Minimized Regret is Sufficient to Model the Asymmetrically Dominated Decoy Effect

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The "decoy effect" is a well known phenomenon in marketing, where consumer behaviour defies logical decision making. In this paper a simple mathematical model is developed to show that such consumer dynamics may be replicated with minimal prior assumptions. Although results may be extended to study many brands with multiple qualities, the model is not designed to fully explain choice dynamics but rather to indicate that the need to critically evaluate more complex models currently in use where the incorporation of additional factors fails to bring about additional new dynamics (the application of "Ockham's razor").

Keywords: Brand selection, Decoy effect, Mathematical model, Minimized regret.

Introduction

Decision making between brands (or other alternatives) is simple if one brand dominates all others, that is, if it is superior to them in all relevant qualities. Brands usually out-perform each other on different qualities, resulting in a trade-off between successfully competing brands. If the evaluation of different brands is completely rational, then any option which is completely inferior to at least one other would be immediately dismissed as irrelevant, and not affect any decision. It has been shown, however, that such options may profoundly influence preferences (Payne *et al.* 1992). The decoy effect occurs when the choice between two superior alternatives is influenced by an inferior alternative (Huber *et al.* 1982).

Consider two brands A and B, which are evaluated by consumers for two distinct qualities (pack price and contents quantity, for example), and that trade-off successfully. By this we mean that each out-performs the other brand on one quality dimension, but is inferior in the other quality dimension. The introduction of a new brand C, which is dominated by both existing brands (perceived as inferior in all quality dimensions to both) does not bring about a significant shift in market share – indeed, such a brand might be expected to fail and take no market share at all. Contrary to rational evaluation, however, an asymmetrically dominated brand (inferior in both quality dimensions to only one of the other brands) may produce a significant shift in market share. The brand that out-performs the new brand on both quality dimensions – referred to as the target brand A – gains market share, at the expense of the alternative brand (the competitor brand B) which out performs the new brand on only one quality. Indeed, the new "decoy" brand C may itself gain only a relatively insignificant market share. This contradicts the "normative choice" model, which predicts a reduction in the preference share of all brands (Luce 1959).

The decoy effect has been observed in practice in a wide variety of consumer products including chocolate bars, televisions and beer (for a review see Heath and Chatterjee 1995). Preference reversal has been achieved in experiments on candidate choice (Highhouse 1996) and analogous effects have been found in, amongst others, gambling (Wedell 1991), policy decisions in a political context (Herne 1997) and consumer choice in travel and tourism (Josiam & Hobson 1995). Similar results have also been obtained concerning predation rates in theoretical models of predator-prey interactions (Wilkinson 2003), and experimental work with humming birds has shown that they appear not to adopt an absolute evaluation mechanism (Bateson *et al.* 2002) (although classic decoy behaviour did not occur in this experiment). The effect can be strong even when no numerical attribute is presented and consumers have to infer quality values in order to make choices (Slaughter *et al.* 1999).

In a study of contextually induced preference reversal models (Wedell 1991), a direct effect of dominance was favoured over the possibility of dimensional weight adjustment. This may be a result of loss aversion (Highhouse 1996), where the decoy is used as a reference point from which to judge other brands. It is well known that negative attributes are over-weighed by consumers (Meyer & Johnson 1995), and the above results therefore indicate that it may be appropriate to first consider a consumer's attempt to minimize the expected regret in any brand choice model. A consumer taking a minimized regret approach prioritizes reducing the potential for disappointment in any choice over finding the best brand.

This paper sets out to show that apparently complicated consumer dynamics may be driven by very simple behaviour rules. The models developed below are the result of a problem presented to the 49th European Study Group with Industry by representatives Unilever. They are just one type from amongst a number suggested (the development of other approaches is work in progress). Indeed, results given here should in no way be taken to imply that complex models are not needed to describe the many underlying processes that occur in a realistic way, but rather to show that certain global trends may be described by simple modes. Thus it should not automatically be assumed that any sophisticated behaviour exhibited by a model is necessarily dependent upon all the complexities included: the addition of each new feature should be justified through the production of new results.

Consumer preference model

Any model determining a brand's market or consumer preference share requires two key components. Firstly, a description of how a consumer's preference moves from one brand towards another. Secondly, a model of the decision making processes driving these changes is required, describing how strong the switch from one particular brand to another is at any time. The rate at which such a transfer occurs is called the "flux" between brands. Here we consider only linear flux between brands, based upon their quality values. Thus we assume that the transfer rate between brands is proportional to preference share each brand holds at any given time. In this way it can be seen whether more complex assumptions are genuinely necessary to produce dynamics such as the decoy effect. Such factors could include loyalty or peer influence, which will strongly depend on the current size of a brand's customer base, or advertising, which may not.

Consider a consumer whose preference is shared out amongst all the available brands in a market, so that the total of all brands' preference share adds up to 1 (100%). The proportion of consumer preference held by brand X at time t is denoted by $X(t)$, since there is no danger of confusion between the two. For example, in a market where only two brands exists, the preference share of brand A plotted against brand B must lie somewhere along the straight line $B = 1 - A$: see Figure 1(left).

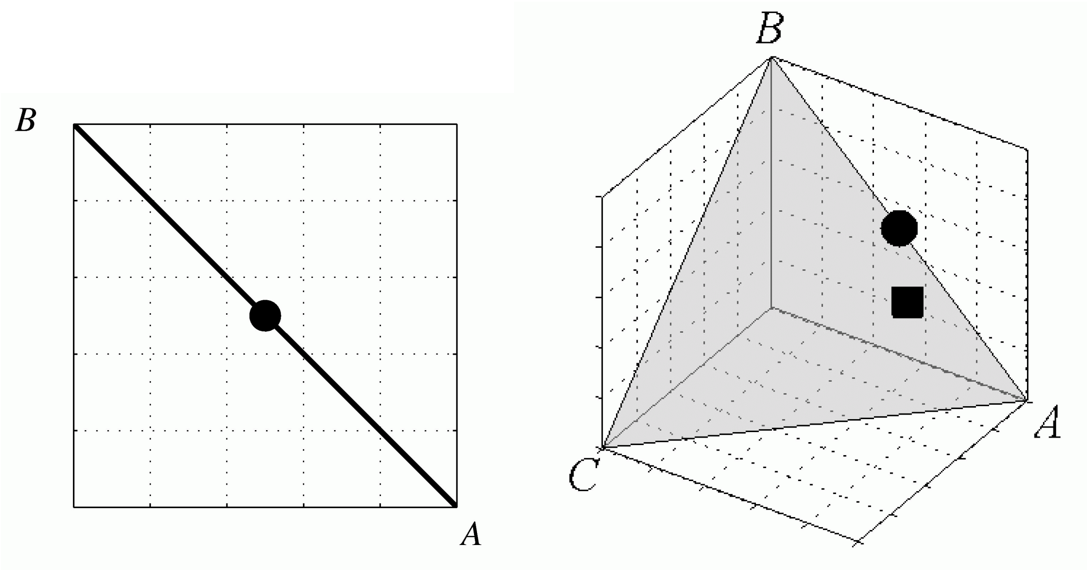

Figure 1. Preference share between two and three brands in a fixed size market.

(left) The preference share of brand A plotted against that of brand B with a circle: for a market place of only two brands, the preference shares will satisfy $A+B=1$, with any changes in proportion being restricted to movement up and down the line.

(right) If a third brand is introduced so that the market is shared in three ways, then brands move onto the plane $A+B+C=1$ in three dimensions: the preference distribution (A,B,C) is plotted with a square. For n separate brands this becomes a $n-1$ dimensional surface in n dimensional space.

Of interest is the case when a third brand is added, possibly as a decoy. The additional brand means that the preference distribution changes from being a straight line in the two dimensional plane (A,B), to a flat plane in three dimensional space (A,B,C): see Figure 1 (right). A successful decoy brand will increase the target brand A's preference share; at the very least a new brand C should result in a reduction in the competitor B's preference share, so that overall own-brand preference share ($A+C$) is increased. In the orientation given in Figure 1, this means moving off the line on the back wall (the (A,B), or alternatively the $C=0$, plane), preferable right ways (increasing A) or at least downwards (decreasing B), while staying on the plane.

Model for switching between brands

In this section the simplest reasonable model to describe changes in brand preference share is developed. Consider a linear flux α_{XY} of preference moving to brand X from brand Y: this is the proportion of a consumer's preference currently given to Y which is switching to X, per unit time, and is distinct from the market share each brand attains (see below). In this *linear* model α_{XY} is independent of X and Y and all that is assumed is that $\alpha_{XY} \geq 0$. We do not need to consider negative flux α_{XY} since there already exists a flux in the opposite direction, α_{YX} . The fluxes are defined explicitly in section 2.3 below.

In a two brand market the resultant differential equations are:

$$\begin{aligned} \frac{dA(t)}{dt} &= -\alpha_{BA} A(t) + \alpha_{AB} B(t), \\ \frac{dB(t)}{dt} &= +\alpha_{BA} A(t) - \alpha_{AB} B(t), \end{aligned} \tag{1}$$

together with

$$A(t) + B(t) = 1. \tag{2}$$

Note that the system is over-determined: only one of equations (1) together with (2) is required to solve for the behaviour of the system. Upon introduction of a third brand into the market, the system will be governed by

$$\begin{aligned} \frac{dA(t)}{dt} &= -(\alpha_{BA} + \alpha_{CA}) A(t) + \alpha_{AB} B(t) + \alpha_{AC} C(t) \\ \frac{dB(t)}{dt} &= +\alpha_{BA} A(t) - (\alpha_{AB} + \alpha_{CB}) B(t) + \alpha_{BC} C(t) \\ \frac{dC(t)}{dt} &= +\alpha_{CA} A(t) + \alpha_{CB} B(t) - (\alpha_{AC} + \alpha_{BC}) C(t) \end{aligned} \tag{3}$$

together with

$$A(t) + B(t) + C(t) = 1, \tag{4}$$

where again only two out of the three equations (3) are required with (4) to determine the full solution behaviour. As a result the model could be reformulated in terms of a single lumped own brand (AC) and a competitor brand (B), but this would obscure any dynamics such as the decoy effect and be inappropriate when attempting to model the preference fluxes between individual brands, which would incorporate the different locations of each in quality space (see Section 2.3).

Market share

Henceforth we exclude the case where all fluxes are zero, since this is trivial. It may be shown that all solutions (for all nonzero initial conditions, which include any satisfying (2)) converge to a unique equilibrium. This may be found by setting

$$\frac{dA(t)}{dt} = \frac{dB(t)}{dt} = 0,$$

in (1) and solving the simultaneous equations given by this and (2):

$$\alpha_{BA} A = \alpha_{AB} B, \quad A + B = 1.$$

For the two brand market place this gives:

$$\left(\bar{A},\bar{B}\right)=\left(\frac{\alpha_{AB}}{\alpha_{AB}+\alpha_{BA}},\frac{\alpha_{BA}}{\alpha_{AB}+\alpha_{BA}}\right). \tag{5}$$

Since $(\bar{A},\bar{B})$ is a globally attractive stable equilibrium, it may be considered as representing the market share of each brand. This is independent of transient changes in preferences and the result of consumer preferences being expressed through purchases. Transient effects are of course important when introducing a new brand (Wright & Sharp 2001) but not appropriate candidates for study in simpler models.

The system (3), (4), also converges to a globally attractive stable equilibrium, giving the market share of each brand as:

$$\begin{aligned}\left[\hat{A},\hat{B},\hat{C}\right]= \quad & \left[\alpha_{AC}\alpha_{CB}+\alpha_{AC}\alpha_{AB}+\alpha_{AB}\alpha_{BC},\alpha_{BA}\alpha_{AC}+\right.\\ & \left.\alpha_{BA}\alpha_{BC}+\alpha_{BC}\alpha_{CA},\alpha_{CA}\alpha_{AB}+\alpha_{CA}\alpha_{CB}+\alpha_{CB}\alpha_{BA}\right] \quad /S_{\alpha},\end{aligned} \tag{6}$$

where

$$\begin{aligned}S_{\alpha} \quad = \quad & \alpha_{AC}\alpha_{CB}+\alpha_{AC}\alpha_{AB}+\alpha_{AB}\alpha_{BC}+\alpha_{BA}\alpha_{AC}+\\ & +\alpha_{BA}\alpha_{BC}+\alpha_{BC}\alpha_{CA}+\alpha_{CA}\alpha_{AB}+\alpha_{CA}\alpha_{CB}+\alpha_{CB}\alpha_{BA}.\end{aligned}$$

Here the fluxes α_{XY} represent the decision making process (see section 3) with the steady states being the long term outcome, namely the proportion of each brand actually purchased. Thus the model allows for significant preference flux between brands (large α_{XY}) while market shares ($\hat{X}$) may remain constant. In the context of decoy behaviour, there may be a large flux towards brand C without necessarily resulting in a significant market share $\hat{C}$. This is because even if the fluxes towards C (α_{CA} and α_{CB}) are large, the eventual market share (steady state solution) may be small if the fluxes away from C (α_{AC} and α_{BC}) dominate.

Criteria for successful decoy effect

The assumption that consumers' preference shares of all the available brands always add to 1 implies that no preference is withheld: for example, in expectation of a currently unavailable brand. Thus the total market size is independent of the number of brands, and new brands are not capable of introducing new customers, i.e.

$$\bar{A}+\bar{B}=\hat{A}+\hat{B}+\hat{C}=\tilde{A}+\tilde{B}+\tilde{C}+\tilde{D}=\ldots=1.$$

To improve sales of the target brand A through the introduction of a third brand C requires $\hat{A}>\bar{A}$, which is satisfied, using (5) and (6), if and only if

$$\alpha_{AC}\alpha_{CB}\alpha_{BA}>\alpha_{CB}\alpha_{BA}\alpha_{AB}+\alpha_{AB}\alpha_{BC}\alpha_{CA}+\alpha_{CA}\alpha_{AB}\alpha_{CB}+\alpha_{CA}\alpha_{AB}^{2}. \tag{7}$$

To increase overall market share of own brands ($A+C$) requires a reduction in the competitor brand, $\hat{B}<\bar{B}$, which is satisfied if and only if:

$$\alpha_{AB}\alpha_{BC}\alpha_{CA}<\alpha_{AC}\alpha_{BA}\alpha_{CA}+\alpha_{BA}\alpha_{AC}\alpha_{CB}+\alpha_{CA}\alpha_{AB}\alpha_{BA}+\alpha_{CB}\alpha_{BA}^{2}. \tag{8}$$

If (7) holds then so does (8), since $\left(\hat{A}-\bar{A}\right)=\left(\bar{B}-\hat{B}\right)-\hat{C}$, and follows directly from the fact that there is a fixed market size.

Before considering what form of flux may be appropriate, note that if α_{AC} is large compared to all other fluxes then

$$\hat{A}\approx\frac{\alpha_{AB}+\alpha_{CB}}{\alpha_{AB}+\alpha_{BA}+\alpha_{CB}}\geq\frac{\alpha_{AB}}{\alpha_{AB}+\alpha_{BA}}=\bar{A},\left(\Rightarrow\hat{B}<\bar{B}\right), \tag{9}$$

with equality if and only if $\alpha_{CB}=0$ i.e. the decoy attracts no preference from the competitor. Thus if there is sufficiently strong change in preference from C to A, then the desired increase in market share A will always occur. How significant this increase is will depend, as can be seen from (9), entirely upon the size of α_{CB}. This intuitively makes sense, since a reasonable preference change from B to C is required for the flux from C to A to produce a significant increase in A.

Note that at present no assumptions have been made with regard to how consumer preference is shifted from one brand to another (i.e. the magnitude of each α_{XY}). In the next section the preference flux between brands is modelled, based upon their location in the perceived quality space.

Choice preference

In this section we attempt to consider the simplest reasonable model of choice preference. It has previously been shown that choice rule recognizes the attribute-wise proximity of an alternative to other brands (Meyer & Johnson 1995), and it is therefore appropriate for preference change to be modelled on the pair-wise ranking of brands in each quality, the simplest perhaps being to assign a positive score to a brand for each successful comparison. Heuristic strategies tend to proceed dimension-wise rather than alternative-wise and may not involve evaluation of all the information (Wedell 1991) (subjects tend to process information in a dimension-wise fashion across a variety of task environments; Russo & Dosher 1983).

It is found that simple binary (pair-wise) comparisons based upon perceived quality attributes alone are sufficient to produce the decoy effect. For this to occur, however, the system must admit a certain amount of asymmetry. It may be shown, for example, that any system where the flux between brands is both reciprocal and transitive will not admit a decoy (see Appendix A).

Weighting based on quality dimensions

The various attributes of a brand may be considered as a location in quality space, and this will affect the transfer of consumer preference from one brand to another. Here preference flux - based upon differing brands relative perceived quality - is modelled with two (or more) quality dimensions P and Q. Each brand is given a perceived quality value in dimensions P and Q. For any two brands we may draw a straight line through their locations in quality space, referred to as the trade-off line. If we denote P_X and Q_X as the two quality values of brand X, then P_X+Q_X is the same for all brands on the trade-off line. A rational evaluation of a new brand should consider only whether it falls above, or below, this line. Three or more brands are unlikely to lie on a straight line, but the concept of a trade-off is still valid (see section 3).

The location of any two existing brands generates up to nine zones into which any new potential brand could be placed. The classic scenario when two brands trade-off successfully – each outranking the other in exactly one quality dimension – is shown in Figure 2.

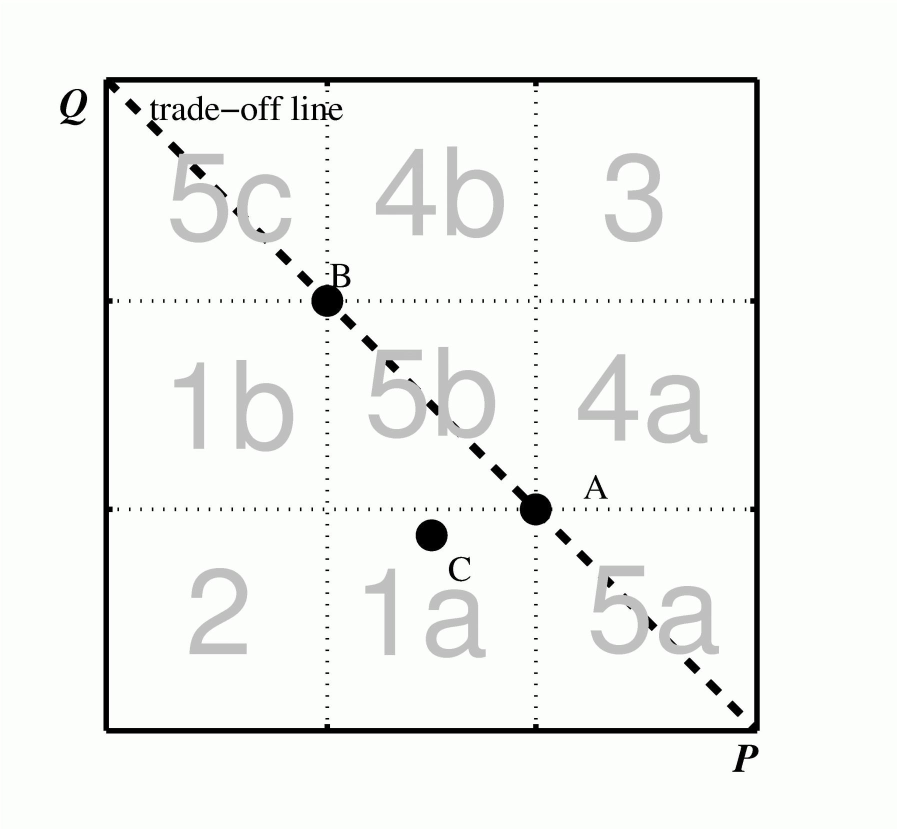

Figure 2. Possible positions for a third brand in two quality dimensions.

Two brands (A and B) distributed along a trade-off line relative to two quality dimensions P and Q will generate nine zones (here labelled 1a to 5c) into which any new produce (C) could be added. Here C has been placed in zone 1a, the target decoy position for A (see Table 1).

Fewer than nine zones will only exist in the degenerate case where the two brands are exactly equal in one or more quality dimension, which is not of interest here. If brand A is the target brand with a trade-off competitor B, and brand C is the new (potential decoy) brand, then the nine zones labelled in Figure 2 are conventionally defined as in Table 1. New brands in zones 1 and 2 should not compete successfully, while those in zones 3 and 4 should fare well. For brands in zones 5 there will be a trade-off with existing brands.

When flux between brands is determined by perceived brand quality, based upon binary comparisons, the simplest outcome by a consumer in such a process is to rank two brands as “better” and “worse” in each quality. More sophisticated consumer behaviour, capable of not only ranking brands but discriminating according to the size of proximity gap, requires more complex modelling, but may be justified since it appears that, subjective attribute valuations at least, are nonlinear, reference-point dependent functions (Meyer & Johnson 1995). Both of these models are considered below, with the latter resulting in more stringent requirement for any new brand to be a successful decoy.

Table 1. Conventional definitions of the zones in quality space given in Figure 3.

5c trade-off	**4b** reverse-competitor-decoy	**3** utopia
1b competitor-decoy	**5b** trade-off	**4a** reverse-target-decoy
2 worthless	**1a** target-decoy	**5a** trade-off

To minimize the expected regret resulting from any choice we assume a consumer will try to find the safe bet by calculating the number of such comparison a brand "wins". To allow for consumers with a preference with regard to qualities, perhaps considering one more important than the other, it is appropriate to weight the scores gained from each comparison. Alternatively, these represent the confidence (weighting), given by a consumer who values all qualities equally, in their ability to judge the ranking in each quality. The simplest reasonable flux is therefore given by

$$\alpha_{XY} = \beta H\left[P_X - P_Y\right] + \gamma H\left[Q_X - Q_Y\right], \tag{10}$$

where $H[T]$ is the Heaviside function defined as

$$H[T] = \begin{cases} 1, & T > 0, \\ 0, & T \leq 0. \end{cases}$$

Thus any brand will independently gain a score of β when it compares favourably on dimension P and a score of γ when it compares favourably on dimension Q. For a consumer whose confidence in judging both qualities is equal and who values both equally we may set $\beta = \gamma$. The final rate of flux from one brand to another is therefore given by the linear sum of its two scores. Note that if two brands trade off there will be a positive flux in both directions (of β and γ respectively). If both qualities are weighted equally then there will be a net exchange of zero between trade-off brands.

The description of fluxes may be made progressively more complex. For example, the complete domination of one brand by another in all quality dimensions may be more obvious to the consumer, so that the flux is greater than simply the sum of the individual scores. If we give this domination factor a score δ, then the flux between brands takes the form:

$$\alpha_{XY} = \beta H\left[P_X - P_Y\right] + \gamma H\left[Q_X - Q_Y\right] + \delta H\left[P_X - P_Y\right] H\left[Q_X - Q_Y\right]. \tag{11}$$

More sophisticated consumers may be able not only to rank brands, but also to quantify the superiority of one over the other. Mathematically, the simplest way of incorporating this is to weight each score by the magnitude of the quality difference, resulting in fluxes of the form:

$$\begin{aligned}\alpha_{XY} \quad = \quad & (P_X - P_Y)\beta H[P_X - P_Y] + (Q_X - Q_Y)\gamma H[Q_X - Q_Y] \\ & + (P_X - P_Y)(Q_X - Q_Y)\delta H[P_X - P_Y]H[Q_X - Q_Y].\end{aligned} \tag{12}$$

Results

In order to see what the minimal requirements to produce behaviour such as the decoy effect are, it is appropriate to first consider the least complex case. Initially, therefore, we use (10) as our definition of flux, with the more complex formulations (11) and (12) considered later. In addition we assume that, unless stated otherwise (see below), $\beta = \gamma$ so that no disparity in quality preference or confidence is expressed.

Ranked quality values

For a consumer who only ranks qualities, and values both qualities equally, the rate at which preference moves to brand X from brand Y is given by, upon substituting $\gamma = \beta$ into (10):

$$\alpha_{XY} = \beta\left(H[P_X - P_Y] + H[Q_X - Q_Y]\right). \tag{13}$$

Consider a new brand placed in the target-decoy zone 1a (see Figure 2). Then the flux from this new brand C to A is $\alpha_{AC} = 2\beta$ because it is dominated, but the flux to B is only $\alpha_{BC} = \beta$ since B outranks C in Q but not P (consequently $\alpha_{CB} = \beta$ also). The dynamics of the system are given by substituting each of these values for (13) into (3). This is a linear differential equation in $A, B, C,$ and may be written in matrix form as:

$$\frac{d}{dt}\begin{pmatrix} A \\ B \\ C \end{pmatrix} = \beta\begin{pmatrix} -1 & 1 & 2 \\ 1 & -2 & 1 \\ 0 & 1 & -3 \end{pmatrix}\begin{pmatrix} A \\ B \\ C \end{pmatrix},$$

Since the matrix is non-singular (it has a non-zero determinant) it follows that all solutions tend to a unique steady state solution, given explicitly by substituting the values for (13) into (6). This is the eventual market share of each brand, and is given by:

$$(\hat{A}, \hat{B}, \hat{C}) = (5,3,1)/9. \tag{14}$$

The original market share of brands A and B were $\bar{A} = \bar{B} = 1/2$, so that market share of A has increased by 1/18 to $\hat{A} = 5/9$. Brand B's market share is reduced by 1/6 to $\hat{B} = 1/3$, lost partly to A and partly to C. Note that, although the decoy effect is evident, the net result upon B is equivalent to competing with two other trade-off brands. The results for all other zones are given in Figure 3, and show the expect behaviour. Only the target-decoy position (zone 1a) will increase the target brand's market share; it follows that placing a new brand in the competitor-decoy zone (1b) will actually harm overall market position. A worthless brand (zone 2) which is dominated by all others will not gain any market share.

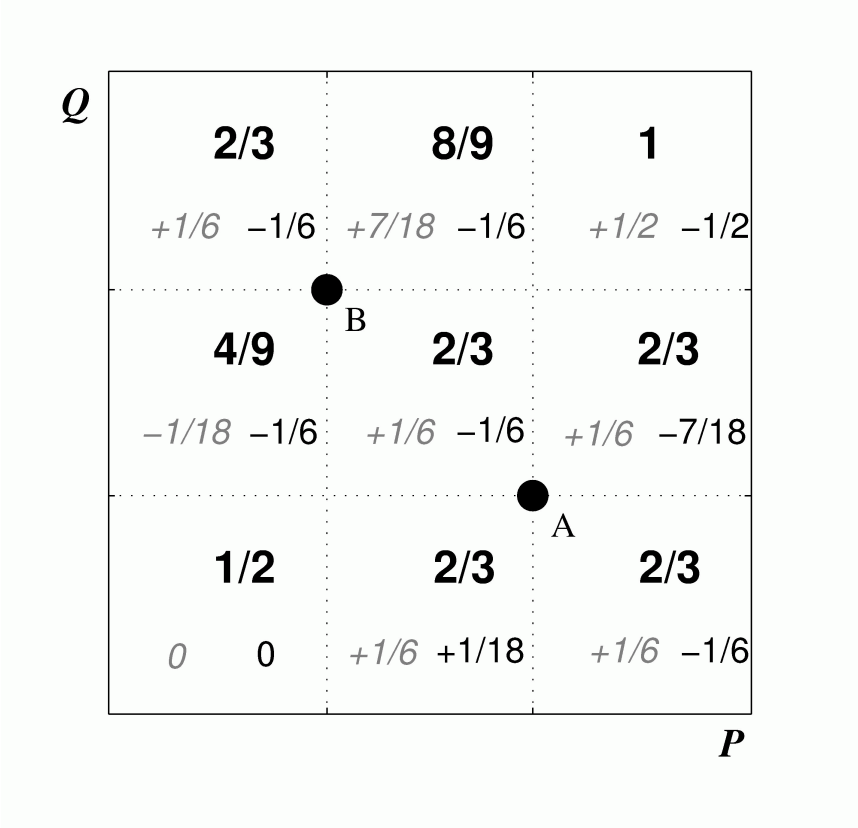

Figure 3. Resultant market share for three brands in two quality dimensions.

Results of placing decoy brand C into each of the nine possible zones created by A and B. Total market share of own brands (target plus potential decoy: $\hat{A}+\hat{C}$) is given in bold; net gain in market share ($\hat{A}+\hat{C}-\overline{A}=\overline{B}-\hat{B}$ i.e. competitor's loss) is given in italic; net gain in target brand ($\hat{A}-\overline{A}$) is given in normal font.

All other locations result in an overall increase in market share between the two own brands A and C, although the only significant gain – i.e. reducing B's market share below the proportional one third – that can be achieved is if the new brand dominates the competitor (zones 3 and 4b). In all other cases the market share gained is simply equivalent to introducing a third trade-off brand (with $\hat{B}$ remaining at 1/3 in all cases), and so there is no benefit from producing a brand which outranks only the target brand – as opposed to the competitor – in any of the qualities. This may easily be seen by clustering brands A and C – see Appendix B. These crude rules will obviously be tempered by any weightings attached to qualities or the magnitude of differences, giving more subtle and realistic behaviour. Note that when multiple brands trade off other effects may come into play, such as "extremeness aversion" (Simonson & Tversky 1992) – see Appendix C.

With additional dominance weighting

If a consumer's preference change is strengthened by noting that a brand is completely dominated, the flux is given by (11). In the absence of quality preference ($\beta=\gamma=\delta$) this results in quantitative but not qualitative differences. For example, the target-decoy position (C placed in zone 1a) results in a market share distribution of

$$\left(\hat{A}, \hat{B}, \hat{C}\right) = (7, 4, 1)/12,$$

as compared to that given in (14). Such weighting increases the flux from C to A and hence the decoy effect; however, the market share of competitor B remains unaltered at $1/3$.

Market share trade-off

It may be shown that in a market place where two groups of brands trade-off (i.e. each member of one cluster outranks all members of the other in exactly one quality dimension, which is the same for each), market share can easily be calculated – see Appendix B. It follows that any target-decoy effect may always be reversed by introducing a competitor-decoy, re-establishing the original market share between the two brand clusters.

Weighted quality values

Quality preferences

Any difference in quality significance ($\beta \neq \gamma$) may skew the outcome of the consumer preference dynamics. As one quality starts to dominate, the problem tends to a comparison in a single quality dimension. In the limiting case the brand with the highest perceived value in that quality will gain the entire market, since it is considered to completely dominate all other brands.

Quality difference weighting

The addition of quantifying one brand's superiority over another significantly complicates the analysis; here fluxes of the form (12) are considered. For simplicity of exposition consider the case where no quality preference is expressed ($\beta = \gamma$) and no additional weighting is given to dominance ($\delta = 0$). To simplify the algebra which follows we re-scale – without loss of generality – the qualities P and Q, so that the trade-off line through A and B satisfies $P + Q = 1$.

Applying (12) to (7) and (8) in each zone we derive criteria under which target brand market share increases and under which overall market share increases (i.e. competition brand market share decreases) respectively. It follows that, although quantitatively different, the qualitative behaviour – with respect to any increase in A or reduction in B – in most zones remains the same as for unquantified comparisons (see Figure 3), the only exceptions being the decoy zones (1a and 1b). Explicitly, the target brand A market share is never increased outside the target-decoy zone (1a), while competitor market share is always decreased by a new brand outside of the competitor-decoy zone (1b), with the exception of a worthless brand (zone 2) which never gains any market share and hence results in no change.

The inclusion of weighted comparisons results in any decoy effect being dependent upon the specific quality values of all three brands. Some algebra shows that a target-decoy placed in zone 1a will only be successful (increase A's market share: B's market share will always be reduced, see above) if

$$Q_A - Q_C > P_C - P_B.$$

The decoy should therefore be as inferior as possible to the target in all qualities, while still outranking the competitor in one quality. Thus a decoy is most likely to work if it is placed in the bottom left of the zone, even though this means it will have the minimum possible superiority over the competitor in one quality, and the maximum inferiority in the other quality.

Multiple brands

The model analysis can easily be extended to a greater number of brands, an example of which is given below. While more than two brands only trade off successfully in the absence of extreme properties (see Simonson & Tversky 1992, for example) it is of interest to consider whether the decoy effect occurs in this case. For details see Appendix D.

Higher dimensions in quality space

Although consumers may only carry out binary comparisons, these may be executed over more than two quality dimensions. With a higher number of qualities the concept of a trade-off between brands becomes more complex, and may not result in equal market shares – for details see Appendix E.

Conclusions

This paper has shown that it is possible to model many intuitive results without the need to draw upon complex assumptions about consumer behaviour dynamics. The asymmetric decoy effect may be replicated with minimal prior assumptions, based only upon the aim of minimized regret. Binary comparisons of brands on separate quality dimensions are sufficient to drive consumer preference towards a target brand, producing a shift in market share. Results confirm that decisions are not rationally weighted by relative perceived quality alone.

It has been shown that if the rate of change from an inferior decoy to a target is sufficiently strong then the desired increase in market share of the target (and consequently the loss in market share of the competitor) will always occur. Furthermore, with such simple strategies only the target-decoy position will increase the target brand's market share, with analogous results for the competitor-decoy zone.

If consumers place additional significance on a brand dominating another beyond the fact that it outranks the other on each quality dimension separately, as might be expected in a minimized regret approach attempting to find a "safe bet", then the size of the decoy effect is increased. For simple unweighted decision processes based upon rank alone the market share gained by a cluster of brands may be calculated, indicating that any target-decoy effect may always be reversed by introducing a competitor-decoy, so that the original market share of both clusters is re-established. The inclusion of weighted comparisons, where consumers not only rank brands in each quality dimension but quantify the difference, makes the potential for any decoy effect less certain. A decoy is most likely to succeed if it is as inferior to the target as possible in all qualities, while still outranking the competitor in one quality.

Results may be extended to a market place with multiple brands which are evaluated on multiple qualities by consumers. At present there appears to be an absence of experimental research considering the decoy effect either for more than three brands or where choices must be made across more than two quality dimensions (Slaughter *et al.* 1999). For simple fluxes the best strategy is for the target-dominated decoy to outrank the competitor in all the qualities in which the target outranks the competitor. All models include the potential for customers to weight the importance they attach to each perceived quality, which may alternatively be viewed as a measure allocated by the consumer according as to how confident they feel in judging that particular quality.

It should be remembered that the inclusion of more than two brands in a market place will, in practice, always involve an assessment of both their quantitative and qualitative locations in quality space. The clearest example of this is the phenomenon of "extremeness aversion" (Simonson & Tversky 1992), where the addition of a suitably weighted third trade-off brand may boost the market share of the middle ("compromise") brand. Again this is a result of result of a cognitive bias –- there is no objective rationale. An indication of how this may be incorporated into the flux model is given in Appendix C; again the observed behaviour can be replicated through very simple rules.

A large body of empirical data already exists giving quantitative and qualitative descriptions of phenomena such as the decoy effect (Heath & Chatterjee 1995) and extremeness aversion (Simonson & Tversky 1992). Results here suggest that simple binary comparisons of perceived quality differences are sufficient to explain many of these observations. While the current model presented here is clearly not sufficiently sophisticated to explain all the many subtleties of consumer choice behaviour, it shows how complex outcomes may result from quite simple driving forces. Furthermore, the model may be used to indicate - where it fails to predict observed behaviour - those areas in which more complicated modelling is necessary and thus justified. The fact that many observable dynamics are replicated suggests that some current models may call for the application of "Ockham's razor", in that certain factors may be removed from the system without any discernible effect on the results. While it is vital that models continue to be developed with the incorporation of additional psychological or sociological factors, it is hard to judge them as real improvements unless their inclusion brings about a genuine difference in behaviour or outcome.

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Appendix A

A certain asymmetry in the resultant flux is required for the decoy effect to occur. For example, in any simple model of preference flux it may be reasonable to assume that the rate at which consumers are attracted to brand X from brand Y is inversely proportional to the rate at which preference is moving the other way (from Y to X), so that flux is reciprocal: $\alpha_{XY} = 1/\alpha_{YX}$. A second reasonable assumption is that the difference between two brands X and Z is the sum of the differences between X and Y, and Y and Z, so that flux is transitive: $\alpha_{XY}\alpha_{YZ} = \alpha_{XZ}$. If both hold true, however, then (7) and (8) reduce to

$$\alpha_{AB} + \alpha_{AC}\alpha_{AB} + \alpha_{AC} < 0 \text{ and } \alpha_{AB} + \alpha_{AC}\alpha_{AB} + \alpha_{AC} > 0$$

respectively, implying that $\hat{A} < \bar{A}$ and $\hat{B} < \bar{B}$. This is because $\alpha_{XY} > 0$ means that the second is always true and hence that the first never holds.

Thus any system where the flux between brands is both reciprocal and transitive will not

admit a decoy, and any new brand will take market share from both existing brands. Although in no way suggesting that consumer preference is not dependent on differing brands' values in quality space, this result does indicate that decisions are probably not rationally weighted by relative perceived quality alone.

Appendix B

If all qualities are equally valued ($\beta = \gamma$, for any δ) then market share can easily be divided between any two brand clusters which mutually outrank each other in one quality dimension each (i.e. trade-off collectively).

Consider the two clusters M and N in Figure 4, consisting of m and n brands respectively. Since each cluster outranks the other in one and only one dimension, there is no flux due to dominance. The flux to cluster M is due only to its superiority in Q, weighted by its size m. Conversely the flux to cluster N is due to its superiority in P, weighted n times. For a flux of the form (13) the market share of each brand cluster is:

$$\left(\bar{M}, \bar{N}\right) = \left(\frac{m}{m+n}, \frac{n}{m+n}\right).$$

This rule may be applied to derive many of the market shares given in Figure 3, and in fact holds for any value of δ.

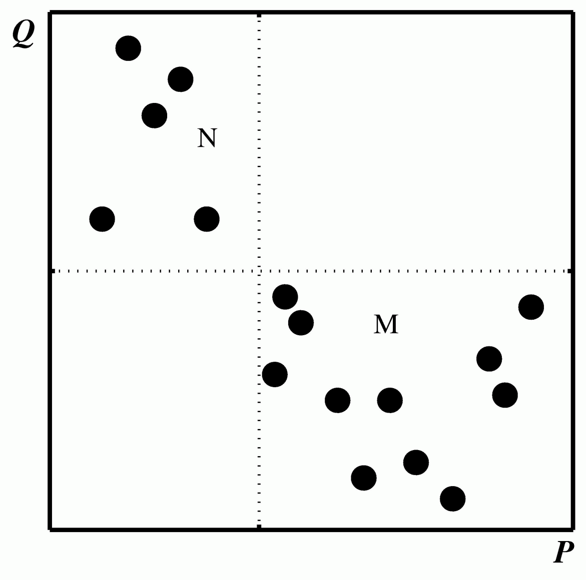

Figure 4. Brand clusters in two quality dimensions.

Any quality distribution in which two brand clusters outrank each other in exactly one quality dimension each will result – for simple fluxes of the form (13) where no quality preference/confidence is expressed – in each group receiving a market share proportional to the group size. Here the dotted line cross wires mark the boundaries between the two clusters.

It follows, for a more general flux of the form (10) or (11) where preferential or confidence weighting is given to different qualities, that the market share gained by cluster M is given by:

$$\bar{M} = \frac{\beta m}{\beta m + \gamma n}.$$

Hence any target-decoy effect may always be reversed by introducing a competitor-decoy, re-establishing the original market share between the two brand clusters.

Appendix C

To account for consumers' perception of how extreme a brands position is in quality space, we may modify the flux from a particular brand by weighting it according to how far it is from the median position in that quality:

$$\alpha_{XY} = \beta H\left[P_X - P_Y\right]\left(1 + N_X^P\right) + \gamma H\left[Q_X - Q_Y\right]\left(1 + N_X^Q\right), \qquad (15)$$

where N_Z^R is the number of brands which outrank brand Z in quality R. With three brands for example, $N = 1$ for the middle ranking brand, while $N = 0$ for the highest ranking brand which has an extreme value (since there is no flux to lower ranking brands, the value of N here is irrelevant). The resultant market share $(\hat{A}, \hat{B}, \hat{C})$ for the simplest case for two competing brands A and B with a decoy C placed in each of the nine zones is given in table 2.

Table 2. Market share for "extremeness aversion" weighted fluxes for the nine distinct zones.

	$\hat{A}$	$\hat{B}$	$\hat{C}$		$\hat{A}$	$\hat{B}$	$\hat{C}$		$\hat{A}$	$\hat{B}$	$\hat{C}$
5c	0.25	**0.5**	0.25	4b	0.25	*0.0625*	**0.6875**	3	*0*	*0*	**1**
1b	0.2	**0.7**	*0.1*	5b	0.25	0.25	**0.5**	4a	*0.0625*	0.25	**0.6875**
2	0.5	0.5	*0*	1a	**0.7**	0.2	*0.1*	5a	**0.5**	0.25	0.25

Note. Market share (A, B, C) for "extremeness aversion" weighted fluxes, given by (15) with $\beta = \gamma = 1$, for the nine distinct zones. When there is a leading brand its market share is given in bold; when there is a single trailing brand it is given in italics.

The model successfully reproduces the expected decoy (and anti-decoy) effect as before, together with the effects of "extremeness aversion". The addition of "extremeness aversion" increased the decoy effect by increasing A's market share even more, to $7/10$ ($>$ than the previous $5/9$): both the competitor B's and the decoy C's market share are less than before. As expected, brands lying along the trade-off line no longer have equal market share, with extreme brands loosing to the more central "compromise" brand(s).

Appendix D

Multiple brands are said to trade-off where, if any brand is superior to any other in P, it will be inferior in Q (and vice-versa); here we assume that brands are sufficiently well group to prevent "extremeness aversion". It follows from the fluxes considered above that each brand attains an equal market share. Note that for only two brands which trade off (always the case where one does not dominate the other) we may draw a straight line through both and define this as the trade-off line (see above). For multiple brands it is probably unhelpful to discuss a trade-off line, since this is unlikely to be straight. The curve in quality space through the brands' locations will still be monotonic, however, i.e. their locations in quality space will stretch from top left to bottom right. It follows that none of the qualitative results are affected, but quantitative results for fluxes considered in section 3.2 will of course change.

Three trade-off brands plus one new brand

Consider the case of a new brand being introduced to a market place with three existing brands which successfully trade-off in dimensions P and Q - see Figure 4. In this case there are sixteen potential zones into which the new brand can be added: each existing brand has a zone which it uniquely dominates and in which a new brand will act as a decoy (in Figure 4, immediately down-left of each brand A, B or C). In addition, however, there exist zones where the new brand would be dominated by more than one brand but not all brands (universal domination of the new brand – bottom-left zone – will, of course, leads to its elimination, as before): in this case the new brand is a weak decoy for both dominating brands. Note that shared dominance may only occur between brands which trade-off consecutively. The resultant market share for each brand under the simple fluxes given by (13) are shown in Figure 5.

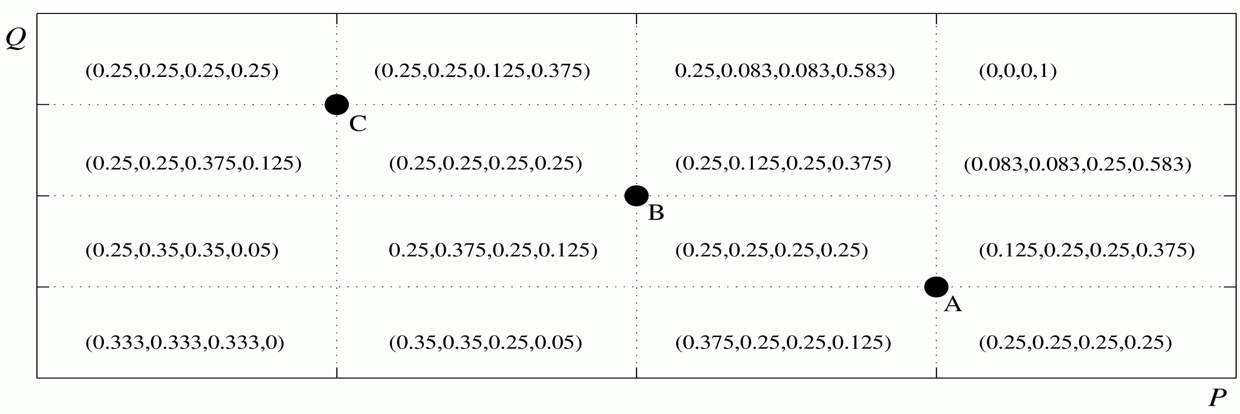

Figure 5. Market share for four brands in two quality dimensions.

The market share distribution $(\tilde{A}, \tilde{B}, \tilde{C}, \tilde{D})$ resulting from placing a new produce D in one of the sixteen zones created when three existing brands trade-off with α_{XY} given by (13).

Appendix E

When there are multiple qualities we define a group of brands as trading-off successfully if no brand is dominated by any other. Thus, in any comparison between two brands, each will outrank the other in at least one quality.

The simplest case for three qualities is a flat trade-off plane given by $P+Q+R=1$ (analogous to the straight trade-off line) - see Figure 5. In general, however, the locations of brands which trade-off will simply lie on some monotonic surface.

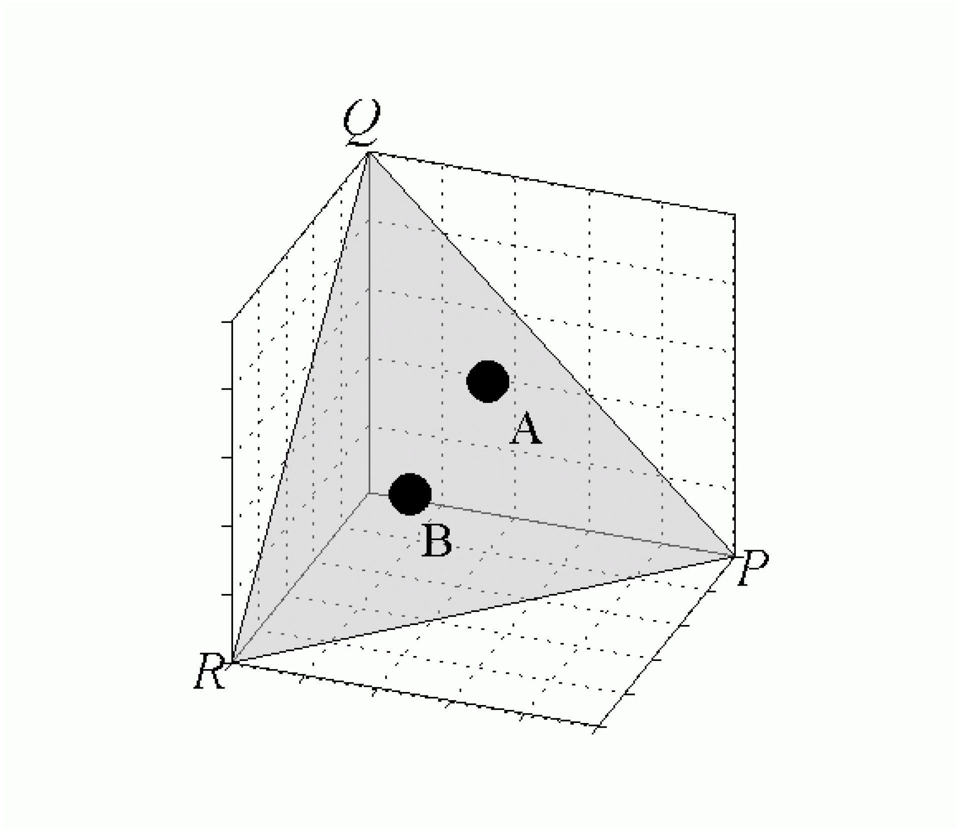

Figure 6. Trade-off plane for two brands in three quality dimensions.

For brands with three quality dimensions there exists a trade-off plane. This may not necessarily flat (as shown here) but will always be a monotonic surface.

Consider the simple flux (13) within a group of n brands. For each separate quality considered, every brand will either gain or loose to each of the $n-1$ other brands. If there are q different qualities being considered, there will be

$$\frac{q\,n(n-1)}{2}$$

exchanges in total. These exchanges are combined for each pair of brands X and Y to give the total gain (for X from Y) α_{XY} and total loss (from X to Y) α_{YX}. Market share will only be the same for all brands if the number of gains and losses for each brand is equal, which cannot occur if the number of exchanges undertaken by each individual brand, $q(n-1)$, is odd.

Explicitly, equal market share is only possible if either (i) there is an even number of qualities; or (ii) the number of brands is odd. This does not of course guarantee it, but simply states that equal market share is never possible with an even number of brands with an odd number of qualities and - see the example below. This condition is a result of the assumption that fluxes are simple, of the form (13): for more complex forms weighted values could compensate for any discrepancy in the number of exchanges

Two trade-off brands plus a decoy in three quality dimensions

The simplest case of interest is when two brands (A and B) trade-off and a third new brand (C) is introduced. Assuming that A and B are not equal in any of the quality dimensions P, Q or R, it follows that one will outrank the other on exactly two qualities, with reversal on the third quality. Without loss of generality consider the case where:

$$P_A > P_B, Q_A > Q_B \quad \text{and} \quad R_B > R_A.$$

If we consider the simplest flux model given by (13), it follows that

$$\left(\bar{A}, \bar{B}\right) = \left(2,1\right)/3.$$

Only with the addition of a third brand C can equal market share – in three quality dimensions – be achieved. For all possible locations of A, B and C there exists a set of regions in which

$$\left(\hat{A}, \hat{B}, \hat{C}\right) = (1,1,1)/3;$$

for the restricted case (1) we have two possibilities:

$$\begin{gathered} P_A > P_B > P_C, Q_C > Q_A > Q_B, R_B > R_C > R_A, \\ P_C > P_A > P_B, Q_C > Q_A > Q_B, R_B > R_C > R_A. \end{gathered}$$

Here, however, we are interest in the potential for C to act as a decoy. There exist only two possible decoy zones, with respect to brand A, where the new brand C may be placed, namely:

$$\begin{array}{lllllllllllllllll} I: & P_A & > & P_C & > & P_B, & Q_A & > & Q_C & > & Q_B, & R_B & > & R_A & > & R_C, \\ II: & P_A & > & P_C & > & P_B, & Q_A & > & Q_B & > & Q_C, & R_B & > & R_A & > & R_C. \end{array}$$

The resultant market share distributions from (13) are given by:

$$\begin{array}{lccc} I: & \left(\hat{A}, \hat{B}, \hat{C}\right) & = & \left(7,2,1\right)/10, \\ II: & \left(\hat{A}, \hat{B}, \hat{C}\right) & = & \left(11,4,1\right)/16, \end{array}$$

showing that both regions produce the desired decoy effect. However, both the increase in brand A's market share (from $\bar{A} = 2/3$ to $\hat{A}$) and the reduction in competitor B's market share (from $\bar{B} = 1/3$ to $\hat{B} = 1/5$ and $1/4$ respectively) are greater in I than II. This follows naturally from the fact that, in I, C is already superior to B in two out of three of the qualities and, although they trade-off successfully, in a two brand market place would result in $(\bar{B}, \bar{C}) = (1,2)/3$ as before.

Because of the original imbalance between A and B, we should also consider the potential of a competitor-decoy for B. There is only one possible zone:

$$III: \quad P_A > P_C > P_B, \quad Q_A > Q_C > Q_B, \quad R_B > R_A > R_C,$$

resulting in a market share distribution of

$$III: \quad \left(\hat{A}, \hat{B}, \hat{C}\right) = (5,4,1)/10.$$

Although A still has the greatest market share, this has been reduced and B's market share increased, so that the decoy effect is present even for weaker brands.

These results indicate – as before, but in higher dimensions – that the best strategy is for the decoy to outrank the competitor in all the qualities in which the target outranks the competitor (while obviously remaining dominated by the target).