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Applied Multivariate Analysis 853
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Retail Demand & its Promotional Lift

Business Problem Statement:

The company is currently interested in determining the most optimal model for predicting retail demand of various promotional lift. The company has over 16,000 observations of past promotions which involves promotional discounts or temporary price reductions. Four alternative non-linear regression models are evaluated to determine the most accurate forecast of promotional lift using Excel's optimization tool, Solver. All four models will vary based on the promotional vehicle (**α**) and/or the discount price through the price elasticity (**PE**) parameters. The price elasticity and the alpha parameters will vary based on the estimation at either the global scale or at the division levels (ranging from 1-4).

Models Description + Strongest Model:

Model 1: $\hat{L}_i = \alpha \cdot e^{PE \cdot disc}$

Model 2: $\hat{L}_i = \alpha \cdot e^{PE_k \cdot disc}$

Model 3: $\hat{L}_i = \alpha_k \cdot e^{PE \cdot disc}$

Model 4: $\hat{L}_i = \alpha_k \cdot e^{PE_k \cdot disc}$

Model Description:

Model 1: Model 1 was developed utilizing alpha and price elasticity parameters at the global scale. Among all four models created, this is the most simple model, yet the weakest in terms of predicting the lift accurately. Training Error: **71.71M.** Validation Error: **42.46M.**

Model 2: Model 2 was estimated using alpha at the global level, yet estimating the price elasticity at the division levels. Model 2 is the runner up in terms of performance at predicting lift accurately. Training Error: **70.30M.** Validation Error: **40.58M**

Model 3: Model 3 was created similar to Model 2, but the estimate on division levels switched from price elasticity to alpha. Price elasticity is estimated at the global scale, while alpha is estimated at the division levels. Model 3 results aren't as strong as other model and has come in second to last among the four models. Training Error: **70.84M.** Validation Error: **41.31M**

Model 4: The last model developed was one that took into consideration of alpha and price elasticity at the division levels. With a total of 8 parameters, 4 for alpha and 4 for price elasticity, Model 4 is the strongest at accurately predicting the retail demand of promotional lift. Training Error: **69.61M** Validation Error: **40.37M**

Model	# of α	# of PEs	Training Error	Validation Error
1	1	1	$ 71,709,295.37	$ 42,463,184.54
2	1	4	$ 70,301,501.15	$ 40,582,933.44
3	4	1	$ 70,844,141.93	$ 41,306,146.62
4	4	4	$ 69,608,748.28	$ 40,373,547.52

Strongest Performing Model:

Out of the four models developed, Model 4 is the strongest in terms of predicting retail demand of promotional lifts. Therefore, the business should use Model 4 to forecast retail demand and its promotional lift. However, if the analysis requires more interpretability and less parameters, Model 2 is recommended, which only has 5 parameters versus Model 4, which has 8 parameters. For ease of interpretability and less parameters, Model 2 is also a strong model, with nearly similar validation error compared to Model 4. Depending on managerial requests, needs, and trade-offs, Model 2 and Model 4 are both adequate models for the business to utilize for future forecast of retail demands and promotional lifts.