Is it Elastic?
Inflation, Problematic. Prices, Automatic.

A MODEL BASED APPROACH TO DECOMPOSE SALES SIGNALS AND ESTIMATE SALES CHANGE GIVEN PRICE

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REDUCED DOLLAR ERROR OF SALES PREDICTIONS BY $5 MILLION AFTER PRICE CHANGES

SALES BREAKDOWN FOR OVER 20000 TIME SERIES INTO SEASONAL AND MACROECONOMIC FACTORS

A 14% INCREASE IN ACCURACY FROM MODEL COMPARED TO PREVIOUS ESTIMATES OF ELASTICITY

MOTIVATION

Problem

Unprecedented inflation has led to necessary price increases.

Goal: Find Elasticity

1% increase in Price → *? % change in Demand*

Business Impact

Accurate Elasticities + Informed Price Change = Increased Sales Revenue

DATASETS USED:

POS Sales Data: Product, Weekly Sales, Average Price, Region

Macroeconomic Features: Inflation, Supply Chain, Distribution unique to Unilever

Number of Categories	19
Number of Regions	226
Total number of Products	1707
Total number of rows in Sales data	90 million

CURRENT METHOD:

$$Elasticity = \frac{\log_{10}(1 + \Delta\%\text{UnitChg})}{\log_{10}(1 + \Delta\%\text{PriceChg})}$$

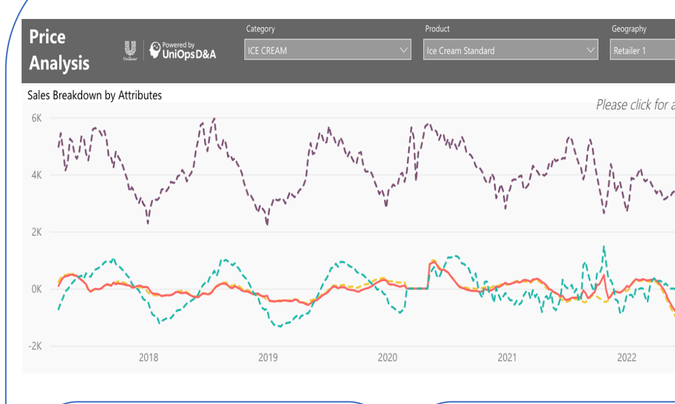
Used For:

- Estimating the effects of price changes.
- Categorizing Unilever's products.

Issues:

- Creates estimate from two points in the data.
- Does not consider seasonality and trend.
- Does not account for macroeconomic factors.

Business Ready PowerBI Dashboard

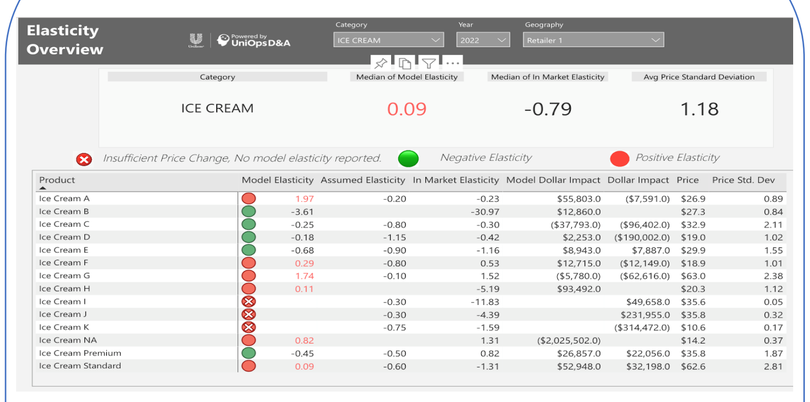


SHOWS
How each signal contributes to a product's sales

IMPACT
Understanding of product behavior and reactions

SHOWS
Expected sales for a given price increase

IMPACT
Dynamic and more accurate predictions



Product	Model Elasticity	Assumed Elasticity	In Market Elasticity	Model Dollar Impact	Dollar Impact	Price	Price Std. Dev
Ice Cream A	1.97	-0.20	-0.23	$55,803.0	($7,591.0)	$26.9	0.89
Ice Cream B	-3.61		-30.97	$12,860.0		$27.3	0.84
Ice Cream C	-0.25	-0.80	-0.30	($37,793.0)	($96,402.0)	$32.9	2.11
Ice Cream D	-0.18	-1.15	-0.42	$2,253.0	($190,002.0)	$19.0	1.02
Ice Cream E	-0.68	-0.90	-1.16	$8,943.0	$7,887.0	$29.9	1.55
Ice Cream F	0.29	-0.80	0.53	$12,715.0	($12,149.0)	$18.9	1.01
Ice Cream G	1.74	-0.10	1.52	($5,780.0)	($62,616.0)	$63.0	2.38
Ice Cream H	0.11		-5.19	$93,492.0		$20.3	1.12
Ice Cream I		-0.30	-11.83		$49,658.0	$35.6	0.05
Ice Cream J		-0.30	-4.39		$231,955.0	$35.8	0.32
Ice Cream K		-0.75	-1.59		($314,472.0)	$10.6	0.17
Ice Cream NA	0.82		1.31	($2,025,502.0)		$14.2	0.37
Ice Cream Premium	-0.45	-0.50	0.82	$26,857.0	$22,056.0	$35.8	1.87
Ice Cream Standard	0.09	-0.60	-1.31	$52,948.0	$32,198.0	$62.6	2.81

SHOWS
Elasticity values and metrics for all products

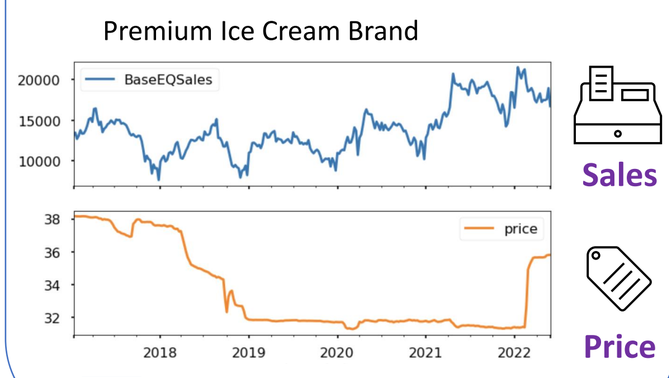
IMPACT
Category outlook and sorting of products tiers

STEP 1:

GOAL: Remove impact of all features except price

HOW: Using Prophet model with seasonality and external regressors

Original Sales Data



Seasonality

3rd order Fourier Series

Macroeconomics

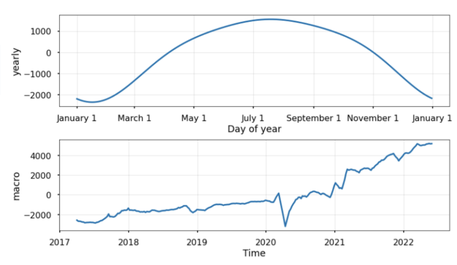
Personal Consumption Expenditures

Distribution and Supply Chain

Internal Unilever Data

Price Independent Sales

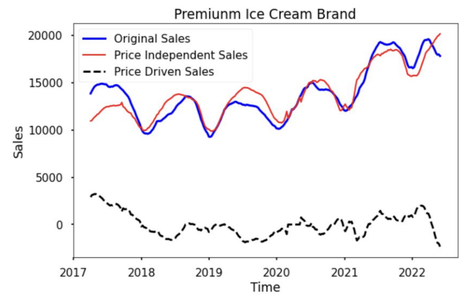
Adjusted using Additive, Zero Trend PROPHET Model

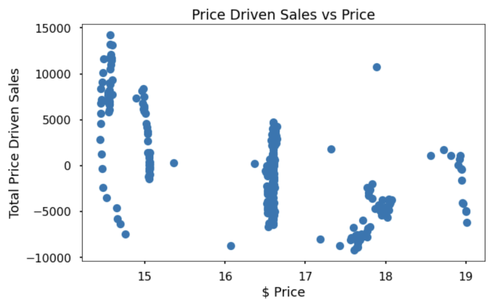


What sales would be, agnostic of price

Price Driven Sales

Calculated as: Original Sales – Price Independent Sales





Elasticity Coefficients

YEAR	MODEL ELASTICITY	PRED. SALES	ACTUAL SALES	DOLLAR IMPACT
2022	- 0.463	-22%	-12%	$13862
2021	No Price Change	None	+24%	None

PRODUCT (Error measured as Sales quantity)	RMSE STEP 1	RMSE STEP 2
Premium Ice Cream Product	15498	8811
Standard Ice Cream Product	27869	12027
Non-Dairy Ice Cream Product	4121	2334
Premium Non-Diary Ice Cream	640	370
CATEGORY AVERAGE	**11350**	**5421**

STEP 2:

GOAL: Use price to explain the remaining variation in sales

HOW: Linear regression, shifting 52-week window

STAKEHOLDERS

We would like to thank all the members of the Unilever team for their feedback during this process. Special thanks to the Data and Analytics team: Syed Haider, Zeya Luo and Saloni Mishra. The Pricing team: Marc Becker and Brett Griswold. And the project leads: Ansu Kurian and Matt Algar.

IRi Growth delivered. databricks Power BI

NEXT STEPS

Implemented Model in Cloud to update automatically

Follow up on Business team after series of price changes.

CITATIONS

[Andreyeva et al., 2010] Andreyeva, T., Long, M. W., and Brownell, K. D. (2010). The impact of food prices on consumption: A systematic review of research on the price elasticity of demand for food.
[Chindarkar and Goyal, 2019] Chindarkar, N. and Goyal, N. (2019). One price doesn't fit all: An examination of heterogeneity in price elasticity of residential electricity in india. Energy Economics, 81:765–778.
[Jawad et al., 2018] Jawad, M., Lee, J. T., Glantz, S., and Millett, C. (2018). Price elasticity of demand of non-cigarette tobacco products:
[Taylor and Letham, 2018] Taylor, S. J. and Letham, B. (2018). Forecasting at Scale. The American Statistician, 72(1):37–45
[Pendzialek et al., 2016] Pendzialek, J. B., Simic, D., and Stock, S. (2016). Differences in price elasticities of demand for health insurance