

The collaborative process of product design co-creation with customer-base behavior and psychological information

Hui-Hsin Huang

Department of Business Administration,

Aletheia University, Taiwan

hoyasophia@gmail.com

Abstract. This research proposes the collaborative process of product design co-creation in the context of customer-base orientation. Product design should be matched the customer's need and want. By standing on the customer view of point, we combine the behavior and psychological information to demonstrate a framework which can provide the reference for the managers in the design process.

Key Words: product design co-creation, collaborative process.

1 Introduction

In the rapidly changing product marketing, customer is not only the user and always plays the passive role on new product development. Product design through interaction between supplier and customer is a key factor to meet the customer's need [1,9,10]. This collaboration with customers can create customer perceived value and also be considered fundamental to company competitive advantage [14]. Because the value creation is the core purpose and central process of economic exchange [13] between customer-supplier relationships. Thus, companies are trying to involve their customers in the co-creation or co-development of new product.

There are many previous researches discuss the advantages of customer collaboration in product design [3,12]. Firstly, as we mentioned in the first paragraph, collaboration with customers can be used as major information which is provided to understand customer's needs and their preference [3]. If customers feel some familiar with the new product which they have suggest the innovation ideals during the designing process, then the more possible they desire to purchase [12]. Secondly, by customer collaboration, company can access to new resource and capability that manufactures lacks in house [12]. Thirdly, collaboration with customer can get the customer's feedback in the early development stage. It can lead to a better product quality and fewer errors which case a reduction of the product development cycle time [3]. Finally, through the

collaboration with customers, firm can decrease the cost of innovation and reduce the technical and financial risk [4].

Since collaboration with customer has been a popular theme for researchers and practitioners [11]. Some of the existing literature discussed the different roles of customers in the product development process. For example, Aarikka-Stenroos and Jaakkol [1] explore the collaborative process of customer value co-creation in the context of knowledge intensive business service. They conduct qualitative interviews method to provide a tentative framework for value co-creation as a joint problem solving process by supplier resources and customer's resources. And they construct a collaborative process framework by considering the customer resources for. In this framework, company should analysis the information about customer's need and goals.

Some researches focus on the different methods for customer involvement in new product development [8]. In [8] it is used survey data to analyze customer collaboration based on four separate dimensions – frequency, direction, modality, and content. But less of these researches propose a stochastic model to merge both psychological and behavioral orientation into customer information for collaborative process. Thus, in this research, we use both survey method and quantitative approach to obtain customer's psychological and behavioral data respectively and combine these data into full customer information. The framework of this research is demonstrates in figure 1.

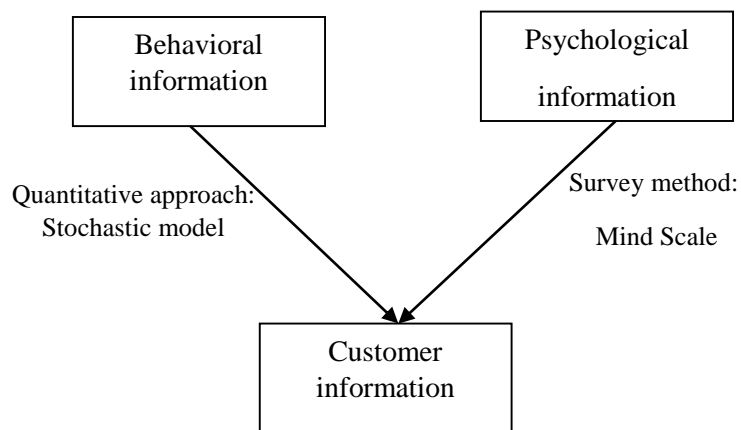


Figure 1. The research framework.

According to Fig.1. The paper is organized as follows. The next section, we introduce the psychological and behavioral orientation of customer information model separately. Firstly, we will demonstrate the psychological information model which includes mind scale of the confidence and resistance. And the behavioral information model which includes customers' purchase monetary and interpurchase time. Then to combine these two information into customer total information with linear regression relationships. Secondly, the empirical data which is from both

survey and company's database is used to estimate the parameters of the proposed models. Finally, the conclusion is made.

2 The Model

2.1 Psychological information

In this paper, we use Mind share model to gather customer's psychological information. According to Huang [5,6,7] it she develops the constructs of Mind Shares from the perspectives of loyalty. Mind Shares is the confidence consumers have in a certain brand and the level of their resistance to switching to other brands. And this reveals the loyalty. The higher Mind Shares a brand commands, the stronger consumers' loyalty is.

Thus, Mind share is a related quantity that composes of confidence and resistance of a certain brand against that of some quantity related to all brands. The confidence and resistance are two variables which compose the Mind share concept.

2.2 Confidence

Confidence consists of belief strength (*bs*) and belief certainty (*bc*). Belief strength is a subjective perception which consumers possess toward the product attributes. It represents subjective probabilities of association between the product and its perceived attribution. It can be estimated between 0.0 (no perceived association) and 1.0 (100 percent perceived). Different degrees of belief strength are the probabilities with which consumers perceive certain attributes of a product.

Belief certainty is the certainty with which consumers can make their own judgments. It is the level of certainty consumers possess regarding their judgment of the connection with product attributes. It ranges from very certain to very uncertain.

$$C_x = \sum_{i=1}^n \sum_{j=1}^m (bs_{xji} \times bc_{xji}) \quad (1)$$

C_x is Confidence Scale toward brand x which represents the confidence concept. bs_{xji} and bc_{xji} denotes respectively the belief strength and belief certainty from customer i ($i=1,2,..m$) to attribute j ($j=1,2,..,n$) of brand Confidence Scale of the i -th consumer in the brand x .

2.3 Resistance

Resistance is a commitment in the form of resistance against brand switching. It refers to the loyalty of consumers who can resist the vast array of marketing messages from competitors and stay with their original brands. Hence, Huang [6] denotes Resistance Scale R_x of brand x is the sum of the total resistance scores.

When T_{ix} denotes the Resistance Scale measuring the resistance of the i th consumer switching to other brands.

$$R_x = \sum_{i=1}^n (T_{ix}) \quad (2)$$

The Resistance Scale are usually calculated by series questionnaires of survey such as " It would be difficult to change my beliefs about this xx" or" Even if close friends recommended another brand, I would not change my preference for others."

Huang [6] denotes Mind scale(*Mscale*) to represent psychological orientation of Mind share.

$$Mscale_x = C_x \times R_x \quad (3)$$

2.4 Behavioral Information

The behavioral information can be demonstrated by gathering the data of customer purchasing. The topic of how much customers spending on their purchases and when they making their purchases are important knowledges to help a company actively target these individuals and customize their offerings. Thus, this paper bases on Huang [7] to consider monetary and interpurchase time as purchase factors. Based on these two factors, we propose a stochastic model to collect customer behavior information and predict their future purchase.

The parameter b is the customer's behavior data includes the information of monetary spending (M) and interpurchase time(T).

$$k(b) = T \times M \quad (4)$$

We denote that the quantity of monetary spending m is a random variable which follows normal distribution with parameters μ and σ^2 .

$$M(m|\mu, \sigma^2) = \frac{1}{m\sigma\sqrt{2\pi}} \exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right], \quad m > 0 \quad (5)$$

The interpurchase time is the time interval that customers make their transactions. We consider it is also a random variable t and follows exponential distribution with parameter λ .

$$T(t|\mu, \sigma^2) = \lambda e^{-\lambda t}, \quad t > 0 \quad (6)$$

The cdf of b is

$$\begin{aligned}
K(b) &= P(T \cdot M < b) \\
&= \int_0^{\infty} P(T \cdot M < b | M = m) \cdot M(m | \mu, \sigma^2) dm \\
&= \int_0^{\infty} P\left(T < \frac{b}{m} | M = m\right) \cdot M(m | \mu, \sigma^2) dm \\
&= \int_0^{\infty} \int_0^{\frac{b}{m}} \lambda e^{-\lambda t} dt \cdot \frac{1}{m\sigma\sqrt{2\pi}} \exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] dm \\
&= \int_0^{\infty} \left[1 - \exp\left(-\frac{b\lambda}{m}\right)\right] \cdot \frac{1}{m\sigma\sqrt{2\pi}} \exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] dm \\
&= \frac{1}{\sigma\sqrt{2\pi}} \int_0^{\infty} m \left[1 - \exp\left(-\frac{b\lambda}{m}\right)\right] \cdot \exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] dm
\end{aligned} \tag{7}$$

Then we can calculate the pdf of b is

$$\begin{aligned}
k(b) &= \frac{d}{db} K(b) \\
&= \frac{1}{\sigma\sqrt{2\pi}} \frac{d}{db} \int_0^{\infty} m \left[1 - \exp\left(-\frac{b\lambda}{m}\right)\right] \cdot \exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] dm \\
&= \frac{\lambda}{\sigma\sqrt{2\pi}} \int_0^{\infty} \exp\left[-\frac{b\lambda}{m} - \frac{(m-\mu)^2}{2\sigma^2}\right] dm
\end{aligned} \tag{8}$$

Finally, the expectation value of b can be calculated as

$$\begin{aligned}
E(b) &= \int_0^{\infty} b \cdot \left\{ \frac{1}{\sigma\sqrt{2\pi}} \int_0^{\infty} m \left[1 - \exp\left(-\frac{b\lambda}{m}\right)\right] \cdot \exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] dm \right\} db \\
&= \int_0^{\infty} \frac{1}{\sigma\sqrt{2\pi}} \int_0^{\infty} \left[\frac{1}{2} + \frac{m^2}{\lambda} \exp\left(-\frac{b\lambda}{m}\right) \right] \cdot \exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] dm
\end{aligned} \tag{9}$$

The behavior model is describing the dynamic pattern and mind share calculation can be explored by questionnaires.

2.5 The Full model of Customer information

We denote a linear regression in which Y is a dependent variable respective to customer full information. $Mscale$ and the expectation value of b (behavioral information) are independent variables which influence Y .

$$Y = \alpha + \beta_1 Mscale + \beta_2 E(b) + \varepsilon \tag{10}$$

3 The Method

Based on our research framework and the full model of customer information, the psychological information can be collected by using survey method and the behavior information can be demonstrated by stochastic model with parameters estimation. Thus, we use survey data to calculate the Mind scale and use the database of customer purchasing behavior to estimate the parameters of the monetary and interpurchase time model.

These data is from a design company in Taiwan. The main business of this company is to design life grocery such as stationery. In the survey data, 376 validate questionnaires are collected by a design company from 1 to 31 July in 2016. These data includes the customers' confidence among the new product and their resistance against the competitors. There are 15796 data from the database of the platform on-line shop of this company which includes the past behavior of customer purchase monetary and interpurchase time of this new product. 15796 is the pair data which records the transactions of customers. One customer may have more than one record of his transactions. And we also get the customer evaluation of satisfaction data (there are 376 sample size) to represent the consumer (full) information.

In the measurement of survey, the content on confidence measures attitude side and judgment certainty. Attitude judgment certainty refers to the level of sureness of consumers in their own judgment of the association to product attributes. It ranges from "extreme certainty" to "extreme uncertainty" and can be measured with a five-point scale. In terms of the reliability of attitude value, the standardized Cronbach α stands at 0.956; in terms of the reliability of judgment certainty, the standardized Cronbach α is 0.978. The five points Likert scale is also used to measure resistance of consumers against brand switching. The standardized Cronbach α is 0.921.

3.1 The parameters estimation

We use MLE (maximum likelihood estimate) to estimate the parameters of equation (7). Let b_j denote the customer's behavior data by customer j . And let L denote the likelihood of the customer's behavior, that is:

$$\begin{aligned}
 L(\mu, \sigma^2, \lambda) &= \prod_{j=1}^n K(b_j) \\
 &= \left(\frac{1}{\sigma\sqrt{2\pi}} \right)^n \int_0^\infty m^n \left[1 - \exp\left(-\frac{b\lambda}{m}\right) \right]^n \cdot \exp\left[-\frac{n(m-\mu)^2}{2\sigma^2}\right] dm
 \end{aligned} \tag{11}$$

We take the solutions of (11) as MLE for μ , σ^2 and λ .

$$\begin{cases} \frac{\partial}{\partial \mu} L(\mu, \sigma^2, \lambda) = 0 \\ \frac{\partial}{\partial \sigma^2} L(\mu, \sigma^2, \lambda) = 0 \\ \frac{\partial}{\partial \lambda} L(\mu, \sigma^2, \lambda) = 0 \end{cases} \quad (12)$$

The details of left-hand side of (12) are given by

$$\begin{aligned} \frac{\partial}{\partial \mu} L(\mu, \sigma^2, \lambda) &= \frac{1}{\sigma\sqrt{2\pi}} \int_0^{\infty} \frac{m(m-\mu)}{\sigma^2} \left[1 - \exp\left(-\frac{b\lambda}{m}\right) \right] \cdot \exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] dm \\ \frac{\partial}{\partial \sigma^2} L(\mu, \sigma^2, \lambda) &= \frac{1}{\sqrt{2\pi}} \int_0^{\infty} m \left[1 - \exp\left(-\frac{b\lambda}{m}\right) \right] \cdot \left\{ \frac{(m-\mu)^2}{\sigma^3} + \exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] \right\} dm \\ \frac{\partial}{\partial \lambda} L(\mu, \sigma^2, \lambda) &= \frac{b}{\sigma\sqrt{2\pi}} \int_0^{\infty} \exp\left(-\frac{b\lambda}{m} - \frac{(m-\mu)^2}{2\sigma^2}\right) dm \end{aligned}$$

The results of parameters estimation are

Table 1 The results of parameters estimation

| μ | σ^2 | λ |
|-------|------------|-----------|
| 21357 | 2.677 | 7.560 |

3.2 The results of regression analysis

We can calculate *Mscale* from survey data (psychological information) and the expectation value of *b* from database through stochastic model (behavioral information). Then, we use regression analysis to test their relations with customer evaluation (customer information).

Table 2 The results of regression analysis

| α | β_1 | β_2 |
|----------|-----------|-----------|
| 1.640*** | 0.605*** | 0.477*** |

$R^2=0.768$, F value=167.305***, VIF=1.881, *** denote as P-value<.000

The results show that both *Mscale* (Psychological information) and the expectation value of *b* (behavioral information) will significantly influence the results of customer evaluations (customer information). And these two variables have 76.8% explanatory power to customer evaluations (customer information). VIF is less than 10.

4 Conclusions

This paper constructs a new model for collaborative process of product design co-creation. Based on the stochastic view of point, the author combines customer-base behavior and psychological information to provide the product managers to make decision of new product design. This information which compose the model not only show the customers' preferences but also involved the variables of customer spending monetary and interpurchase time. These two variables reveal the connection between customer-base product design and product selling. This model can help company to achieve customers' need and want. Managers can use this model to design suitable product and also to consider the market sale. According to different industries, the researchers can use this model to explore new product design process in the future.

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