PRO PROJECT

RETAIL PROMOTIONS PRICE OPTIMIZATION

EXECUTIVE SUMMARY

Team Rock was engaged to build a revenue management system focused on promotional price optimization for a major national Canadian food retailer. The goal was to analyze sales performance for potato chips products and identify opportunities to enhance category performance.

Team Rock chose to pursue a pricing strategy that would optimize margin for the top six products and performed a deep-dive analysis on the sales history. The R statistical computing language was used to build demand models that forecasted estimated numbers of units sold based on difference price levels and a profit function was developed to identify the prices that would likely yield the highest possible margin. Two types models were constructed with the first set being more aggressive and the second more conservative on optimizing margin.

Two simulations were then conduced for each product wherein the newly suggested prices were entered into a promotional calendar based on the last fifteen weeks of the dataset (July – October 2019) and the predicted performance numbers were compared to the actual results. The aggressive model predicted a **7%** gain in raw margin while the conservative one predated a **2%** gain. While the results were promising and within realistic revenue management expectations, there were several additional factors that would need to be considered before deploying the strategy.

CHALLENGE CONTEXT

The retail landscape has undergone tremendous change as companies continue to adapt to shifts in customer behavior and competitive threats that present significant disruption to traditional business models. Slowing top-line growth in developed economies, specialty stores claiming market share from established players, industry consolidation, e-commerce and incursions by discounters have resulted in an incredibly fierce competitive environment where retailers who find themselves no longer offering a strong value proposition for their consumer base will lose. Those that seek out new opportunities and capitalize on these shifts can however win strong market positions and enable continued growth.

Promotions are one of the primary tools a retailer can employ to boost performance, and they often make up 10-45% of sales[1]. This has led to an over reliance on discounting which is problematic because it has outpaced sales growth and the actual effects of promos are often not well understood and are highly variable. In an ideal situation they would boost sales while still yielding acceptable margin levels but the reality is that they often generate no discernible sales lift at all and simply dilute margins. In the worst case they actually lose money since the resulting sales and margin do not cover the costs of running the promo in the first place.

These problems arise because many retailers lack the ability to effectively gauge promotion effectiveness. Plans are often created in separate silos with little coordination across the company meaning that there is little though put into how a promo will impact other categories.

[1] https://www.bcg.com/en-ca/industries/retail/improving-promotional-effectiveness.aspx

Plans are often recycled from previous years with the main metric of performance being year over year sales so promos are continually re-run even if they are not optimal. Additionally, suppliers will offer incentives to push their brand which often influences how promos are planned. The problem is that suppliers are only motivated to increase sales volume of their own products which could dilute the category as a whole for the retailers.

Retailers are also often unable to ascertain clear insights into which types of promotion mechanics are the most effective. Not knowing if flyer positions, loyalty offers or store placement is optimal hampers the ability to systematically improve over time and makes coordinating around a company's larger strategic objectives very difficult which results in costly lost opportunities.

By leveraging the vast amount of data that traditional retailers generate, it is possible to significantly improve promotional effectiveness by employing a revenue management plan based around price optimization using advanced data analytics methodologies. By focusing on pricing and eliminating or modifying existing promotions, companies can potentially see margin gains as high as 2-8%[2].

For this reason, Team Rock was engaged to construct a pricing strategy for a major Canadian food retailer that would focus on realizing untapped margin potential in the potato chips product category.

DATA EXPLORATION

The dataset was obtained from a data warehouse that contains point of sale transactional data. It includes two years of sales history for aggregated by week for a single Ontario region grocery banner which consists of 92 stores. It contains 316 products from the potato chips sub-category representing $38M in sales.

Team Rock opted to select the top 6 products for optimization which represented 24% of total sales. This enabled the team to focus on the items that would have the highest impact while refining the overall scope of the engagement.

The following table summarizes the key metrics for the top 6 articles:

Top Line Metrics

Description	Units	Sales	TPR %	Margin %	Min. Price	Max. Price	Elasticity
Lays Classic	697K	$2.0M	78.2%	10.2%	$1.99	$3.79	1.8
Ruffles Regular	501K	$1.5M	64.0%	11.8%	$2.02	$3.69	1.6
MissVick Sea Salt /Vinegar	405K	$1.4M	62.1%	13.0%	$2.89	$4.29	1.8
Lays Wavy Original	483K	$1.4M	80.2%	9.7%	$1.99	$3.79	2.1
Ruffles All Dressed	438K	$1.3M	63.7%	11.7%	$2.03	$3.69	1.6
MissVick Original	361K	$1.3M	62.4%	13.0%	$2.89	$4.29	1.9

The products ranged in sales from $1.3M to $2.0M with margin percentages that hovered around 10-13%. Of particular interest was the temporary price reduction (TPR) percentage which indicated that 62-78% of total sales came from when the products were on promotion. This is very high and showed that promotions are very important for these articles.

[2] https://www.bcg.com/en-ca/publications/2015/retail-pricing-how-retailers-can-improve-promotion-effectiveness.aspx

This was also reflected when examining prices and elasticities. The maximum is the regular price of the article when not on sale while the minimum is the cheapest ever price. With the sale price being up to 50% off, it showed that the discounting for these products can be quite deep.

The price elasticities range from 1.6 to 2.1 meaning that all of the items are highly elastic and changes in price have a very significant impact on number of units sold. An elasticity of 1.8 for instance would indicate that a 10% reduction in price would increase units sold by 18%.

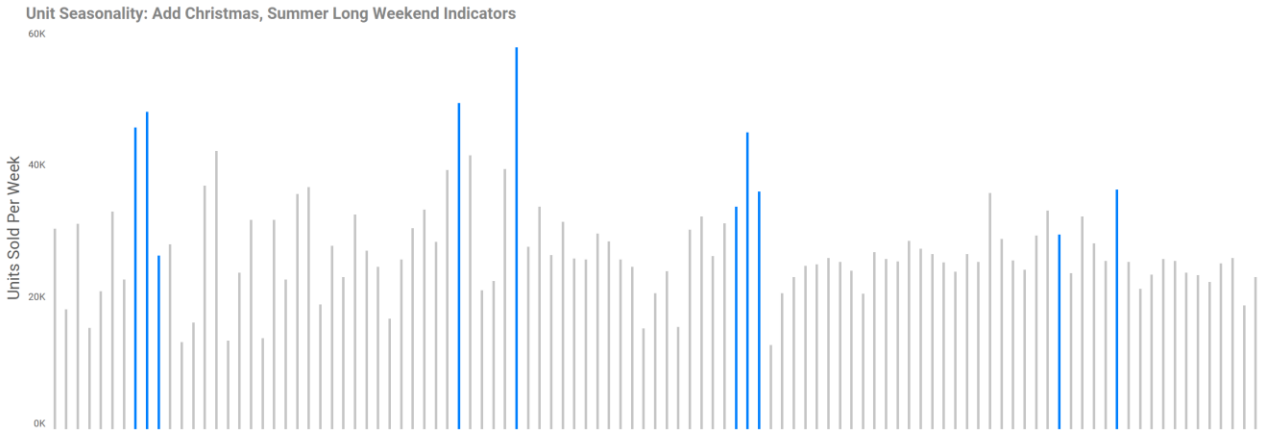
These metrics confirmed that these products are highly promotionally driven. They were frequently on sale and the price had a very large effect on units sold which made them very good candidates for a pricing optimization solution.

FEATURE ENGINEERING

Team Rock next examined the structure of the dataset to determine if it contained information that could be used to create new features that would enhance the accuracy of the demand models. It found that flyer position, seasonality and price index were relevant indicators.

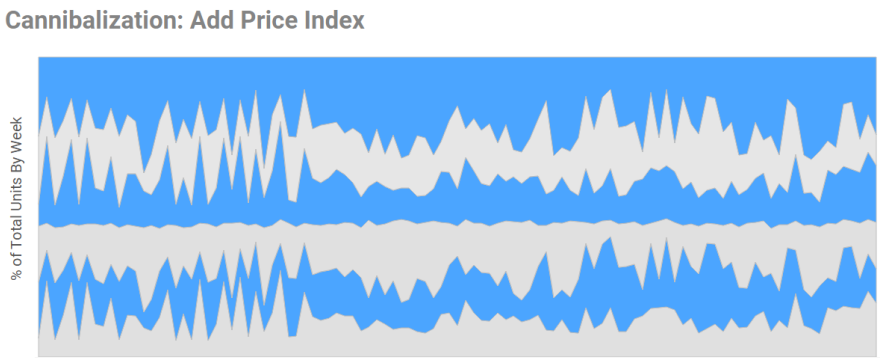
The initial raw data included a breakdown of sales based on when the items appeared on the front, back and inside pages of the flyer. This is an important factor in the grocery domain since appearing on the front and back page will generally boot the sales for a product. To account for this, an indicator column was created where the number 1 would flag when the item appeared on the front or back page of the flyer while a 0 would mean no flyer promotion.

Seasonality is also a major factor in the grocery industry which led Team Rock to carefully analyze the number of units sold per week which is shown in the below chart.



The number of units sold clearly spike up at certain points. These are highlighted in blue and coincide with the Christmas holiday season and summer long weekends which are important seasonal events where customers purchase more snack items including potato chips. An indicator column for holidays was added to the dataset to flag the weeks where units sold were unusually high due to holiday events. This feature had a very significant impact on demand model accuracy.

Cannibalization or product substitution due to promotions also appeared to be a factor in the data as shown in the below graph which displays the % of total sales for each product by week.



The large up and down spikes implied that the percentage share of a product varied noticeably week to week. When looking at the prices during those spikes it is clear that when one product was on sale and others were not, it climbed up in total share which supported the idea that customers would choose to opt for the cheaper product. Confirming this would have required building association rules and basket analyses which were outside the scope of the engagement so a price index was calculated to flag when a product was cheaper or more expensive than its counterparts within a given week. This would assist the demand model with identifying when more units were likely to be sold due to price that is cheaper than the rest of the set.

DEMAND MODEL

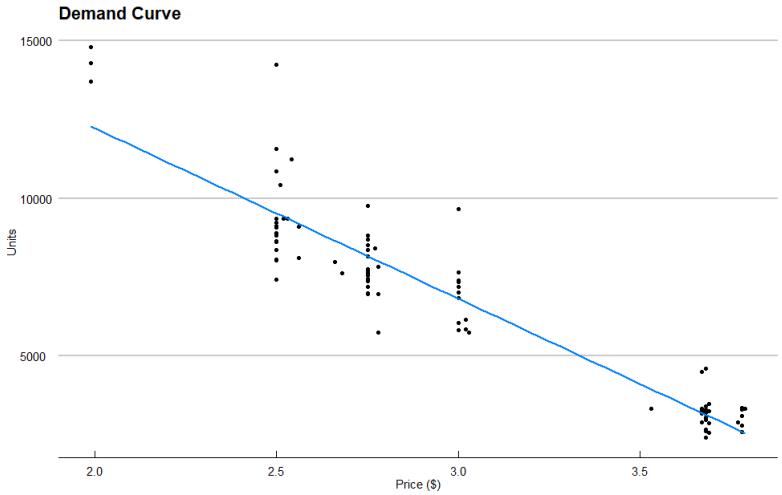
In order to estimate the unit demand levels at different price points for each product, Team Rock used basic linear regression in R. This approach was relatively straight forward but ensured a clear framework that was flexible with easily interpretable results.

The linear models were built using the first 90 weeks of the dataset with the last 15 being withheld for validation. The formula and summary for the largest product by sales (Lays Classic) is shown below.

```
Call:
lm(formula = units ~ price + is_holiday, data = .)

Residuals:
     Min       1Q   Median       3Q      Max
-1933.83  -491.33   -41.11   357.99  2645.59

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  21830.3      488.3  44.711  < 2e-16 ***
price        -5092.2      157.0 -32.445  < 2e-16 ***
is_holiday    2514.8      276.2   9.105 2.74e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 765.4 on 87 degrees of freedom
Multiple R-squared:  0.939,     Adjusted R-squared:  0.9376
F-statistic: 669.9 on 2 and 87 DF,  p-value: < 2.2e-16
```

With a 0.93 R-squared value, the regression model fit very well with the dataset meaning that price and seasonality were both very strong predictors for number of units sold. The front/back flyer page indicator and price index features were removed from the formula as they ended up having very little significance and the model was already very strong without them.

Plotting the model reveals the above linear relationship between units sold and price. The steep slope reflects the high elasticity discussed in the exploratory analysis and confirms that demand shifts immensely at different price levels.



The results for each product's demand model when evaluated against the 15-week holdout sets are outlined below. In all cases the model performance was very strong which indicated that regression would generate reasonable estimates for demand at different prices.

Product	R2	MAPE	MSE	RMSE	MAE	AVG
Lays Classic	0.91	0.19	897993	947	837	6375
Ruffles Regular	0.73	0.14	671607	819	587	3701
MissVick Sea Salt/Vinegar	0.91	0.14	206952	454	358	3733
Lays Wavy Original	0.87	0.21	647300	804	678	4068
Ruffles All Dressed	0.78	0.11	376582	613	415	3519
MissVick Original	0.93	0.2	277432	526	449	3519

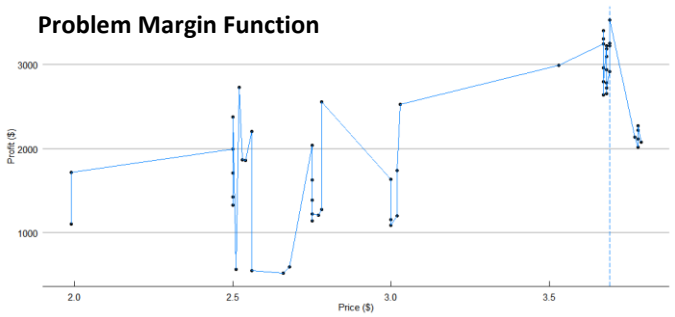
COST MODEL

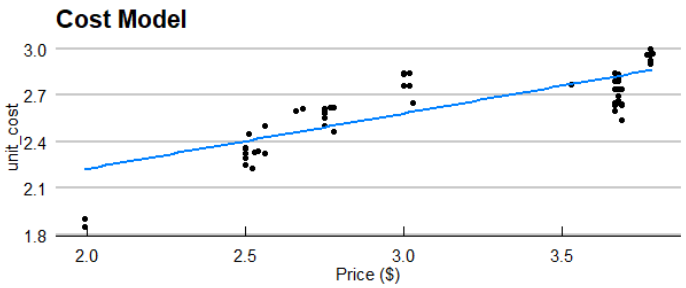
Calculating the optimal margin based on the predicted number of units sold at each price was accomplished using the basic formula margin = units * (price – cost). Finding the max value of the resulting set identifies the optimal price point.

The issue with this approach was that the unit cost in this product category is not static and fluctuates based on factors such as supplier funding and retailer subsidy. This meant that there were times when a certain price point was very profitable but it only occurred one time which made estimating the optimal price very problematic.

In order to find the optimal price, a more stable unit cost had to be identified. The average could not be used as it would have resulted in weeks with negative margin which never occurred in the actual data. The different cost values did follow a linear distribution so the solution used was to create a second set of regression models to predict unit cost. The differing unit costs, problem optimal margin and cost model for Lays Classic is shown in the below charts.

price	unit cost
1.99	1.85 1.9
2.5	2.25 2.29 2.32 2.35 2.36
2.51	2.45
2.52	2.23 2.47
2.53	2.33 2.46
2.54	2.34
2.56	2.32 2.5
2.66	2.6
2.68	2.61
2.75	2.5 2.55 2.58 2.6 2.61 2.65
2.77	2.62
2.78	2.46 2.62
3	2.69 2.75 2.76 2.83 2.84
3.02	2.76 2.84
3.03	2.65
3.53	2.77
3.67	2.6 2.63 2.65 2.74 2.79 2.84
3.68	2.65 2.66 2.69 2.74 2.79 2.81 2.83
3.69	2.54 2.63 2.64 2.74
3.77	2.96 2.97
3.78	2.9 2.92 2.96 3
3.79	2.92 2.97

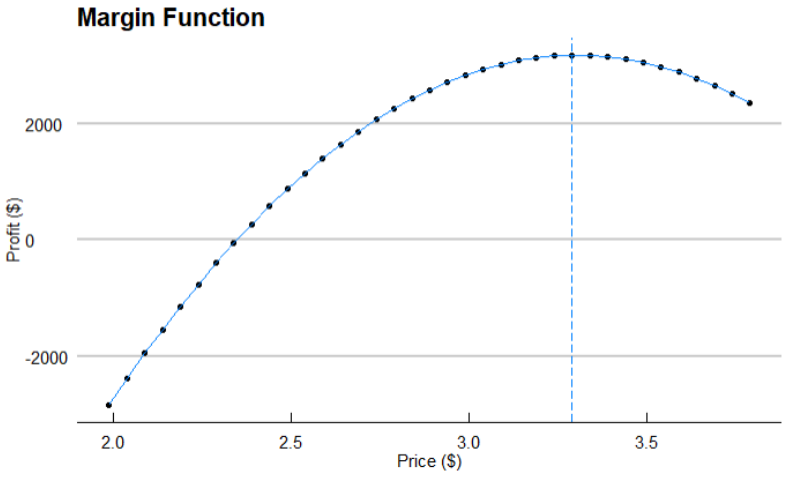




MARGIN FUNCTION

With the combined demand and cost models in hand, Team Rock was able to estimate margin for many additional prices and likely unit costs that never occurred in the actual data. As the engagement was focused on promotional optimization, only prices the fell between the minimum and maximum in five cent increments were simulated for each product with the end goal being to find the best promotion price only.

The initial margin function suggested optimal prices that were not much lower than the max price. As this would have meant far less overall discounting it would be a very dramatic change from the actual plan that may be difficult for the retailer to accept. To account for this a second set of more conservative price simulations were run wherein the maximum possible price could only be 80% of that actual max. This ensured that a lower optimal price would be selected and result in discounting levels that were more on par with the retailer's actual strategy. The price simulations and optimal margin functions are summarized in the below chart and table.



MODEL 1

Product	MIN Price	MAX Price	OPTIMAL Price	Margin
Lays Classic	1.99	3.79	3.29	3175
Ruffles Regular	2.02	3.69	3.42	2405
MissVick Sea Salt/Vineg	2.89	4.29	3.89	2336
Lays Wavy Original	1.99	3.79	3.24	2150
Ruffles All Dressed	2.03	3.69	3.43	2086
MissVick Original	2.89	4.29	3.89	2049

MODEL 2 (Max price * 0.8)

Product	MIN Price	MAX Price	OPTIMAL Price	Margin
Lays Classic	1.99	3.03	2.99	2834
Ruffles Regular	2.02	2.95	2.92	1862
MissVick Sea Salt/Vineg	2.89	3.43	3.39	1719
Lays Wavy Original	1.99	3.03	2.99	1958
Ruffles All Dressed	2.03	2.95	2.93	1620
MissVick Original	2.89	3.43	3.39	1528

15 WEEK PLAN SIMULATION

After the estimated optimal price points were derived from each model, they were used to simulate a promotional plan based on the last fifteen weeks of the dataset for each product. The approach involved following the same promotional calendar that was used in the actual plan and inserting the new optimal prices only into weeks that were on promo. The regular price weeks kept the same values.

By only changing the promotional prices, the plan remained similar to what was actually used in the real world which allowed for a more controlled method of testing promo prices specifically. This ensured the performance comparisons would result in benchmarks that would not deviate drastically from the actual plan and would be within reasonable client expectations.

The plans for Lays Classic and Miss Vick Sea Salt are shown below. The weeks that ran a promotion where the new optimal prices were substituted in are highlighted in gray.

Promotional Calendar - Lays Classic

	Model 1			Model 2			Actual		
	Price	Units	Margin	Price	Units	Margin	Price	Units	Margin
2020-012	$3.29	5,077	3,097	$2.99	6,604	2,708	$3.00	7,788	1,245
2020-013	$3.29	5,077	3,097	$2.99	6,604	2,708	$3.00	6,714	1,653
2020-014	$3.29	7,592	4,631	$2.99	9,119	3,739	$2.52	11,821	631
2020-015	$3.78	2,582	2,091	$3.78	2,582	2,091	$3.78	3,569	2,798
2020-016	$3.78	2,582	2,091	$3.78	2,582	2,091	$3.77	3,603	2,896
2020-017	$3.29	5,077	3,097	$2.99	6,604	2,708	$3.00	7,649	2,391
2020-018	$3.29	5,077	3,097	$2.99	6,604	2,708	$2.68	8,828	650
2020-019	$3.29	5,077	3,097	$2.99	6,604	2,708	$2.53	8,050	560
2020-020	$3.29	5,077	3,097	$2.99	6,604	2,708	$3.00	6,643	1,062
2020-021	$3.29	5,077	3,097	$2.99	6,604	2,708	$3.00	7,035	1,133
2020-022	$3.78	2,582	2,091	$3.78	2,582	2,091	$3.78	3,486	2,724
2020-023	$3.78	2,582	2,091	$3.78	2,582	2,091	$3.79	3,740	3,249
2020-024	$3.29	5,077	3,097	$2.99	6,604	2,708	$2.75	7,123	722
2020-025	$3.78	2,582	2,091	$3.78	2,582	2,091	$3.78	3,607	3,086
2020-026	$3.29	5,077	3,097	$2.99	6,604	2,708	$2.75	5,977	602

Promotional Calendar - MissVick Sea Salt/Vinegar

	Model 1			Model 2			Actual		
	Price	Units	Margin	Price	Units	Margin	Price	Units	Margin
2020-012	$3.89	3,097	2,323	$3.39	4,632	1,667	$3.54	4,554	1,978
2020-013	$4.29	1,869	1,832	$4.29	1,869	1,832	$4.29	2,529	2,516
2020-014	$3.89	3,654	2,741	$3.39	5,189	1,868	$3.50	4,953	2,033
2020-015	$4.29	1,869	1,832	$4.29	1,869	1,832	$4.29	2,680	2,646
2020-016	$3.89	3,097	2,323	$3.39	4,632	1,667	$3.50	4,733	1,941
2020-017	$4.29	1,869	1,832	$4.29	1,869	1,832	$4.29	2,550	2,366
2020-018	$4.29	1,869	1,832	$4.29	1,869	1,832	$4.29	2,728	2,535
2020-019	$4.29	1,869	1,832	$4.29	1,869	1,832	$4.29	2,106	2,070
2020-020	$3.89	3,097	2,323	$3.39	4,632	1,667	$3.50	4,194	1,720
2020-021	$3.89	3,097	2,323	$3.39	4,632	1,667	$3.50	3,818	1,571
2020-022	$3.89	3,097	2,323	$3.39	4,632	1,667	$3.50	3,916	1,613
2020-023	$3.89	3,097	2,323	$3.39	4,632	1,667	$3.50	4,309	1,780
2020-024	$3.89	3,097	2,323	$3.39	4,632	1,667	$3.50	4,415	1,820
2020-025	$3.89	3,097	2,323	$3.39	4,632	1,667	$3.50	4,199	1,722
2020-026	$3.89	3,097	2,323	$3.39	4,632	1,667	$3.50	4,321	1,788

SIMULATION RESULTS

The results of the simulated promotional plans showed that with the full 6 product plans combined, model 1 (minimal discounting) estimated a 7% raw margin gain ($43,462) while model 2 (higher discounting) saw a 2% increase ($18,372). The full performance is outlined in the below table.

Plan Performance	Sales	Units	Margin	Margin %	Difference
Actual	1,229,988	373,775	143,812	11.7%	► 0%
Model 1	1,019,480	283,562	187,274	18.4%	▲ 7%
Model 2	1,181,307	360,518	162,184	13.7%	▲ 2%

Plan Gains	Model 1	Model 2
Margin	▲ **23%**	▲ **11%**
Units	▼ 32%	▼ 4%
Sales	▼ 20%	▼ 4%

The results were very promising and in line with the 2-7% margin gains that could realistically be expected when employing a revenue management system.

While the $18K margin increase estimated by model 2 may not seem very impactful to a multi-billion-dollar company, if this strategy was used for a full 52-week plan and rolled out to the full 1200+ stores there would be an estimated margin gain of **$624K** (**$1.5M** with model 1). These are highly variable numbers but they show the incredible potential that price optimization can achieve in boosting company profitability.

RESULTS INTERPRETATION

The primary insight that the retailer can learn from this simulation is that there is a very strong likelihood that the 6 tested products are **over-discounted**. The increase in unit sales does not justify the reduction in margin so a higher promo price point should be selected to maximize margin.

Looking at the broader overall business implications does however introduce several additional caveats.

By simply discounting less, or in effect raising prices, margin will go up but in the case of model 1 units went down by 32% and total sales decreased by 20% (model 2 down 4% in both). Since market share is measured primarily in sales and unit volumes, these decreases would be concerning to management, analysts and shareholders who would see ceding market share for margin as a short-term strategy.

Eventually customers will change their price perception as they notice lower prices at competitors and change their shopping habits. Losing the loyalty and trips of these customers would be detrimental over the long term.

Linked to this is the idea of trip driver / basket builder items. For certain products that a retailer believes will bring customers into the store, it is acceptable to offer deep discounts and lose margin that would be made up for through ancillary item purchases. Potato chips falls into this category, so a full basket analysis that identifies product associations would need to be conducted to determine if lower potato chip prices boost overall margin though an increase in purchases of other items. This would be a necessary step to determine the true viability of the plans simulated by Team Rock.

The final piece is that there are many additional factors that need to be considered when assessing promotion performance. Supplier funding, retailer subsidy, stock ups, marketing, supply chain, store costs and competitor activity would all need to be accounted for which would require added data fields, advanced algorithms and more complex profit calculations.

CONCLUSION

Team Rock was engaged by a major national Canadian grocery retailer to investigate opportunities to improve performance in the potato chips product category. A revenue management strategy aimed at boosting margin for the top six products through price optimization was selected.

Demand models were developed to predict the number of units sold based on price and seasonality. Due to the variable unit costs, a second set of cost models were constructed. This allowed likely unit costs to be identified for a wide range of price points that occurred between the min and max prices. From this, a margin function identified the optimal price point for each product.

These prices were entered into a simulated plan based on the last fifteen weeks in the data set and compared to the actual performance. The more aggressive model estimated a 7% gain in raw margin ($43K) while the more conservative model estimated a 2% gain ($18K). These numbers ramp up considerably when estimated for a full 52-week calendar and national store rollout.

Team Rock's revenue management strategy showed very promising results that could significantly improve margin performance for the selected set of products. Before this strategy can be deployed however, Team Rock would need to conduct a full basket level analysis to determine if the decrease in number of units sold due to higher optimal prices would cause drops in the sales of associated products which may hurt broader store performance.

At a minimum, the retailer should strongly consider going with higher overall promotional prices as their current plan appears to include unnecessary levels of discounting that dilute margins. By utilizing advanced analytics to inform a price optimization strategy, the retailer can prevent unnecessary undercutting of its own performance.