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Understanding the Customer Involvement in Radical Innovation

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Abstract. This study aims to identify the factors fostering radical innovations during new product development (NPD), and investigate into the importance of customer involvements. Based on an analysis of a large number of relevant research, the hypothesis is established: **H1**, The customer is not the most or the only significant factor affecting radical innovation performances in NPD. To test **H1**, an interactive multiple regression model is adopted to detect the impacts of innovation-related factors. Through calculation and comparison, the results showed the radical innovations are more sensitive to professional consulting institutions such as 'consultants, commercial lab or private R&D institutions' rather than 'customers, clients or end users'. Based on the analysis, conclusions are drawn that firms should properly distribute research focus on all important aspects, and carefully control the customer involvements so as to achieve the best benefits.

Keywords. Customer involvement; Radical innovation; Hypothesis testing; Interactive multiple regression model

1. Introduction

Nowadays, the market is dynamic and constantly changing. Without the adaptability to outside challenges, enterprises will eventually fail in competition. Product innovation is such a notion which suggests seeking solutions for product improvements through the creation and introduction of a good that is either new or improved on previous goods. Particularly, radical innovation which is new to the market contains more chances to be innovative and competitive. Considering the key factors of successful product innovation, customers secure a crucial position. For radical innovation, it should be considered carefully to comprise the consumers' resistance to novelties.

Normally, customers were assumed to be beneficial to product innovation. Various studies have demonstrated that *customers, rather than manufacturers, often serve as the idea generators and initial developers of products that later become commercially significant* (Enos 1962; Freeman 1968; Shaw 1985; von Hippel 1988; Lilien et al. 2002). It is revealed that customers are helpful for firms to face the changing market conditions and survive in the competitive market environment. Therefore, much attention has been placed on customers as presented in related research, and firms heavily rely on customers in design and innovation activities (e.g. participatory design,

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customer co-creation). Moreover, the openness of enterprises to customers or external sources has become one important estimator to forecast the innovation performance (Huang & Rice, 2012). It appears that more customer involvements and wider relevant cooperation with customers may induce better innovation solutions.

However, it lacks further investigations whether the more participation of customers will bring out more innovative or radical ideas. In most cases, the engagement of customers in the innovation process means a great consumption of resources in terms of time and effort (Lilien et al. 2002). Furthermore, the quality of customer involvements cannot be ensured owing to the great difficulties in selection of customers and identification of customers' qualifications and intentions. If customers are involved improperly, the information provided by customers may be invalid. These problems have been noticed by some researchers (e.g. Brockhoff, 2003). Although some viewpoints are stated about the disadvantages of customer involvement, there still lacks sufficient study on the disclosure of the relationships between customer involvement and innovation performance from a quantitative perspective.

In this paper, a study based on innovation survey data is presented attempting to identify the influence of customer involvements on radical innovation performance in NPD. The remainder is organized as: existing work is introduced in section 2, meanwhile problems are uncovered and the hypothesis is established accordingly. In section 3, the proposed models are explained in details. Results are given in section 4 with specific illustrations and discussions. According to the results, conclusions are derived in section 5. Finally, the limitations of this work are analyzed and the future work is prospected in section 6.

2. Literature review and Hypothesis development

In this section, relevant research is presented mainly from the perspective of customers in product innovation. Based on existing research, two problems are uncovered, and one hypothesis is developed accordingly to lay out our research focus.

2.1. Literature review

As the vital design participator, customers have become the significant factor of product innovation (Ngo and O'Cass, 2012; Szainfarber, et al., 2010). It has been demonstrated that the degree of customer satisfaction determines the success of a new product. Therefore, various innovation models are proposed based on the assumption that the customer is the starting point and the ending point of a design process.

However, customers do not always positively facilitate product innovation. For instance, customer involvement in product innovation is synonymous to a considerable amount of resource investment (Lilien, et al., 2002). To control the investment within the competence of a company, the scale of customer involvement should be ensured with a good balance between the cost and expected benefits.

For radical innovation, it is high-degree innovation with new features or functions. Brockhoff (2003) stated the higher degrees of innovation demand more careful management that indicates deliberate attention should be paid to the customer participation in radical innovation. However, there are no sufficient studies emphasizing on this problem.

On the other hand, the selection of customers who are actually able to contribute to new product development is, in practice, very challenging (Brockhoff, 2003). It cannot be guaranteed that we can find the right partner, and the consequences of a poor collaboration can be harmful. Particularly for radical innovation, the confidentiality issue is very important. Nevertheless, customers have no immediate responsibility to design projects, and the wrong participations or information disclosure, which impairs the market performances of radical innovation, will easily happen.

Additionally, customers are not always trustworthy. In some cases, they are not even clear about what they really want. Even though they have a clear understanding of their preferences, there is no guarantee that they can articulate themselves clearly and exactly. Therefore, the information gathered from customers should be handled carefully. Considering these respects, customer involvements are not always equal to good innovation performance.

Based on the understandings, the customer involvement is vital to product innovation. Small scaled involvement of customers cannot fully take advantage of customers' value. However, heavy customer involvement will consume too much economical funds and human efforts (Patricia Sandmeier, 2008). Furthermore, vague customer demands will even raise bias and uncertainties, which carry with more difficulties for designers to use them. Therefore, the customer involvement in the product innovation process deserves serious considerations.

Based on an analysis of related research, two issues are revealed as follows:

- The research focus is mostly placed on customer involvement, thus other potential significant factors may be neglected;
- There lacks sufficient study focusing on the identification of the importance of customer involvements in radical innovation.

Hence, the objective of this study is to explore the importance of customer involvements to radical innovation in NPD through a quantitative and analytical manner. A basic hypothesis testing method is applied in this work to examine above issues.

2.2. Hypothesis development

Based on the above literature review, customers attract most focus of firms in product design and innovation process which can be seen from relevant research and projects. However, there are also other factors showing effective influences on radical innovation. For example, competitors are necessary concerns in innovation management (Sarpong and Maclean, 2012). Cooperation with competitors through partially sharing market information can attain more initiatives to face the changing market conditions, and reach more openness to the market. This can help reach more satisfactory innovation performance. However, cooperation with competitors contains the risks of valuable resource loss and barriers to develop products new to the market (Wu, 2012). In the same sense, professional consultants or research institutions also have influence on innovation performance, since they are able to provide more professional suggestions and technical supports (Sarpong and Maclean, 2012). Based on the above examples, it is indicated that there are other factors affecting innovation performance besides customers. Hence, the hypothesis is proposed as:

- **Hypothesis 1**: The customer is not the most or the only significant factor affecting radical innovation performance in NPD.

According to the study of existing research, two issues of customer involvements in radical product innovation are uncovered and lead to the following study. In the next section, the method to test this hypothesis will be explained into details.

3. Research method

The core of this work is to reveal the importance of innovation related factors crossing inbound and outbound sources in order to identify the factor with a significant positive correlation with radical innovation performance (in this work, the business case number of products new to the market is measured as radical innovation performance), and verify the importance of customer involvements.

3.1. Data

In particular, this study adopts the 2011 UK innovation survey data (The National Archives). This survey covered the period from 2008 to 2010, and consists of a nationally representative sample of business with 10 or more employees in sections B-N of the Standard Industrial Classification (CIS) 2007. In total, 28,079 questionnaires were distributed and valid responses were received from 14,342 enterprises to give a response rate of 51.1%. The core questionnaire covers a broad range of innovation-related concepts. Amongst them, the "important information source" is the focus of this study, since it gives the inputs of innovation activities. In addition, the factor "business cases of products new to the market (the introduction of a new good or service to the market before competitors)" is processed as the radical innovation performance in NPD.

3.2. Descriptive statistics

The survey shows only 7.3% firms have products new to the market. This percentage is low indicating the lack of radical innovation and the necessity of related research. The standard errors of collected data of every attribute vary from 0.31 to 0.80. The errors are mainly caused by the vagueness of questionnaire questions and cannot be avoided.

3.3. Pre-model steps

Firstly, the factors to be studied will be identified. These factors are mainly selected from sources of important information. Based on the 2011 UK innovation survey database, totally 8 elements are selected as estimated variables to be processed. The business case number of products new to the market is processed as the response namely outputs of radical innovation. However, these data are not all suitable for quantitative processing (e.g. invalid data, incomplete data). Thus, necessary pre-processing is needed which includes:

1. Cleaning – The survey results include invalid data (some items received no answers from investigated firms). In this work, the data sets with void items will be discarded since they are fuzzy and uncertain.

2. Coding – For this survey, most attributes are collected through choice of 'yes' or 'no' which are qualitative. In order to achieve quantitative analysis, these expressions or qualitative formats should be coded with numerical formats. In this work, 'yes' will

be marked as '1' and 'no' will be marked as '0'. For attributes which are assessed through rating system, the rating number set by participating firms will be regarded as the numerical representations of related attributes.

3. Weighing – According to research focus, attributes deserving more innovation efforts will be assigned with more weights. For example, the factor "cooperation with other institutions" has various levels: local, UK national, European, and worldwide. The wider cooperation indicates the stronger capability of a company in product innovation, thus should be assigned with more weights.

4. Scoring – To simplify the calculation, the dimensions of every observation should be controlled under a proper level. The main attributes of every observation are 8, and it is better to avoid more detailed sub-dimensions under every attribute. Therefore, the sub-attributes should be combined and integrated to one score which can reflect the overall performance of the related attribute. The score can be computed through the formula below.

$$Score = \sum_{j=1}^{n} Code_{ij} \times W_{ij} \quad (1)$$

Where $Code_{ij}$ is the coding number of *j*th dimension of *i*th attribute; W_{ij} is the weight of *j*th dimension of *i*th attribute; *n* is the total dimension number of *i*th attribute.

3.4. Model specifications

Through pre-processing, the data now are consistent and can be calculated and compared. Since the estimated variables (attributes) are 8, an interactive multiple regression model is preferred to deal with multi-dimensional inputs. As the intention is to extract the most significant factor, iterative computations are conducted to identify the influence of every factor step-by-step. Amongst them, the influence of customer related dimension 'clients, customers or end users' will be focused. The algorithm of this model is making use of interactive linear regression to compute the beta coefficients of every estimated variable, and the larger beta magnitude means larger influences of the variable. The t-distribution is adopted to judge whether the variable has significant influence on response.

4. Experiment results

Through simulations using Matlab, the interactive multiple regression gives the effects of these factors related to product innovation.

4.1. Significance of every influential factor

In this step, every observation consists of eight attributes which are all important information sources for firms. Hence the inputs are multi-dimensional. Products new to the market are outputs of radical innovation which are one-dimensional. Through first-round calculation, the factor 'within business or enterprise group' (-.0035952, p=0.97253) is not reliable, since it has a very large p-value. To improve the confidence of this experiment and the final result, this factor should be discarded as accidental case. In the second-round computation, the dimensions of inputs are reduced to seven.

Applied algorithms are similar and the results are shown in Table 1. From the perspective of p-values, the results are acceptable.

Table 1 Results of the second-round computation through interactive multiple regression model

	Coef	StdErr	tStat	pVal
Constant	3.5752	2.6155	1.3669	0.17928
Suppliers of equipment, materials, services or software	-0.26595	0.083115	-3.1998	0.002692***
Clients, customers or end users	0.18029	0.068758	2.622	0.012304**
Competitors or other businesses in your industry	-0.42843	0.13507	-3.1719	0.0029065***
Consultants, commercial labs or private R&D institutes	1.1134	0.23622	4.7133	2.9383e-005***
Technical, industry or service standards	0.52831	0.307	1.7209	0.092996*
Conferences, trade fairs, exhibitions	0.25726	0.23696	1.0857	0.28412
Scientific journals and trade/technical publications	-0.22341	0.15051	-1.4844	0.14554

*p<0.1
**p<0.05
***p<0.01

Amongst these factors, factor 'Suppliers of equipment, materials, services or software' (-.26595, $p<0.01$), factor 'Competitors or other businesses in your industry' (-.42843, $p<0.01$) and factor 'Consultants, commercial labs or private R&D institutes' (1.1134, $p<0.01$) have very high reliabilities, so the coefficients can reliably reflect the correlation between factors and response. Specifically, factor 'Suppliers of equipment, materials, services or software' has a negative influence on response and the absolute value is not large which means the influence is not very obvious. Factor 'Competitors or other businesses in your industry' also has a negative effect on response and the effect is not large. This phenomenon demonstrates the viewpoints of some researchers (e.g. Wu, 2012) that cooperation with competitors is always damaging the market performance of product innovation. For factor 'Consultants, commercial labs or private R&D institutes', it has the greatest positive coefficient which implies it stimulates the response significantly. This result indicates the importance of consultants for radical innovation through an analytical perspective. Actually, the cooperation with outside consultants or commercial R&D institutions has attracted some industries. For example, banking industry often outsources their business (e.g. risk management) to consulting companies which have long-term and trusty cooperation with them to seek professional guidance and pursue promising solutions. Therefore, consultants or commercial R&D institutions can also support product innovation through providing professional knowledge and methods, ensuring the confidentiality of project and avoiding the risks of wrong and invalid participation.

The estimation of factor 'Clients, customers or end users' (.18029, $p<0.05$) is reliable under the confidence level $\alpha=0.05$, and the influence is positive. However, the absolute value is small that means the effect is not major. This result reveals the influence of customers is not as significant as expected. Although some work suggests that '*a strong focus on the customer organization perilously can alienate the manufacturer from its inherent core competencies*' (Lilien et al. 2002), there still lacks

further and deep considerations. This experiment demonstrated that there are other significant factors which have positive impacts on radical innovation performance.

For factor 'Technical, industry or service standards' (.52831, $p<0.1$), it is reliable under confidence level $\alpha=0.1$. In fact, this estimation is not ideal since normally 0.05 is the acceptable ledge, but can be accepted. The estimations of factor 'Conferences, trade fairs, exhibitions' (.25726, $p>0.1$) and factor 'Scientific journals and trade/technical publications' (-.22341, $p>0.1$) indicate poor reliability, thus the implication of the analysis of these two results is limited. Moreover, the magnitudes of the coefficients are small. Therefore, it is reasonable to neglect these two factors.

From the results, **H1** gets supported that factor 'Consultants, commercial labs or private R&D institutes' shows more significant positive influence on radical innovation performance. Therefore, it may be not wise to simply emphasize on the customer involvements in the product innovation process and consultants can be promising to help improve radical innovation.

4.2. Influence tendency of essential factors

Based on the computation of related factors, a focused study is performed to mainly disclose the essential correlation between important factors. Thus, the third-round calculation is based on factors which we are interested. Factor 'Clients, customers or end users' is undoubtedly included. The factor 'Consultants, commercial labs or private R&D institutes' is also included since it has the most significant influence. Otherwise, the factor 'Competitors or other businesses in your industry' is also analyzed, as it is an important concern for decision managers. Therefore, the inputs are three-dimensional.

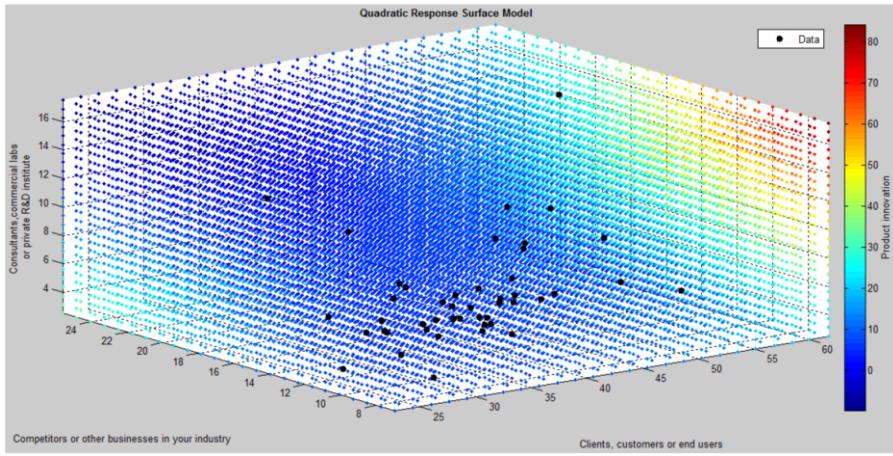

Figure 1 Quadratic response surface of interactive multiple regression model (x-clients, customers or end users; y-competitors or other businesses in your industry; z-consultants, commercial labs or private R&D institutions)

To understand the comprehensive correlation of these three factors with the response, a quadratic surface model is preferred. In this model, the linear correlation, interactive correlation, and square correlation are all concerned, thus a convictive comprehensive estimation is achieved. The result is presented in Fig. 1. X-label is factor 'Clients, customers or end users', Y-label is factor 'Competitors or other

businesses in your industry', and Z-label is factor 'Consultants, commercial labs or private R&D institutes'. The HSV (Hue-Saturation-Value) grades reflect the "products new to market" which are measurements of the radical innovation performance.

From the figure, it is clear that centric part of this cube has very low innovation performance where all dimensions are set at medium level. As extending to the ledge, innovation performance is becoming better. The reason may be that the effects of y-label are contrary with effects of x- and z-label. They cannot lead to optimal innovation in a consistent direction. The possible way to achieve optimization is to set some factors at extreme values and offset opposite effects caused by other factors. Furthermore, the distribution of potential best radical innovation is centralized around one corner where X and Z values are high and Y value is low. It indicates that radical innovation will be promoted by customers and consultants but weaken by competitors. This conclusion is in line with the computation results in above step.

5. Discussion and conclusion

Customer involvement has become an important way for firms to improve product design and innovation in order to face changing market condition and survive in a competitive business environment. In particular, radical innovation endows firms with sharp advantages that differentiate from competitors. This study investigates into the customer involvements in radical product innovation, and the major result is that the potential influential factors in radical product innovation are detected, and the importance of customer involvement is verified.

Based on this study, the innovation performances are more sensitive to 'consultants, commercial labs or private R&D institutions' rather than direct involvements of customers. It does not deny the importance of customers, but want to point out more opportunities to reach innovative products. Actually, consultants can provide professional knowledge and solutions for the development of innovation project which cannot be achieved on a firm's own. However, many firms neglect the importance of consultants. In the same sense, there are also other factors lacking sufficient concerns due to too much attention on customers. Thus a reasonable redistribution of research focus is recommended to concern all significant aspects sufficiently. Especially for firms stuck in a bottleneck, there is little space to extend the benefits from customers, thus promising directions for further improvements may be to improve other factors, such as a corporation with consultants or research institutions.

By and large, the significance of customers is detected. It is proven that careful considerations are worthwhile during developing radical innovations. Therefore, controlling the customer involvements by estimating expected benefits and forecasting potential risks is important. Furthermore, research efforts should be properly distributed on related aspects to pursue the best benefits.

6. Limitation and Further work

This work was based on 2011 UK innovation survey data which are collected through questionnaires. Nevertheless, the answers unavoidably contain errors and uncertainties, such as the bias caused by misunderstanding of the questions, and implicit uncertainties caused by void answers, just to name a few. In addition, the data do not explicitly focus

on customer involvements. This constraint implies that the analysis may not provide a complete picture of the antecedents of a firm's customer involvements, because certain relevant variables may not have been included. For further research, the error sources will be still detected and processing methods will be further improved to be more accurate to avoid potential errors. Otherwise, this study also provides interesting directions for product design and product innovation which can be studied through empirical study as well as theoretical work.

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