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Efficacy of Centering Techniques for Creating Interaction Terms in Multiple Regression for Modeling Brand Extension Evaluation

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ABSTRACT

Interaction terms (representing interaction of the model variables) are commonplace when it comes to multiple regression. Our primary contribution is to verify the benefit of applying different statistical techniques for creating interaction effects in multiple regression models, specifically for the case of brand extension model. Cross product interaction term is considered as a traditional technique for creating interaction effects as compared to mean centered interaction term or the residual centered interaction term. Prior research indicated the problem of multicolinearity in using cross product interaction term and suggested use of the recent analytical techniques, which involved centering of the variables. In the current study, it was found that centering only helps multicollinearity disappear and doesn't quite improve the regression model as such.

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INTRODUCTION

The current study presents a comparison of three statistical approaches of creating interaction terms in the regression model discussed in the formative research of Aaker and Keller (1990) (henceforth A&K) in the domain of brand extension. A&K's regression model included cross product interaction terms. While their study worked as founding pillars for the budding researchers in the brand extension domain, it had its fair share of criticism for the multicollinearity present in their model. Researchers later suggested using centering techniques to alleviate multicollinearity. The utility of such techniques still has to be tested with regards to improvement in the overall model. The present study aims to address the above issue of studying the impact of centering techniques in improving the regression models.

Consumer evaluations of brand extensions has been well studied by marketing scholars in the past focusing on key factors influencing brand extension evaluation (e.g., Bottomley and Doyle, 1996; Sunde and Brodie, 1993; Aaker and Keller, 1990). Aaker and Keller's (1990) formative study motivated several brand extension researchers to conduct replication studies (Bottomley and Holden 2001; Olavarrieta et. al 2009; Barrett et. al 1999; Kaur and Pandit 2015). A&K explored various factors that affect consumer's attitude toward brand extensions. Moderated regression model, postulated to test their hypotheses, also included several interaction terms. They proposed that consumers evaluate brand extensions based largely on: (a) the amount of perceived fit between the parent brand and its extension, (b) their perception of the quality of the extension, mathematically represented as the interaction of the degree of fit with the quality of the parent brand (Quality), and (c) their perception of difficulty (Difficulty) in designing and manufacturing of extension, given the capability and expertise in manufacturing the parent brand. To quantify perceived fit, they considered three measures namely complementarity (Complement) of the two products, transferability (Transfer) of manufacturing skills resulting in easy manufacturing of the extension category, and substitutability (Substitute) across parent and

extension categories. Majority of their variables were found to be affecting extension evaluation except for Quality of the parent brand. However, multiple replication studies performed later on proved that quality impacts the brand extension evaluation strongly whereas difficulty in manufacturing the extension product had mixed results from the researchers (e.g., Sunde and Brodie, 1993; Patro and Jaiswal, 2003; Kaur and Pandit, 2014; Holden and Barwise, 1996).

Replication and meta-analysis studies also found that the primary reason for inconsistency in earlier research could primarily be linked with the presence of multicollinearity which was established to be corrected using residual centering (Barrett, Lye and P. Venkateswarlu, 1999; Bottomley and Holden (2001); Kaur and Pandit, 2014). These replication studies articulate the need for further empirical generalizability and for deeper understanding of utility of centering techniques, which were established as the major reason for differences in results among others such as different methodology or stimuli.

As an illustration of how a cross product term may cause the problem of multicollineairtity, the Equation 1 given below has p1 and p2 independent variables along with p1p2 as cross product interaction term.

$$Y= \alpha_1 p_1 + \alpha_2 p_2 + \alpha_3 p_1 p_2 + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Multicollinearity involves the situation when the cross product term p_1p_2, representing interaction, is highly correlated with the term $x_1$and x_2. As a result, it gets difficult to distinguish the separate effects of p_1p_2 and p_1 (and/or p_2) (Irwin and McClelland 2001; Sharma, Durand, and Gur-Arie 1981). To avoid multicollinearity, several researchers including Jaccard, Wan, and Turrisi (1990) and Aiken and West (1991) recommended mean-centering the variables p_1 and p_2 for creating interaction term. A review of the leading marketing journals demonstrates that marketing researchers have commonly adopted mean centering in their regression models (Echambadi and Hess, 2007)

Empirical results demonstrate that mean centering results in reduced covariance and correlation between the independent variables (p_1 and p_2 in Equation 1) and their interaction term (p_1p_2 in Equation 1). As a result, the problem of multicollinearity gets alleviated and the precision of estimates increases. The procedure of centering is commonly endorsed to moderate the possible impact of multicollinearity between independent variables and their cross-product terms. While centering has proven to improve interpretation of the predictor variables (Gwowen Shieh 2011), if the regression model includes interaction terms, the statistical interpretations of several coefficients in the linear model will not remain the same as in the model where interaction terms are excluded. Echambadi, Arroniz, Reinartz, and Lee (2006) and Kaur and Pandit (2014) very strongly endorsed a full effects model that includes interaction effects between the independent variables if the coefficient of the interaction term is non zero.

LITERATURE REVIEW

A survey through the accomplished literature clearly demonstrates that the problem of multicollinearity has been of concern in several linear regression models (Belsley 1991, Belsley, Kuh, and Welsch 1980, and Fox and Monette 1992). Researchers have differed in their ways of reducing the multicollinearity by using residual centered interaction terms (Bottomley and Holden 2001) and mean centering for creating interaction terms (Aiken and West 1991). Another plausible solution for lightening multicollinearity could be to obtain larger amount and better quality data (Judge et al., 1988, p. 874). A few other researchers suggest that the effects of multicollineairity could be offset by enough power in the model (Mason and Perreault, 1991).

On the contrary, Andrew et al., (2011) argue that although mean centering does reduce the unnecessary multicollinearity, thereby easing the computational and interpretational problems that may arise but mean centering or standardization is not a requirement per se (Echambadi and Hess 2007, Shieh 2011). Hayes (2013, p. 289) elaborates the enhanced interpretational ability of the model containing mean centered moderator variables but also refutes the improvement in the model coefficients as a result of reduced multicollinearity. Lance (1988)'s residual centering is considered as a comparable alternative to mean centering for eliminating non-essential

multicollinearity. Residual centering primarily involves a two-stage ordinary least squares (OLS) procedure wherein the product or the powered term is regressed onto their corresponding first-order effect(s) (Little, Bovaird and Widaman, 2006). Bottomley and Holden (2001) and Kaur and Pandit (2014) used the data set of A&K for further analyses of their brand extension model. Both of them, after accounting for correction of multicollinearity, concluded that the residual-centering method indeed resulted in substantial reduction of collinearity between the moderating variables. According to another research (Echambadi and et al., 2006) residual-centering approach used by Bottomley and Holden (2001) to alleviate collinearity problems is inappropriate. (Little et al., 2006) highlighted that the advantage of residual centering is its ease of implementation. McClelland et. al. (2016) in their critical research verified the irrelevance of multicollinearity in the model with moderator variables.

As discussed above, a lot of contrary opinions and outcomes of the research in the literature exists which forms the basis for the current study to investigate the utility of centering techniques in improving the model and alleviating the multicollinearity.

In the next section, the methodology adopted for the current study is explained along with the research hypotheses and the data analysis. Results are discussed in detail thereafter. Finally, conclusions include the limitations as well as proposed suggestions for future extensions.

METHOD

Stimuli

A set of six well known CPG brands and their widely advertised extensions were used as stimuli in this study. Brands meeting the criteria of Aaker & Keller (1990) - generally perceived as high quality, being relevant to subjects, not extended previously and eliciting specific associations, were shortlisted for the study. Preliminary tests were conducted before shortlisting the final set of brands and their corresponding extensions. All the measures selected in this study, for quantifying the success of brand extension, were taken from prior literature. Reliability and validity tests (item-to-total correlation for internal consistency, Cronbach's alpha and factor

analysis for uni-dimensionality of the construct) were run before the main study was conducted. Parent brands and their extensions finally selected for this study are illustrated in Table 1. Primary data, together with secondary data from prior literature, is then used to perform statistical and comparative analysis.

Parent Brand	**Brand Extension**
Amul Butter	Amul Ice Cream
GarnierFructis Shampoo	Garnier Color Naturals Hair Color
Maggi 2 Minute Noodles	Maggi Healthy Soups
Dettol Antiseptic Liquid	Dettol Hand-Wash
Dove Cream Bar	Dove Conditioner
Horlicks Health Drinks	Horlicks Biscuits

Table 1: Brands and their extensions used in this study

Sample

Sample set for the study included Management students of a renowned National University of India. Both full-time and part-time students were included to ensure diversity. The respondents were contacted during classes (while taking prior permission from the concerned faculty). All the students present on the day, survey was conducted, were distributed first round of questionnaire in which their demographic profile and their familiarity with the brands selected in the study were sought. Care was taken to ensure that only the respondents that were familiar with a specific brand provide information on that brand.

A total of 1050 questionnaires were distributed. Of these, 87 were found to be incomplete and further 127 were discarded due to missing response. Overall, a total of 837 responses were considered for the primary analysis. Statistical Package for Social Sciences (SPSS) was used for computation of results.

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Research Objectives and Hypotheses Formulation

Formative work of Aaker and Keller (1990) motivated several brand extension research studies in various countries. This exploratory study gave pivotal knowledge about the factors influencing the consumers' attitude towards the brand extension. Replication studies that followed showed varying results. Such variations were primarily attributed to interaction effects between the independent variables leading to multicollinearity. Such lack of generalization served as basis for the further analysis undertaken in the current study.

Objective: To test the utility of creating and using centered interaction terms instead of cross product interaction terms for brand extension evaluation model, as proposed by Aaker and Keller (1990)

DATA ANALYSIS AND RESULTS

The regression model used for this study (as also hypothesized by Aaker and Keller) is mentioned below:

$$\text{Attext} = \alpha + \beta_1 * \text{Quality} + \beta_2 * \text{Complement} + \beta_3 * \text{Substitute} + \beta_4 * \text{Difficulty} + \beta_5 * \text{Transfer} + \beta_6 \text{ Quality*Complement} + \beta_7 \text{ Quality*Substitute} + \beta_8 \text{ Quality*Transfer} + \varepsilon'' \quad \ldots(2)$$

Regression results using three different techniques for creating interaction terms, using data collected from responses from the survey of management students (mentioned in detail in the previous section), are reported in Table 2, 3 and 4. Table 2 reports regression results of brand extension model of Aaker and Keller (1990) with cross product interaction terms, residual centered and mean centered interaction terms. Table 3 reports these results in a more summarized manner with the direction of the beta coefficients (positive or negative) and their statistical significance. Table 4 shows collinearity statistics of using all the statistical approaches to creation of interaction effect.

Next, each of the four hypotheses as first observed in Aaker and Keller (1990) are taken for comparison (βrc, βmc, βcp respectively denote beta coefficients for the three regression models – the first one using the residual centered terms, the second one using the mean centered terms and the third one using the cross product interaction terms).

The first hypothesis (H1), from A&K, postulates that parent brand with higher quality perception will result in more favorable evaluation of the extension. Regression results of all the three techniques support H1. However, the initial study from A&K failed to support it. In the current work, the coefficient for Quality term (β_1) is both positive and statistically significant (βrc = 0.606, $p < .05$; βmc= .640, $p < .05$ and βcp= .688, $p < .05$). These results indicate direct link between consumers' attitude towards brand extension and their perceived Quality of the brand. The magnitude of beta coefficient involving no centering comes out to be highest for H1. These results, supporting H1, are in line with a few other replication studies of A&K model (Olavarrieta et al. 2009; Patro and Jaiswal 2003; Bottomley and Holden 2001; Sunde and Brodie 1993; Kaur and Pandit 2015).

The second hypothesis (H2), from the original A&K study, postulates that the brand's perceived Quality is better transferred to the extension when both of them fit well together. Regression results from the interaction between Quality and the three variables representing perceived fit vis-a-vis Transfer, Substitute and Complement, can help test this hypothesis. Mixed results were found for the two interaction terms i.e. quality & complement (βrc = -0.060, $p < .05$; βmc= -.0001, $p > .05$ and βcp= .006, $p > .05$) and quality & substitute (βrc = 0.081, $p < .05$; βmc= -.0190, $p > .05$ and βcp= .076, $p < .05$) though the results for the interaction term, quality and transfer were found to be more consistent, beta coefficient being negative in all three techniques (βrc = -0.021, $p > .05$; βmc= -.083, $p > .05$ and βcp= -.069, $p < .05$) though it was not significant statistically.

In the third hypothesis (H3), A&K postulated that the Perceived Fit between the parent brand and its extension has a direct positive association with the attitude of customers towards brand extension. Our regression results corroborate the role of fit in the formation of customer attitude

towards brand extension. Following A&K model, we also examined the relationship of customer attitude with all the three components of fit individually using different statistical techniques. The results for substitute (βrc = -0.020, p> .05; βmc = -.031, p< .05 and βcp = -.333, p< .05) and transfer(βrc = 0.075, p< .05; βmc = .068, p< .05 and βcp = .354, p< .05) are consistent in full effects model using different statistical techniques though for complement, the direction of the beta coefficients differ in case of the residual centered interaction term vis a vis others (βrc = 0.000, p> .05; βmc = -.005, p > .05 and βcp = .032, p > .05). Results demonstrate that Transfer is a relatively important predictor of customer attitude towards brand extension, as compared to complementarity or substitutability. This result also likely reflect relatively fewer brand extensions that represent actual substitutes or complements of the parent brand in the consumer goods segment or else it may lead to cannibalization for the manufacturers.

Final hypothesis (H4) from A&K proposes positive relationship between the difficulty of manufacturing the product extension and customer attitude. Regression results in negative beta coefficient for the "Difficult" variable, which is not statistically significant in all three statistical techniques. Correspondingly, results on our data and model do not support H4.

Similarities in the regression results for all the three statistical techniques can be observed suggesting low utility of using interaction terms in multiple regression.

Collinearity control

Table 4 shows collinearity statistics of using all the statistical approaches to creation of interaction effect. Multicollinearity disappeared visually in cases where centering techniques have been used as tolerance values are close to 1 and Variance Inflation Factors (VIF) values are all much less than 10 for both residual centered and mean centered results, whereas the VIF in the regression model where cross product interaction effects are used, seems to be a problem, indicating multicolllinearity. Prior research (Janssens et al, 2008; Arslan and Altuna, 2010; Myers, 1986) has shown VIF value greater than 10 and tolerance value smaller than .10 to result in the multicollinearity problem.

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CONCLUSION

The results show almost similar explanatory power of the model in all three cases (Adjusted R^2 between 37- 40%). Also, majorly the results are similar using different approaches to interaction effects. The magnitude and direction of the beta coefficients are majorly similar, except for a few cases where direction of the beta coefficient is opposite or not significant. Results from the current study show no remarkable improvement in either the beta coefficients or the power of the model while using any of the much hyped centering techniques vis a vis cross product interaction terms. This study concludes that centering techniques apparently remove collinearity but do not miraculously improve their computational or statistical conclusions or model per se. These findings will help future researchers understand the over hyped benefits of centering and hence avoid it while creating interaction terms in multiple regression, unless the inclusion of interaction terms is critical to the model (Echambadi and Hess 2007, Shieh 2011).

Future research should test the utility of centering techniques on different models measuring consumer behavior for generalizing the utility of centering techniques in regression models related to various fields of study in marketing.

Table 2: Regression results

	Residual centering	Mean centering	Cross Product
Quality	.606	.640	.688
Substitutes	.020	-.031	-.333
Transfer	.075	.068	.354
Complements	.000	-.005	-.032
Difficulty	-.007	-.005	-.006
Q*S	.081	-.019	.076
Q*T	-.021	-.083	-.069
Q*C	-.060	-.001	.006
Adjusted r2	.374	.400	.403

Table 3: Summary of results showing direction and statistical significance (S – Significant, NS – Non Significant)

	Residual centering	Mean centering	Cross Product
Qualiy	+ve & S	+ve & S	+ve & S
Substitute	-ve & NS	-ve & S	-ve & S
Transfer	+ve & S	+ve & S	+ve & S
Complements	+ve & NS	-ve & NS	-ve & NS
Difficulty	-ve & NS	-ve & NS	-ve & NS
Q*S	+ve & S	+ve & NS	+ve & S
Q*T	-ve & NS	-ve & S	-ve & S
Q*C	-ve & S	-ve & NSs	+ve & NS

Table 4: Collinearity statistics

	Residual centered		Mean centered		Cross Product	
	Tolerance	VIF	Tolerance	VIF	Tolerance	VIF
Qualiy	.987	1.013	.948	1.055	.042	23.62
Substitute	.940	1.064	.927	1.078	.020	50.213
Transfer	.899	1.112	.929	1.076	.020	51.131
Complements	.866	1.155	.985	1.015	.986	1.014
Difficulty	.997	1.003	.874	1.144	.017	58.842
Q*S	.933	1.071	.862	1.160	.018	54.184
Q*T	.872	1.147	.832	1.202	.013	74.997
Q*C	.831	1.203	.904	1.106	.015	67.411

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