

OPTIMAL PRODUCT LINE DESIGN WHEN CONSUMERS EXHIBIT CHOICE SET DEPENDENT PREFERENCES

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ABSTRACT. Research in Marketing and Psychology has shown that a product's relative standing in a choice set can influence its utility. Consequently, the independence of irrelevant alternatives assumption is frequently violated. This paper incorporates this robust empirical regularity into a model of product line design in order to investigate how a firm's product positioning and portfolio strategies change if the potential customers' exhibit such preferences. To this end, a general choice-set dependent utility framework that incorporates loss aversion is employed, where the multi-attribute reference point is endogenous to the choice set.

The optimal product line width and the product positions differ from those of the standard model. Specifically, the extended model yields three sharp predictions in regards to market outcomes when consumer preferences are choice set dependent:

Compression Effect: Compared to the strategy recommendations of standard economic models, the optimal product positions are such that the ranges of the attributes are compressed towards the reference point. Given a product width, the extent of compression is increased by the degree of loss aversion.

Pooling Effect: A further implication of the compression effect is the pooling effect where the firm offers a single product to serve multiple segments of customers even though it is costless to introduce a product. This finding runs counter to the standard model predictions.

Augmentation Effect: The firm manages its product line such that it may introduce or delete a product simply to augment utilities of other products. The "augmenting" product portfolio improves the perceived reference point of key consumer segments, a market phenomenon that could not be accounted for by the standard model.

The results show that it is important for the firm to quantify the degree of choice set dependency of preferences in formulating the optimal product line strategy.

1. INTRODUCTION

Product line design is one of the most important marketing-mix decisions. In order to decide on the number and positioning of products in its product line, a firm must understand the preferences of consumer segments and their choice behavior. To this end, existing approaches frequently adopt utility specifications which assume that the consumer preferences are independent of the choice set. However consumers often violate this assumption of independence and exhibit choice-set dependent preferences. Previous research has found evidence of choice-set dependent choice behavior, resulting from the effect of comparisons between alternatives in local contexts, which explains seemingly inconsistent preferences of consumers (Shafir, 2002, Huber, Payne and Puto (1982), Simonson(1989), Simonson and Tversky(1992), Mellers and Cooke (1996), Hsee and Leclerc (1998), Brenner, Rottenstreich and Sood (1999)). The question here is whether firms and researchers benefit from considering the possible effect of the choice-set on the choice behavior. To the extent that the attractiveness of an option is influenced by its relative standing with respect to other options, current frameworks will fall short of predicting how choices vary with alterations to the choice set (Sen, 1997). It is shown to be important to capture the systematic violations to the standard utility framework in order to predict choice and to develop optimal product line strategies for a firm which faces consumer segments to whom it would like to offer a set of products.

To this end, this paper develops a general model that is flexible enough to allow for and predict various patterns of choice-set dependent preferences. This dependence is captured by a model that is based on the concept of reference dependence and loss aversion, where reference levels are determined by the choice set the consumer is presented with. The proposed specification includes the consumption utility as well as comparative utility, where the comparative utility captures the importance of the relative standing of a product with respect to others in the choice set. It specifically is a function of the valuation of the departures of attribute levels of a product from the reference point where the reference point is endogenously determined by the products in the choice set.

The presented framework is psychologically richer than the standard framework and it reduces to the latter when choice-set dependency is not present.

Having specified a framework that captures how the choice behavior varies with the choice set, this paper proceeds to study how the product line design changes as a result. If consumer preferences are choice-set dependent, a firm offering a menu of products, should not only consider the substitution between alternatives and its selection motives, but also take into account how each product's demand will be affected by its relative standing among the other products. This insight results in new strategy implications for the firm.

Conditional on the number of products, the firm introduces distortions in quality provisions, due to the influence of each product's position on the demand of others in the product line. Thus, contrary to the standard models, the consumer segment with the highest value for quality with respect to price, may receive less than the level of quality provided if this segment was the only one in the market. On the other hand, the lowest-end consumer segment will receive a higher quality provision compared to the standard model. Therefore, conditional on the identity of segments being served, the range of the quality offered will be narrower, as the end quality provisions are compressed towards the reference point, a result labelled as the "*compression effect*" in this paper. The extent of this compression depends on the degree of loss aversion. In general, the degree of quality distortion for any segment is proportional to the influence of the segment's product on the relative standing of other products.

Since the existence as well as the positioning of a product affects the relative standing of other products, the product line length also is a tool for profit management. The firm may trim the product line to serve all consumers with the same product, if the increase in profits due to separation is outweighed by the loss in profits due to loss aversion induced by comparisons. This result is called the "*pooling effect*". The intuition behind the pooling effect is that by offering several products the firm may make all segments worse off since this introduces perceived losses in comparative evaluations. Consequently, the firm is better off by serving some or all consumers with just one product instead of going after the extra rents that could be extracted by separation. This finding provides an

explanation to why some firms target the low-end and the high-end segments with the same product, even when the standard framework would predict that the firm leaves money on the table by not separating the high-end consumers. By targeting the high-end consumers, the firm may lower its profits because the product offering meant for high-end customers can decrease low-end consumers' utility. Therefore the firm may pool the types even if segmentation is costless.

Another finding that cannot be predicted by the standard model is that the firm may change the number of products carried and the choice of segments served, simply to increase profits from key segments in the market by influencing their perceived relative standing. The “*augmentation effect*” refers to this finding where the firm may manage the reference point by the addition or the deletion of products, and thus enhances the utility that the key segments derive from their offerings. Although these trimming or extension strategies may not be profitable on their own, they increase the total profits derived from the product line. The firm may find it profitable to stop serving a segment if the absence of the product for that segment moves the reference point in a favorable fashion for the profits extracted from other key segments. Alternatively, the firm may add a product to manage the reference point. In such a case, the additional product serves a consumer segment that would not have been served otherwise. These phenomena, while occurring frequently in the real world, cannot be reconciled by the standard framework.

In sum, this paper proposes a utility model that is descriptive of the consumer behavior that has been documented to violate the standard framework. Based on this general framework, new strategy recommendations are derived for firms facing vertically differentiated consumer segments which cannot be identified a priori. To arrive at these managerial recommendations, the paper builds on the findings and strengths of research across different fields. Consequently, it fills the gap between our understanding of the actual behavior of consumers and the strategy recommendations regarding the product line design.

The rest of the paper is organized as follows. Section 2 provides an overview of the related literature, Sections 3 presents the utility framework that extends the

standard model to account for choice-set dependency. Section 4 analyzes the outcomes in the marketplace with two vertically differentiated consumer segments, and Section 5 discusses the extensions of the model such as increasing the number of segments and studying the effect of excess utility from gains as well as loss aversion. Section 6 concludes.

The empirical question of the magnitude of the reference price effects on choice has been studied by Hardie, Johnson and Fader (1993), Bell and Lattin (2000) and Klapper, Ebling and Temme (2005). This research stream focuses on the past experiences for the option under consideration rather than the reference effects of the external choice-set. This research has found some evidence for loss aversion in prices, when prices deviate from their expected means. It also was shown that the degree of loss aversion can be explained by consumer characteristics.

2. PREVIOUS LITERATURE

Many local context effects have been documented by Simonson and Tversky (1992), Simonson (1989), Huber, Payne and Puto (1982), to name a few. I would refer the interested reader to Drolet, Simonson and Tversky (2000) for a more complete overview of how choice set influences choice. It is clear from the findings of the literature that consumers may violate the Independence of Irrelevant Alternatives assumption in individual choice and that their preferences may depend on the choice set and the comparisons it provides.

Simonson and Tversky (1992) show that the intermediate options fare better than extreme options and label this effect as extremeness aversion. When people exhibit extremeness aversion toward both attributes, this effect is called the compromise effect. To represent the findings, in Figure 1, alternative L will fare better if presented in the choice set of $\{K,L,M\}$ than in the choice set of $\{L,M,N\}$. The opposite will be true for alternative M. In the same article, Simonson and Tversky also demonstrate enhancement and detraction effects. Enhancement effect labels the observation that option F in Figure 2 does better when presented with both A and B, than when presented with either A or B. Detraction effect labels the observation that option G does worse when presented with both A and B than when presented with either of the two. Moreover, Huber, Payne and Puto (1982)

and Simonson (1989) have demonstrated asymmetric dominance and asymmetric advantage effects, as depicted in Figure 3. The addition of alternative D to the choice set of $\{A,B\}$, increases the share of B compared to A, and the addition of alternative E to the choice set $\{A,B\}$ increases the relative share of A.

Just as Drolet, Simonson and Tversky (2000) put, empirical evidence suggests that preferences “travel” with the choice set. Parducci (1965, 1974) offers a range-extension explanation to this phenomenon. However previous studies such as Huber and Puto (1983) and Bodner and Prelec (1994) suggest that a range extension model may not be sufficient to explain observed context effects. Bodner and Prelec (1994) model context dependent choice with reference dependence and loss aversion concepts, where the reference point is the centroid of the offered alternatives. They contrast this model with the tournament model of Tversky and Simonson (1993), who account for choice-set dependency based on the idea that preferences are influenced by the trade-offs implied by the other options under consideration. In the proposed tournament model, each alternative is pairwise compared to other alternatives in the choice set and losses are weighed more than gains. Dhar and Glazer (1996) propose a perceptual-based explanation where the choice set affects preferences through changing the judgements of similarity between options. Kivetz, Netzer and Srinivasan (2004a, 2004b) empirically test alternative theories that may explain the compromise effect. They also discuss how proposed models can explain other context effects. Their research finds empirical evidence that modeling the local choice context leads to better predictions and fit compared to the traditional models. The authors find support for models that use a single reference point over tournament models. The proposed model rests on loss aversion and reference dependence, where the reference point for each attribute is the mid-point of the observed range of that attribute.

Previous research by Wernerfelt (1995) explains the compromise effect with an asymmetric information setup where consumers do not know their preferences, except for their place in the distribution and can infer their types from what the firm offers, who is assumed to know the distribution of tastes. However Prelec, Wernerfelt and Zettelmeyer (1997) show that the compromise effect can only be explained in part with the proposed theory. Although many behavioral

explanations are proposed for each context effect in the literature, the common concept underlying these models is that consumers make comparative evaluations and care about the relative standing of a product.

3. A CHOICE-SET DEPENDENT SPECIFICATION

Our utility framework should be consistent with findings of contextual dependency and systematically explain the directional deviations of these observations from the standard utility framework. To this end, this paper proposes a model which incorporates the local context effects with the use of reference dependent preferences. The proposed model uses a novel reference point formation, where the reference point travels with the choice set. This is how the effects of the choice set on the preference structure is captured. This framework is a psychologically richer version of the standard utility framework and reduces back to it when there is no reference dependence.

This formulation extends the reference dependent utility model of Kahneman and Tversky (1991) to include both the consumption utility and gain-loss utility, as in Koszegi and Rabin (2005). This approach allows the researcher to compare the relative importance of two sources of utility, while extending the standard framework. It rests on the observation that both the departures from the reference point matter for utility, as well as the levels of consumption. Furthermore this approach allows us to study the effects of the different aspects of comparative evaluations separately, namely loss sensitivity and gain sensitivity. This is useful in identifying the way in which the gain sensitivity and the loss sensitivity influence firm's strategies in different ways.

The total utility is assumed to be separately additive over attributes as well as utility types. Let the alternatives in a choice set be indexed by $j = \{1, 2, \dots, J\}$ and the attributes of products be indexed by $k = \{1, 2, \dots, K\}$. Then the individual i 's utility for alternative j can be expressed as

$$u_{ij} = \sum_{k=1}^K v_{ik}(x_{jk}) + \sum_{k=1}^K f_k(v_{ik}(x_{jk}) - v_{ik}(r_k))$$

where $v_{ik}(x_{jk})$ is the choice set independent consumption utility and $f_k(v_{ik}(x_{jk}) - v_{ik}(r_k))$ is the comparative utility. In this formulation, $|f_k(|y|)| < |f_k(-|y|)|$, which captures the main intuition of loss aversion that the same change in the attribute levels matter more when the consumer perceives to be in losses in that attribute than when she perceives to be in gains in that attribute. Around the reference point $f_k(\cdot)$ has a local kink, $\frac{\lim_{y \rightarrow 0} f'_k(-|y|)}{\lim_{y \rightarrow 0} f'_k(|y|)} \equiv \delta_k > 1$. Fixing δ_k , the importance of the comparative utility is increasing in $\lim_{y \rightarrow 0} f'_k(|y|)$.

Using the following function is sufficient to capture the effects of gain and loss sensitivity ¹,

$$f_k(v_{ik}(x_{jk}) - v_{ik}(r_k)) = \begin{cases} \lambda_k \cdot [v_{ik}(x_{jk}) - v_{ik}(r_k)] & \text{if } x_{jk} < r_k \\ \gamma_k \cdot [v_{ik}(x_{jk}) - v_{ik}(r_k)] & \text{if } x_{jk} \geq r_k \end{cases}$$

where $\lambda_k \geq \gamma_k \geq 0 \forall k$ and $r_k = g(x_{1k}, x_{2k}, \dots, x_{Jk})$. In order for this model to capture choice set dependency, the reference point for each attribute is designed to be a function of the attribute offerings. A reasonable assumption on $g(\cdot)$ is that the reference point is a weighted average of what is offered ², in other words, $r_k = \sum_{j=1}^J \rho_j x_{jk}$ where $\sum_{j=1}^J \rho_j = 1$. This formulation is general enough to allow for any reference point within the convex hull of the observed attributes.

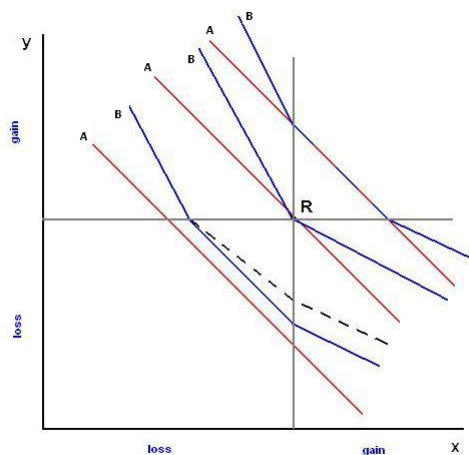
In sum, both the absolute level of consumption as well as the relative standing of a product matter for the overall utility of a product. This approach enables us to measure how important comparative evaluations are with respect to the utility from consumption alone. Moreover it allows us to study different aspects of comparative evaluations. The loss parameter, λ_k , captures the dis-utility of being in the losses compared to the reference point. When the losses are zero, the total utility equals the consumption utility. To capture the intuition of loss aversion, this parameter alone is sufficient. The gain parameter, γ_k , on the other hand, captures the increase in utility of being in the gains compared to the reference

¹When taking this model to data one may want to allow and test for diminishing sensitivity in the comparative utility.

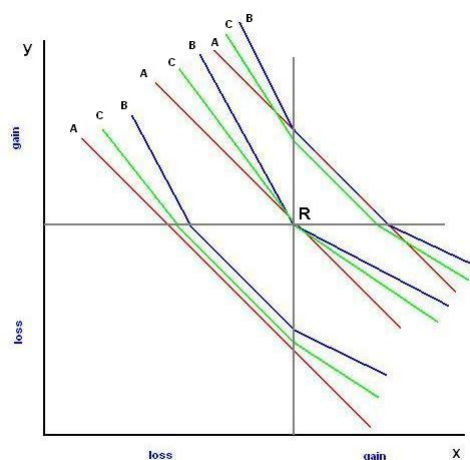
²The reference point can alternatively be formed such that the linear combination is not taken over attributes but the valuation of attributes. The two approaches are equivalent when utility is linear in attributes.

point. For example, in the price dimension, this reflects increased utility due to knowing that one paid less than one expected, in other words, some sort of a “deal effect”. When both the gain and the loss parameters are included, the ratio of these parameters capture how gains are weighed less than losses in the comparative evaluations.

Let me give an example, with linear valuations of attributes x and y , how the model parameters change indifference curves of a hypothetical consumer. In the first illustration in the following page, the linear indifference curves of a consumer under the standard model are labelled with the letter **A**. The indifference curves labelled as **B** represent the same utility level as their **A** counterparts in a model which introduces the loss parameters. At the reference point and in the domain of gains in both attributes, the indifference curves coincide. However, the level of utility decreases in regions of loss due to the introduction of loss aversion. Also, since the attribute sensitivities increase in the domain of losses, the slope of the indifference curves change across regions.



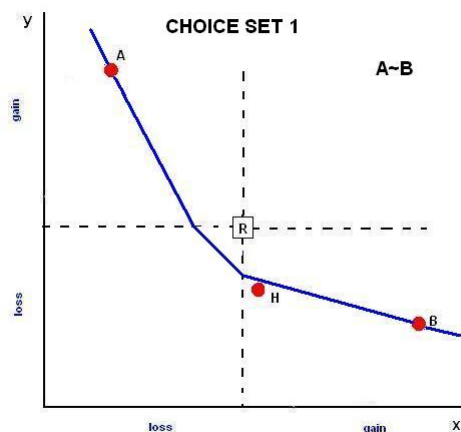
In the domain of losses in both attributes, the indifference curves reflect the overall decreased utility. If the loss parameters are the same for both attributes, the indifference curve in this domain is parallel to the standard one. However this does not need to be the case, as depicted by the dashed line, where the impact of losses in attribute x is lower than the impact of losses in attribute y . In regions



where the consumer perceives to be in losses only in one of the attributes, the consumer is more sensitive towards the attribute which is perceived to be in losses. The change of slopes across regions of gain and loss reflect this phenomenon. When the consumer has is sensitive to the disutility of losses, the level of utility of the consumer is lower than or equal to that in the standard case, resulting in the indifference curves to be enveloped by standard indifference curves.

The effect of gains in the comparative utility is twofold compared to a model only with losses. The attribute sensitivities are closer to that of the standard model and the level of utility is increased. The second illustration depicts an example of how the indifference curves may look under a model that considers gains as well as losses in the comparative utility. The indifference curves labelled as **C** illustrate how the utility changes compared to the standard model (**A**) or compared to a model with only loss sensitivity (**B**).

Given a choice set, the indifference curves change across regions of gain and loss, and the intensity of change is affected by the degree of reference dependency. The way in which choice set dependency gets factored into the model is through the reference point formation. We can show how changing the choice set leads to unstable preferences with a simple example, demonstrated in the following page. Consider two choice sets where the position of the products denoted with **A** and **B** are the same across choice sets, but the third product is shifted along

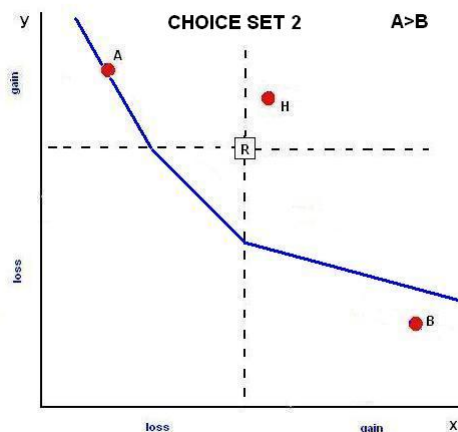


the vertical dimension. To the extent that the third alternative in the choice set, **H**, affects the reference point, the reference point is shifted along the vertical dimension as well. As a result of this change in the third alternative, ranking of alternatives **A** and **B** change.

This is due to the fact that losses loom larger than gains. Therefore the increase in losses (in the vertical dimension) for alternative **B** decreases its utility more than the same amount of decrease in gains does for alternative **A**. In this framework, within a choice set, indifference curves are parallel to each other. However, due to changes in the reference point, across choice sets, indifference curves may cross and thus preference reversals may occur.

In this framework the preferences will travel with the choice set, to the extent that changes in the choice set reflect on the reference point. The model can also be extended to allow the reference point to also be a function of determinants outside the choice set. This approach translates the classical utility model into a psychologically richer one without changing the core formulation, so if the consumers do not exhibit any context dependence in their preferences, the model reduces back to the standard model.

The model captures the empirical regularities labelled as extremeness aversion, asymmetric dominance and advantage effects, enhancement and detraction effects. It also explains the changes in the shares of two extreme options, as a



result of local changes in the middle option, which does not change the range of the attributes. Please see the Appendix for more details on how this utility framework captures the mentioned local context effects.

4. OPTIMAL MENU DESIGN WITH VERTICALLY DIFFERENTIATED CONSUMERS

Profit maximizing firms will take into account that the alternatives in the menu that are not targeted to a particular type of consumer are still going to influence her valuation of the alternative that is targeted to her, since it will define the relative standing of that alternative. This will result in a rich interaction of substitution, selection and spill-over effects. The following model incorporates these considerations, and offers an explanation to some product line strategies that are not in line with the current models.

Consider the case where a firm faces different consumer segments with different attribute sensitivities, however does not have information about a specific consumer's sensitivity. The firm can offer a menu of products, which leads the consumers to self-select into buying one of them. This problem has been studied extensively under the standard utility framework (Mussa and Rosen, 1978, Maskin and Riley, 1984).

Assume that the firm is offering one type of good with two attributes, which can be quality and price. Assume there are two segments of consumers, segment h has a higher valuation of quality over price compared to segment l . The firm wants to choose a menu of products that will elicit the types of consumers and extract the highest possible surplus.

Let q_l, q_h be the qualities that types l and h respectively buy, and p_l, p_h be the prices they pay for these alternatives. Then the firm's objective is to maximize

$$\Pi = \sum_{i \in L, H} \alpha_i (p_i - c(q_i))$$

where α_i is the proportion of type $i \in L, H$ consumers in the population. The marginal cost function $c(\cdot)$ equals zero when $q = 0$ and is assumed to be twice differentiable and strictly convex. Firm chooses the most profitable (p_l, q_l) and (p_h, q_h) it will offer if it finds it optimal to serve both segments. The utility of each type $i = l, h$ is

$$U_i(q, p | q_r, p_r) = \theta_i q - p + f_q(\theta_i q - \theta_i q_r) + f_p(p_r - p)$$

where

$$f_q(\theta_i q - \theta_i q_r) = \begin{cases} 0 & \text{if } q \geq q_r \\ -\lambda_q \theta_i (q_r - q) & \text{if } q < q_r \end{cases}$$

and

$$f_p(p - p_r) = \begin{cases} 0 & \text{if } p < p_r \\ -\lambda_p (p - p_r) & \text{if } p > p_r \end{cases}$$

The reference point for an attribute is a linear combination of all the level of attributes in the choice set³.

$$p_r = \eta_l p_l + \eta_h p_h$$

³This is a uni-reference model, where the reference point is formed by some weighting of the attribute levels observed in the choice set. The model can be extended to allow for different reference point formations for the evaluation of each alternative, if such an extension is behaviorally warranted.

where $\eta_l + \eta_h = 1$. As long as $\lambda_p > 0$, I assume $\eta_h > 0$, which preserves the effect of the choice set on the utility. The reference quality is formed similarly

$$q_r = \mu_l q_l + \mu_h q_h$$

where $\mu_l + \mu_h = 1$. If the consumers can be ordered in their relative valuations of quality versus money⁴, then the optimal quality provisions are increasing in these valuations. Thus in equilibrium, $q_l < q_r < q_h$ and $p_l < p_r < p_h$.

The consumers' outside utility is normalized to zero. This means that if a consumer is buying a product, it should provide at least zero utility. This is known as the Individual Rationality (IR) constraint. Also in equilibrium the firm wants each consumer to find the product intended for his/her type the most desirable in the product line. This is known as the Incentive Compatibility (IC) constraint. The firm maximizes its profits subject to these constraints. The IR constraint for the low type and the IC constraint for the high type are binding⁵ in this setup. The Individual Rationality (IR) constraint for the low type is

$$\begin{aligned} U_l(q_l, p_l | q_r, p_r) &\geq 0 \\ \Rightarrow \theta_l [q_l - \lambda_q (q_r - q_l)] - p_l &\geq 0 \end{aligned}$$

Note that the utility of the low type consumer is reduced for any given quality level due to the dis-utility she incurs from being in losses in quality. On the other hand, to the extent that being in gains in the price dimension makes consumers happier about their purchase, the utility is enhanced.

The Incentive Compatibility (IC) constraint for the high type is

$$\begin{aligned} U_h(q_h, p_h | q_r, p_r) &\geq U_h(q_l, p_l | q_r, p_r) \\ \Rightarrow \theta_h q_h - p_h - \lambda_p (p_h - p_r) &\geq \theta_h [q_l - \lambda_q (q_r - q_l)] - p_l \end{aligned}$$

⁴For this ordering to be preserved across the parameter space, the choice set dependency of preferences should not overwhelm type differences, Particularly, I assume that $\theta_h/\theta_l > (1 + \lambda_p \eta_l)(1 + \lambda_q \mu_h)$

⁵Please see appendix for why these sets of constraint are the only ones that bind.

which reflects increased utility from consuming the high end product due to gains in quality, and decreased utility due to losses in prices. It is worth noting that the IC constraint is easier to satisfy as the loss aversion in quality increases.

Therefore the prices that can be charged to the type l and type h consumers are

$$p_l = \theta_l[q_l - \lambda_q(q_r - q_l)]$$

and

$$p_h = \frac{1}{1 + \lambda_p \eta_l} \theta_h q_h - [\theta_h - (1 + \lambda_p \eta_l) \theta_l] (q_l - \lambda_q(q_r - q_l))$$

When we introduce disutility due to losses to the standard model, the price that can be charged for the low end product is decreasing in the loss parameter for the quality dimension. Similarly, the price that can be charged for the high end product is increasing in the loss aversion in quality, because of potential losses that the high type will incur if the high type pretends to be low type. In other words, it is easier to convince the high type not to pretend, without having to give a high information rent⁶. Compared to the standard model, the IC constraint becomes easier to satisfy, at given quality levels, because the high type would hate losses in quality more than the low type does.

The sensitivities are asymmetric, in the sense that the high types care more about marginal changes in the quality when he pretends to be low type, but his valuation of quality does not change for the product that is targeted to him. Therefore this model makes it easier for the firm to separate the high type without leaving too much rent on the table. This is the main difference between decreasing the differentiation between two types in the standard model and a model with loss aversion. The underlying preference structure of types shift with respect to their relative offers. A firm that has a naive model of context-independent preferences, and observes the relative valuation of types, will leave too much rent on the table, assuming that the high type will have the same high valuation if

⁶The information rent of the high type decreases in the loss aversion for quality. Information rent: $(\theta_h - \theta_l)q_l - \lambda_q(\theta_h - \theta_l)[q_r - q_l]$

it deviated to the low type's product. However the firm can use the existence of loss aversion to its advantage if it has the right model in mind.

Losses in prices, λ_p , can effectively be seen to make the high type consumers more price sensitive, thus reducing the price that can be charged for any given quality level.

Given how the prices change with the model parameters, let's now examine the optimal quality provisions. The firm's problem is to maximize profits with respect to quality levels for high and low types,

$$\begin{aligned} \max_{q_l, q_h} \Pi &= \sum_{i \in L, H} \alpha_i (p_i - c(q_i)) \\ \text{s.t. } IR &= 0, IC = 0 \end{aligned}$$

Proposition 4.1. *The inclusion of disutility due to losses results in an increase in the optimal quality provision of the low type compared to its counterpart in the standard model, due to the increased quality sensitivity of the low type, and the negative spill-over effect of its price on the profits extracted from the high type.*

Proof. We can characterize the optimal quality provision to type l implicitly as

$$c'(q_l) = \frac{(1 + \mu_h \lambda_q)(\theta_l - \frac{\alpha_h \theta_h}{1 + \lambda_p \eta_l})}{\alpha_l}$$

Since the marginal cost function is convex in q , we can see that the quality provision for the low type will be higher than the standard case and will increase in both loss aversion parameters. \square

Distortion at the bottom in the standard case is a result of the IC constraint of the high type. However in the current model, this effect is first dimmed by the loss aversion in prices, which increases the effective price sensitivity of the high type, and decreases the price that can be charged to this segments in proportion to the perceived losses and the effect of the low segment's price on the reference price.

Second, the loss aversion in quality puts a downward pressure on the revenues that can be extracted from the low type. Due to the loss in utility, the firm faces an upward pressure in the quality provision for the low type. At the same time,

loss aversion in quality results in a bigger dis-utility to the high type in case of deviating, which would mean that the firm could save on information rent by decreasing the quality provision of the low type. When the firm finds it profitable to have positive quality provisions to both segments,⁷, the overall effect of loss aversion in quality results in the incentive to increase the quality of the low type.

Proposition 4.2. *The inclusion of disutility due to losses results in a decrease in the optimal quality provision of the high type compared to its counterpart in the standard model, due to the increased price sensitivity of the high type, and the negative spill-over effect of its quality provision on the profits extracted from the low type.*

Proof. We can describe the quality provision to the high type with

$$c'(q_h) = \frac{\frac{\alpha_h \theta_h}{1 + \lambda_p \eta_l} - \mu_h \lambda_q (\theta_l - \frac{\alpha_h \theta_h}{1 + \lambda_p \eta_l})}{\alpha_h}$$

Loss aversion in quality reduces q_h since there is a positive externality on the utility of the low type, which overwhelms the increase in revenues from the reduction of information rent. Loss aversion in price reduces q_h since the effective price sensitivity of the high type is increased by loss aversion. \square

Proposition 4.3. *If the loss aversion in quality is large enough, then the firm will find it profitable to pool the two types.*

Proof.

$$c'(q_h) - c'(q_l) = \frac{\alpha_h (\frac{\theta_h}{1 + \lambda_p \eta_l} - \theta_l) - \mu_h \lambda_q (\theta_l - \frac{\alpha_h \theta_h}{1 + \lambda_p \eta_l})}{\alpha_l \alpha_h}$$

this difference will be positive only if

$$\mu_h \lambda_q < \frac{\alpha_h (\theta_h - \theta_l (1 + \lambda_p \eta_l))}{\theta_l (1 + \lambda_p \eta_l) - \alpha_h \theta_h}$$

⁷The firm finds profitable that segment l as well as segment h buy positive qualities in equilibrium, only when $\theta_l - (\alpha_h) \frac{\theta_h}{(1 + \lambda \eta)}$ is positive.

Since c' is convex, this shows that $q_h > q_l$ only when the above condition holds. If the loss aversion is big enough, quality provision to both types will be equal. \square

In the standard framework, the quality provision of the high type is strictly bigger than that of the low type, which is a result of the monopolist finding serving both types of consumers with different products always more profitable than serving all types with one product. However the loss aversion effects decrease the differentiation of two products. When the loss aversion in quality is large enough, $\mu_h \lambda_q > \frac{\alpha_h(\theta_h - \theta_l(1 + \lambda_p \eta_l))}{\theta_l(1 + \lambda_p \eta_l) - \alpha_h \theta_h}$, the firm may find it profitable to serve all segments only with one product. Although under the standard model for all parameters $f'(q_h) - f'(q_l) > 0$, due to loss aversion parameters, this may not be the case under this model. Increasing the price loss aversion decreases the difference between quality provisions, since effectively the quality sensitivity of the high type is reduced. Moreover, increasing the quality loss aversion, in cases where the effect of the high quality product on the quality reference is significantly high, decreases the spread between the two products. In fact, the monopolist might find it more profitable to offer only one product. Unlike the standard framework, loss aversion in quality might result in pooling in equilibrium. This is due to the fact that serving the high type with a separate product creates a negative influence on the utility of the low type. Existence of price loss aversion makes this even more severe, by decreasing the revenues extracted from the high type.

An important intuition is that the loss aversion in quality makes it harder for the high type to pretend to be the low type, however at the same time it decreases the revenues from the low type. When both segments are buying positive quality levels, the firm wants to decrease the quality reference point. Due to this spillover, we see that the quality provision to the high type is less than it would have been if the high type were the only consumer segment in the market. However price of high type can be higher than before, if λ_q is large, λ_p is small and the increase in q_l does not increase the information rent more than the potential losses due to loss aversion decreases it.

The existence of loss aversion in prices may look like the firm will serve the low type in more circumstances, since the revenues from the high type are not

as lucrative as in the standard case. However this intuition is wrong, since the spill-over effect of the low type's price offer to the high type's utility disappears when the low type is not served. This result highlights why this model is different than a model that simply changes the relative valuations of segments. A model with a lower valuation of the high type, and a higher valuation of the low type would also result in less differentiation. However the preferences would be stable across choice sets, and across alternatives within a choice set. However a model with context dependent preferences will result in non-stable valuation rules across alternatives and choice sets. This means that the high type will not have the same valuation of quality when consuming the product offered to the low type. Similarly, the consumer will not have the same preferences if they were presented with only one option rather than a menu. The first effect, as we discussed, leads to the firm leaving less information rent to the high type, but this effect is overwhelmed by the decrease in revenues from the low type, which decreases the attractiveness of serving the low type. The second effect, may result in pooling or may also decrease the incentives to serve the low type, since providing a positive quality option to the low type, with a lower price, induces price loss aversion for the high type, which would not happen with one option.

If in equilibrium, the low type is not served, the firm can charge a much higher price to the high type, not only because there would be no need for information rent, but also because the high type would not be in losses in the price.

Let's examine the decision to serve both types versus only the high type.

Proposition 4.4. *When the firm separates the low and high type, its profit decreases in the loss parameters, and is lower than its counterpart in the standard model.*

Proof. Loss aversion in both attributes decrease profits when the firm finds it profitable that both types consume positive amounts in equilibrium.

$$\frac{d\Pi}{d\lambda_p} = -\frac{\theta_h \alpha_h \eta_l}{(1 + \lambda_p \eta_l)^2} [q_h - q_l + \lambda_q (q_r - q_l)]$$

$$\frac{d\Pi}{d\lambda_q} = -(q_r - q_l) \left(\theta_l - \frac{\alpha_h \theta_h}{1 + \lambda_p \eta} \right)$$

When the firm serves only the high type, its profit is

$$\Pi_h = \alpha_h(\theta_h q_h^* - c(q_h^*))$$

where q_h^* is the socially optimal quality provision, s.t. $c'(q_h^*) = \frac{\theta_h}{c}$. This is the same profit as in the standard case, due to the fact that choice-set dependency disappears when there is just one product offered, since there are no available comparisons.

When the firm serves both types, its profit is

$$\begin{aligned} \Pi_{l,h} = & \alpha_h \left[\frac{\theta_h}{1 + \lambda_p \eta_l} q_h - \left(\frac{\theta_h}{1 + \lambda_p \eta_l} - \theta_l \right) (q_l + \lambda_q (q_r - q_l) - c(q_h)) \right] \\ & + \alpha_l [\theta_l (q_l - \lambda_q (q_r - q_l)) - c(q_l)] \end{aligned}$$

where the optimal quality provisions are as above. The firm will serve both segments only if $\Pi_{l,h} > \Pi_h$.

The gain from serving the low types is decreasing in the loss aversion in quality. The losses are the information rent, and the reduction in the high type's utility. There are two reasons why the firm may stop serving low types sooner than it would in the standard case⁸. The first is that the utility of the low type is decreased by the quality loss aversion, therefore the extra revenues from serving the low type may be lower. The second is that the existence of a provision for the low type has a negative externality on the revenues that can be extracted from the high type.

If we assume a quadratic functional form for the marginal cost function, such that $c(q) = (\omega_1 q + \omega_2 q^2)$, then we can compare the profits of serving both types under this model ($\Pi_{l,h}$), with the profits of serving both types under the standard model ($\Pi_{l,h}^{st}$).

$$\begin{aligned} \Pi_{l,h}^{st} - \Pi_{l,h} = & \frac{[\alpha_h \lambda_p \eta_l \theta_h + \lambda_q \mu_h (\theta_l (1 + \lambda \eta_l) - \alpha_h \theta_h)]}{4 \alpha_l \alpha_h \omega_2 (1 + \lambda_p \eta_l)^2} \\ & \cdot [\alpha_h (1 + \lambda_p \eta_l) (\theta_h - \theta_l) + \alpha_h (\theta_h - (1 + \lambda_p \eta_l) \theta_l) - \lambda_q \mu_h ((1 + \lambda_p \eta_l) \theta_l - \alpha_h \theta_h)] \end{aligned}$$

⁸Please refer to the Appendix for the conditions in the standard case.

Since for the firm to serve both types, rather than pool, we have $\mu_h \lambda_q < \frac{\alpha_h(\theta_h - \theta_l(1 + \lambda_p \eta_l))}{\theta_l(1 + \lambda_p \eta_l) - \alpha_h \theta_h}$, the expression above is always positive, and increasing in the loss aversion parameters λ_q and λ_p .

Therefore the firm will find it always less profitable to serve both segments under this model than it does under the standard model. \square

This result shows that there are cases where the firm would serve the low type consumers under the standard model, however stop serving this segment under this model. The reason is twofold. First, serving both segments is less profitable due to loss aversion in quality. Second, when both segments are served, the high type suffers losses in price. However when the firm only offers a product to the high segment, the high segment's relative quality valuation is increased compared to the case where the firm provides two products.

This result demonstrates that choice set dependent preferences differ from the standard framework in the way that the relevant utility functions will be different under different choice scenarios. The result highlights the “jump” in preferences when the choice set changes. This difference is the reason why the firm charges more to the high type due to increased punishment of deviation, sometimes stops serving the low type or pools the two types.

The general results that the firm's profits decrease with the magnitude of loss aversion, that the firm could pay less information rent to those segments above the quality reference point, that the firm decreases the range of its quality provisions and that the firm would restrict itself to serving the high type or pool different types in more cases carry over to scenarios with more than two segments of consumers.

5. EXTENSIONS

The framework with two segments of consumers demonstrates the main forces that affects the optimal product line design. There are two important extensions to the current model. The first is to examine how the generalization of the model to more than two types contributes to our understanding. Second is to study the

different strategies a firm can take if its consumers also have excess utility from perceived gains in an attribute, over and beyond the consumption utility.

5.1. Three Segments of Vertically Differentiated Consumers. The main forces that drive the product line strategies in the two segment case extend to cases with more consumer segments although the spill-over structure becomes more complex. A special feature of the two segment framework is that pooling or serving one segment less, both lead to elimination of choice set dependency, since the choice set reduces to one option. However the choice set dependency might have a much stronger impact on some quality provisions when for example the choice set reduces from three to two options. Moreover, in the framework with two segments, whether a product is in the loss or the gain region with respect to the reference point is stable. However, in a framework of three segments, the product targeted to the middle segment might be in the gain region for quality when there is a product targeted to the low segment, but will be in the loss region for quality if the firm does not serve the low segment. These differences will result in a richer set of product positioning possibilities.

It can be seen from the optimal quality provisions in a framework with three segments in the Appendix that when the firm serves more than one segment, the influence of one product's positioning onto other products' evaluations follow the same intuition as in the two-segment case. The firm may pool some types (middle and high) which would never be the case in the standard model. This "*pooling effect*" extends from the two segment case, due to negative influence the higher types' quality provisions have on the lower types' utilities. The same force will be an incentive to pool the middle type with the low type more often than in the standard case, as well as the incentive of the augmenting the utility of the high type.

Studying more than two types contributes to our intuition about the results of choice set dependency, since dropping only one type or pooling only two types does not bring us back to the standard model. It highlights strategies of firms that may seem unprofitable, if the choice set dependency is not taken into account,

such as carrying products solely for the purposes of perception management, which we labelled as the “*augmentation effect*”.

Augmentation Effect: In the previous section we’ve seen that the firm may manage choice set dependent valuations dropping the low segment. The following stylized example demonstrates how the choice set dependency might in fact incentivise the firm to serve more segments. When the loss aversion in quality is significant and the proportion of middle types is large, the firm might drop the low type less often than it would in the standard case, if serving the low type decreases the middle type’s losses in quality. This finding is a result of the intuition behind the findings of compromise effect.

Assuming a quadratic cost function, we can compare the decision to stop serving the low type under the standard framework, and compare it to a specialized case of this framework. This stylized example will highlight the features discussed above. We will concentrate on the effect of loss aversion in quality. Assume that when the firm offers three products, the reference point for quality is perceived to be below the quality provision of the middle type. Assume that type’s quality sensitivities are such that an equal proportion of consumer segments lead to the firm serving all segments if costs are zero, thus equal proportion of consumer segments is assumed.

In the standard framework, the firm will serve the low type if $K \equiv \Pi_{l,m,h}^{st} - \Pi_{m,h}^{st} > 0$, and similarly in our framework if $N \equiv \Pi_{l,m,h} - \Pi_{m,h} > 0$. Please see the appendix for the derivation of profits when the middle type’s quality level is above the reference point. If the firm would serve the low types in our framework in cases where the firm would have stopped serving them in the standard framework, we expect $N > K$. We find that

$$\begin{aligned} N - K = & \frac{\lambda_q}{6\gamma_2} \cdot ((3\theta_l - 2\theta_m)(\theta_h(\mu_m - \mu_h) - 2\theta_m\mu_m + \\ & (3\theta_l - 2\theta_m)(\mu_h(1 + \lambda_q\mu_h) + \beta\mu_h\mu_m + \mu_m(1 + \lambda_q\mu_m))) \\ & + \nu_h(2\theta_m - \theta_h)[2(\theta_h - \theta_m) - \lambda_q\nu_h(2\theta_m - \theta_h)]) \end{aligned}$$

where ν_h is the weight of the high type's quality provision on the reference quality when the low type buys no good in equilibrium. This expression increases in the loss aversion parameter λ_q , as well as ν_h . The bigger the ν_h , the higher the losses the middle type would be incurring if the firm did not serve the low type segment. When the weight of the low type's offer on the reference quality is approaching one, this expression will always be positive.

This example shows that in cases where segments size of the low type consumers are too small for the firm to find it profitable to serve them in the standard case, the firm may serve them in our framework. The firm provides a low quality product because its existence augments the utility of the middle type. This result parallels the compromise effect findings in the empirical literature. This can often be seen in the marketplace, as the cheapest wine induces sales of the second cheapest, and the worst cell phone option induces the sales of the next ones up.

A similar effect can be found for the positive influence the high end product has on the middle product, due to the decreased perceived losses in price. This influence increases the quality provision of the high type (see Appendix). When there are fixed costs to introducing products, a firm that may not find it profitable to serve the high type in the standard model, may do so due to its positive externalities on the middle type, if the proportion of the middle segment is very large.

5.2. Studying Gain Sensitivity. Having studied the results of loss aversion, let us extend the comparative utility to include utility from gains. It is an advantage that the model can incorporate the effects of introducing loss aversion and gain sensitivity separately, since these phenomena may occur independently. It is an empirical question whether the gain sensitivity is large enough to change the strategies of the firms. This section extends the strategy recommendations of the paper in cases where the firm can profit by managing the perceived gains of consumer segments. Since the effect of gains are smaller than the effect of losses, in many scenarios, this inclusion may not change the directional results in

optimal quality provisions. In cases where the directional results do not change, the magnitude of the results will be decreased.

The utility of each type $i = l, h$ is

$$U_i(q, p|q_r, p_r) = \theta_i q - p + f_q(\theta_i q - \theta_i q_r) + f_p(p_r - p)$$

where

$$f_q(\theta_i q - \theta_i q_r) = \begin{cases} \gamma_q \theta_i (q - q_r) & \text{if } q \geq q_r \\ -\lambda_q \theta_i (q_r - q) & \text{if } q < q_r \end{cases}$$

and

$$f_p(p - p_r) = \begin{cases} \gamma_p (p_r - p) & \text{if } p < p_r \\ -\lambda_p (p - p_r) & \text{if } p > p_r \end{cases}$$

In this setup, the Individual Rationality (IR) constraint for the low type is

$$\begin{aligned} U_l(q_l, p_l|q_r, p_r) &\geq 0 \\ \Rightarrow \theta_l [q_l - \lambda_q (q_r - q_l)] - p_l + \gamma_p (p_r - p_l) &\geq 0 \end{aligned}$$

Note that the utility of the low type consumer is reduced for any given quality level due to the dis-utility she incurs from being in losses in quality. On the other hand, to the extent that being in gains in the price dimension makes consumers happier about their purchase, the utility is enhanced.

The Incentive Compatibility (IC) constraint for the high type is

$$\begin{aligned} U_h(q_h, p_h|q_r, p_r) &\geq U_h(q_l, p_l|q_r, p_r) \\ \Rightarrow \theta_h [q_h + \gamma_q (q_h - q_r)] - p_h - \lambda_p (p_h - p_r) &\geq \theta_h [q_l - \lambda_q (q_r - q_l)] - p_l + \gamma_p (p_r - p_l) \end{aligned}$$

which reflects increased utility from consuming the high end product due to gains in quality, and decreased utility due to losses in prices. Although the loss aversion in quality makes the IC constraint easier to satisfy, the gains in price and quality weaken this effect.

The prices that can be charged to the type l and type h consumers are

$$p_l = [1 + \lambda_p \eta_l + \gamma_p \eta_h]^{-1} \{ (1 + \lambda_p \eta_l) \theta_l [q_l - \lambda_q (q_r - q_l)] \\ + \gamma_p \eta_h [\theta_h (q_h + \gamma_q (q_h - q_r)) - (\theta_h - \theta_l) (q_l - \lambda_q (q_r - q_l))] \}$$

and

$$p_h = [1 + \lambda_p \eta_l + \gamma_p \eta_h]^{-1} \{ \theta_h (1 + \gamma_p \eta_h) (q_h + \gamma_q (q_h - q_r)) \\ - [\theta_h - (1 + \lambda_p \eta_l) \theta_l + \gamma_p \eta_h (\theta_h - \theta_l)] (q_l - \lambda_q (q_r - q_l)) \}$$

The inclusion of gains parameters, in both dimensions, increase the price charged to the high type. It is straightforward that when the consumers care a lot about being in gains in quality, the high-end product will seem more attractive, and consumers will be willing to pay more for the same item. The gains in the price dimension puts an upward pressure on the prices charged for the high end product, to the extent that this product influences the reference price, in order to increase the utility of the low-type consumer for any given quality level. The net effect of gains in prices is positive on the price of the high end product. Although the IC constraint is harder to satisfy as γ_p increases, this effect is outweighed by the utility increase of the low type.

The inclusion of gain parameters affect the utility of the low type through the gain parameter in prices. The direct effect of γ_p on the price that can be extracted from the low type is positive, since it increases this segment's utility for any given quality-price bundle. The gains in quality, γ_q , also increase the low end price. This is an indirect effect through γ_p . Since the gains in quality increase the high end product's price, to the extent that the high price contributes to the reference price, the reference price is increased. This increases the perceived gains in prices for the low type consumer, thus increasing the price that can be extracted from them. Similarly, an increase in the loss aversion in prices, λ_p , will decrease the price that can be charged to the high type, which also decreases p_l . These effects only exist to the extent that γ_p is significant. The effect of losses in quality has a more intricate effect on the price of the low end product. It has a negative influence through the decreased utility due to losses in quality,

as discussed above, which makes the IR constraint harder to satisfy. However, on the other hand, since the losses in quality makes the IC constraint easier to satisfy for the high type, p_h increases, resulting in an increase in utility for the low type, to the extent that γ_p is significant. Therefore the net effect will depend on the sign of the term $[\gamma_p \eta_h (\theta_h - \theta_l) - \theta_l (1 + \lambda_p \eta_l)]$. As long as the loss aversion in prices is large enough compared to the difference in types or the effect of the high type's product on the reference price is small enough, $\frac{1 + \lambda_p \eta_l}{\gamma_p \eta_h} > \frac{\theta_h - \theta_l}{\theta_l}$, losses in quality will decrease p_l .

The total profits of the firm decrease with relative losses in the price dimension, and increase with relative importance of gains in both dimensions.

The optimal quality provisions can be described as

$$c'(q_l) = \frac{(1 + \mu_h \lambda_q) \theta_l (1 + \lambda_p \eta_l + \gamma_p \eta_h) - (\alpha_h + \gamma_p \eta_h) \theta_h (1 + \lambda_q \mu_h + \gamma_q \mu_l)}{\alpha_l (1 + \lambda_p \eta_l + \gamma_p \eta_h)}$$

$$c'(q_h) = \frac{(\alpha_h + \gamma_p \eta_h) \theta_h (1 + \lambda_q \mu_h + \gamma_q \mu_l) - \theta_l (\mu_h \lambda_q) (1 + \lambda_p \eta_l + \gamma_p \eta_h)}{\alpha_h (1 + \lambda_p \eta_l + \gamma_p \eta_h)}$$

Keeping the loss parameters constant, the quality provision of the high type increases with both gain parameters, and the quality provision of the low type decreases with both gain parameters.

As long as $(\theta_l \mu_h \lambda_q + \alpha_h \theta_h) (1 + \lambda_p \eta_l + \gamma_p \eta_h) > (\alpha_h + \gamma_p \eta_h) \theta_h (1 + \lambda_q \mu_h + \gamma_q \mu_l)$, the previous findings that the low type will receive more and the high type will receive less quality than they would under the standard model and that profits will be lower will carry through. If this condition is reversed, these observations will be reversed. Studying the effects of comparisons in each dimension separately, we find that this condition implies that the loss aversion parameters should be large enough compared to the gain parameters. In a case where the only comparisons are made on the quality dimension, the quality provisions will be compressed towards the reference point if $\frac{\lambda_q}{\gamma_q} > \frac{\mu_l \alpha_h \theta_h}{\mu_h (\theta_l - \alpha_h \theta_h)}$. Similarly, in a case where only the comparisons in the price dimension matter, the quality range will be compressed as long as the loss to gain ratio in prices is large enough compared to the ratio of consumer segments and the influence of their price on the reference price, $\frac{\lambda_p}{\gamma_p} > \frac{\alpha_l \eta_h}{\alpha_h \eta_l}$. The difference between the quality provisions can be implicitly described

as

$$f'(q_h) - f'(q_l) = [\alpha_l \alpha_h (1 + \lambda_p \eta_l + \gamma_p \eta_h)]^{-1} \{ (\alpha_h + \gamma_p \eta_h) \theta_h (1 + \lambda_q \mu_h + \gamma_q \mu_l) - \theta_l (\alpha_h + \mu_h \lambda_q) (1 + \lambda_p \eta_l + \gamma_p \eta_h) \}$$

Compared to a model with only the loss parameters, this difference is greater. The firm will find it profitable to pool both types if the loss aversion in quality is large enough. In a case where only the comparisons in quality matter, this translates to the condition that $\mu_h \lambda_q (\theta_l - \alpha_h \theta_h) > \alpha_h (\theta_h - \theta_l) + \alpha_h \theta_h \mu_l \gamma_q$. Due to the gains parameter in quality dimension, this condition will be satisfied less easily than in the case with just loss parameters. In general, the condition for pooling is, $\theta_l (\alpha_h + \mu_h \lambda_q) (1 + \lambda_p \eta_l + \gamma_p \eta_h) \geq (\alpha_h + \gamma_p \eta_h) \theta_h (1 + \lambda_q \mu_h + \gamma_q \mu_l)$, which is made easier by the loss aversion in the price dimension, if $\frac{\lambda_p}{\gamma_p} > \frac{\alpha_l \eta_h}{\alpha_h \eta_l}$.

An intuitive result when the gain sensitivity in the quality dimension as well as the proportion of the high type segment is high is that the firm may keep serving the low end segment in cases where under the standard model it would not have found it optimal to do so.

6. DISCUSSION AND CONCLUSION

The goal in this paper was to fill the gap between our understanding of the actual behavior of consumers and our optimal product line strategies. The relevance of examining the strategic implications of reference-dependence has been touched upon recently (Narasimhan et al., 2005). To this end, a fully specified model of choice set dependent preferences which can accommodate existing evidence was suggested. The building block of the utility model is that the consumers care about comparative utility as well as consumption utility and that the comparative utility is defined with respect to a reference point which is endogenously formed by the choice set. The focal point of the paper is the proposal that a firm facing different segments of consumers it would like to separate, should realize the potential to manage the utility of consumers through the product line it offers.

The paper concentrates on the prediction of choice when formulating a utility framework. There may be many reasons for choice-set dependency (Sen, 1997).

The main focus is to use the predictive choice model to provide insight into optimal mechanism design problems, where the principal is offering a list of options to induce self-selection of agents, who have choice-set dependent preferences. The paper highlights new strategies provided by this model which depart from the predictions of the standard model.

Contrary to a model which does not consider choice set dependency, it suggests that the quality provision for the highest types will be different depending on whether this segment is served alone or with other segments. This effect is due to the negative influence of the high types' product on the utility of types that are in "losses" in quality. This distortion at the top is a novel effect. Following the same spill-over reasoning, the quality provision to the low types will be higher as the loss aversion parameters increase. This "compression effect" increases as the loss aversion in choice set dependency becomes stronger.

The firms might find pooling to be profitable if the disutility from loss aversion is high enough. This result is also contradictory to the standard strategy recommendations, since pooling is never optimal under the standard model.

It also provides insight to when the choice set dependency will result in more or less products in a product line. It finds support for carrying products whose only purpose is to manage the relative standing of key segments' products in a favorable way. For the same reason, those products that have a negative influence on the relative standing of important segments may be dropped. This "augmentation effect" underlines how the firm can increase the profits it can extract from some segments by managing the existence of products for other segments.

The model provides evidence that choice set dependence of preferences can lead to marketplace outcomes that are distinct and highlights the importance and need to take such effects into account when studying demand or strategic decisions of firms. For example, allowing for such effects will be crucial when a firm knows the attribute sensitivities in a given choice set and would like to predict behavior in other choice sets. The firm would leave money on the table if it naively projects the local tradeoff in attributes to other regions of gain and loss. The model provides a profitable tools for firms in their product line

decisions. It also demonstrates how the marketplace changes as a result of choice set dependency on the consumers' side.

Several aspect of the model fall short of an ideal formulation, since some of the assumptions are based on intuition rather than direct evidence. These aspects can be refined with further empirical evidence. For example, the reference point formation is modelled as a linear combination of the alternatives in the choice set. This formulation can be extended to take past experiences or expectations into account. The reference point may be comprised of prior reference points, sales messages and additional information (Puto, 1987). However, as long as the firm knows where the reference point is and how it moves with the changes in the choice set, the reference point does not have to be in the convex hull of the alternatives for the general results of the model to go through.

Another assumption on the reference point formation is that the reference point is perceived to be the same for each segment and the weights are exogenously determined. If the reference point is determined by the product that sells the most, or if it is determined by the products the consumer did not buy, this assumption will not hold. Although the details of the model will change, the qualitative results will be similar. For example, a model that constructs the reference point by the products a consumer did not buy (counterfactual thinking) will exaggerate the effects. The way people construct the reference point is an important research question. The strategic implications of the model rest on basic forces that generalize across different reference point formation assumptions.

Also, this research has considered cases where the consumers have perfect information about the attribute levels. One direct extension would be studying product line design under uncertainty of attribute levels. Then the choice set may be influential in providing information to consumers, which may change the evaluability of options (Hsee, 1996).

The consideration set is assumed to be the product line. Moreover, the consumers are assumed to have one global consideration set. However the firm may want to induce local consideration sets in favor of the more profitable options (Simonson, Nowlis, Lemon, 1993). A more dynamic formation of the reference point will allow such considerations.

Finally, the model also assumes that the sensitivity to the comparative utility in an attribute with respect to the comparative utility in other attributes for a given consumer, is proportional to the attribute sensitivity ratios. In other words, a consumer that is more quality sensitive than other consumers is also more sensitive to losses and gains in quality than other consumers. Although this assumption follows the common intuition behind earlier work, it was not based on direct evidence in this paper. This is another area of empirical research that has direct implications for the assumptions of this model.

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7. APPENDIX

7.1. How the proposed utility framework captures local context effects.

Compromise effect can be captured with a model that uses the average of observed attributes in the choice set, which will set the reference point closer to the intermediate option than the extreme options. Since losses loom larger than gains, the consumer would prefer to incur very small losses (or none at all) and very small gains around the reference point, rather than to incur a big loss and a big gain. When extremeness aversion is exhibited only towards one attribute, this effect is called polarization, which can be captured by allowing the loss aversion parameters to be attribute specific. The way that the model captures the extremeness aversion findings is in the same spirit of the loss aversion model proposed by Kivetz, Netzer, and Srinivasan (2004).

Detraction and Enhancement effects can also be explained by the proposed model. In Figure 2, F is likely to be in the gain region for both attributes compared to the reference point generated by the choice set $\{A,B,F\}$, and G is in the loss region (albeit small) for both attributes compared to the reference point generated by $\{A,B,G\}$, where A and B have losses in one attribute and gains in another. However in binary comparisons, for example $\{A,F\}$, both A and F have losses in one attribute and gains in another. The fact that F fares better in $\{A,B,F\}$ than in both binary comparisons suggests that the consumers exhibit loss aversion in both attributes. The fact that detraction is observed suggests that the small losses on both dimensions are causing bigger disutility than a bigger loss and a bigger gain in either dimension, which calibrates the model's parameters. This effect cannot be captured with a linear comparative utility, and rests on the degree of its concavity.

Asymmetric advantage and asymmetric dominance effects can also be captured by this model. For example, in Figure 3, the addition of E pulls the reference point in "attribute y" up, and slightly decreases the reference point in "attribute x". This reduces the perceived losses in "attribute x" associated with the purchase of A, and increases the perceived losses in "attribute y" associated with purchasing

B. Similarly, the addition of D decreases the reference point in "attribute y", which decreases B's losses, and this decrease is more utility enhancing than the increase in gains in the same dimension for alternative A. Therefore B's relative share increases.

In a recent study (Orhun, 2005), consumers demonstrated sensitivity to the position of the intermediate option when evaluating the relative attractiveness of the extreme options, as depicted in Figure 4. Alternative A's relative share to alternative B was increased when the intermediate option was either X or S, and decreased when the intermediate option was Y or T. This finding supports the proposed model that weights all the attributes present in a choice set, rather than using the range to determine the reference point. As demonstrated, the proposed utility function is flexible enough to capture the documented context effects, and can be used for estimation of how the consumer preferences are affected by the choice set.

7.2. IR constraint for the high type is slack. Information rent is positive.

7.3. IC constraint for the low type with respect to the high type's product is slack. We need to show that

$$\theta_l[(1 + \lambda_q)q_l - \lambda_q q_r] - p_l + \gamma_p(p_r - p_l) > \theta_l[(1 + \gamma_q)q_h - \gamma_q q_r] - p_h - \lambda_p(p_h - p_r)$$

Note that $p_r = \eta_l p_l + \eta_h p_h$. Therefore equivalently we need to show that

$$(p_h - p_l)(1 + \gamma_p \eta_h + \lambda_p \eta_l) > \theta_l([(1 + \gamma_q)q_h - \gamma_q q_r] - [(1 + \lambda_q)q_l - \lambda_q q_r])$$

Due to IR_l and IC_h^l ,

$$p_l = \frac{1}{1 + \lambda_p \eta_l + \gamma_p \eta_h} \{ (1 + \lambda_p \eta_l) \theta_l [q_l - \lambda_q (q_r - q_l)] - \gamma_p \eta_h [\theta_h (q_h + \gamma_q (q_h - q_r)) - (\theta_h - \theta_l) ((1 + \lambda_q) q_l - \lambda_q q_r)] \}$$

and

$$p_h = \frac{1}{1 + \lambda_p \eta_l + \gamma_p \eta_h} \{ \theta_h (1 + \gamma_p \eta_h) (q_h + \gamma_q (q_h - q_r)) - [\theta_h - (1 + \lambda_p \eta_l) \theta_l + \gamma_p \eta_h (\theta_h - \theta_l)] ((1 + \lambda_q) q_l - \lambda_q q_r) \}$$

We have

$$(1 + \lambda_p \eta_l + \gamma_p \eta_h)(p_h - p_l) = \theta_h(q_h + \gamma_q(q_h - q_r) - (q_l - \lambda_q(q_r - q_l)))$$

By assumption on the type ordering,

$$\theta_h(q_h + \gamma_q(q_h - q_r) - (q_l - \lambda_q(q_r - q_l))) > \theta_l(q_h + \gamma_q(q_h - q_r) - (q_l - \lambda_q(q_r - q_l)))$$

7.4. Standard Model, 2 segments.

$$p_l = \theta_l q_l$$

$$p_h = \theta_h q_h - (\theta_h - \theta_l) q_l$$

$$c'(q_l) = \frac{(\theta_l - \alpha_h \theta_h)}{\alpha_l}$$

$$c'(q_h) = \theta_h$$

7.5. Standard Model, 3 segments.

$$p_l = \theta_l q_l$$

$$p_m = \theta_m q_m - (\theta_m - \theta_l) q_l$$

$$p_h = \theta_h q_h - (\theta_h - \theta_m) q_m - (\theta_m - \theta_l) q_l$$

$$c'(q_l) = \frac{(\theta_l - (\alpha_h + \alpha_m) \theta_m)}{\alpha_l}$$

$$c'(q_m) = \frac{((\alpha_h + \alpha_m) \theta_m - \alpha_h \theta_h)}{\alpha_l}$$

$$c'(q_h) = \theta_h$$

7.6. Three Segments, Choice set dependency. The IC constraints are downward binding, and IR of the lowest type binds, as long as the order of valuations are preserved, similar to before.

When $q_m < q_r$, and $p_m < p_r$ we can characterize the prices that each type is charged as

$$p_l = \theta_l(q_l - \lambda_q(q_r - q_l))$$

$$p_m = \theta_m(q_m - \lambda_q(q_r - q_m)) - (\theta_m - \theta_l)(q_l - \lambda_q(q_r - q_l))$$

$$p_h = \frac{1}{(1 + \lambda_p(1 - \eta_h))} [\theta_h q_h + (\theta_h - \theta_m(1 + \lambda_p \eta_m))(q_m - \lambda_q(q_r - q_m)) \\ + (\theta_m(1 + \lambda_p \eta_m) - \theta_l(1 + \lambda_p(1 - \eta_h)))(q_l - \lambda_q(q_r - q_l))]$$

and when $q_m > q_r$, and $p_m > p_r$ the prices are

$$p_l = \theta_l(q_l - \lambda_q(q_r - q_l))$$

$$p_m = \frac{1}{(1 + \lambda_p \eta_l)(1 + \lambda_p)} [(1 + \lambda_p)\theta_m q_m + \theta_h \eta_h \lambda_p(q_h - q_m) \\ - (1 + \lambda_p)(\theta_m - \theta_l(1 + \lambda_p \eta_l))(q_l - \lambda_q(q_r - q_l))]$$

$$p_h = \frac{1}{(1 + \lambda_p \eta_l)(1 + \lambda_p)} [\theta_h(1 + \lambda_p(1 - \eta_m))q_h - \theta_m q_m(1 + \lambda_p) \\ - (\theta_m - \theta_l(1 + \lambda_p \eta_l))(q_l - \lambda_q(q_r - q_l))]$$

When $q_m < q_r$ and $p_m < p_r$, the optimal quality provisions can be implicitly expressed as

$$c'(q_l) = \frac{1}{\alpha_l(1 + \lambda_p(1 - \eta_h))} \{\theta_l(1 + \lambda_p(1 - \eta_h))(1 + \lambda_q(1 - \mu_l)) \\ + \theta_h \alpha_h \mu_l \lambda_q - \theta_m(1 + \lambda_q)[\alpha_h(1 + \lambda_p \eta_m) + \alpha_m(1 + \lambda_p(1 - \eta_h))]\}$$

$$c'(q_m) = \frac{1}{\alpha_m(1 + \lambda_p(1 - \eta_h))} \{\theta_m(1 + \lambda_q)[\alpha_h(1 + \lambda_p \eta_m) + \alpha_m(1 + \lambda_p(1 - \eta_h))] \\ - \theta_l \lambda_q \mu_m(1 + \gamma_p)(1 + \lambda_p(1 - \eta_h)) - \theta_h \alpha_h(1 + \lambda_q(1 - \mu_m))\}$$

$$c'(q_h) = \frac{\alpha_h \theta_h(1 + \lambda_q \mu_h) - \lambda_q \mu_h \theta_l(1 + \lambda_p(1 - \eta_h))}{\alpha_h(1 + \lambda_p(1 - \eta_h))}$$

and when $q_m > q_r$, and $p_m > p_r$

$$c'(q_l) = \frac{1}{\alpha_l(1 + \lambda_p \eta_l)} \{\theta_l(1 + \lambda_q(1 - \mu_l))(1 + \lambda_p \eta_l) - \theta_m(\alpha_h + \alpha_m)(1 + \lambda_q(1 - \mu_l))\}$$

$$c'(q_m) = \frac{1}{\alpha_m(1 + \lambda_p \eta_l)(1 + \lambda_p)} \{(\alpha_h + \alpha_m)\theta_m(1 + \lambda_p)(1 + \lambda_q \mu_m) \\ - \theta_h[\alpha_h(1 + \lambda_p \eta_l) + \eta_h(\lambda_p(1 - \alpha_l))] - \theta_l \lambda_q \mu_m(1 + \lambda_p)(1 + \lambda_p \eta_l)\}$$

$$c'(q_h) = \frac{1}{\alpha_h(1 + \lambda_p\eta_l)(1 + \lambda_p)} \{ \theta_h[\alpha_h(1 + \lambda_p\eta_l) + ((1 - \alpha_l)\eta_h\lambda_p)] \\ + \theta_m(1 + \lambda_p)\mu_h(1 - \alpha_l)\lambda_q - \theta_l\lambda_q\mu_m(1 + \lambda_p)(1 + \lambda_p)\eta_l \}$$

Note that when $q_m < q_r$, the externality of increasing quality on the profits is more negative, therefore the quality provisions are dampened by bigger amounts. This is due to the fact that increasing the quality reference now hurts the middle type's utility, and this effect never overwhelms the decreased information rent from the high type as a result.

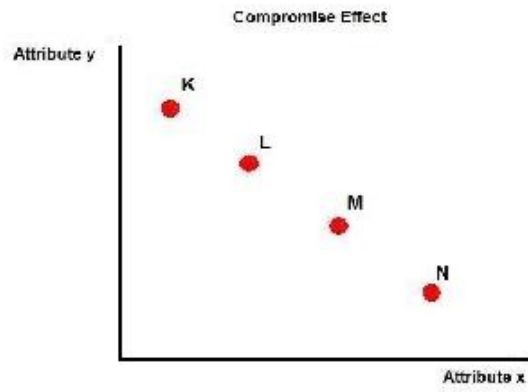


FIGURE 1. Compromise Effect

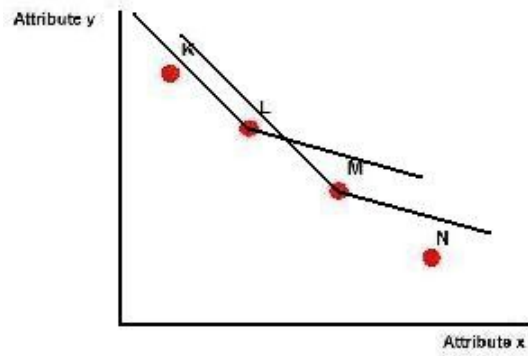


FIGURE 2. Capturing Compromise Effect

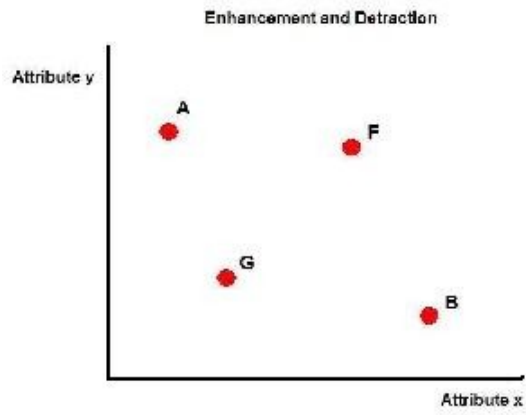


FIGURE 3. Enhancement and Detraction

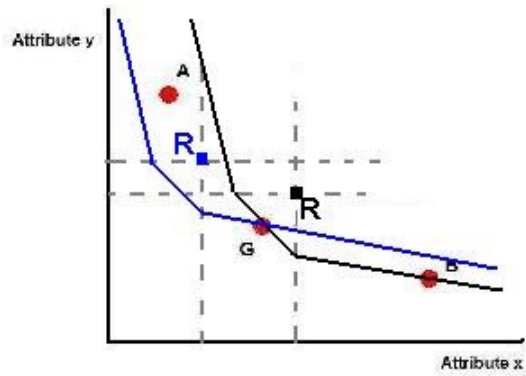


FIGURE 4. Capturing Enhancement

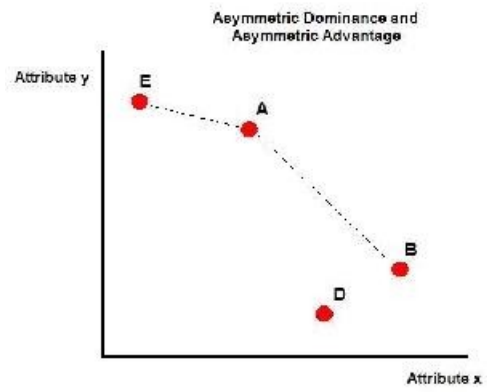


FIGURE 5. Asymmetric Dominance and Asymmetric Advantage

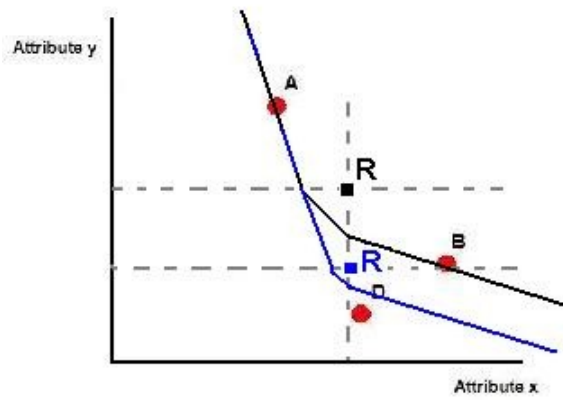


FIGURE 6. Capturing Asymmetric Dominance

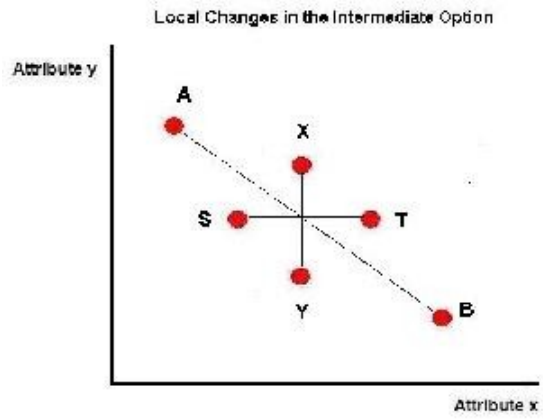


FIGURE 7. Local Changes in the Intermediate Option