A Statistical Approach to Quantify Promotion Corrected Measure of Item Loyalty

Diptarka Saha[*]

[*] WalmartLabs, Bengaluru

Abstract - Customers' loyalty towards an item is an indispensable component of the item's performance, yet this is an unobservable quantity and may be studied from many angles, as have been done by various authors. Another major goal of any item performance metric would be to eliminate the effects of promotion while calculating loyalty. This study provides a general framework for calculating item loyalty as a function of the exponentially weighted average of the customers' purchases along with penalties and rewards that reflect the effect of promotion. The methods developed have been applied on Walmart's panel data to generate meaningful and robust promotion corrected loyalty values for several products.

Index Terms*- Item Loyalty, Promotion Corrected Loyalty, Panel data, Walmart Canada*

I. INTRODUCTION

As a core objective of marketing activities, maintaining and enhancing brand loyalty have been widely acknowledged [1]. The value of brand loyalty is self-evident for a company [2]. To have consumers that are loyal towards your brand is something that every brand prioritizes, since those customers are a great source of possible revenue in the form of lesser price elasticity, word of mouth promotion etc. [3].

As a result, few topics have captured as much attention among practitioners and academics alike as brand loyalty. Despite the abundance of the studies performed, no universal model for measuring customer loyalty has been accepted [4]. Heuristically, the word loyalty is used to describe the customer's tendency to repurchase the same brand [5]. A *conceptual definition* provided by Jacoby and Kyner [6]. The definition is expressed by a set of six necessary and collectively sufficient condition. These are that brand loyalty is

1. Biased or non-random
2. Behavioural response (i.e. from purchase)
3. Expressed over time
4. By some decision-making unit (e.g. households)
5. With respect to a set of alternatives
6. Function of some psychological process

In particular, any measure of brand loyalty should differentiate itself from market-share, there may be items, typically high-priced items that don't generate high volume of sales compared to other (typically low-priced) items, but have a customer base that is immensely loyal toward the brand due to some unique selling point of the brand. A so-called '*niche*' brand [7]. This study provides a definition of loyalty that is able to detect such items and thus provide important insights that is not apparent on the surface.

Another important question to keep in mind while measuring loyalty is what other factors can collude sales other than loyalty – one very common occurrence we see in real world data is that sales is driven by promotion; which to a casual eye may look like a result of customer's loyalty towards the item. One of the major goals of this study is to eliminate effects of promotion while calculating loyalty.

II. LITERATURE REVIEW

Majority of the *operational definitions* of loyalty maybe categorized into two major classes: behavioral or attitudinal, based on their emphasis on purchasing or cognitive component [8]. Both approaches have their respective strength and weaknesses. Behavioral loyalty focuses on actual purchases especially giving emphasis on repeat purchases and purchase volumes [9]. Since they are based on long-term purchase data, data for behavioural loyalty measures are easy to collect and are unlikely to be incidental. Biggest limitation of this approach is its unidimensional nature, especially the fact that the distinction between repeat purchases and loyalty is non-existent; as many authors have pointed out that a customers' inertia alone may result in her repeat purchases – that do not necessarily imply her unrivalled affection towards that product – the so called '*spurious loyalty*' [10]. In fact, nearly three quarters of customers purchases are based on their emotion and attitude [11].

On the other hand, attitudinal measures rely on stated preferences, attitudes, intentions; these measures are typically based on surveys. For example, Anselmsson [12] presents an interesting case study of how customers are willing to pay a price premium for their preferred brands. Although attitudinal loyalty measures do provide insights into customer mindsets that are not captured by purchase history they still suffer from a number of disadvantages. First and foremost, would be the availability of data, behavioral measures require point of sale data, which is easily available due to automatic capturing, however, attitudinal measures require ground surveys – which can be time consuming, expensive in terms of money and human resources and overall hard to come by. Along with this, attitudinal measures may prove to be inaccurate as it depends on the mood of the person being surveyed when he's being surveyed; moreover, intentions may not always imply loyalty or even a probability of future purchase, one may consider example of expensive cars in this regard. And finally, the survey results typically represent one single time point and hence may not always convey robust information.

Due to these reasons, more recent measures pioneered by Dick and Basu [13] have incorporated behavioural and attitudinal measures simultaneously. They proposed attitude as a cause of repeat purchases. In fact, purchases induce a favourable outlook towards the brand in the mind of the customer which, in turn, generates more repeat purchases and hence loyalty is seen as a function of *attitude-manifested behaviour*. [14]

III. METHODOLOGY

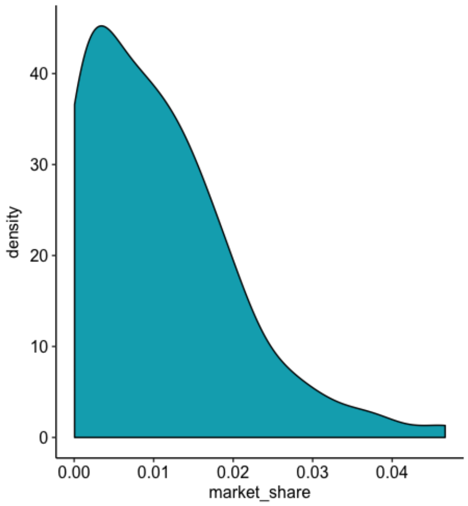
A. Data

This work is based on point of sale data provided by Walmart Canada. As new product contenders fight for the shelf space in Walmart, identifying suitable items for a modular drop becomes all the more crucial and hence the need for an accurate yet interpretable loyalty scores. We will be demonstrating our work using products under the category *Mouthwash*. The motivation behind choosing mouthwash for this task is our belief that customers are likely to be unwilling to change their choices of mouthwash and tend to stick to their preferred brand/product. However, since this is also a relatively expensive product and vanity product in the sphere of oral care products, there would be a segment of the population who will be inclined to give in to promotional frenzies and yet another segment of the population who will display loyalty to their preferred product in face of extensive promotional bonanza – this creates an ideal situation to isolate effects of promotion on loyalty. The data contains all purchases made in Walmart Canada from June 2017 to June 2018. Each entry in this data (sample: table 1) contains one household ID, the product ID (UPC), purchase date, the price, and whether or not that product was on promotion at the time of the purchase. As can be seen, this data doesn't contain any attitudinal features, hence we will be proposing a behavioural measure of loyalty. Although this doesn't encompass every aspect of customer loyalty this fits well into our framework and is sufficiently informative, objective, and reasonable regarding the aspect of available data.

UPC	***Purchase Date***	***Household ID***	***Price***	***Promotion***
6379370730	02/01/2018	101	5.77	1

Table 1: Example of the Data

In the given period, the data consists around 17 million purchases of 94 products by over 3 million households. For calculating the loyalty measures, we discard purchases made by light users, households with less than 3 purchases in the past 52 weeks. In the figures below, we summarise basic properties of the data.



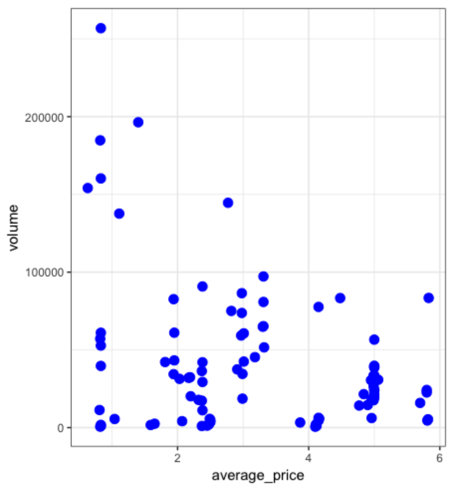


Figure 1(a): Empirical Density Plot of Market Share of The Products

Figure 1(b): Scatterplot of Volume vs Price

From these plots the data provides some insights, figure 1 shows positively skewed distribution which is expected as most of the items have low market-share and very few have (relatively) large share. Similarly, in figure 2 we have an overall negative correlation between price and volume of products, with a typical funnel like shape.

B. Definitions

With these specifications in mind, we begin describing our proposed measure. The following definitions will be used while describing the measure.

First, to define the premise, we have H households $\mathbb{H} = \{1, 2, \dots, H\}$. Every household makes t_h many visits to buy a mouthwash, in the given 52 weeks – each time they have n products $\mathbb{J} = \{1, 2, \dots, n\}$ to choose from. They buy exactly one product at each visit.

In what follows suffixes h, j, t will always denote household ID, product ID, and visit number respectively.

1. **Transaction (T):** The random variable transaction is defined as

$$T_h(t) = j \text{ if HH h bought the product } j \text{ at visit number } t$$

2. **Promotion (P):** This is an indicator variable that defines whether a transaction was made under promotion or not. So, for a transaction $T_h(t) = j$

$$P(T) = \begin{cases} 1, & j \text{ was on promotion duringt visit } t \text{ of HH } h \\ 0, & j \text{ wasn't on promotion during visit } t \text{ of HH } h \end{cases}$$

3. **Promotion Delta (ΔP):** This is another categorical variable that takes value 1 if the HH's last transaction was not under promotion but the current one is and vice versa. Formally,

$$\Delta P(T) = P\big(T_h(t)\big) - P\big(T_h(t-1)\big)$$

4. **Switch (S):** Finally, this variable denotes if a transaction is different from the one before it.

$$S(T) = \begin{cases} 1, & T_h(t) \neq T_h(t-1) \\ 0, & T_h(t) = T_h(t-1) \end{cases}$$

5. **Loyal HH:** A household is said to be a loyalty HH if they buy the same product in every visit.

$$T_h(t) = j \; \forall t \; for \; some \; j \in \mathbb{P}$$

Let $\mathbb{L} \subseteq \mathbb{H}$ denote the set of all the loyal HHs

Along with these also define, $\mathbb{H}_j \subseteq \mathbb{H}$ as

$$\mathbb{H}_j = \{h \in \mathbb{H} \mid j \in \bigcup_t T_h(t) \}$$

Having these definitions in hand, we attempt to find out how much sale of a product was due to promotion. One simple measure would be

6. **Beta ($\boldsymbol{\beta}$)**: This measures the proportion of sales of a particular product under promotion. More formally,

$$\beta(j) = \frac{\sum \mathbf{I}(T = j \cap P(T) = 1)}{\sum \mathbf{I}(T = j\,)} \#(1)$$

Where, **I** is the indicator function defined by: $\mathbf{I}(A) = \begin{cases} 1 & A \; true \\ 0 & else \end{cases}$

However, this is a very aggregated view and doesn't give us any information about the propensity to change preference of any HH; hence, it doesn't answer the question if a HH will switch preference if *j* was under promotion. To facilitate more intricate insights, we define the following statistics.

7. **Gamma ($\boldsymbol{\gamma}$)**: The γ of a product j measures if households switch from other products to j due to promotion.

$$\gamma(j) = \frac{\sum \mathbf{I}(T = j \cap \; S(T) = 1 \cap \; \Delta P(T) = 1)}{\sum \mathbf{I}(T = i \cap S(T) = 1)} \#(2)$$

This may be understood as the proportion of switches to product j in which $\Delta P = 1$, i.e. among all the transactions where a HH switched to product j, what proportion was "*due to*" introduction of promotion, as one should understand *if this is high then the sale of product j is* *primarily driven through promotion and all such transactions should be penalized while calculating loyalty.*

8. **Omega (ω)**: In a similar tone we also define ω of a product j, which measures if households don't switch from product j once promotion is withdrawn.

$$\omega(i) = \frac{\sum \mathbf{I}(T = i \cap S(T) = 0 \ \cap \Delta P(T) = -1)}{\sum \mathbf{I}(T = i \cap \ S(T) = 0)} \#(3)$$

This may be understood as the proportion of transactions where HH did not switch from product j in which $\Delta P = -1$, i.e. among all the transactions where a HH did not switch from product j, what was the proportion where promotion was withdrawn, *as one should understand if this is high then even though the HH may have started buying the product j due to the promotion they didn't switch back when the promotion was withdrawn developing some kind loyalty to the product and all such transactions should be rewarded while calculating loyalty.*

We will use these three statistics for each product to measure the compound effect of promotion on sale and loyalty - business decisions can also be taken by having a quick look at these numbers only, however in the next section we will use similar concepts to extend and adjust Loyalty for promotion.

C. L-prob

Using definitions used above, we will define two measures of loyalty; but before that we will digress a little and introduce a simple and quick behavioural measure of loyalty we call '*L-prob*'. It measures 100% commitment of a household towards a product. This can be difficult to find in a category such as say juice, as people tend to switch around quickly and this switching is more often than not idiosyncratic. However, this may be very useful in categories such as electronics. That being said let's introduce the measure

$$L(j) = \frac{|\mathbb{L} \cap \mathbb{H}_j|}{|\mathbb{H}_j|} \#(4)$$

In informal terms, this is the probability that a HH never buys anything but the product j. The measure is really simple and easy to compute and interpret, however – it lacks the rigor to capture hidden patterns in the purchase data, we will primarily use this as a baseline to judge the performance of our loyalty measures.

C. Loyalty Measures

Now we are ready to introduce two measures of loyalty $\{\psi_1, \psi_2\}$. Both are similar in anatomy; however, $\psi_1$is based only on past purchases – whereas, ψ_2 also utilises information on promotion during those purchases. Comparison between ψ_1, ψ_2 in the light of statistics β, γ, ω defined above will provide accurate insights regarding the effect of promotion and sale and loyalty of the products.

To give a brief overview, we create '*Loyalty Proportion*' for each household as a function of an *exponentially weighted average of its past purchases* (for ψ_1) along with penalties and rewards that reflect the effect of promotion (for ψ_2). Once we have this, we aggregate results for each household to get an overall value for loyalty that reflects how much the market is loyal to that product after correcting for promotion.

To define *Loyalty Proportion* for a HH we have to first create the following indicator variables:

- $$Y_{hj}(t) = \begin{cases} 1, & T_h(t) = j \\ 0, & else \end{cases}$$
- $$Z_{hj}(t) = \begin{cases} 1, & T_h(t) = j \text{ and } P(T) = 1 \\ 0, & else \end{cases}$$
- $$U_{hj}(t) = \begin{cases} 1, & T_h(t) = j \text{ and } (T) = 1 \text{ and } \Delta P(T) = 1 \\ 0, & else \end{cases}$$
- $$W_{hj}(t) = \begin{cases} 1, & T_h(t) = j \text{ and } S(T) = 0 \text{ and } \Delta P(T) = -1 \\ 0, & else \end{cases}$$

Now define for some $\alpha \in (0,1)$,

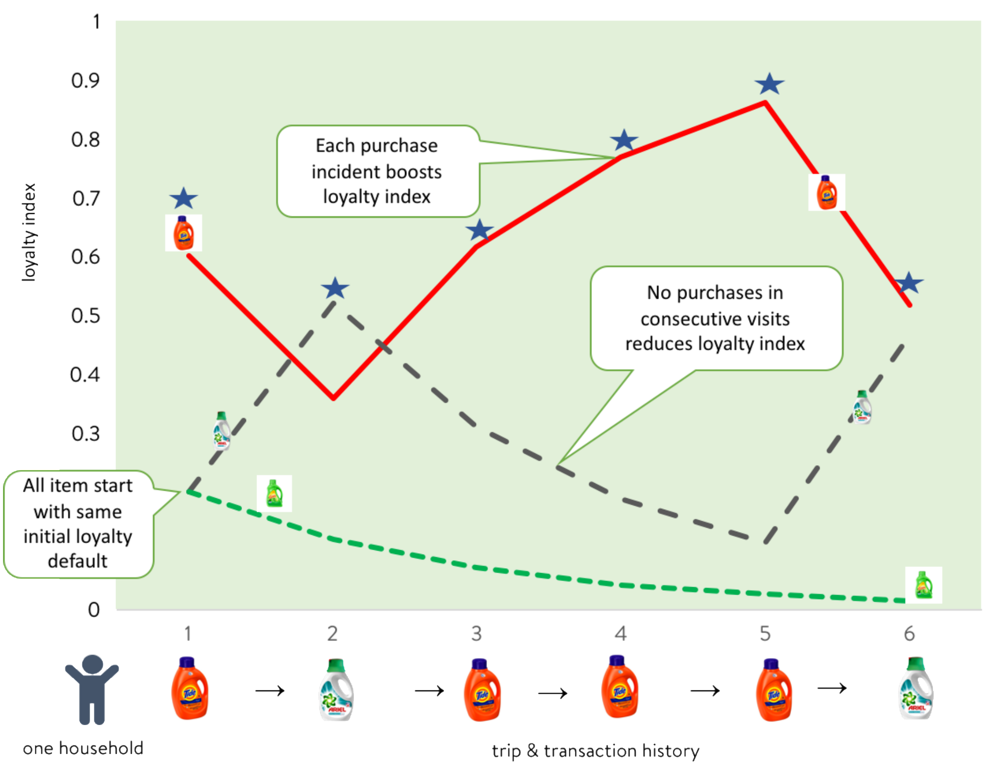
$$Loy_{jh}^{1}(t) = \alpha\, Loy_{jh}^{1}(t-1) + (1-\alpha)\, Y_{ij}(t) \;\; \#(5)$$

And a more general version of this using the promotional information as

$$Loy_{jh}^{2}(t) = \alpha\, Loy_{jh}^{2}(t-1) + (1-\alpha)\, Y_{ij}(t) - \beta\, Z_{ij}(t) - \gamma\, U_{ij}(t) + \omega\, W_{ij}(t) \;\; \#(6)$$

Where, $\alpha \in (0,1), \beta = \frac{1}{n}\sum_j \beta(j),\ \gamma = \frac{1}{n}\sum_j \gamma(j),\ \omega = \frac{1}{n}\sum_j \omega(j)$

Note, the variable $Loy_{jh}^{1}(t)$, henceforth called *loyalty index*, was introduced in [5] to be used as a predictor variable in predicting customer purchase probability using an *MnL* model. However, for our purposes we will deviate from that and use this as a descriptive statistic that will capture the bias of each households towards a particular product against its alternatives. This can be viewed in the following toy example involving 6 purchases of a household involving 3 items



denotes the item with highest loyalty index after that visit, e.g. if the red line has , then had highest index at that time

Figure 2: Toy Example 1

The variable $Loy_{jh}^{2}(t)$ adds to this index by penalising purchases made under promotion and rewarding purchases made without promotion and hence will be able to eliminate the effect of promotion while calculating the aforementioned bias. Loy^{1} and Loy^{2} will act as backbones of ψ_1, ψ_2 respectively.

Once we have the *loyalty indices* for each household/product at each time point we proceed to define *loyalty proportion* for the household.

Define,

$$M_h^1(t) = argmax_j \left(Loy_{jh}^1(t)\right) \#(7)$$

$$M_h^2(t) = argmax_j \left(Loy_{jh}^2(t)\right) \#(8)$$

We understand, this value denotes the product which the household h is most biased towards at time t. Since these values are dependent for a household; over time, the long run frequency of these values will be a good proxy for that household's overall bias towards a particular product against its alternatives.

Finally, define:

$$p_h^1(j) = \frac{1}{t_h}\sum_t \mathbf{I}\left(M_h^1(t) = j\right)\#(9)$$

$$p_h^2(j) = \frac{1}{t_h}\sum_t \mathbf{I}\left(M_h^2(t) = j\right)\#(10)$$

$p_h^1(j), p_h^2(j)$ will serve the *loyalty proportion* for the household, in the sense if the loyalty of a household is a constant number this is the share for each product.

Finally, we summarise $p_h^1(j), p_h^2(j)$ across households as follows:

$$\psi_1(j) = \frac{\sum_j p_h^1(j)\mathbf{I}\left(p_h^1(j) > 0\right)}{\sum_h \mathbf{I}(p_h^1(j) > 0)}\#(11)$$

$$\psi_2(j) = \frac{\sum_j p_h^2(j)\mathbf{I}\left(p_h^2(j) > 0\right)}{\sum_h \mathbf{I}(p_h^2(j) > 0)}\#(12)$$

Note, if $p_h(j) = 0$ for some j, h, we don't consider household h for calculating loyalty for the product j. This is due to the fact that generally $|\mathbb{J}| = n \gg t_h$ and hence most of the entries in $p_h$will be zero – so it will be ambiguous to consider these "disloyal" households while calculating loyalty as they will change the measure by huge margin and the measures will have no meaning.

This completes our definition of loyalty measures for each product under a category – both with and without adjustment for promotion. Before we dive into results from real life data, let us illustrate how the results actually differ using this simulated data of one household's purchases in a two – product scenario.

Product bought	A	A	B	B	B	A
Promotion index	0	0	1	1	0	0
Δ P	-	0	1	0	-1	0
Z	0	0	1	1	0	0
U	-	0	1	0	0	0
W	-	0	0	0	1	0

Table 1(a): Toy Example 2 - Data

This shows most of B's purchases were a result of promotional activity, however – it also shows some new-born loyalty toward B at visit number 5 where the HH continued with B even when the promotion was taken away. The loyalty numbers for this HH would be

	Basket Share	$\boldsymbol{\psi_1}$	$\boldsymbol{\psi_2}$
A	0.5	0.5	0.67
B	0.5	0.5	0.33

Table 1(b): Toy Example 2 – Results

Expectedly, the fact that B's sales are not organic in nature but are rather induced by promotion is completely ignored by $\psi_1$reflected in the value of ψ_2 and hence although both products are bought exactly three times, our promotion corrected measure of loyalty is able to differentiate between them.

IV. RESULTS

We now present our findings for products in mouthwash category in Walmart Canada. Due to privacy reasons, the authors may not always be able to produce exact names and information in a tabular form and will hence focus on figures and summary statistics to judge validity of our results.

First, a brief overview of the statistics β, γ, ω for the products is shown here:

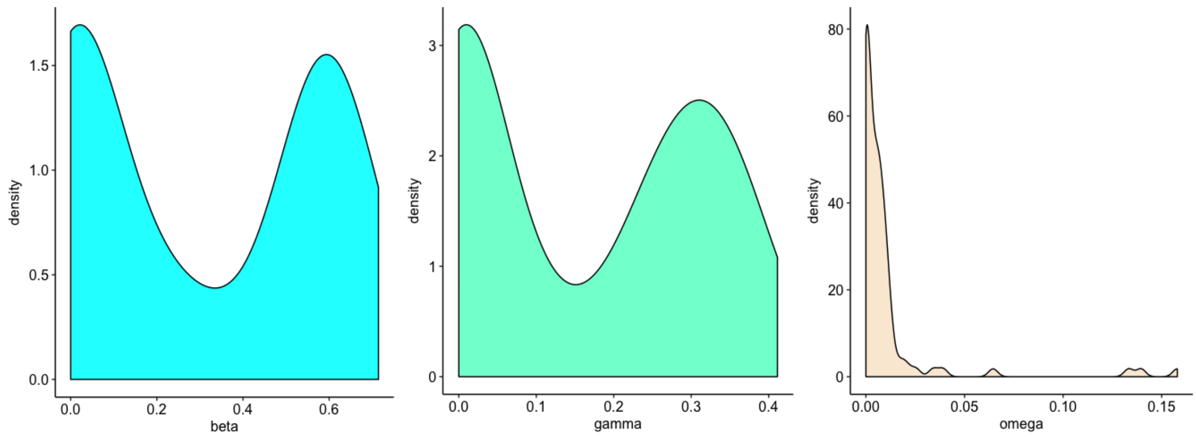


Figure 3: Density of statistics β, γ, ω for Walmart Mouthwash products

So, interestingly β, γ have a similar bimodal distribution – this indicates most of the products were not on promotion for long in the given time, however there are a bunch of products who were on promotion on almost more than 50% of the time, this will create a great contrast in the product universe, we should be able to see vastly differing ψ_2 in products having similar ψ_1. On the other hand, the behaviour of ω is much more routine, most of the mass is concentrated towards zero – which indicates that for most products, very few households were willing to continue with the product once promotion was withdrawn, a passive overview that the promotions were not really effective in building long – term item loyalty.

Proceeding to actual loyalty values – first, we would like to compare the three loyalty measures $\{L_{prob}, \psi_1, \psi_2\}$ of the products with their respective market shares. As we specified earlier our loyalty measure must be able to differentiate itself from market shares. Moreover, as we expect high degree of correlation between L_{prob} & ψ_1. We also add the following figures along with associated correlation matrix between these item performance metrics for comparison.

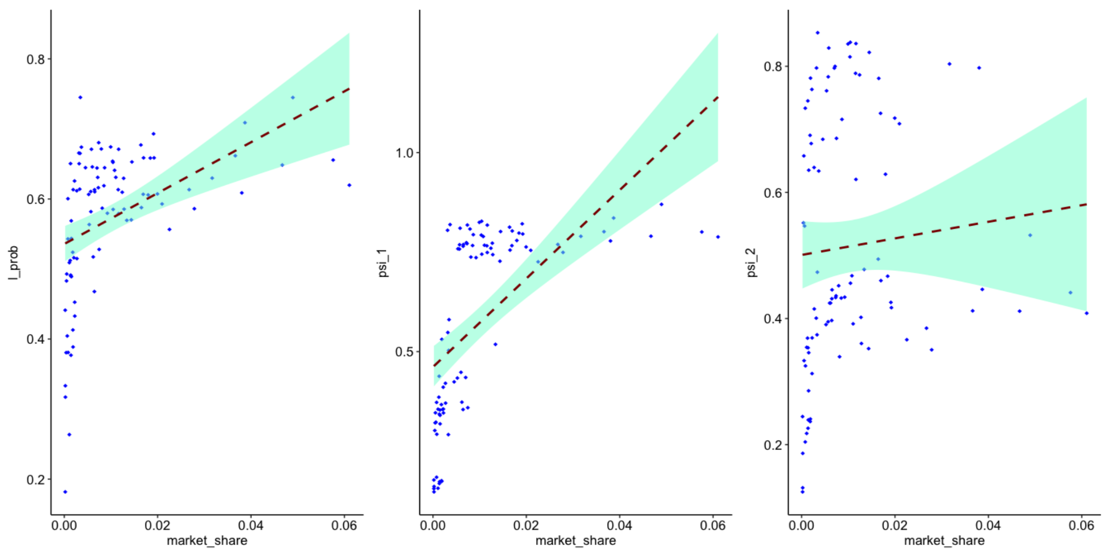


Figure 4: Scatterplot of L_{prob}, ψ_1, ψ_2 with Market share for Walmart Mouthwash products

	market_share	*l_prob*	*psi_1*	*psi_2*
market_share	1.00	0.44	0.60	0.08
l_prob	0.44	1.00	0.78	0.53
psi_1	0.60	0.78	1.00	0.43
psi_2	0.08	0.53	0.43	1.00

Table 2: Correlation between Market Share and Loyalty measures

Let us deep dive into the results,

- First, we see ψ_1 is fairly correlated with market share, however the correlation is not very high, in fact, the plot identifies products which might have low market share but relatively high loyalty, few such UPCs are

UPC	*Average price*	$\boldsymbol{\psi_1}$	*Market Share*
69702932417	$ 11.97	0.76	0.005
6081503995	$ 9.97	0.82	0.003

Table 3: Low-Performance-High-Loyalty Items

- Next, there is a strong correlation between L_{prob} & ψ_1 – this is also expected as described earlier.
- However, by far the most interesting outcome would be the relationship of ψ_2 with other metrics, we have seen the influence of promotion is quite high from the results of figure 3 – As a result, $\psi_2$is virtually uncorrelated with market-share as most of the purchases are done due to promotion and item loyalty is penalised for such instances. We also, saw around 30 - 40 % products have a high β, γ value this suggests large deviations between ψ_2 & ψ_1. This is observed in the data as correlation between them is only 0.43 – were promotions not causing the preponderance of sales we would expect this to be higher since ψ_2 & $\psi_1$will become identical functions.

Finally, we compare some individual products to see exactly where we can see effects of promotion and how that is being adjusted in the definition of loyalty. Consider the products

UPC	**market_share**	$\boldsymbol{\beta}$	$\boldsymbol{\gamma}$	$\boldsymbol{\omega}$	$\boldsymbol{\psi_1}$	$\boldsymbol{\psi_2}$
6260095395	3.66 %	0.6272	0.3827	0.0109	0.8013	0.4122
7906801318	3.17%	0.0004	0.0000	0.0000	0.7896	0.8037

Table 4: Difference between ψ_1, ψ_2 due to promotion: effect of β, γ

These two products have almost similar market share and similar $\psi_1$values, but if we add the promotion information we can see product in the first row (call it P_1) has very high β, γ values and low ω values – customers are only buying this due to promotion, on the other hand product in the second (call it P_2) row has virtually non-existent β, γ values – suggesting the sales are organic; we can see this difference mirrored in the ψ_2 values of the products. We see, $\psi_2(P_2) \approx \psi_1(P_2)$. For P_1, ψ_2 drops drastically. Thus, this measure provides us with a unique view of loyalty where it has successfully eliminated any 'spurious' loyalty created due to promotional activities.

Also consider, this following pair of products (row 1: P_3; row 2: P_4)

UPC	**market_share**	$\boldsymbol{\beta}$	$\boldsymbol{\gamma}$	$\boldsymbol{\omega}$	$\boldsymbol{\psi_1}$	$\boldsymbol{\psi_2}$
5800031086	0.08%	0.5372	0.2877	0.1579	0.1844	0.2043
6260095976	3.87%	0.5935	0.3821	0.0096	0.8356	0.4462

Table 5: Difference between ψ_1, ψ_2 due to promotion: effect of ω

Now, P_4 seems like a typical example from above, high market-share and ψ_1 but sales are actually driven by promotion and hence reduced $\psi_2$values. However, the case of P_3 is actually very interesting. It has similar β, γ values as P_4 – so most of its sales are also initiated via promotion, however we notice it has (relatively) high ω, this means this product has been somewhat successful in retaining customers even after end of promotional activities and hence doesn't see a huge difference between ψ_1, ψ_2; almost as if counter – acting forces balancing each other.

V. CONCLUSIONS

This study presents novel statistical measures for product loyalty based on past purchases of the customers along with promotional information. We attempt at deriving a theoretically robust loyalty measures that aren't only dependent on sequential purchase and are able to successfully ascertain and eliminate effects of promotions, as a result, we can distinguish between products that have high sells and products that actually have high loyalty – this holistic approach helps while making optimal assortment decisions such as deletion, expansion. Apart from these, we have presented simple, interpretable statistics, β, γ, ω and L_{prob} which along with market-share can provide important aspects of promotion and loyalty in a glance due to their intuitive nature.

The future scopes of this study include but is not limited to –

- Enhance this process by introducing some cognitive properties thus making it multidimensional.
- Evaluate loyalties at several time points to test for a seasonality component.
- Evaluate demand transfer dynamics within category/ substitutable products, e.g. what happens when a high / low loyalty product is dropped?

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