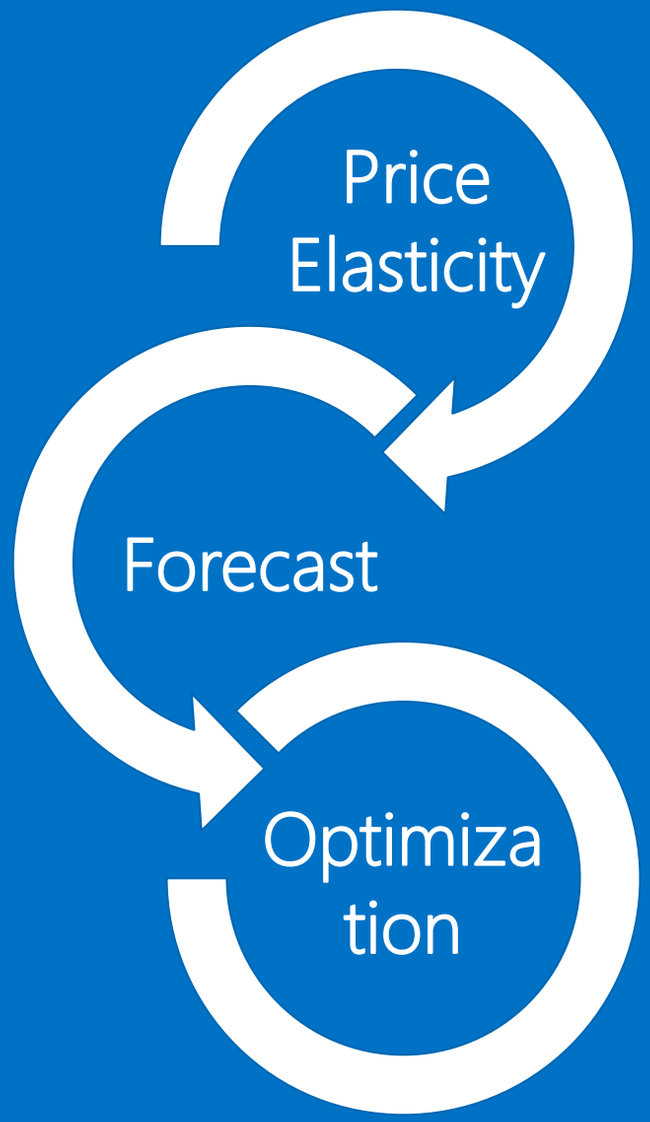
- Best: Randomized Price Experiments

A Sample Architecture



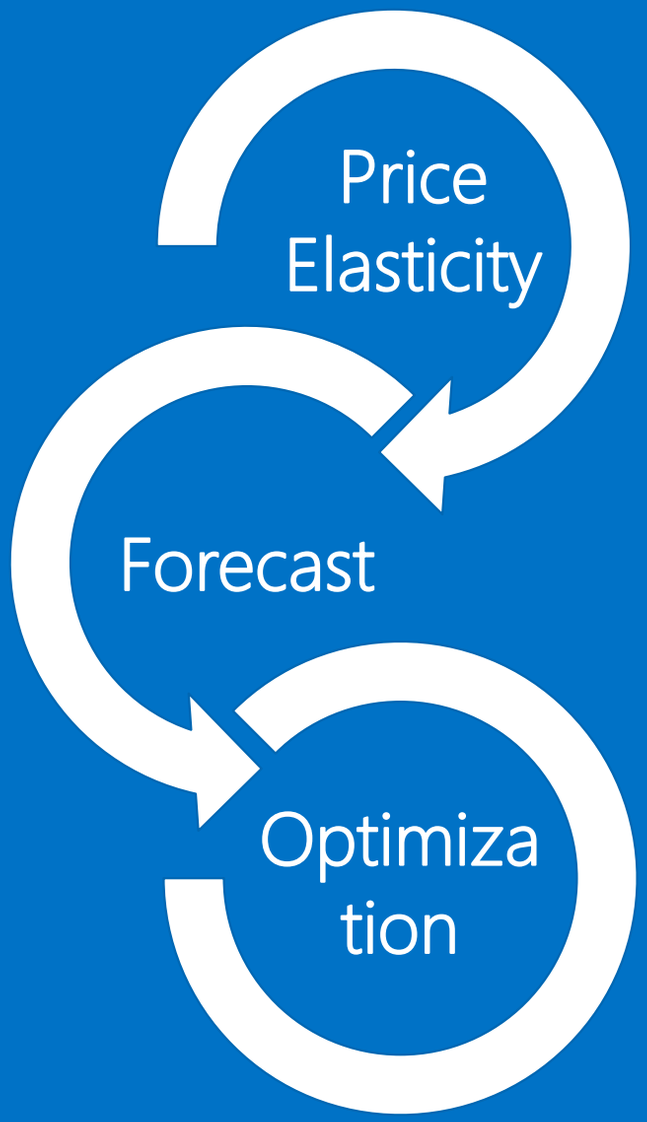
Definition

- Estimate Price Elasticity in Business
  Identify sensitive stores and items
- Forecast Demand and Revenue
- Optimize Prices



Orchestrated by:

Cortana Analytics Suite



Price Elasticity
Forecast
Optimiz ation

Price Elasticity
Forecast
Optimiz ation
Hi, I'm Cortana.

Microsoft

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