RETAIL & MARKETING ANALYTICS REPORT
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*CAN THE **PROSPECT THEORY**[1] BE PROVEN IN THE INSTANT COFFEE DATASET?*

The paper “Prospect Theory: An analysis of decision under risk” by Daniel Kahneman and Amos Tversky earned the former the Nobel Memorial Prize in Economics. Despite never having taken a single economics course. Kahneman went on to write a New York Times bestseller “Thinking, Fast and Slow”. A book that summarizes some of his research.

As a fan of Kahneman’s book I have chosen to base my research project on looking for evidence of the Prospect Theory in the raw data provided by Kantar Worldpanel transactions of instant coffee.

Kahneman and Tversky got their data from randomized questionnaire booklets that were given to students and university staff across the World. The respondents were faced with hypothetical choice problems, a method which may carry uncertainties with regards to extrapolating its findings to real World scenarios.

For this paper I will use field data that we have been granted access to by Kantar. This contains panel data of real consumer choices and I have used it to design a model of economic behaviour by computing utilities of the user’s repeating choices over many periods. After appropriately defining gain and loss in I set out to compute the utility function as well as the best fit for the demand function of each brand. This comprises the main part of the analysis.

In addition insights were drawn from the analysis of price elasticities of demand and the varying effect of isolating loss aversion in these. I have then derived the elasticities for selective demand from these utility functions and simulated price increases and price reductions. Some attempts on the latter did not prove fruitful and have been included in the appendix simply for reference.

It should be noted that the presented model relies on approximations and definitions that also carry with them uncertainties with regards to its application outside this experiment.

In answering the research question I wanted to get a clear understanding of what *prospect theory* proposes and how it translates in the marketing and retail context. Therefor the first step for completing this analysis is establishing a clear understanding of the *prospect theory* and its implication.

[1] Daniel Kahneman and Amos Tversky (1979). “Prospect Theory: An Analysis of Decision under Risk.”

I. THE PROSPECT THEORY

The prospect theory from 1979 was disruptive when it was first released and it has been cited nearly 40,000 times. A theory that breaks with the dogmas of its time will cause a domino effect of new ideas and I believe studying some of these are equally important in understanding the full extent of its implications.

When first introduced, the prospect theory broke with the hitherto ubiquitous model defined under the *expected utility theory*[2]. One of the main tenets in this model was that of asset integration: “A prospect is acceptable if the utility resulting from integrating the prospect with one's assets exceeds the utility of those assets alone.”

The prospect theory broke with this by introducing the concept of *reference dependence* [1]. This suggests that individuals weigh their decision by the value of a present time metrics (such as current income flow) rather than lifetime value of the same metric (in this case lifetime wealth).

This reference dependence was explored further by economist Richard Thaler in his paper on *mental accountin*g.[3] A theory in which people tend to group expenditures into categories causing a tendency that can violate the economic principle of fungibility. He derives his findings by applying a new concept of *transaction utility*, a method also applied in this paper.

In a marketing and retail setting this can translate into inertia in terms of accepting a different price than expected. This reference price can be defined in a number of different ways and at least two have been explored in this model.

The prospect theory and the expected utility theory share the conclusion that on average, individuals are loss averse. This aversion to loss looks slightly different in the prospect theory as it notes how individuals have a low ability (and perhaps desire) to evaluate each option objectively.

Kahneman and Thaler collaborated on research that built on conclusions reached with the prospect theory in their paper on the Endowment Effect[4]. Here it was found that people demand more to sell an item they already own than they would be willing to pay for it. In other words the negative utility of a loss is of greater magnitude than the gain of something of equal objective value.

In practice it this translates as an inability to appropriately evaluate opportunity costs of not being willing to try something new. In the marketing setting this may translate into a particular high degree of brand loyalty which has been controlled for in the analysis concluded by this paper.

To summarise, the concepts derived from prospect theory that will be examined in this paper include the shape of the loss curve under this theory (i.e. being steeper in the region of losses vs gains - “losses loom larger than gains”) and reference dependence. It may be noted that the concepts, from the same theory, of diminishing sensitivity and the function of decision weighting are not being tested here. This is due to how they deal with higher values and more extreme cases

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[2] Daniel Bernoulli (1738) and built on by von Neumann–Morgenstern (1947)

[3] Richard Thaler (1985). “Mental Accounting and Consumer Choices”

[4] Kahneman, Knetsch, Thaler (1991). “The endowment, loss aversion, and status quo bias”

that our data is not equally suited for and would necessitate radical assumptions in order to simulate this.

II. PROPOSED MODEL

In looking for evidence of the prospect theory in the coffee dataset two separate models were explored. When looking for the effects from the consumer's standpoint it seems natural to approach the problem by looking at the magnitudes of these at: (1) a transactional level on the utility function, and (2) at an aggregated level on the demand function with the error terms accounting for unobserved household heterogeneity.

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(1) $\text{UTILITY}^{t}_{ij} = \alpha_0 + \beta_i * \text{Price} + \alpha_1 * \text{PROMO} + \alpha_2 * \text{LOYALTY} + \ldots.. + \lambda * u_i$

(2) $\text{DEMAND}^{t}_{ij} = \gamma_0 + \delta_i * \text{Price} + \gamma_1 * \text{PROMO} + \ldots\ldots\ldots + \omega * v_i$

(1) $\beta_i = \beta_1 + \beta_2 * 1 * \{P^{t-1}(\text{choice}) - P^{t-1}(\text{choice}) > 0\} + \beta_3 * 1 * \{P^{t-1}(\text{choice}) - P^{t-1}(\text{choice}) < 0\} + \square * u_i$

(2) $\delta_i = \delta_1 + \delta_2 * 1 * \{P^{t-1}(\text{brand}) - P^{t-1}(\text{brand}) > 0\} + \Omega * V_i$

In this paper I propose the presence of a dummy variable interacting with the parameters associated with price [β_i ; δ_i] as seen above. The dummy variable is related to the reference price [β_2 ; δ_2] respectively defined for each function.

1. PART I : ESTIMATION OF UTILITY FUNCTION

In this model the aforementioned concept of transaction utility is applied. As defined by Thaler being the utility derived from each transaction as the *perceived* value of each transaction. Looking at a transactional level enables the use of a reference price specific to each household as being the price they last paid for a good in the same category.

Furthermore, in order to capture the effect of the true shape of the loss function two dummies are included to interact both when a loss is incurred - i.e. the reference price is lower. *And* that when a gain occurs - i.e. getting a good deal.

If either of these parameters are of significance it will allow a conclusion to be made on the presence of *reference effects*. Furthermore, comparing the magnitude of these parameters will allow a conclusion to be made on the magnitude associated with each of these. Meaning we can see how utility associated to losses compare to those of gains, in relative terms.

2. PART II : ESTIMATION OF DEMAND FUNCTION and PRICE ELASTICITY OF DEMAND

Due to the extensive assumptions necessary to convert the data into the format necessary for *Part I* of the analysis, the analysis on the demand function was initially intended to serve as confirmation of the findings from Part I.

For the demand model the data is aggregated to a average daily level, making a different definition of the reference price more intuitive. Here the dummy associated with loss and gain will depend on the average price of the brand in the previously observed period.

III. ANALYSIS AND RESULTS

PART I : ESTIMATION OF UTILITY FUNCTION

Table 1 shows the estimated variables for the brand choice model given multinomial logit function. Certain brands with a small representation in the total data as well as the generic brands were excluded as the aggregation of these caused disturbance in the model estimation.

Model 1 does not account for price responses that are asymmetric as specified by the prospect theory. The relative brand preferences are computed with Carte Noire as the baseline, which also seems to be the least prefered brand, relatively speaking and amongst the brands considered (also see Appendix 1). From table 2 we see that the most preferred brand is also that which is least frequently promoted and that Carte Noire as the least preferred brand is also amongst the most heavily promoted one.

In model 2 we account for asymmetric price responses by consumers. We see that the parameter associated with the marginal utility of price decreases as we introduce these new variables to the model. With this introduction the parameter associated with both price and price promotion are reduced. This is in part because we are now isolating the effect of loss aversion from the price parameter. The loss and gain relative to the reference price of the consumer captures some of this effect from the price parameter. Both loss and gain are statistically significant and loss appears to impact utility negatively 13% more compared to gain. Losses do indeed loom larger than gains.

The effect this isolation has on the price promotion parameter may signify that although the utility of a promotion is positive, the utility associated with finding the same product no longer on promotion on the next shopping trip outweighs its benefit somewhat.

	MODEL 1		MODEL 2	
	Estimate	Std.	Estimate	Std.
Douwe Egbert	0.839	(0.017)	0.872	(0.018)
Kenco	1.409	(0.016)	1.447	(0.017)
Nescafe	1.672	(0.017)	1.714	(0.017)
price	-0.129	(0.007)	-0.064	(0.008)
promo_price	0.045	(0.024)	0.033	(0.024)
loyalty	0.003	(0.073)	0.001	(0.075)
loss			-1.248	(0.050)
gain			-1.089	(0.050)

Table 1: Utility Estimates from Consumers Choices

	Price		Price Promo	
	Mean	Std.	Proportion	Frequency
Carte Noire	3.070	(0.916)	0.805	26%
Douwe Egbert	3.276	(0.707)	0.883	27%
Kenco	3.230	(0.709)	0.821	25%
Nescafe	4.003	(0.782)	0.734	18%

Table 2: Spread of Price and Proportion of price promotions

PART II : ESTIMATION OF DEMAND FUNCTION and PRICE ELASTICITY OF DEMAND

The function of demand for each brand was computed using stepwise regression with the help of manual tuning. As expected the aggregation of the *other brands* (being the brands that on their own have a negligible market share, defined as less than 5000 units sold over the entire year) and generic *shop brands*, caused disturbance in the estimation of other parameters. This is evidenced by the positive elasticity of demand computed for the *other* brands coupled with the unusual effect of the generic brands having a lower elasticity compared to the high end brands.

By design, the first model for each brand did not include the *loss variable*. In the second model the loss variable was added to the best fit model. There seems to be significant heterogeneity with regards to price sensitivities across all brands, even amongst high end brands. The parameter associated with the loss did not prove significant across all brands, though in particular it was insignificant for the low end brands (i.e. other and supermarket generic).

Table 3 shows the own price elasticities of demand as computed from the parameters associated with the two distinct types of demand models. When excluding the *other* and *supermarket* brands we see that by not including loss aversion in the model the price elasticity of demand is underestimated by nearly ~10%. This implies that isolating the effect of loss aversion releases the consumers' inertia caused by brand loyalty.

	Model 1	Model 2
Average	0.822	0.904
Carte	0.425	0.515
Douwe	1.107	1.232
Kenco	1.630	1.564
Nescafe	0.127	0.307
Other	*(0.388)*	*(0.244)*
Super	*0.001*	*0.043*

Table 3: Price Elasticities Demand computed from model excl. and incl. LOSS

III. CONCLUSION and RECOMMENDATIONS

The reference effect and loss aversion observed in the analysis of the utility function proved robust. Both in determining that the reference effect was significant as well as showing that gains are less significant than losses. The observed reference effect from the demand function was not equally visible, though still present. Even when simulating price increases as well as price reduction on the demand function the effects on the price elasticity of demand were negligible (see Appendix 2).

It is important to note the difference in the definition of the reference price in these two models and how this would largely explain these differences in results. As a reminder reference price was was defined in the demand model as the difference between the lagged value of the daily average price, where the time frame for the lagged variable was taken from a week. It may be interested to include other definitions such as the price set by the market leader or the prices of competing product lines such as ground coffee and coffee beans.

The consumer behaviour behaviour described in the prospect theory is accepted as being a norm as it has been observed in many different markets. Or as observed by Peltzman in his paper on asymmetric price responses[5] : "In a cross market study for 77 consumer goods and 165 producer goods finds there to be asymmetric price adjustment" and "on average, the short term response to a positive cost shock is at least twice the magnitude of the response to a negative shock."

Some possible consequences come to mind that marketers may want to be wary of as a consequence of these effects. As an example it may be beneficial to run long running promotion rather than frequent and separate in time. However this strategy must be used with particular caution as long running campaigns may cause households to get used to these. The pertinent questions to ask becomes how long do reference effect last, how long / often do they take to form?

Another unintended consequence may be that high end brands that are competing closely with each other (i.e. have high cross price elasticity) might have an interest in running promotions simultaneously. Both to avoid losing market share at the time of the competitors' promotional period, as well as to avoid the possibility of losing users to the competitor in the periods following their own promotional period.

[5] Sam Peltzman (2000) : "Prices Rise Faster than They Fall"

APPENDIX 1

Regressing only choice on price to derive the relative market share of brands.

	Relative Market Shares	
	Estimate	Std.
Douwe Egbert	0.844	(0.017)
Kenco	1.416	(0.016)
Nescafe	1.677	(0.016)
price	-0.126	(0.006)

Table 4: Relative Market Shares

APPENDIX 2

Selective demand elasticities derived from the utility function in part 1 of the analysis.

	Selective Demand Elasticity			
	MODEL 1		MODEL 2	
	Mean	Std.	Mean	Std.
Carte Noire	0.093	(0.037)	0.192	(0.080)
Douwe Egbert	0.094	(0.037)	0.195	(0.081)
Kenco	0.093	(0.037)	0.192	(0.080)
Nescafe	0.113	(0.045)	0.235	(0.098)

Table 5: *Selective* Demand Elasticities computed from model excl. and incl. LOSS

APPENDIX 3

Comparing simulated price increases and reduction in the price of each brand from the demand function derived from first excluding reference effects (Model 1) and then including (Model 2).

	Model Excluding Loss			
	Mean	Std.	Mean	Std.
	Δ p > 0		Δ p > 0	
Average	0.757	(0.291)	0.760	(0.098)
Carte	0.624	(0.230)	0.611	(0.238)
Douwe	0.757	(0.079)	0.794	(0.067)
Kenco	0.820	(0.820)	0.811	(0.050)
Nescafe	0.825	(0.037)	0.824	(0.037)
Other	0.611	(0.194)	0.543	(0.242)
Super	0.837	(0.035)	0.837	(0.035)

Table 6: *Simulated* Price Elasticities Demand computed from model *excl.* LOSS

	Model Including Loss			
	Mean	Std.	Mean	Std.
	Δ p > 0		Δ p > 0	
Average	0.751	(0.101)	0.754	(0.102)
Carte	0.630	(0.227)	0.615	(0.236)
Douwe	0.759	(0.077)	0.796	(0.067)
Kenco	0.790	(0.063)	0.781	(0.068)
Nescafe	0.826	(0.036)	0.824	(0.037)
Other	0.621	(0.192)	0.518	(0.245)
Super	0.838	(0.035)	0.837	(0.035)

Table 7: *Simulated* Price Elasticities Demand computed from model *incl.* LOSS