Global Consulting

Demand & elasticity modelling for P&C insurance pricing under various conditions

Can Baysal – Insurance Data Science Conference, 18 June 2024

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1 Introduction

Image: William Patin / allroundMEDIA

Customers shop around for affordable insurance quotes

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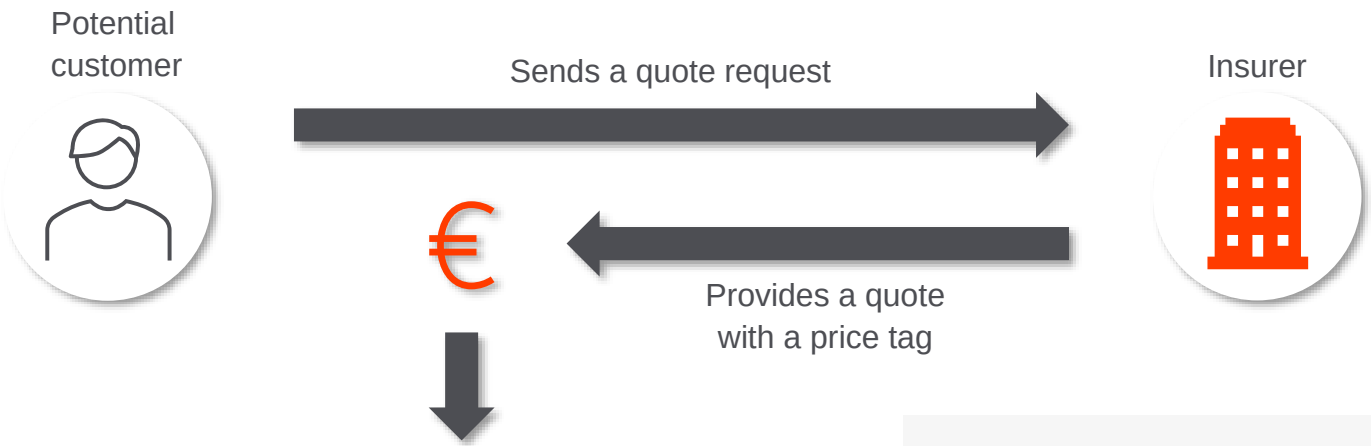

Employ advanced algorithms and methodologies to develop the most precise logistic regression model for the response

Digital channels facilitate effortless comparison of multiple quotes

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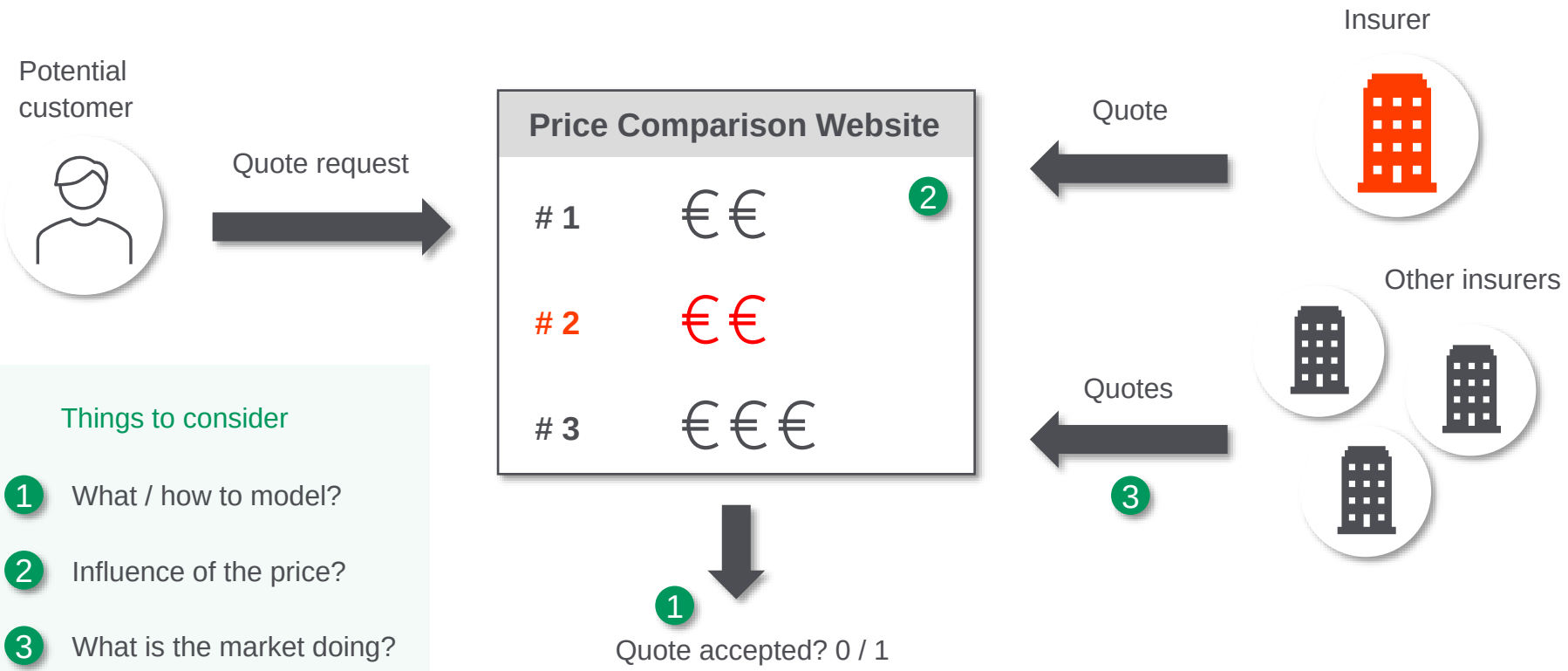

Things to consider

1. What / how to model?
2. Influence of the price?
3. What is the market doing?

Demand models enable insurers to analyse customer purchasing behaviour across different price levels

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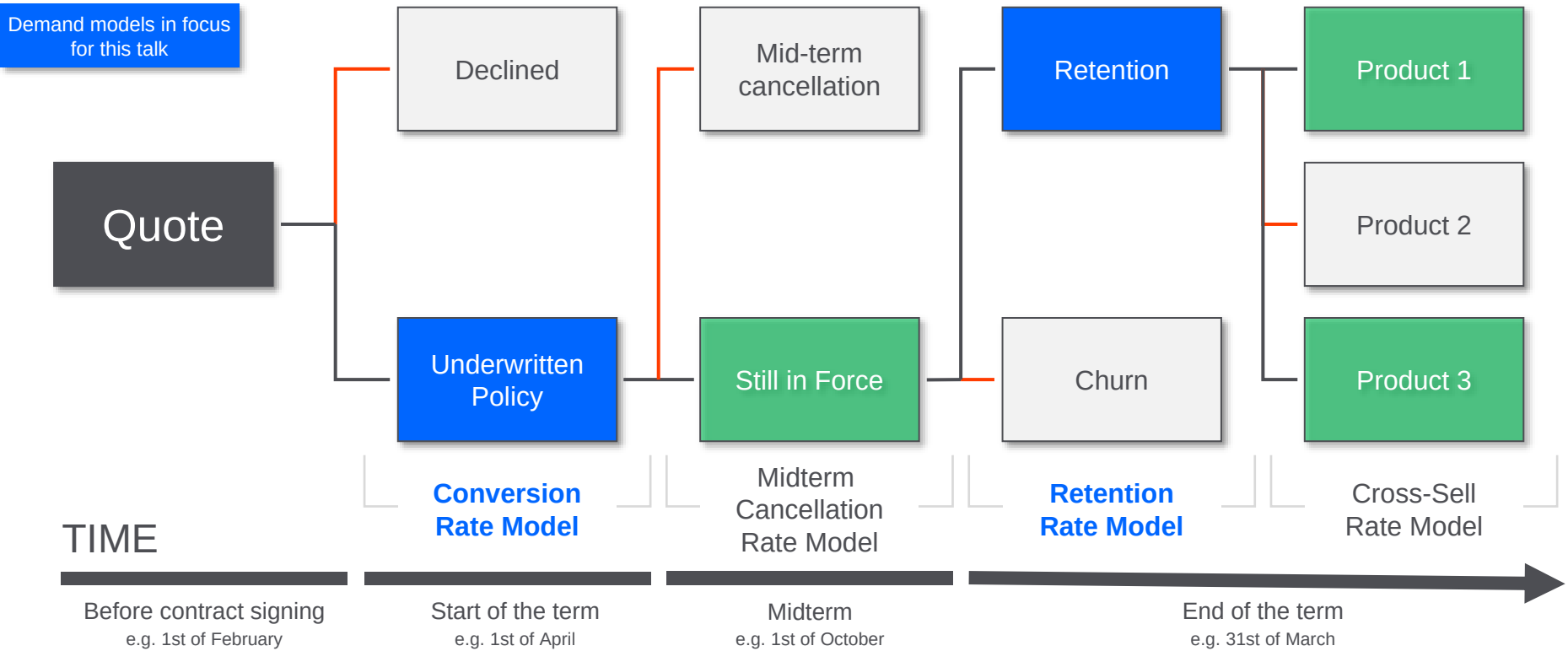

2 Business applications

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Practical applications of demand models provide valuable solutions for diverse business challenges

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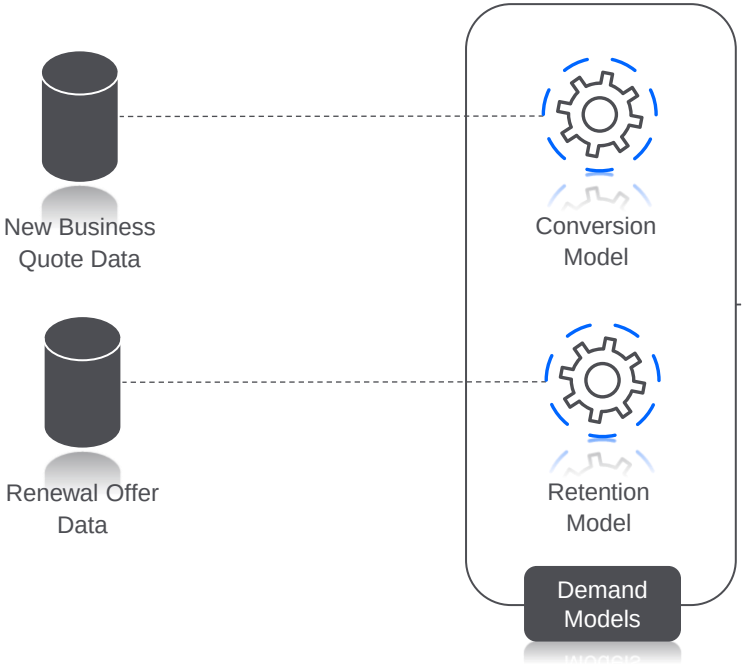
Advanced integration into the pricing process



Customer Insights

- Understanding customer demand to a product at a particular price point and customer segmentation

Scenario Testing

- Estimating the impact of price changes on customer mix and key performance indicators

Price Optimisation

- Generating optimised pricing scenarios using customer price elasticity to construct efficient frontiers

Analysing the relationship between price and demand uncovers price elasticity insights

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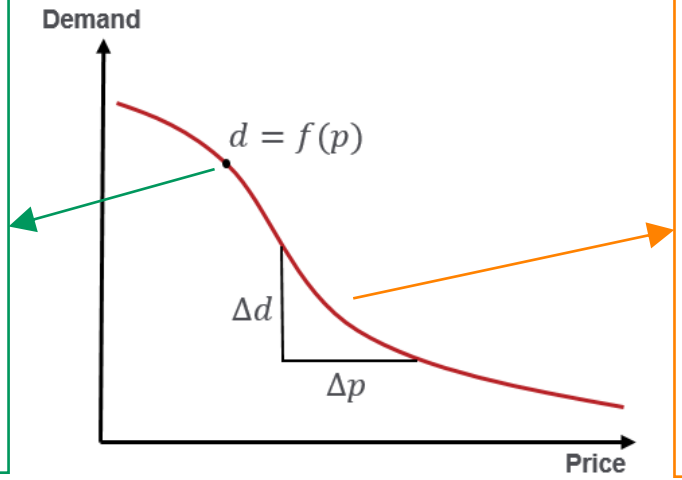
Demand

If a premium of €200 is offered …

… What is the probability of converting/renewing at a given price point?



Elasticity

How does the probability of converting/renewing change?

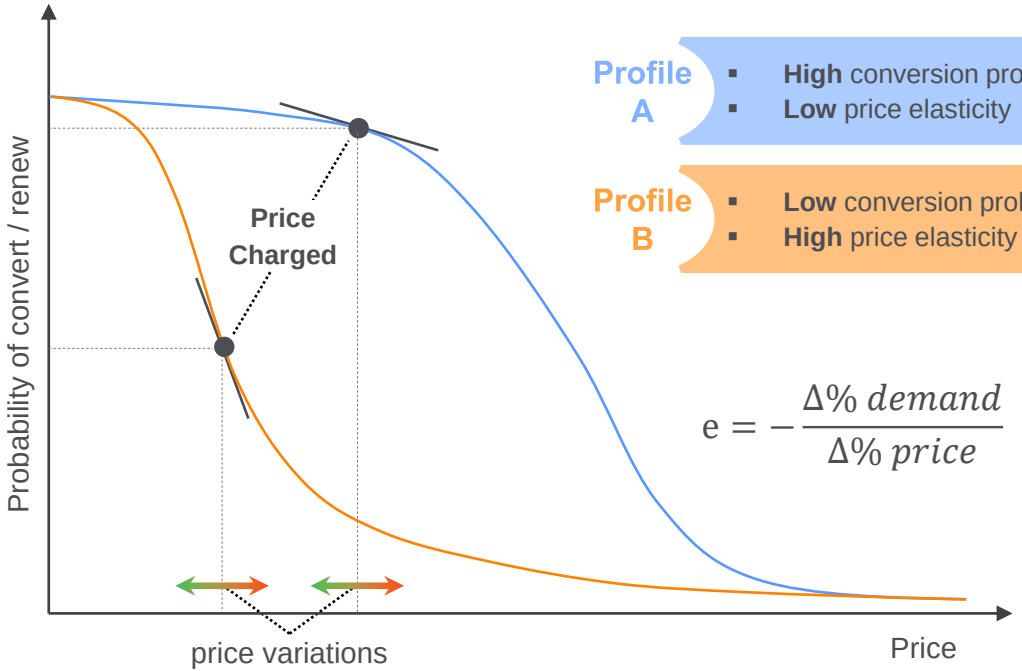
$$e = -\frac{\Delta\%\ demand}{\Delta\%\ price}$$

Formal:

$$e = -\frac{\frac{d(p_1) - d(p_0)}{d(p_0)}}{\frac{p_1 - p_0}{p_0}}$$

p_0	old price
p_1	new price
$d(.)$	demand

Demand drivers are identified for customer segmentation and isolating the effect of price



Profile A
- **High** conversion prob.
- **Low** price elasticity

Profile B
- **Low** conversion prob.
- **High** price elasticity

$$e = -\frac{\Delta\%\ demand}{\Delta\%\ price}$$

Non-price related features

Price related features

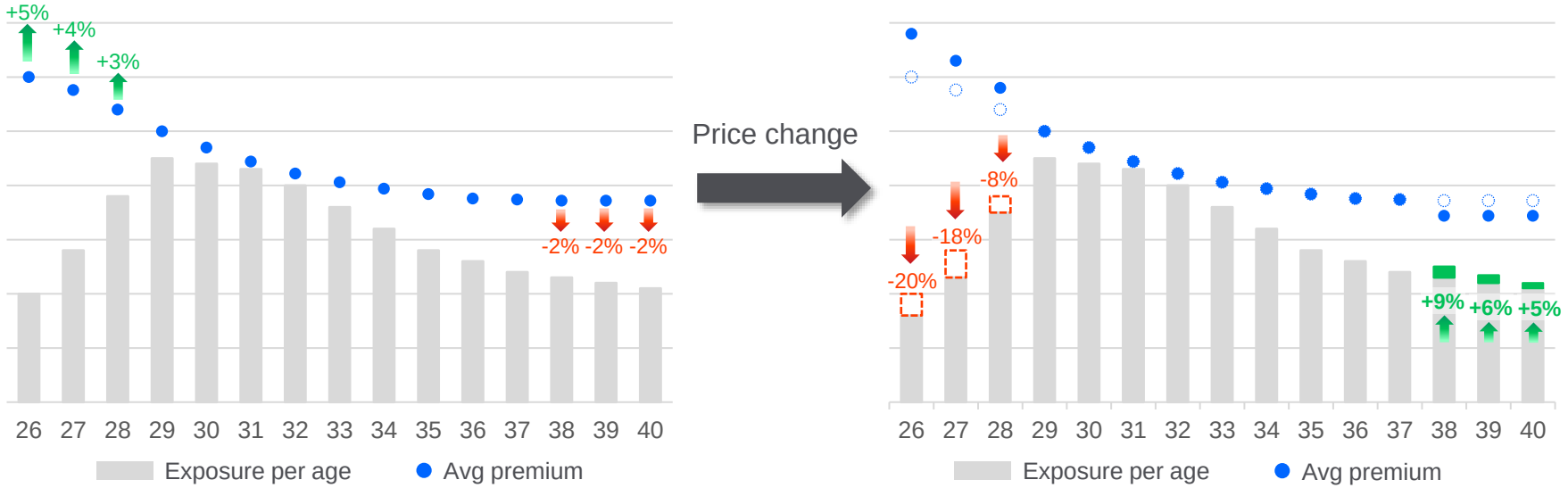
At a specific price point…

… what features influence customer demand, and what are their effects?

…what is the impact of price on customer demand? …how responsive are customers to price changes?

Demand Models

Quantifying price impact on segment volumes is crucial for managing insurance portfolios effectively



Demand modelling for scenario testing

Price changes have asymmetric effects on the customer mix

Demand-sensitive analyses enhance the accuracy of scenario testing

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Age group	Avg premium		Technical premium	Premium change	Avg margin		Renewal offer count	Retention rate	
	Current	Proposed			Current	Proposed		Current	Proposed
18-25	950	1,025	950	8%	0	75	10,000	80%	80%
26-35	700	650	550	-7%	150	100	10,000	80%	80%
36-45	500	450	350	-10%	150	100	10,000	80%	80%
46-65	650	700	550	8%	100	150	10,000	80%	80%
65+	800	850	750	6%	50	100	10,000	80%	80%

Demand Model

Retention rate	
Current	Proposed
80%	60%
80%	90%
80%	85%
80%	75%
80%	75%

Illustrative Figures

Price-Only Analysis

	Current	Proposed	Change
Retention rate	80%	80%	0%
Expected written premium	€ 28.8m	€ 29.4m	2%
Expected margin	€ 3.6m	€ 4.2m	17%

Demand-Sensitive Analysis

	Current	Proposed	Change
Retention rate	80%	77%	-4%
Expected written premium	€ 28.8m	€ 27.5m	-5%
Expected margin	€ 3.6m	€ 4.1m	13%

Demand models serve as the guiding compass in the price optimisation process

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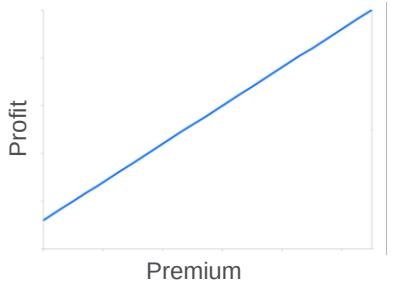
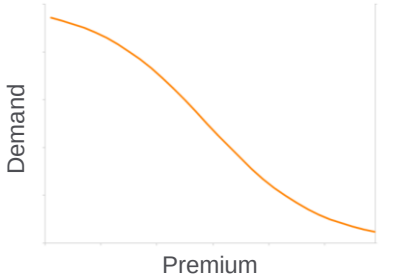
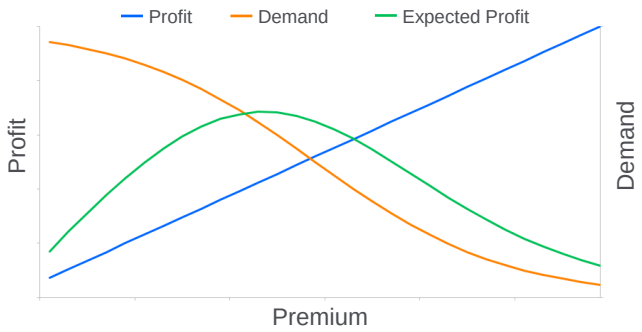
Risk Models



Demand Models



Price Optimisation



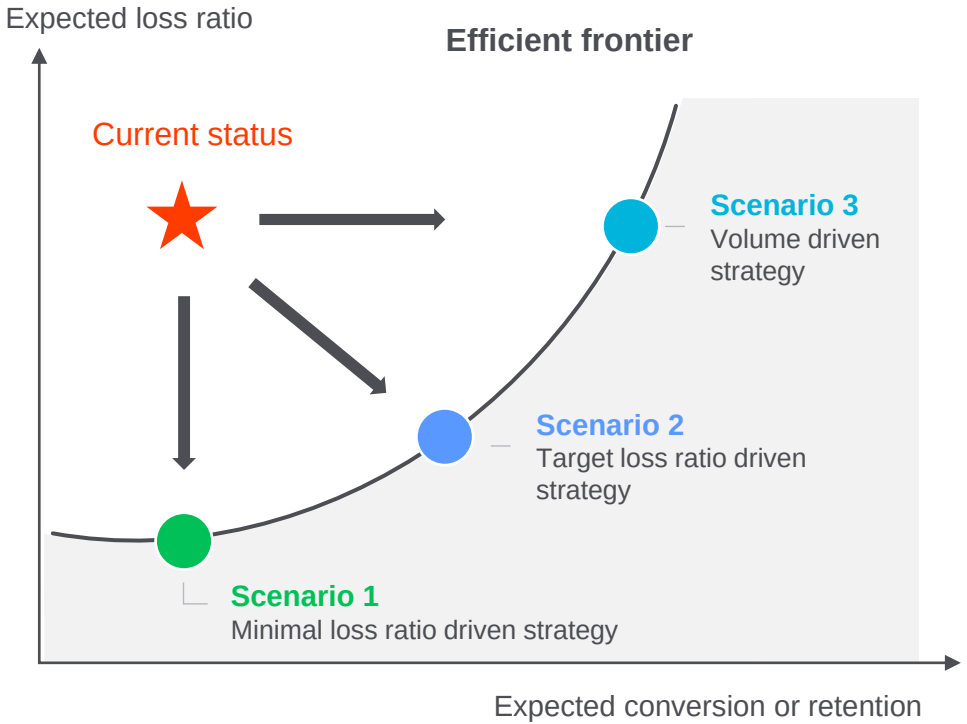
Price optimisation at the individual policy level based on cost and demand

Impacts

Determine the optimal price to meet business objectives for each policy

- Profit: Enhance bottom-line growth
- GWP: Drive top-line growth
- Volume: improve conversion and retention rates

Price optimisation drives strategic pricing decisions to maximise efficiency and achieve business objectives



- The optimal pricing positions are constantly changing due to:

Customer demand | **Market prices**

Macroeconomic indicators | **Regulations**

- Insurers need to capture and adapt to these changes, steering their portfolios proactively.

- Frequent updates on demand models are necessary to maintain accurate projections.

3 Data gathering

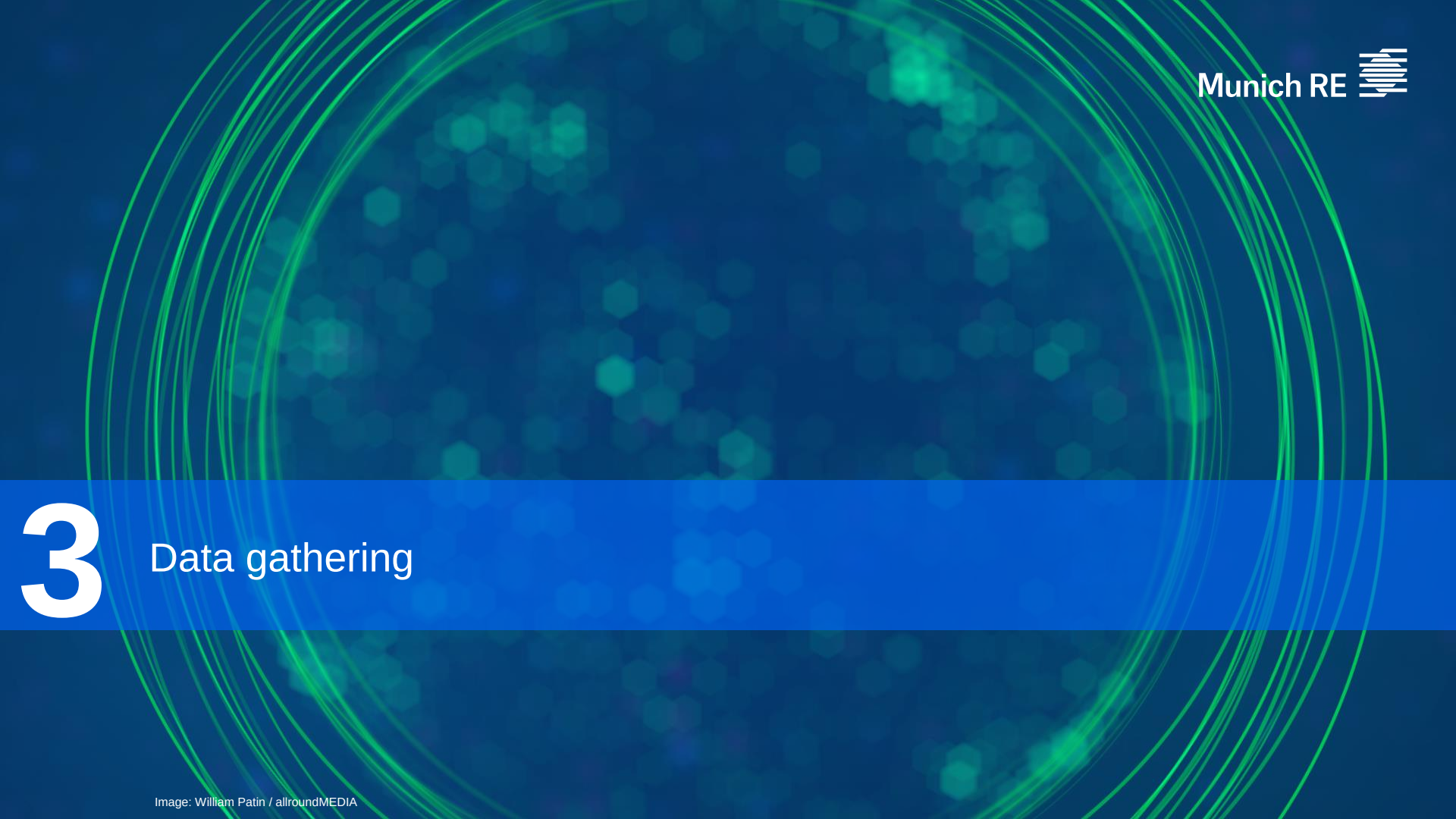


Image: William Patin / allroundMEDIA

Demand models are trained on new business and renewal offers structured similarly to policy databases

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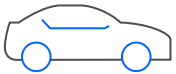
Customer

- Driver Age
- License age
- Marital Status
- Occupation
- Previous Company
- Tenure
- …



Vehicle

- Make
- Model
- Vehicle's age
- Horse Powers
- Fuel type
- Sum insured
- …

Claim's History

- Number of claims in the last "n" years
- Total claim amount in the last "n" years
- Bonus Malus
- NCD
- …

Territorial / Economical

- Zip-Code / Postal Code
- Region
- Geo-demographical info
- Payment Method
- Instalment
- Credit Score
- …

Quote ID	Driver Age	Vehicle Make	Payment Type	Price	…	Purchased?	Predicted Rate
12345	35	BMW	Monthly	750	…	**0**	0.05
12346	22	Audi	Yearly	1250	…	**1**	0.10
12347	55	Jaguar	Yearly	1000	…	**0**	0.02
…	…	…	…	…	…	…	

Additional Info

- Actual premium (previous year)
- Offered premium
- Commercial premium
- Risk premium
- Discount amount
- Competitive market analysis
- Premium variation (between price test groups) (%)
- Other policies (e.g. house, health)
- Change of product
- Type of cover
- Number of endorsements (risk changes)
- Distribution channel
- …

Data gathering with randomised price tests allows insurers to observe changes in demand resulting from price variations

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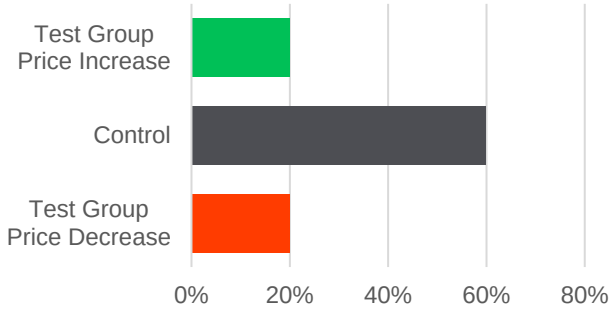
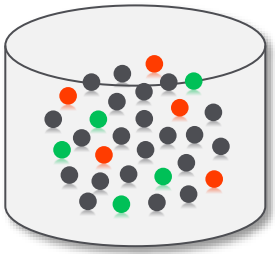
Experiment design

- **Randomly** assign parts of the portfolio to a higher / lower price
- Then use this information as a predictor variable in the model

Randomised price test groups





Quote Data /
Renewal Offer Data

Considerations

- Deliberately mispricing generates a “cost”
- A trade-off must be found between these costs, the size of the test groups, and the duration of the test
- Reputational and legal aspects must be considered as well

When randomised price test isn't feasible, a short-term price change is applied to capture price-demand relationship

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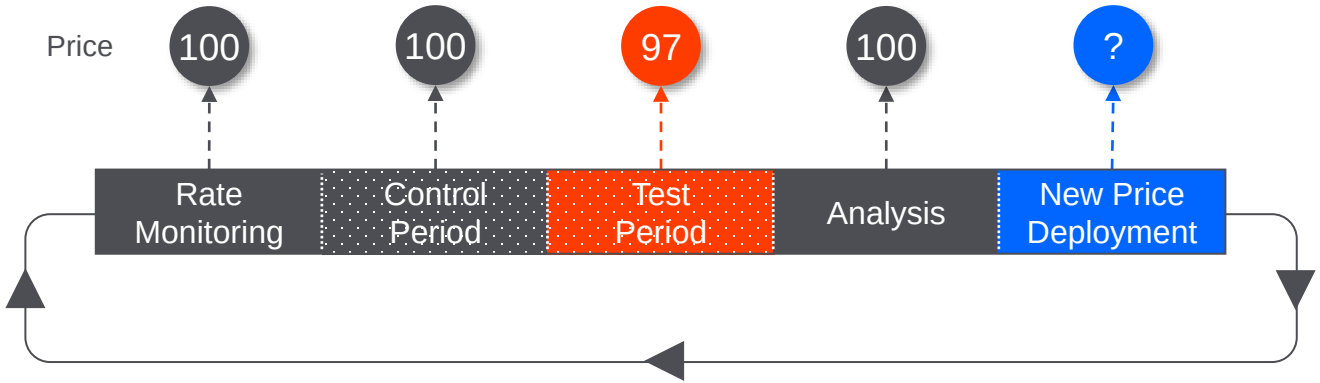
Experiment design

- Use a control date period instead of a randomly selected control group
- Apply a price shock to all quotes during the test period
- Assume no significant change in external factors that could affect customer demand during the experiment period



4 Critical elements in demand model development

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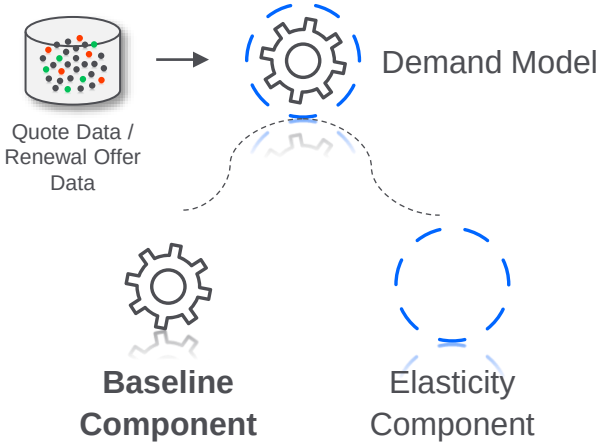
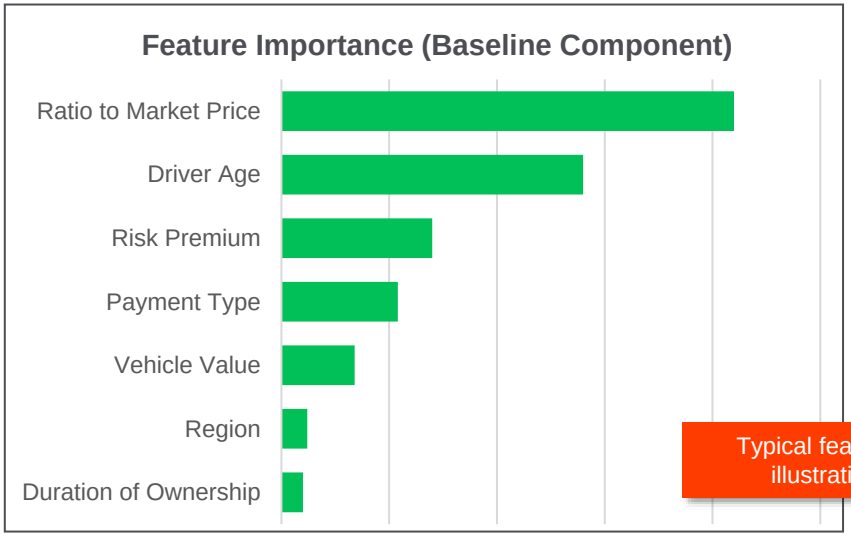
Baseline component of the demand model provides foundation for understanding demand patterns



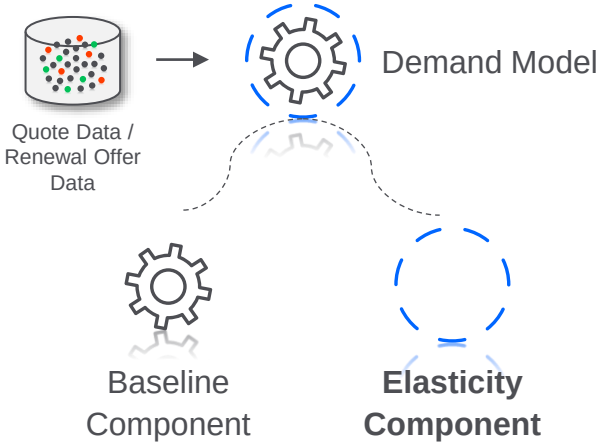
model = glm(data, family = binomial,

response ~ Feat.1 + … + Feat.N)

- Starting point of demand model development
- Aims to establish baseline level of demand by focusing on features unrelated to price variations
- Statistical success is predominantly achieved here



Elasticity component estimates the effect of price variations and segments price elasticity

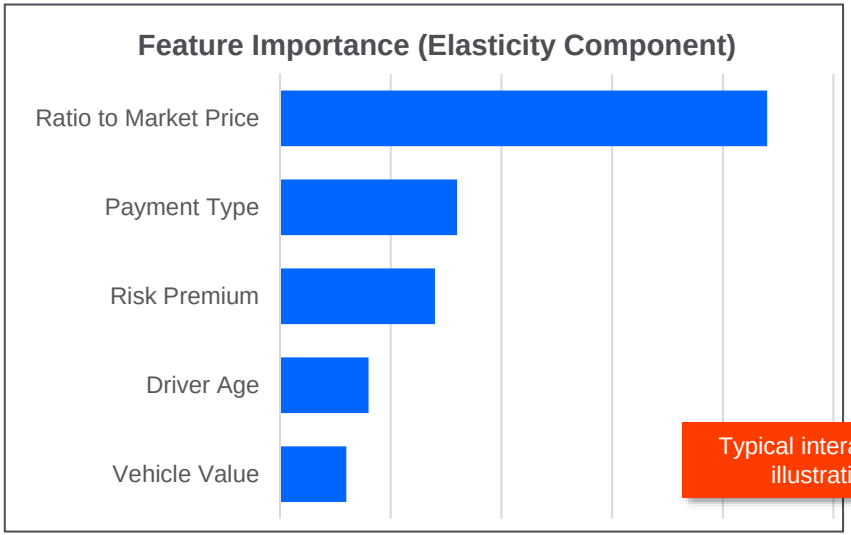


model = glm(data, family = binomial,

response ~ Feat.1 + … + Feat. N + Price.Var +

Feat.1*Price.Var + … + Feat.K*Price.Var)

- Price variation features integrated into the model
- Interactions between the baseline component and price variation features are tested to align predicted elasticity with observed elasticity



Price.Var: Feature represents price variations

Price variation range must be aligned with price change limits to ensure accuracy of elasticity component

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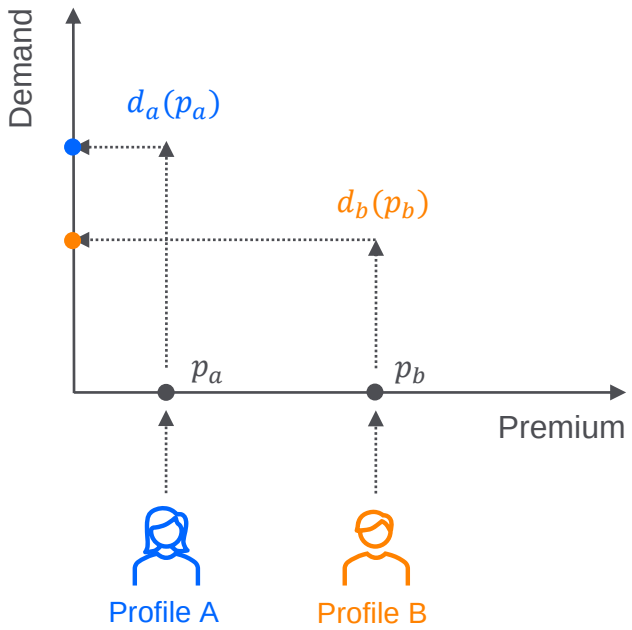
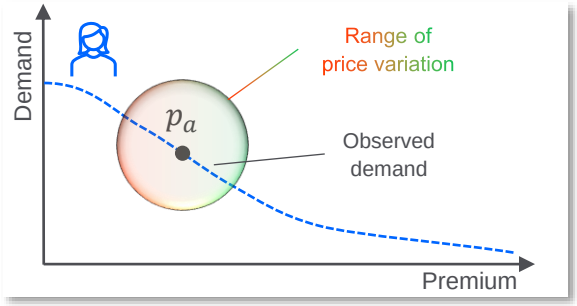
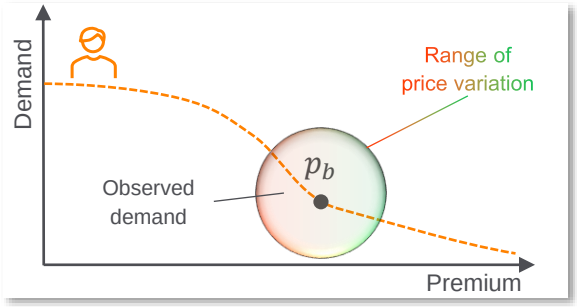
Outputs from the **baseline** component



Outputs from the **elasticity** component





The accuracy of predicted demand decreases as the magnitude of the price change exceeds the range of the tested price variations.

However, if the range of tested price variations is set too wide, the model cannot accurately estimate changes in demand in response to small price changes.

When modelling is done with GLMs, the interpretation of the model is straightforward and transparent

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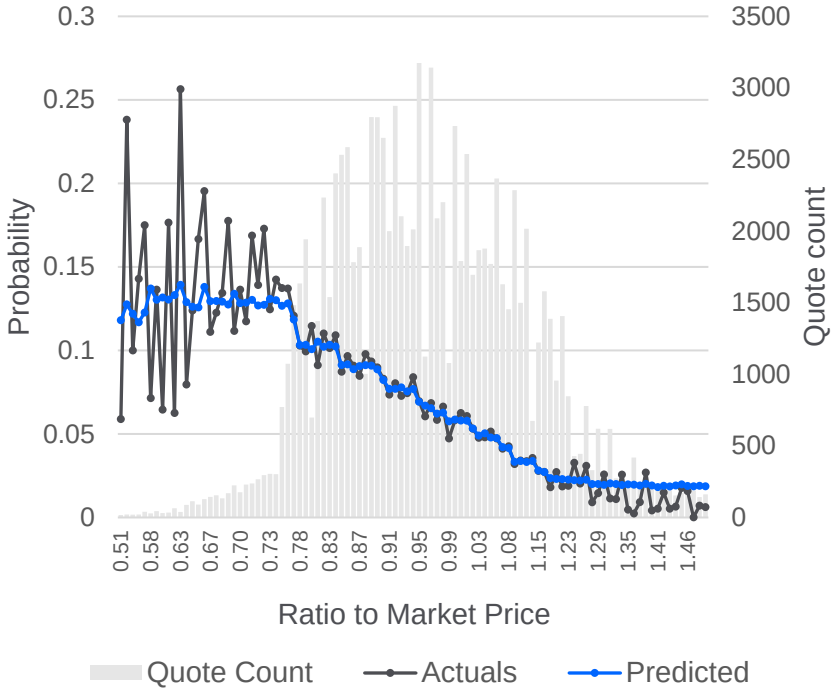
Illustrative Figures

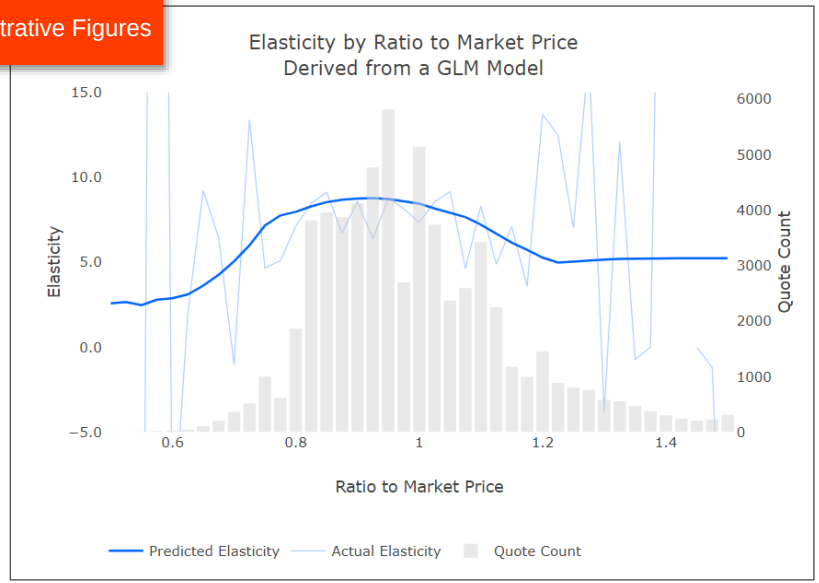
Coefficients

Actual vs Predicted



Visual comparisons between actual and predicted elasticity guides the construction of the elasticity component

Illustrative Figures



Elasticity Intensity

Too cheap — Too expensive

- Within each interaction term included in the elasticity component of a demand model, price elasticity varies.
- One of the most important features explaining demand and price elasticity is the relative position of our product in the market in terms of price.
- This relative position is generally defined by the ratio between the price of our product and the average market price.
- Customers show higher price elasticity when our prices are close to market average.
- Price elasticity decreases in segments where our prices are either too low or too high relative to the market, as small price changes do not significantly change our competitive position.

Tree-based demand models improve accuracy but produce less smooth and plausible elasticity curves

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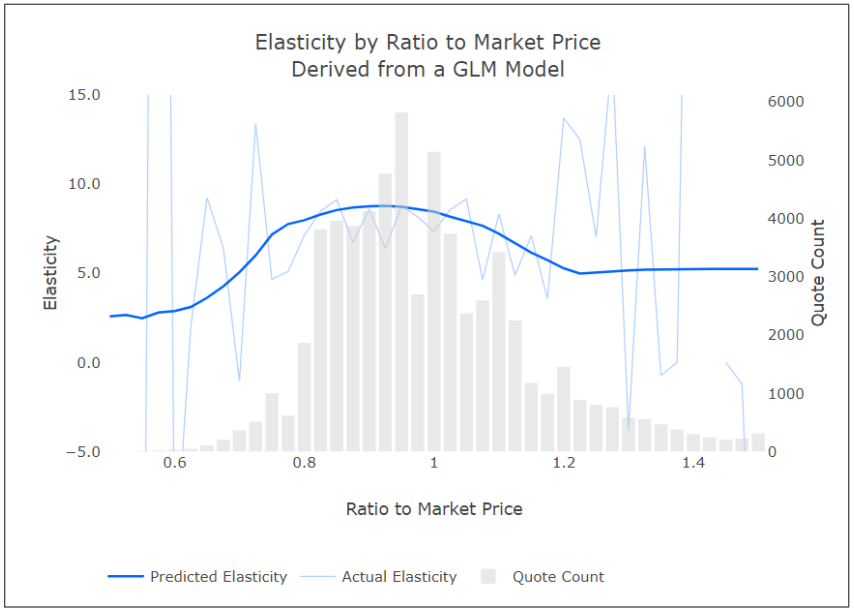
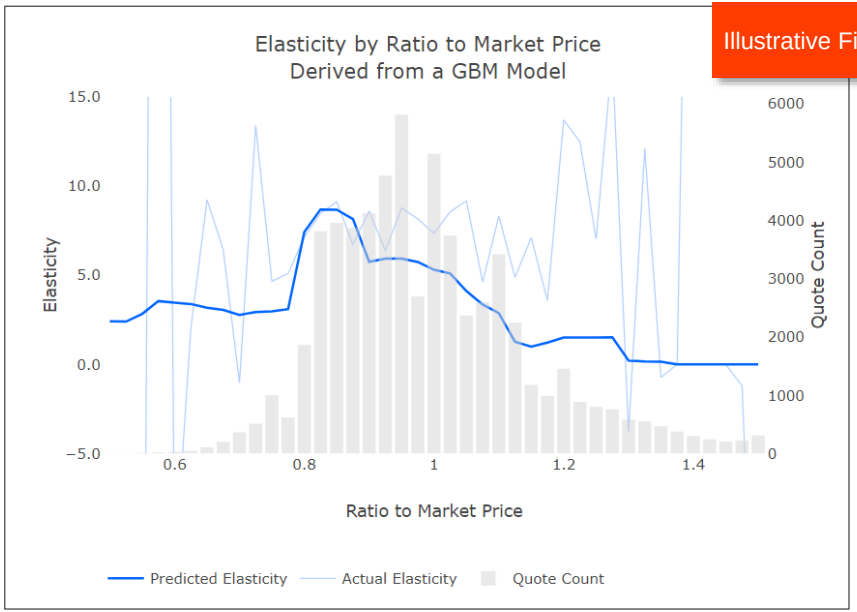
Illustrative Figures





- It is more difficult to control the smoothness of the elasticity curves generated by demand models built using tree-based algorithm compared to those built using GLMs. Although modelers can prevent overfitting, weak learners capture a higher degree of interaction involving price variation features, resulting in jagged elasticity curves.

When direct measurement of elasticity is not feasible, it can be estimated through simulated pricing experiments

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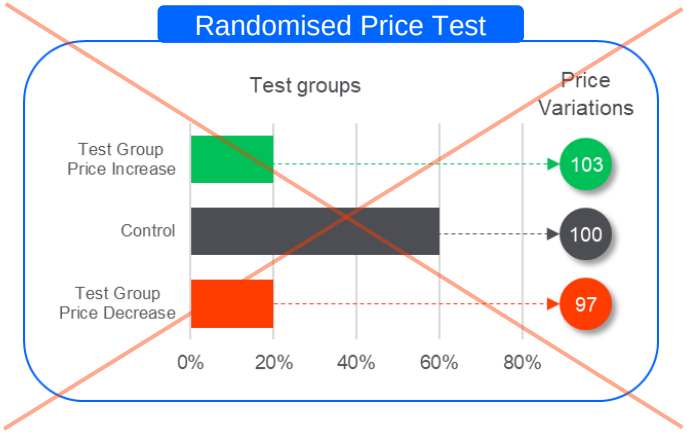

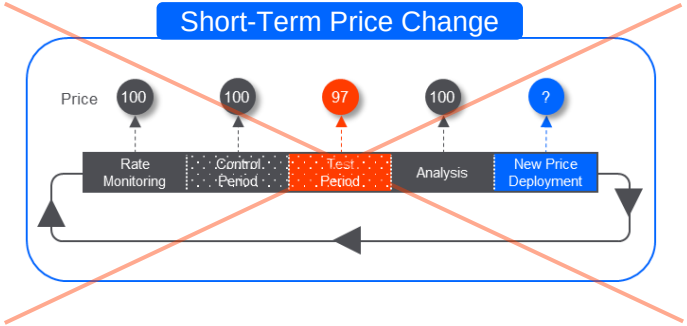

Quote Data / Renewal Offer Data

Demand model without elasticity component

- No observed price elasticity is available.
- A feature representing the final price charged to each customer (commercial price after all discounts) should be included in the model.
- After constructing the model, final price values will be shifted up and down, and predicted demand will be calculated by the demand model.
- Predicted elasticity can be calculated and visualised by comparing the change in demand with respect to changes in the final price, to validate the results.
- A variation of this method can be applied with a set of features representing different layers of prices charged to the customers.

Thank You

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