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以資料探勘法鏈結顧客知識管理於創新性產品開發專案之研究

LINKING INNOVATIVE PRODUCT DEVELOPMENT WITHCUSTOMER KNOWLEDGE: A DATA-MINING APPROACH

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致　謝

承蒙指導教授 蘇朝墩博士及沙永傑博士悉心指導與鼓勵，並對本文逐字斧正，使本文得以完成。受教多年，其嚴謹治學與謙恭處事之態度和樂觀、積極的精神，一直為筆者學習之典範。因為有指導教授持續的鼓勵與殷切的督促，本文方得以順利完成。口試期間承蒙盧淵源教授、楊千教授、范書凱教授、駱景堯教授之不吝指正，並提供寶貴意見，使本文更趨完備，僅此深致謝忱。

就學期間，蒙中華汽車公司前任總經理蘇慶陽先生、副總經理吳海博士、副總經理黃重洲先生支持筆者深造，多所鼓勵與協助，皆令筆者銘謝難忘。也感謝工業技術研究院機械所研究所副所長蘇評揮博士於筆者共同參與經濟部「先進車輛技術科專(93-EC-17-A-16-R7-0295)」期間的指導鼓勵。

最後僅以本文獻給我最敬愛的家人，感謝他們的支持，讓我無後顧之憂以奮力向學，使得本文得以順利完成，願與他們分享所有努力的成果。

摘　　要

當今知識經濟中，知識被視為組織內的資產，推行知識管理有助於公司開發創新性產品及制定關鍵性的策略決策。產品的創新必須鏈結顧客知識到產品設計及製程上的技術能量，使上市的產品滿足顧客需求，以在市場上獲致成功。儘管知識管理在技術創新上的重要性長久以來已被認知，然而對於顧客知識上所能發揮的效益卻尚未廣為研究，所以本論文提出一個整合性知識管理模型之概念架構以及實施應用時之方法論，來論述創新性產品開發中同步管理產品知識和顧客知識，有助於降低產品風險並獲得市場成功。

在知識管理領域中，最重要的任務就是將隱性知識轉換成顯性知識。此時可借重資訊科技如網際網路市場調查法和資料探勘法（如多變量分析，類神經網路）先進行市場區隔作業，再來萃取各市場區隔內的顧客知識。在本研究中，此整合性知識管理模型已實際應用於一項和行動商務相關的產品開發專案，資料探勘的結果滿足了多項評鑑準則，因而讓開發團隊作出重要的產品型態規劃決策。本論文的貢獻在於原創出一個鏈結顧客知識於創新性產品開發專案的新方法論，兼顧 KM 理論架構和產品開發實務，並在顧客 KM 流程中導入計量方法，既有原創性的學術貢獻，也能夠在產業界實際應用。

關鍵詞 ：顧客知識管理，資料探勘，創新性產品開發，行動商務，網際網路市場調查.

ABSTRACT

In today's digital economy, knowledge is regarded as an asset in organization, and the implementation of knowledge management supports a company in developing innovative products and making critical management strategic decisions. Product innovation must link technological competence such as engineering and process know-how with customer knowledge, so that the product will meet the customers' needs, in order to secure market reception. Even though the importance of knowledge management in the technological product innovation has long been recognized, its potential for customer knowledge has not been widely studied. To address the need of customer knowledge in innovative product development, this dissertation proposes an integrated knowledge-management model with a methodology to precisely delineate the process of congruently managing product knowledge and customer knowledge for innovative product development.

In the knowledge management domain, an important task is the conversion of tacit knowledge into explicit knowledge, allowing information technology application such as web-based surveys and data mining approach to extract customer knowledge from different market segments. An empirical study applying the proposed integrated knowledge-management model has been carried out in a Mobile-commerce oriented Telematics product development project. The result meets the evaluation criteria in a multiple-assessment scheme for showing a satisfactory justification. This study makes a contribution toward the creation of a new methodology by linking innovative product development with customer knowledge, in order to reduce project risk and ensure market success.

Keywords: Customer knowledge management, Data mining, Innovative product development, Mobile-commerce, Web-based market survey.

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CHAPTER 1

INTRODUCTION

Technological innovation allows us to cope with increasingly intensive competition when facing challenges from a rapidly changing market situation. Most companies make an effort in knowledge management (KM) to enhance their competitive advantage in product innovation in order to ensure market success. An important component in knowledge management is 'knowledge creation'. This knowledge creation is supported by two key factors: (1) converting tacit knowledge into explicit knowledge, and (2) translating this tacit knowledge of experts or customers into a comprehensible form (Nonaka 1998). Elaborating on knowledge work can have innovative outcomes, such as the discovery of new technologies for the development of new products and new processes. For an innovative product to be successful, the product innovation for a company must link technological competence such as engineering and process know-how with customer competence such as knowledge of customer needs and communication channels (Danneels 2002).

1.1 RESEARCH BACKGROUND

The importance of knowledge management in the product technology innovation has been duly recognized (Corso 2001); however, the potential for customer knowledge management has not been studied in any great depth (Grover 2001, Soo 2002), and little discussion has been devoted to the outcomes of knowledge application (Gold 2001, Plessis 2004). Thus, among many types of knowledge in a company, product knowledge and customer knowledge fall into the 'crucial' category, because they directly contribute to the product's acceptance in the market, the competitive advantage and the financial performance of the company. Therefore, any study on knowledge work improvement should focus on making products/services more attractive in order to increase value and to prevent project failure (Davenport 1996). This is especially important for innovative new product development (NPD) project, which demands huge amount of investment and complex technological input, as the business excellence relies on not only technology breakthrough but also the success of market outcome.

1.2 RESEARCH MOTIVATION

For organizations working at developing innovative product to facilitate early stage market acceptance and satisfactory return in investment, there is a demand on studying how to congruently manage both product knowledge and customer knowledge to create product value and to reduce market risk.

In the digital economy, customer relationship management (CRM) is a contemporary management tool. It manages the relationship with customers by employing up-to-date information technology to understand, to communicate with, and to attract them. Its objective is to satisfy and retain customers (Dyche 2002). Increasing the productivity of knowledge work and managing customer knowledge so as to understand their needs and wants, enables a company to gain a competitive advantage in the market. Recently the 'customer knowledge management' (CKM) model has drawn much attention by the combining of both the technology-driven approach in CRM and the people-oriented approach in KM, with a view to exploit their synergy potential (Davenport 2001). The expectation from this endeavor is to more effectively create knowledge 'for' customers, knowledge 'about' customers, and knowledge 'from' customers, so that an attractive product can be delivered to the right group of customers to ensure business success. The difference between CRM and CKM is shown in Table 1 (Garcia-Murillo 2002).

Table 1. The difference between CRM and CKM

Difference	CRM	CKM
Direction	One way	Two ways
Medium	Technology	Personal
Information	Data	Customer
Objective	Identify profitable customers, Customized marketing	Gather customer ideas, New product Development

Gerbert (2003) and his associates provided a well-structured "Customer knowledge management model" that describes the interaction between customers and a company's marketing activities. However, their work lacked the implementation details and methodology. Shaw (2001) presented an "Integrated knowledge management system for marketing model" involving shared marketing knowledge, supply chain partners and marketing decision support application. In the article he indicated the challenges in marketing KM as (1) knowledge discovery through data mining, (2) cross-organizational boundaries, and (3) customers classification, but provided no solution how to practically tackle the challenging issues. Corso's paper offered a "Knowledge management in product innovation model" to emphasize the interaction stages between KM process and KM sources/uses, both internal and external (Corso 2001). It pointed out the need for the development of empirically tested supportive models to foster the KM applications.

Even though researchers have made efforts to address the importance of KM on product development or for customers in marketplace, their studies not yet congruently took product and customer into consideration, and also had lack of procedure for implementation, not to mention the introduction of up-to-date methodology such as the application of information technology (IT). Herby it arouses the motivation to propose an conceptual framework entitiled as the integrated knowledge management model to (1) link customer knowledge with product development, (2) delineate the methodology and the procedure for implementation and also (3) by the intervention of IT application to conduct an empirical study. The knowledge derived from the implementation of this integrated KM model in an industry level empirical study, can be applied to an innovative NPD project. The outcome of knowledge application demonstrates that technological innovation NPD requires not only the sophistication of knowledge, but also the fusion from knowledge influx of other sort.

1.3 RESEACH OBJECTIVE

With the background and the motivation of addressing the essentiality of customer knowledge in innovative NPD, this dissertation presents a methodology to support the argument that in order to ensure business excellence, a product's features must meet the needs of specific customer groups in the market. An conceptual-framework-based integrated KM model implemented with the application of information technology is used to accomplish it. In this model, aside from product knowledge management, there is also the introduction of a web-based survey approach and data mining techniques to accomplish the outcome of customer knowledge management. The customer knowledge management process is as follows. First, the features of a product are transformed into 'benefits' that customers need, paving the way to understand the response of the customer toward the benefits those features bring out. Next, a customer's needs toward the perceived product benefits are taken as the base to form market segments. By this approach it is possible to convert tacit customer knowledge into explicit knowledge, so as to support the company in developing different product variants for various customer groups having a similar attraction. Because market segmentation, market targeting, and market positioning are the three major tasks to be carried out in target marketing (Kotler 2003). To be successful in marketing, market segmentation is certainly a very important task.

In order to justify this integrated model as applicable in the field, a multi-assessment scheme consists of three criteria is employed for evaluation: (1) does the customers accept the web-based survey approach and does he/she render a sufficient response for data mining? (2) Can the data mining technique successfully extract the customers' needs pattern in order to facilitate NPD? (3) If multiple data mining methods are all qualified to cluster customers into segments, then which one is the most appropriate method?

Therefore, the research objectives of this study are:

(1) Addressing the imperativeness of managing product knowledge and customer knowledge in an innovative NPD project, by proposing an integrated KM model.

(2) Setting up the methodology for extracting knowledge of the customers in market to facilitate the NPD project, by web-based survey and data mining technique.

(3) Justifying the robustness of this integrated KM model by an empirical study, if the result meets three evaluation criteria in a multiple-assessment scheme.

1.4 ORGANIZATION OF THIS DISSERTATION

The remaining part of this dissertation is arranged as follows. In chapter 2 we review the literature on knowledge management regarding innovation, new product development and the customer in the market place, as well as data mining application in market segmentation. Then in chapter 3 we propose an integrated KM model to link CKM with an innovative NPD project, details of the implementation process are also described. In chapter 4 we report the application of the integrated KM model in a Telematics NPD project, and then present an empirical study and the result.

The outcome that meets the evaluation criteria will confirm the feasibility of this model in the real world business environment. It enables the application of customer knowledge in making product variants for different target market segments, in reducing project risk, and in meeting custimers' satisfaction, so as to make the business a success. In chapter 5 we will present the discussion and compare the results of these three data mining methods, and finally in chapter 6 we draw our conclusion and indicate the direction for further research.

CHAPTER 2

LITERATURE REVIEW

2.1 THE EVOLUTION OF NEW PRODUCT DEVELOPMENT STUDIES

It is well recognized that to substantiate a company's success the market offerings whatever products or services must meet customers' requirement or even more, to exceed their expectation. So the importance of new product development cannot be underestimated. To explore the best practice how to bring out successful products, industry and academic community have made efforts to study the theoretical foundation and real world case by means of domestic investigation and international survey.

In U.S.A. a systematic study for product development management practice has been done to report that the basic product development processes should be: new product strategy, exploration, screening, business analysis, development, testing and commercialization (Booz 1982). Brown organized the within-ten-years empirical research literatures on product development into three main streams: the 'rational plan approach' emphasized determinants of financial performance of the product, the 'communication web approach' dealt with communication effect on project result, and the 'disciplined problem solving approach' concentrated on factors that bring product into being – team, suppliers, project leader (Brown 1995). He also proposed an 'integrative model for product development' by taking product effectiveness and process performance as the most influential points for the financial success of the product developed. Eleven large-scale surveys sponsored by Product Development and Management Association, U.S.A., have been conducted from 1990 to 1996. The results were summarized to conclude a consistent clue that multi-functional team, rational process/resources and considerate strategy are crucial part for success; however, best practices may be context-specific (Griffin 1997).

Another article evaluated product development literatures in the past ten years to assess the relationships between project performance and several specific product development characteristics: product development process, product definitions, organization context and cross-function teaming. The positive impact factors found are: the use of overlapping/interaction activities by cross-function teaming, employment of integrated tools and formal methods, and the organizational influence of team leaders (Gerwin 2002).

Other school of study was focused to the successful practices in specific industry of certain countries. Teams of scholars at Massachusetts Institute of Technology, Harvard University and the University of Michigan have identified a number of strengths in Japanese automobile industry (Lynn 2002). For instance, technology fusion by convergence of different technologies from separate disciplines (Kodama 1992), integrating of suppliers' technology capability in development stage (Kamath 1994), set-based concurrent engineering (Ward 1995, Liker 1996), technology integration by incremental improvement (Iansiti 1997), and organizational mechanism (Sobeck 1998). The taxonomy and evolution of technology strategies of Taiwan's high technology-based firms was reported too (Hung 2003). However, methodology down to the product structure level is relatively seldom to be studied, except researches about product modularization by several scholars (Baldwin 1997, Diaz 1998, Sanchez 1999, Schilling 2000, Mikkola 2003) to emphasize the design strategies aiming at less lead time and less cost for introducing new product variants for multiple market segments.

Recent studies in the NPD literatures look into new issues such as sustainable development, innovative problem solving theory, and knowledge management. The Earth Summit held in Rio de Janeiro, Brazil in 1992, produced a conference document: Agenda 21, which is regarded as "a blueprint for action for global sustainable development into 21st century". From then on, sustainable development become a new concept for environment protection by collaboration among governments, industries and education institutes. Therefore, many environment assessment tools were developed to measure the impact on environment by industrial products, for instance, life cycle analysis (LCA), cumulative energy expenditure (KEA), material input per service input (MIPS) and so on.

However, some firms may see the approach of sustainable development as a constraint undermining their economic interest, they indicates that financial resources assigned by firms for environment sustainability must be rewarded by market success for the sustainability of firms. Innovative technology development and management is a key success factor in sustainability of both environment and firm. Through technological collaboration and value chain management in 3R (reduce, reuse and recycle) countermeasures for product and process design, a competitive advantage can be gained in an innovative new product development project. WBCSD (World business council for sustainable development) has identified seven major eco-efficiency elements to guide companies in developing eco-friendly products for reducing environment impacts (Desimone 1997): (1) reduce the material intensity of its goods and services, (2) reduce the energy intensity of its goods and services, (3) reduce the dispersion of any toxic materials, (4) enhance the re-cyclability of its materials, (5) maximize the sustainable use of renewable resources, (6) extend the durability of its products, (7) increase the service intensity of its goods and services.

In February of 2003, European Community announced the proposal for two directives: (1) WEEE, a directive on Waste Electrical and Electronic Equipment, (2) RoHS, a directive on 'the Restriction of the use of certain Hazardous Substance' in electrical and electronic equipment. The registration of environment protection measure will certainly influence the future NPD program.

On the other hand, innovation in NPD has already been well studied, however, merely in the level of conceptual frame (Lynn 1996, Goel 1998, Thomke 2002, Rice 2002, McDermott 2002, and Chapman 2004). A tool to help engineers to tackle systematic incompatibility and technical contradiction problem in an innovative NPD project has drawn attention in recent years. It is TRIZ (an acronym in Russian: Theory of Inventive Problem Solving), a methodology developed in 1946 by Genrich Altshuller by investigating the intellectual property contained in 200,000 patents (Smith 2003) . The core of TRIZ are the 40 principles and a matrix of contradictions with 39 parameters to reduce creativity to an exact science. It has been proven to be a very powerful method for creating new NPD solution by providing a new and more problem-solving-oriented way of creation of innovative conceptual design solution (Orloff 2003, Bariani 2004). The TRIZ function analysis helps in coping with design problems involves some kinds of conflict condition such as: (1) a product should be stronger but lighter—the technical contradiction, (2) a product should be of higher quality but lower cost—the management contradiction. Therefore, researcher has tried using TRIZ to deal with eco-innovative NPD problems: achieving material reduction, energy reduction, toxicity reduction in a more durable, better service product (Chang 2004).

The most significant contribution of TRIZ is the conversion of tacit knowledge (Polanyi 1966) hoarded in the world's finest inventive and innovative minds into a codified and comprehensive form, and becomes the explicit product knowledge to facilitate the innovative new product development.

2.2 KNOWLEDGE MANAGEMENT

2.2.1 Technological Innovation and Knowledge

Peter Drucker defined innovation as “The effort to create purposeful, focused change in an enterprise’s economical or social potential”. He indicated that most successful innovation stemmed from seven areas of opportunities and ‘industry and market change’, ‘changes in perception’ as well as ‘new knowledge’ are three among those seven areas. Knowledge-based innovation requires not only one kind of knowledge but many, and the innovation that creates new users and new markets should be carefully aimed at the specific application (Drucker 1998). Betz (2003) defined technological innovation as: “Technological innovation is both the invention of a new technology and its introduction into the marketplace as a new high-technology product, process, or service.” Technological innovation allows us to cope with increasingly intensive competition in a rapidly changing marketplace. Most companies should use their knowledge to promote their competitive advantage in product innovation, by enhancing their capability in managing that knowledge so as to convert it into useful products and services. In the past decade, knowledge has been recognized as one of the most valuable asset in organization as indicated by Peter Drucker: “The most important contribution management needs to make in the 21^{st} century is to increase the productivity of knowledge work and knowledge worker” (Drucker 1999).

Among many examples on definition about knowledge given by researchers, Davenport’s pragmatic one is “The most valuable form of contents in a continuum starting at data, encompassing information, and ending at knowledge” (Davenport 1996). Researchers, a long time ago, defined the knowledge category using the concept of explicit knowledge and tacit knowledge (Polanyi 1966). Then, Nonaka used a SECI model shown in Figure 1 to identify knowledge creation as a spiral process of interaction between explicit knowledge and tacit knowledge. The 'externalization' step which takes place at 'interaction ba' plays an important role in knowledge creation, it is supported by two key factors: (1) converting tacit knowledge into explicit knowledge and (2) translating the tacit knowledge of experts or customers into comprehensible forms (Nonaka 1998).

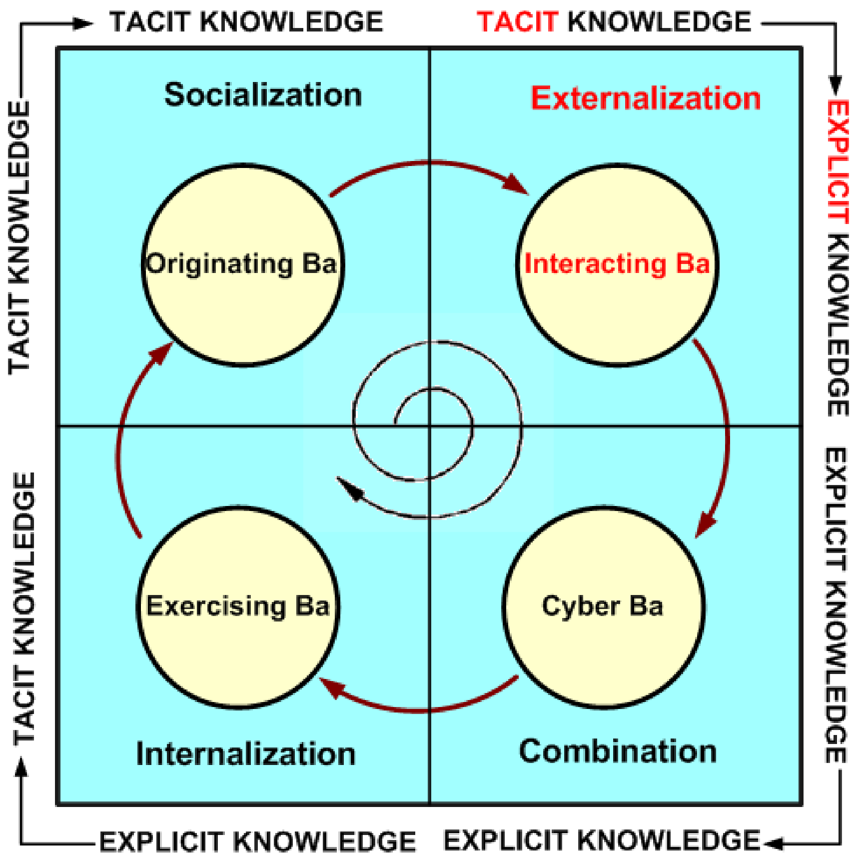


Figure 1. The SECI Model (Nonaka 1998)

Investment in knowledge work can lead to innovation efforts such as the discovery and the development of new technologies, new products, and new production processes according to Carneiro (2000). Danneels (2002) offered an important insight when he argued that product innovation for a company must link technological competence such as engineering and process know-how with customer competence such as knowledge of customer needs and communication channels.

Therefore, it is worthwhile to manage the knowledge a company desires to have and it is also imperative to institutionalize the knowledge management process for transforming knowledge into company's competitive advantage. Different, however similar approaches have been proposed by researchers in this field: Davenport again pointed out that the knowledge process lies somewhere between information and a company's products and services, and the knowledge process consists of three sub-processes: knowledge generation, knowledge codification, and knowledge transfer / realization (Davenport 2001). Bhatt (2000) defined the knowledge development cycle as four phases: (1) knowledge creation, (2) knowledge adoption, (3) knowledge distribution and (4) knowledge review and revision, and addressed that appropriate strategies should be required for each phase to organize knowledge into the development cycle. His viewpoint is largely concurred with Kakabadse's four distinct stages of knowledge institutionalization: (1) knowledge creation, (2) knowledge sharing, (3) knowledge application, and (4) knowledge acquisition from outside (Kakabadse 2001).

2.2.2 Knowledge Management on New Product Development

The importance of knowledge work for a company has been well recognized. However, justifying this knowledge as being valuable is a must for a company in order to qualify the knowledge as an intangible asset. "Knowledge assets underpin competence, and the competence in turn underpins the company's products and services offering in the market." (Styre 2002). Indeed, the success of a knowledge-conscious company relies on its efficiency in creating knowledge, and its effectiveness in applying that knowledge to products and services that offer a deliverable value to customers thereby generating a profit for the company. Researchers argued that the challenge for a new product development task is to design and create organizational context for the knowledge work. Therefore, they proposed a conceptual model of the NPD organization as a knowledge enterprise, the model constitutes four high-level constructs that shapes up the knowledge system: (1) contextual organizational elements such as information quality, participants from boundary spanning structure, and etc., (2) knowledge work behaviors such as linking knowledge sources and knowledge users, creating opportunities for producing new knowledge, and etc., (3) knowledge outcomes such as effective knowledge use and new knowledge generation, (4) knowledge effectiveness such as organizational performance in quality, innovation, customer focus, knowledge and productivity (Mohrman 2003). A cross-functional collaborative KM model in NPD teams is also proposed to create internal knowledge repositories by developing IT-based KM tools to store NPD process knowledge, as a successful company should be able to continuously create new knowledge, quickly disseminate knowledge and embody knowledge in new products (Ramesh 1999). Other researchers have emphasized the use of KM for reducing the risk in NPD, by collecting data from internal and external sources and then extracting relevant information in order to prevent product failure. The internal problems affecting product failure are: being unable to meet performance, reliability, or cost requirement, while the external problems are: unsuccessful reception in the market, changing regulations, and so on (Cooper 2003).

Today the role that KM plays in the NPD activities is better understood. However, it only makes a contribution to within-organization NPD outcomes such as product/service quality, cost, and deliverables-to-market. In fact these NPD outcomes should link with market outcomes like products sales, customer satisfaction, and return on investment, and to be jointly assessed in order to evaluate the business success. Therefore, customer knowledge is an important attribute of any NPD project.

2.2.3 Knowledge Management on The Customers in Marketplace

Li (1998) suggested that market knowledge competence in NPD is composed of three processes: (1) a customer knowledge process; (2) a competitor knowledge process; and (3) the interface between marketing research and R&D. Based on his work, Campell (2003) proposed a conceptual framework of "customer knowledge competence" to create and integrate customer knowledge within an organization. It is composed of four processes: (1) a customer information process, (2) a market-IT interface, (3) senior management involvement, and (4) employing evaluation and reward system. He explained that a customer information process is a set of activities that generate customer knowledge about customers' current and potential needs for products and services. As far as market-IT interface is concerned, data about customers can be available through a customer relationship management (CRM) database. However, data needs to be converted into information and the company can then integrate the information to develop customer knowledge. Another researcher further opined that CRM cannot take place without KM, because in order to deliver products and services to delight customers, knowledge from customer must be well managed to make sure that the deliverables a company offers meet customers' satisfaction (Plessis 2004).

CRM, with the support of IT, has already been recognized as a contemporary management tool in the digital economy for managing the relationship with customers. It does so by taking advantage of on-line data analysis, data mining and a database management system to assist a company in its management decisions. In order to maintain a good relationship with customers, it is crucial that a company communicates and interacts with its customers in a satisfactory manner, and provides market offerings that the customers want. This requires the deliberate management of different categories of 'customer knowledge' shown in Table 2 (Davenport 2001, Garcia-Murillo 2002, Gebert 2003).

Table 2. The categories of customer knowledge

(1) Knowledge 'for' customers	satisfies customers' requirement for knowledge about products, the market, and other relevant items.
(2) Knowledge 'about' customers	captures customers' background, motivation, attitude, and preference for products or services.
(3) Knowledge 'from' customers	understands customers' needs pattern and/or consumption experience of products and/or services.

In this regard, customer knowledge obtained via a CRM system is a valuable intellectual asset for a company to develop or improve products and services in order to meet or even exceed customers' expectations. CRM systems that collect information for customer knowledge are classified into three main categories shown in Table 3 (Dyche 2002, Gebert 2003).

Table 3. The categories of CRM systems

(1) Operational CRM systems	enhances the efficiency of a CRM process through service-center management and marketing-automation like database marketing.
(2) Analytical CRM systems	evaluates knowledge of an individual customer's attitude, needs, and values for cluster analysis. Data mining is a typical technique in this category.
(3) Collaborative CRM systems	synchronizes customer communication time through channels such as e-mail, the Internet, and/or the telephone.

In the literature most studies on KM and CRM are treated in separate research domains. However, lately their mutual synergy potential has drawn the attention of researchers in the field by employing KM in an effort to help CRM to transcend from its original technology-driven and data-oriented approach into a more people-oriented 'customer knowledge management' model or CKM model, it has already invoked a convergence of the two (Davenport 2001, Garcia-Murillo 2002). The CKM model emphasizes a bi-directional communication channel. This interaction with customers, and customer knowledge management set up strategies for how a company can develop attractive innovative products, or improve its service to win customers satisfaction.

2.3 DATA MINING FOR GENERATING CUSTOMER KNOWLEDGE

2.3.1 Market Segmentation to Support NPD

To secure market acceptance, customer knowledge on customer group of the same propensity is very important for a company in deciding which product variant to develop, to satisfy or delight customers in that market segment. Extracting knowledge of customers behavior in various segments for making decisions in product variants development is critical to the success of marketing efforts, as shown in Figure 2. Heinrichs (2003) stipulated prerequisites for company to sustain competitive advantage, one of them is the use of leading edge information technology tools for effective knowledge management, for example, web-based data mining tools to build up specific capacities in information presentation, knowledge discovery and analytical capabilities.

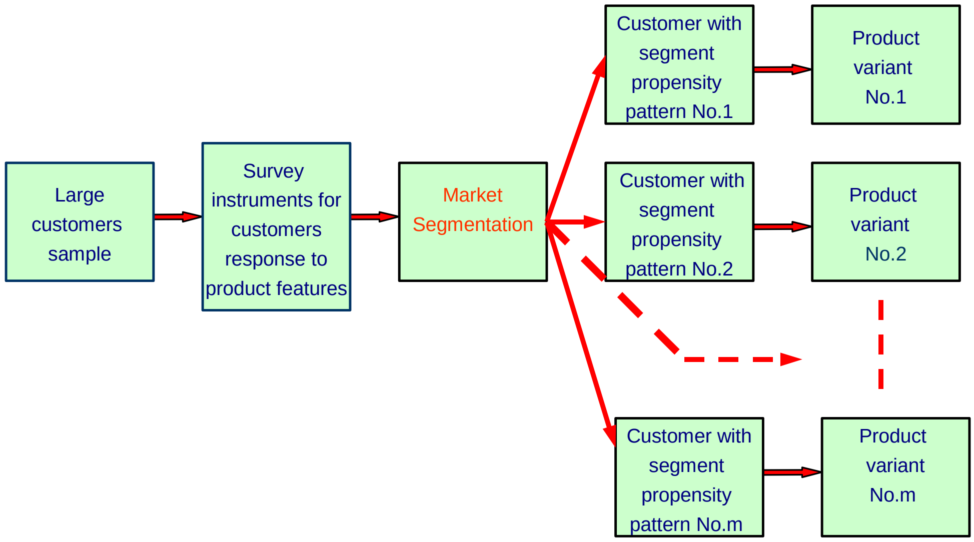


Figure 2. Product variants for various segments

2.3.2 Market Segmentation to Form Customer Clusters

The concept of market segmentation was presented along with the concept of product differentiation by Wendell R. Smith to describe the demand-supply condition in imperfect competition market (Smith 1956). Since then, segmentation concept dominated marketing research literature and practice. Major considerations involved in segmentation research studies are the selection of the bases of segmentation -- a set of variables to allocate potential customers into homogeneous groups. Variables employed as bases (the dependable variable) or descriptors (the independent variable) can be divided into two categories: 'general' customer characteristics and 'situation specific (product specific)' customer characteristics (Wind 1978). Kamakura (2000) further classified variables into 'observable' ones (i.e., be measured directly) and 'unobservable' ones (i.e., inferred). For example, geographic and demographic variables are 'general-observable', situations and usage frequency variables are 'product specific-observable', psychographics and life-style variables are 'general-unobservable', and benefits, preferences variables are 'product specific-unobservable'.

'Benefits' has been regarded as a preferred segmentation base for understanding a market and for making decision about market positioning and new product development (Wind 1978). Haley (1985) argued that 'causal segmentation schemes' (segments based on benefits, experiences, beliefs) are more likely to discover potential responsive subgroups and more attractive targets, when compared with 'descriptive segmentation schemes' (segments based on demographic and volumetric characteristics). Because demographic segmentation only describes customers behavior without explaining it, and the change in the perception of benefits delivered by brand/product can alter customers' attitude – the tacit customer knowledge. Today, concerning the base for segmenting consumer market, customer characteristics such as geographic, demographic, and psychographic variables, are one of two broad groups of variables for segmenting the market. The other group is the response customers towards benefits/needs, situation and brand. Six criteria are employed to evaluate the effectiveness of different segmentation bases: identifiability, substantiality, accessibility, stability, actionability and responsiveness (Kotler 2003). 'Benefit-based' or 'needs-based' segmentation scheme is ranked as the most appropriate one if taking into account the overall performance (Kamakura 2000). Using market survey instrument to collect data that represent customers' response towards product benefits or product features enables data mining technique to contribute in performing cluster analysis to form several target customer segments.

Generating customer knowledge in each segment requires a precedent segmentation task. There are two principal segmentation frameworks for segmentation studies (Green 1977, Wind 1978) and a hybrid two-stage segmentation method (Punj 1983):

(1) **A priori segmentation** Management decides in advance some variables as segmentation bases such as customers' gender, age, and etc., then classifies them into predetermined number of

segments to show each segment's size and demographic, socioeconomic status.

(2) **Post hoc segmentation** Management may chooseas segmentation base a set of variables responsive to some marketing stimuli, e.g. benefits, needs and preferences. The aggregate individual customer's response score or rating then be clustered into groups with the best within-group homogeneity as well as the highest between-group heterogeneity, to result in the number and the type of clusters for further investigation. It is also referred as 'cluster-based' segmentation.

(3) **Hybrid segmentation** It is called 'two-stage' method by combining both a priori and post hoc segmentation procedures in consequence.

2.3.3 Data Mining Techniques for Market Cluster Analysis

Today, with the rapid advancement of computing power, data mining plays an important role in knowing customers' wants and needs toward benefits that products offered (Amstel 2000). In an article, Shaw (2001) presented a well-illustrated taxonomy of data mining tasks for creating customer knowledge (Figure 3), so as to support his argument that effective CRM only be validated by the actual understanding of customers and their needs, preferences, manifested itself in the form of pattern extraction

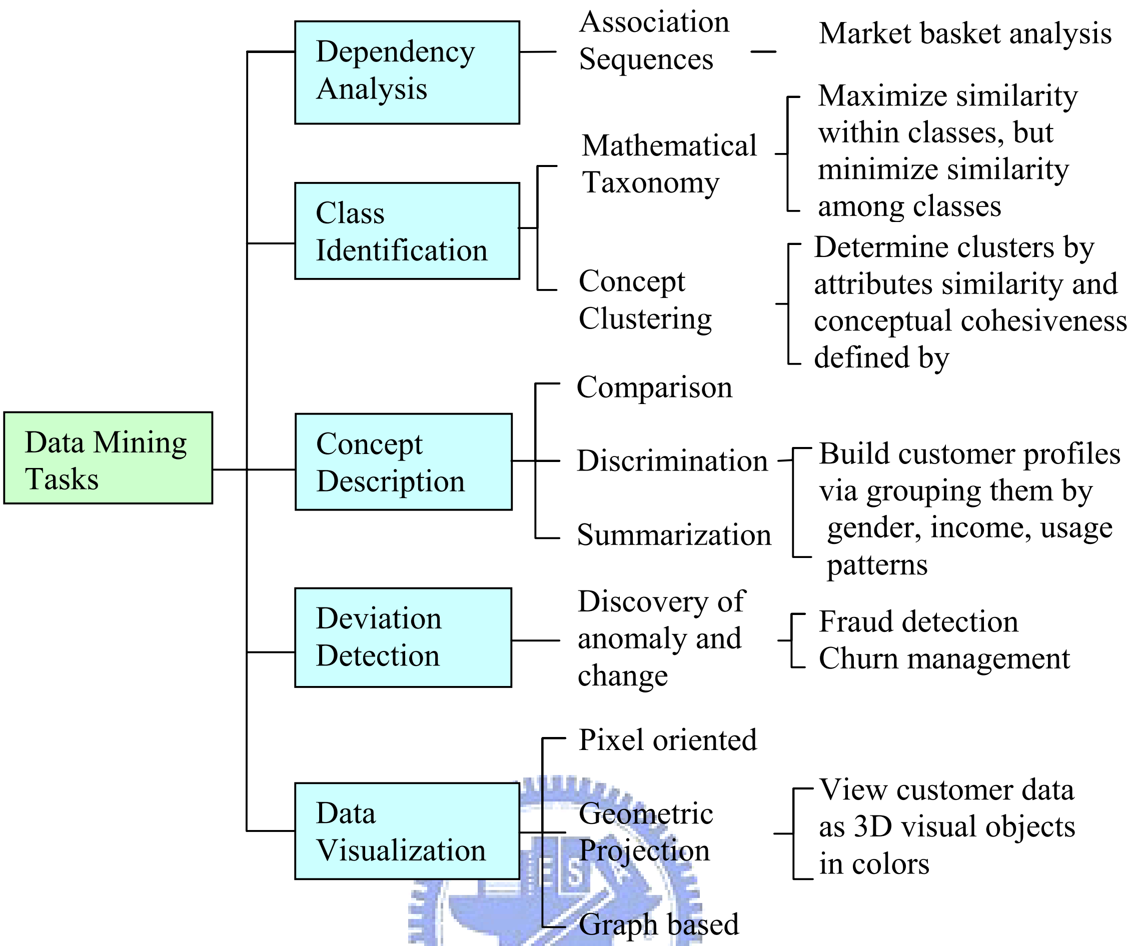


Figure 3. A taxonomy of data mining tasks, revised from (Shaw 2001)

Han (2001) referred 'data mining' to extracting knowledge from large amounts of data, by the following steps: (1) data cleaning, (2) data integration, (3) data selection, (4) data transformation, (5) data mining, (6) pattern evaluation, and (7) knowledge representation. Some functionalities of data mining technique are shown in Table 4.

Table 4. Functionalities of data mining

(1) Cluster analysis	analyzes data objects without knowing in advance the known category labels, so as to generate such labels.
(2) Classification	builds a model to distinguish data set into various classes with labels.
(3) Association analysis	discovers association rules for data attributes that frequently take place together.
(4) Prediction	builds up a model to predict data value.

Han (2001) again classified clustering techniques by categories such as: partitioning methods (K-means, K-medoids and variations), hierarchical methods (AGENS, DIANA, BIRCH, CURE and Cameleon), density-based methods (DBSCAN, OPTICS, DENCLUE), grid-based methods (STING, WaveCluster, CLIQUE) and model-based methods (statistical approach and neural network approach). In this study, neural network model and K-means algorithm are employed for cluster analysis.

2.3.4 Neural Network Application in Market Segmentation

An overview of neural network application history in business has been done (Smith 2000) to report that multilayered perceptron (MLP) neural network, Hopfield neural network and self-organizing feature map (SOM) neural network as the three main models used in business. Another review (Wong 2000) on 302 research articles related to the neural network application in business during the period of 1994-1998, indicated that 4 articles among the 302 articles were associated with market segmentation. In another article, the MLP neural network outperformed traditional statistical approaches, namely the discriminant analysis and the logistic regression model in segmenting customers by purchase intentions (Dasgupta 1994). The MLP neural network also obtains higher hit ratio in an industrial segmentation problem, compared with discriminant analysis and logistic regression methods (Fish 1995). Another study reported that neural network with frequency-sensitive competitive learning algorithm didn't outperform K-means clustering technique, however, in case that the result of network is used as the seeds to be input into K-means algorithm, a better segmentation outcome appears (Balakrishnan 1996). However, an article reported that a supervised MLP neural network didn't do better than logistic regression in segmentation for target marketing (Zahavi 1997).

In another comprehensive survey on 95 articles by describing artificial neural network in different dimensions: network architecture, learning rule, algorithm and performance comparison with traditional statistical method (Krycha 1999), 4 articles of neural network application in marketing segmentation, overwhelmingly employing MLP networks, reported better outcomes than traditional statistical approaches. Krysha identified that although artificial neural network can be applied to many marketing decision situations which could only be dealt previously with multivariate statistical analysis, its two typical contribution areas are: market segmentation tasks (statistical methods in this application are discriminant analysis for classification and other clustering techniques) as well as market response modeling (statistical method in this application are is multiple regression analysis). He also pointed out that the most crucial point for marketing research activities is lacking applications on the individual level data (Krysha 1999).

To focus on more broad area such as management, marketing and decision making, 93 papers has been surveyed and found that 74 out of 93 papers, made use of MLP network trained by the backpropagation learning rule, the others employed unsupervised approach, mainly SOM network. Among them, 6 articles were for market segmentation. The MLP network has successfully tackled the problems. After recognizing the fact that the MLP network is basically a supervised network architecture for classification rather than for clustering, the researcher urged on more segmentation studies by means of unsupervised neural network (Vellido 1999a).

SOM has made much presence in segmentation research studies, for example, the segmentation of the on-line shopping market (Vellio 1999b), and the mining procedure to support on-line recommendation (Changchien 2001). On the other hand, K-means algorithm has been regarded as the benchmarking tool in evaluating the performance of artificial neural network, because K-means is the most popular and most widely used post hoc procedure for market segmentation (Kamakura 2000). When the performance of these three methods are compared one another, it can be found that an earlier article described a unfavorable performance of SOM network against K-means clustering algorithm (Balakrishnan 1994), and another research article on the clustering of binary market research data reported that SOM was inferior to the performance of K-means (Larkin 1999). However, K-means algorithm failed to discover cluster structure compared to a special designed MLP network (Hrushka 1999).

It is interesting to note that the artificial neural network based on Adaptive Resonance Theory (ART), which is also an unsupervised neural network, also appears in the literature to form customer cluster (Chen 2002). Therefore, the FuzzyART network is also applicable in the market segmentation study.

2.4 THE FINDINGS

From the literature review, we found that although researchers hade made efforts to address the importance of KM on product development and that on customers in marketplace, their studies treated product KM and customer KM in separate domain, and there was seldom any article to congruently took product and customer into consideration.

A susbstantial volume of research articles dealt with KM conceptual framework, however; there were in the lack of procedure for implementation, not to mention the introduction of up-to-date methodology such as the application of information technology and quantitative method such as data mining. Herby there is a need to explore the possibility of proposing a conceptual framework entitled 'integrated KM model' to link customer knowledge with innovative product development, and also delineate the methodology and the procedure for implementation. It will be preferable that an empirical study to be done to support the validality of this integrated KM model.

CHAPTER 3

AN INTEGRATED KM MODEL FOR MANAGING PRODUCT AND CUSTOMER KNOWLEDGE

Innovative products often stemmed from radical innovation that is defined as: "A basic technology innovation that establishes a new functionality". Radical innovation differs from incremental innovation that is defined as: "A change in an existing technology system that does not alter functionality but improve performance" (Betz 2003). Radical innovative product weighs heavily on enhancing company's competitive advantage for business success. However, the adverse side effects happen on user's side shouldn't be underestimated. The reason is that advanced features delivered by high technologies indeed offer certain benefits to customer though, the accompanying complexities of application and cost mark-up inevitably offset customers' perceived value against the innovative product. Radical innovation features three dimensions: (1) product benefits, (2) technology capabilities and (3) customer use pattern (Veryzer 1998). Therefore, it is important to elaborate the generation of customer knowledge on how they evaluate from these dimensions the radical innovative product, because without attractive quality, a radical innovative product will hardly find a strong position for market viability.

To achieve market success, company has to deal with many sorts of knowledge including suppliers knowledge, product knowledge, customer knowledge, industry knowledge, competitor knowledge, employee knowledge and operations knowledge (Garcia-Murillo 2002). Among them, product knowledge and customer knowledge fall into the category of priority concern, for they directly contribute to the company's competitive advantage and financial performance.

Based on the findings of many studies in the above-mentioned literatures, either the importance of KM on NPD project or the requirement of KM on the customers in the market has been separately addressed. Therefore, it is imperative to explore the interaction of both product knowledge and customer knowledge as a whole, as well as the procedure for KM implementation in an innovative NPD project. Therefore, this study from the perspective of implementation proposes an integrated KM model as a new approach for managing both product knowledge and customer knowledge. The structure of this integrated model is shown in Figure 4.

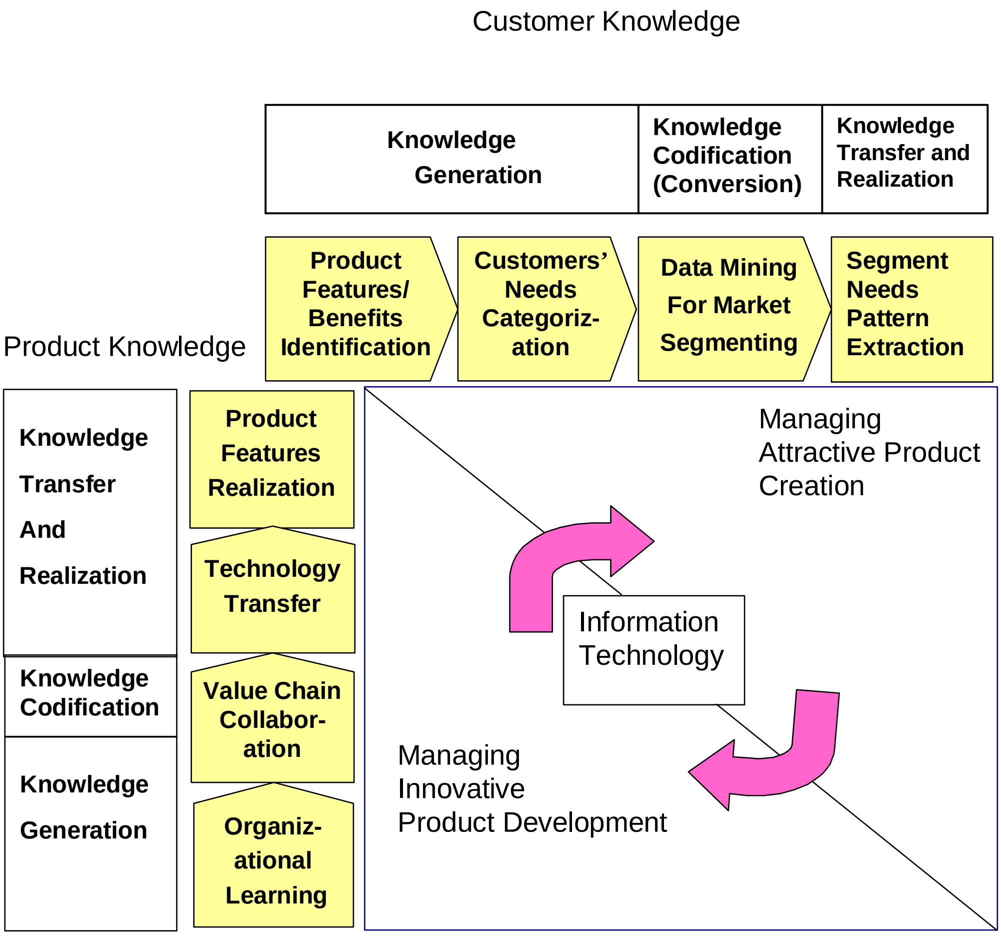


Figure 4. Integrated KM model for managing both product knowledge and customer knowledge

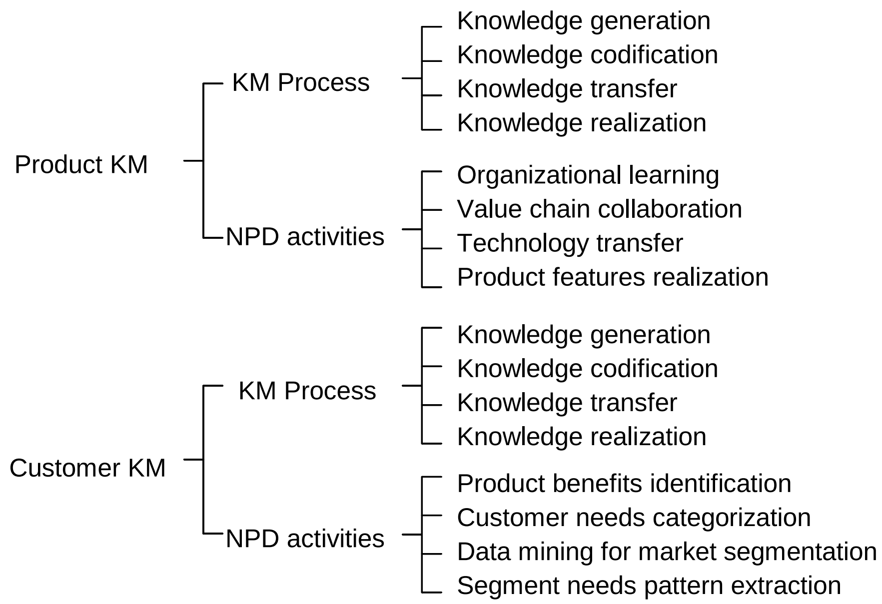


Figure 5. In both product KM and customer KM dimensions, NPD activities go through KM process to result in the KM outcomes

The integrated KM model features two dimensions: the product knowledge dimension and the customer knowledge dimension (Figure 5). In both dimensions, NPD activities go through KM process to result in KM outcomes, by interwoven knowledge flows via IT application. The product KM NPD activities stem from the outcomes of research literatures and industry practices, and the customer KM NPD actitivies are the original work of this dissertation. Both embrace, as indicated by Davenport (2001), the knowledge process represented by several sub-processes: 'knowledge generation (creation)' involves the acquisition and development of knowledge, 'knowledge codification' involves the conversion of knowledge into an accessible and applicable format, 'knowledge transfer' includes the movement of knowledge from its point of generation or codified form to the point of use, and 'knowledge realization' which refers to the process involved in creating value. In the product knowledge dimension, the focus is on organizational networks aiming at knowledge creation and application, while in the customer knowledge dimension, the focus is on information technology application targeted at knowledge extraction.

The value of this model is that it provides a practical solution to overcome the complexities of value chain collaboration by heterogeneous industries, and also offer a feasible solution to extract customers' needs, so as to culminate the success of an innovative NPD project. The integrated KM model makes contribution to both academic community and industry level application.

3.1 THE ACTIVITIES OF PRODUCT KNOWLEDGE MANAGEMENT

Managing product knowledge in an innovative NPD project requires both the cross-functional team within an organization to share interdisciplinary knowledge and the collaboration from heterogeneous industry partners to acquire and to develop the complementary knowledge, so as to inspire creativity for bringing the product of innovation into being. The integrated KM model articulates the product knowledge process by dealing with four product development activities: (1) knowledge generation takes place at the stages of organizational learning and value chain collaboration, (2) collaboration across organizational boundaries creates new knowledge for products or processes, and NPD project teams then codifies the newly created knowledge into documents or database, (3) knowledge embodied in the form of technology is further transferred to collaboration the partners via meetings, Intranet, Internet, and experiments in order to result in (4) knowledge realization by coming up with the physical prototype of attractive product.

In this study, an innovative NPD project such as the Mobile-commerce related product involves wireless communication, mobile Internet connectivity, multimedia computing, and in-vehicle application. The input of financial investment and human talent is too much to afford a premature market outcome. Under the circumstance, customer knowledge pertinent to whether the products are perceived as attractive or beneficial turns into a crucial part of knowledge in this innovative NPD project.

3.1.1 Organizational Learning

In an innovative NPD project, boundary-spanning organization comprising internal and external teams becomes necessary. Organizational learning consists of five disciplines: system thinking, personal mastery, mental models, shared vision, and team learning, they can accelerate the pace that team members develop the required knowledge (Senge1994). Sharing control with those who have competence and those who implement tasks, and avoiding defensive interpersonal and group relationships are very important factors to encourage organizational learning.

Many studies in the literature address the issue how to enhance organizational learning for knowledge generation. The 'situated organizational learning' approach moves the focus from individuals to the activity systems within organization, as organizational learning depends on the ability to generate and adopt knowledge from horizontal and vertical sources (Nidumolu 2001, Bhatt 2000). These studies all provide an excellent foundation for inspiration in how to design an appropriate organizational learning structure, however, there is a short supply of articulate guidelines in how to actually fulfill the task. An exception is the research article of Sanchez, which proposed a "modular organization" that continuously changes and solves problems through interlinking coordinated self-organizing processes (Sanchez, 1996). In which incremental learning, modular learning, architectural learning, and radical learning take place to access advanced architectural knowledge about product components and their interactions.

Based on Sanchez's work, this study proposes a 'hierarchical interface learning' scheme to tackle the demand that learning occurs at the interface between marketing and product design, the interface among value chain stakeholders, the interface among heterogeneous technologies, and etc. An innovative NPD project needs not only the sharing of existing interdisciplinary knowledge, but also the generation of new knowledge to integrate different types of knowledge for product innovation.

3.1.2 Value Chain Collaboration

In the realm of E-commerce, telecommunication companies, computer hardware manufacturers, software design houses, contents providers, logistics enterprises and finance institutions make their presence as stakeholders in the value chain. Advancing to Mobile-commerce, which takes mobile Internet connectivity as the prerequisite, additional more elements of advanced technology and communication media have to join in the existing E-commerce infrastructure.

The complexity of innovative product is located in two areas: the complexity of the product's internal architecture and the complexity of product-user interface. The more complex the product is, the more the NPD teams demand cross-functional "concurrent engineering" to cope with the complex situation. When taking into account of value chain partners and support by information technology, a wider context entitled "collaborative engineering" comes into being (Willaert 1998). The contribution IT makes to NPD collaboration is in interpersonal communication, efficiency, and effectiveness by offering (1) design tools such as CAD/CAE and simulations, (2) collaboration tools such as product data management systems and groupware like video conferencing and web-mail, and (3) tailor-made KM software packages for decision support and knowledge codification.

Integrating value chain partners into an NPD collaboration network often induces issues of conflict and cooperation (Coles 2003) and brings in variables like organization culture, job sharing responsibility, time to participate, methods for communication, intellectual property issues, and so on. Thus, in addition to make efforts that foster organizational learning, it is also imperative to diminish the organizational barrier so as to generate collaborative knowledge, by overcoming the complication encountered among various disciplines and team units that are heterogeneous in specialization and objective. Because it is the value chain collaborative activities that determine the success or failure of an innovative NPD program, every effort should be made to enhance the spirit of teamwork and in the meantime to eliminate negative factors that may impede the NPD progress. Tacit knowledge sharing among parties in value chain is not so difficult, codification of generated knowledge still be possible if presented in a mutual-agreed format. However, when comes to the transfer of knowledge-embedded technology, it becomes an invincible barricade.

3.1.3 Technology Transfer

The ultimate form of knowledge transfer among NPD project partners is the transfer in terms of technology for product realization. In the process of collaboration, useful new knowledge can be generated and then be codified into the repositories of each organization as the intellectual capital. The problem arises as to what extent partners one another are willing to transfer the codified knowledge and the associated knowledge-embedded technology. Organizational level knowledge or technology flow takes place as intra-company flows, cross-company flow among heterogeneous industries, and cross-company flow among homogeneous industries. The small-scale knowledge or technology exchange via IT groupware, seminar and regular meeting for the necessary project coordination is not so hard, compared to the high-level technology transfer that requires certain benefits exchange and business setting.

In the innovative NPD project, domain knowledge hoarded in each collaboration partner is too sophisticated and too trivial to transfer without any compensation, let alone the issue of intellectual property. On the other hand, without knowledge transfer one another, the technology-intensive product will never be created. Therefore the feasible way to tackle the dilemma could be a pragmatic arrangement that each party transfers only the technology that is required at the interface of different domain knowledge to let NPD progress continue. Thus, a 'hierarchical interface technology transfer' scheme is used to go with the above-mentioned 'hierarchical interface learning' scheme. This setting conserves the proprietary knowledge within organization of each party, but at the same time renders the technologies required for interface elaboration. All knowledge and technology to be transferred make up the 'value chain knowledge/technology architecture' as the blueprint for knowledge/technology transfer.

3.1.4 Product Features Realization

Customers normally judge a product by three important elements: product features and their quality, price, as well as service mix and its quality. To be a successful product, benefits offered out of product features must not only satisfy customers, but also delight them. 'Benefit' is the needs a customer wants realized from a product purchase and use (Blackwell 2001). After a new product concept is formulated, the NPD project team should identify product benefits in terms of customers' perceived value or responses toward product features, functions, and other forms, in order to communicate with customers. It is the stage where knowledge of customers' needs and want is used by NPD project team to review and revise the product's definition, or plan the product line-up. It is also the final step of product knowledge realization and the initial step of prototype product features realization in terms of technological elements.

Robertson (1998) advocated the concept of “product re-configurability” or “product modularity”, where a product architecture featuring major building blocks that are called the ‘platform’. Product elements such as sub-systems or components are assigned to a series of physical layers to offer the re-configurable functions so as to meet customers’ demand in different market segments.

For the innovative NPD project, the ‘multi-layered architecture’ definition of a product can better secure the success of a new product, because as soon as a concept has been converted into a commercialized product, the product configuration immediately exposes itself to the scrutiny of customers and right away confronts the uncertainty of market success or failure. The existence of modularity within the product structure enables product re-configurability by allowing product features change to be kept within minimal rework and cost. In case of a successful introduction, product re-configurability provides the opportunity of in-time product variants line-up; in case of retarded product introduction in the market, re-configurability comes to rescue by repositioning the revised offering to the market in the shortest period of time.

3.2 THE ACTIVITIES OF CUSTOMER KNOWLEDGE MANAGEMENT

To secure customer acceptance toward products, it is necessary to set an appropriate process to manage customer knowledge. However, for most studies in the research, the procedure of how to exploit customer knowledge has not been well worked out (Koenig 2000). Conversely, a company often conducts market research to collect data and information for making a strategic decision in NPD endeavor. The main purpose of market research is to understand as much as possible about customers in terms of the variety of preference or needs patterns. It is based on data collected from customer groups classified by demographical characteristic or classified by benefits or needs they pursue. Although customers have been recognized as an excellent data source of market research, they are not yet fully utilized as knowledge providers for the company, as there is a tendency for managers to overemphasize the importance of customer data acquisition and underestimate the interpretation of customer information. As a consequence, they fail to generate the necessary customer knowledge.

As discussed before, both product knowledge and customer knowledge are important and intricate factors attributed to the success of an innovative NPD project. Customers are eager to know products' features from different competitive companies so as to evaluate whether the products indeed offer the benefits they want. The NPD team has to know which customer segment is the target to deliver the products of attractive quality and what customers really need and are willing to pay. The generation of knowledge in this regard is very valuable for the NPD team to make product definitions and set pricing policy. Thus, the procedure for customer knowledge generation, codification, transfer, and realization must be developed.

The proliferation of business applications on the Internet has grown rapidly since the late 1990s. Compared with a conventional mail survey the web serves as an ideal delivery system for a company to conduct an on-line survey because of its timeliness and ease. However, 'coverage error problem' and 'sample error problem' are the two major factors when considering the validity of this emerging method. Then there is the 'filter problem', which is associated with software tools that filter the so-called 'junk' and 'spam' mails. In addition there is the 'delete problem' for impatient recipients to give up answering the whole survey instrument, and all of this affects the response rate (Fought 2004). Under these circumstances, a company wanting to conduct a web-based survey to extract customers' knowledge should take counter-measures to overcome the above-mentioned problems. For instance, selecting the target survey samples from a current customer database instead of using a general sampling plan; sending a short e-mail to the sample recipients to inform them of the fact that a survey instrument has been posted at a website rather than sending them an e-mail with a long list of questionnaires attached, and so on.

Figure 6 shows how information technology is employed in the customer knowledge management process.

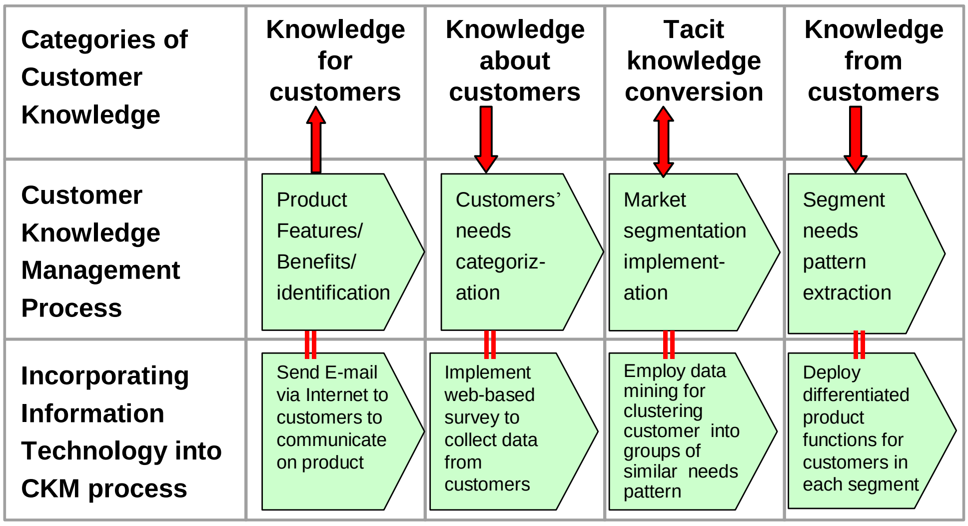


Figure 6. The customer knowledge management process supported by IT

3.2.1 Product Features/Benefits Identification

At the initial step of prototype product features realization, the NPD project team reviews perspective product benefits in terms of a customer's perceived value toward product features and functions, so as to communicate with them. At this stage, the NPD project team generates and delivers product knowledge 'for' customers. In the CKM process of the integrated KM model, a bi-directional communication channel like personal interviews, phone interviews, and/or self-administered questionnaires is used to contact an individual customer to acquire his/her response based on his/her own preference toward these features or benefits. Among these channels, a mail survey by sending a mail with self-administered questionnaires has been assessed as a good way of accomplishing the objective (Cooper 2001).

Supported by IT, a survey instrument that packs the self-administered questionnaires with product benefit knowledge into an e-mail can be sent to customers via the Internet, or by sending out an e-mail to solicit the recipient to answer a survey instrument posted at a predetermined website. The feedbacks toward a questionnaire provide responses from customers about their attitudes, preferences, needs, and perceived values toward a product's features and benefits offered. The total of the customers' responses, collected in the form of data will be arranged as the 'customer response database'. This procedure creates an opportunity to identify that the customers have already acquired product knowledge about the benefits the product features may offer.

3.2.2 Customers' Needs Categorization

In the integrated KM model, a web-based survey presenting an interval rating scale instrument appears at a website to collect the primary data about customers' demographical background as well as the extent how customers need or prefer the product's features. In the field of business research, there are several response methods using an interval rating scale, among them the 'multiple rating list scale' is the most appropriate one for a web-based questionnaire as it provides a layout of easy visualization (Cooper 2001) and also accepts mouse 'click' streams to replace conventional hand-written customer responses. In the questionnaire, an individual customer presents his or her own specific pattern of needs, in addition to his or her demographic data and other relevant information. The aggregate of the data collected from all customers in the study first undergoes a data pre-proccesing treatment, then constitutes a database ready for the categorization of customers' needs and subsequent data mining tasks. At this stage, the survey activity generates knowledge 'about' customers by understanding customers' demographical background, needs and preference pattern toward product features or benefits.

3.2.3 Market Segmenting: Use Data Mining to Convert Tacit Customer Knowledge into Codified Knowledge

As an important element in the integrated KM model, the data mining technique is used to cluster all the customers in study based on their needs patterns into groups of customers with similar propensity, namely, the 'market segmentation' task. As mentioned before, the benefit-based or the needs-based segmentation methodology is ranked as the most appropriate one if taking into account the overall performance. The fact is that demographic segmentation merely describes customers' behavior, but fails to explain the reason -- the tacit customer knowledge -- why this is so; on the contrary, the benefits a product delivers can alter the customers' needs and attitude (Haley 1985), so segmentation scheme based on benefit/needs is appropriate to support the conversion of tacit customer knowledge into useful explicit knowledge. Taking advantage of IT capability, data mining technique entitles itself to carry out the clustering operation in the market segmentation task.

Through communication with customers, the NPD project team has acquired the knowledge 'for' customers and the knowledge 'about' customers to conduct the appropriate market segmentation task. After the segments are formed, each segment's needs or preference patterns toward a product's features are also well delineated, and then different characteristics of each segment are further identified and analyzed. At this stage, tacit customer knowledge hidden within customer segments is excavated and converted into explicit customer knowledge in a codified form for transferring to the NPD project team. The details will be given at section 3.2.5.

3.2.4 Segment Needs Pattern Extraction

Once the segmentation task is done, the characteristics of each segment and customers' needs or preferences patterns in each segment are also studied to extract the customer knowledge in each segment as the knowledge 'from' customer. Customer knowledge is next transferred to the NPD project team for further investigation. The newly codified customer knowledge enables the team to aim at the right target market segments and make appropriate strategic business decisions in product variants realization and marketing activities deployment. If needed it helps the NPD team to revise the original product definition thanks to the product's re-configurability capability, to set priorities for product features to add on, to enhance the functionality of the attractive product elements, and to rule out product features that customers have no interest towards. The differentiated needs pattern and demographic data disclosed from each segment becomes the valuable customer knowledge for the team to take the right tactics for future product planning to again serve each target segment. At this stage, customer knowledge realization comes true to help the NPD project team in reducing market risk and creating a product having attractive quality.

However, in this study the clustering operation for market segmentation is based on the database consists of data set provided by the customers in the rating scale instrument via a web-based survey questionnaire. After segments are formed, for survey instruments to be valid and possess practical business utility to serve each segment, the construct it represents must be sufficiently reliable. In the integrated KM model, a multiple- assessment scheme is used to judge both the clustering outcomes and the survey construct reliability.

3.3 DATA MINING TECHNIQUE TO IMPLEMENT MARKET SEGMENTATION

This dissertation proposes three data mining methods as applied in the integrated KM model for customer clustering operation, they are: K-means, Self Organizing Feature Map neural network (Kohonen 1990), and a network based on the Fuzzy Adaptive Resonance Theory (Carpenter 1991). A description of these methods and how they operate to extract customer knowledge are given in the following section.

The reason why this study selects K-means, SOM and FuzzyART network as data mining methods is based on the following arguments: (1) K-means algorithm has been regarded as the benchmarking tool in evaluating the clustering performance of an artificial neural network. Because it is the most popular and most widely used procedure for market segmentation (Kamakura 2000), (2) researcher urges on more studies by means of unsupervised neural network like SOM, because cluster-based problems such as market segmentation problems have been successfully tackled by MLP network, basically a supervised network architecture (Vellido 1999), (3) the potential of FuzzyART network in clustering task motivates the further exploration of more possibilities in the marketing segmentation problem.

3.3.1 The Self-Organizing Feature Map Network for Data Mining

The SOM network is a fully connected two-layered network that can learn a topological map from *p* continuous-valued *n*-dimensional input vectors into a two-dimensional feature space. It provides a way to visualize high-dimensional data through a two-dimensional presentation. SOM as a neural network architecture proposed by Teuve Kohonen (Kohonen 1990), has the special property of creating with effectiveness from the input vectors' features into a spatially organized 'internal representation'. It employs an unsupervised competitive learning mechanism, in which neighboring nodes in a neural network compete by mutual lateral interactions, to develop adaptively a specific detector of different input patterns. In the application of pattern recognition, the classification accuracy of SOM network can be much enhanced if the nodes are fine-tuned in advance using supervised learning. Value of topological neighborhood parameter and learning rate parameter must be set for the operation of the SOM. Quoted below is the operating procedure:

Input vectors and weight vectors: each input vector is an n-dimensional continuous-valued vector $\mathbf{X} = (x_1, x_2, \ldots, x_i, \ldots x_n)$, it is fully connected to all nodes of a two-dimensional grid-like network, and weight vector for node j is denoted as

$$\boldsymbol{w}_j = (w_{j1}, w_{j2}, \ldots w_{ji}, \ldots w_{jn}).$$

Parameters: SOM network operation requires two kinds of parameter

(1) The topological neighborhood radius parameter Nc(t) around node c, it can be set as very wide in the beginning and shrink monotonically with time t.

(2) Learning rate parameter: $\alpha(t)$, $o<\alpha(t)<1$, it will decrease with time elapsed.

Selection of the best-matching node: The matching value for each node j is the Euclidean distance between $\mathbf{X}$ and $\boldsymbol{w}_j$ defined as

$$\mathbf{M_J}(\mathbf{X}) = \| \mathbf{X} - \boldsymbol{w}_j \|_2 = \Big(\sum_{i=1}^{n} (\mathbf{x}_i - \boldsymbol{w}_{ji})^2 \Big)^{1/2} \qquad (3.1)$$

The best-matching node is the one with the minimum matching value to win the competition.

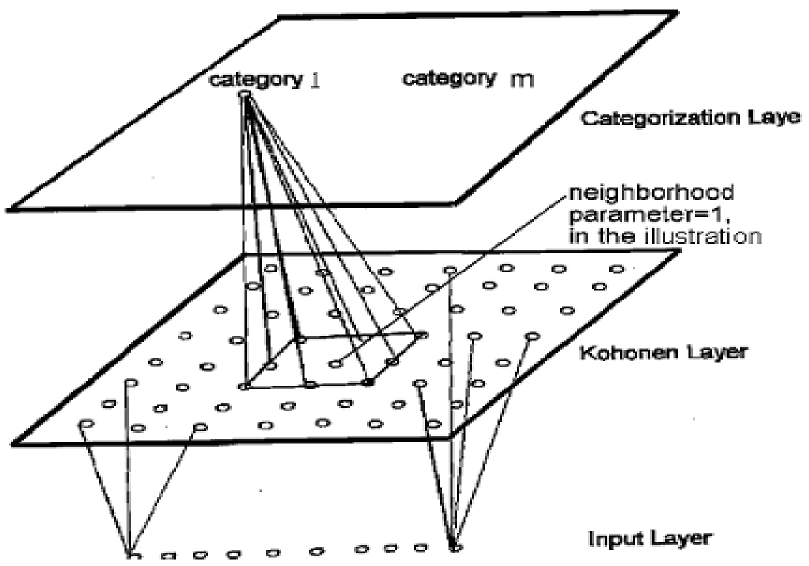
Adaptation of the weight vectors: the weight-updating rule is

$$\boldsymbol{w}_j(t+1) = \begin{cases} \boldsymbol{w}_j(t) + \alpha(t)[\mathbf{X}(t) - \boldsymbol{w}_j(t)], & \textit{if } j \textit{ is in } \mathrm{Nc}(t) \\ \boldsymbol{w}_j(t), & \textit{if } j \textit{ is not in } \mathrm{Nc}(t) \end{cases} \qquad (3.2)$$

then update the learning rate and radius of neighborhood, both decrease with time t.

In the final stage, only the weight of winner-the best-matching node-gets updated, in which condition the process is reduced to simple competitive learning.

Thanks to the competitive learning mechanism and weight updating in the neighborhood of winning unit, vectors neighboring (measured by similarity) in the source space are mapped to points that are neighboring in the target space. After mapping, neighborhoods are preserved to result in a "topological ordered map". In market segmentation task, the network can cluster the data set of customer needs pattern represented as p continuous-valued vector $\mathbf{X} = (\boldsymbol{x}_1, \boldsymbol{x}_2, \ldots.\boldsymbol{x}_i, \ldots\boldsymbol{x}_n)$ into m clusters. n is the number of instrument scale items; $\boldsymbol{x}_i$ is the value of selection options for each item (Figure 7). This is the reason why use SOM network in this study.



$$X_1 = (x_1 \ldots\ldots x_i \ldots\ldots x_n)_1$$

•

•

$$Xp = (x_1 \ldots\ldots x_i \ldots\ldots x_n)_p$$

Figure 7. The architecture of SOM network

3.3.2 The FuzzyART Network as One of The Clustering Methods

FuzzyART network is one of neural networks based on Adaptive Resonance Theory (ART) developed by Carpenter and Grossberg (Carpenter 1991). The ART network clusters the input vectors into the same category by comparing their similarity measured by the city-block distance. There are three major ART architectures, namely ART 1, ART 2, and FuzzyART. ART 1 is used for binary-valued input vectors, and ART 2 is for continuous-valued vectors. FuzzyART can apply both binary and continuous-valued inputs.

There are three parameters to determine the operation of the FuzzyART network: choice parameter, learning rate parameter, and vigilance parameter. The major difference between FuzzyART and other unsupervised neural networks is the vigilance parameter (ρ).

Learning is stable in a FuzzyART network because all adaptive weights can only monotonically non-increase in time, learning also stabilizes after just a few epochs of presentation by each input vector. Category clustering performance can improve by training the system several times by presenting the input data set to the network in different ordering sequence (Carpenter 1992). Quoted below is the FuzzyART operating procedure:

Input data vector: each input data vector is an n-dimensional analog-valued vector

$\mathbf{x} = (x_1, x_2, \ldots x_i, \ldots x_n)$, where each component x_i is within the interval [0,1].

Weight vector: in the category layer, each category node j (j=1……m) is associated with a category (j) corresponds to a vector $\mathbf{w}_j = (w_{j1}, w_{j2}, \ldots w_{ji}, \ldots w_{jn})$ of adaptive weights or LTM (long term memory) traces. Initially the weights $w_{j1} = w_{j2} \ldots w_{jn} = 1$, and each category is uncommitted. After a category is selected for an input vector it becomes committed. Each LTM trace w_{ji} is monotonously non-decreasing through training time and finally converges to a limit.

Parameters: FuzzyART operations are determined by three parameters

(1) Choice parameter α, its value is larger than 0.

(2) Learning rate parameter β, its value is within the interval [0,1].

(3) Vigilance parameter ρ, its value is within the interval [0,1].

Cluster categories choice: for each input vector **X** and a cluster category *j*, the choice function T is defined by: $\mathbf{T(X)} = \dfrac{|\mathbf{X} \wedge \boldsymbol{w}_j|}{\alpha + |\boldsymbol{w}_j|}$ (3.3)

Where $\boldsymbol{w}_j$ is a continuous-valued weight vector associated with cluster category *j*.

"∧" denotes the fuzzy AND (Zadeh 1965) operator defined by

$$(\mathbf{a} \wedge \mathbf{b})_i = \min(a_i, b_i) \quad (3.4)$$

The L one-norm || **.** || is defined by: $\|\mathbf{a}\| = \sum_{i=1}^{n} \|a_i\|$ (3.5)

α as the choice parameter is a small constant; increase the value of α will make the search more towards clusters with large $\boldsymbol{w}_j$. Each input vector is assigned to the category choice index **J**, when

$$\mathbf{T_J}(\mathbf{X}) = \max\{\mathbf{T}_j(\mathbf{X}) : j = 1, 2, \ldots m\} \quad (3.6)$$

The node **J** in category layer becomes committed

Resonance or Reset: A match function of that chosen category **J** is defined as

$$\mathbf{M_J}(\mathbf{X}) = \frac{|\mathbf{X} \wedge \boldsymbol{w}_\mathbf{J}|}{|\mathbf{X}|} \quad (3.7)$$

Mismatch reset takes place if

$$\frac{|\mathbf{X} \wedge \boldsymbol{w}_\mathbf{J}|}{|\mathbf{X}|} < \rho \quad \text{(vigilance parameter)} \quad (3.8)$$

Then the value of choice parameter is set to – 1, to prevent its being selection during subsequent search. A new index **J** will be chosen by equation (3.6).

Resonance occurs place and learning continues if

$$\frac{|\mathbf{X} \wedge \boldsymbol{w}_\mathbf{J}|}{|\mathbf{X}|} \geq \rho \quad (3.9)$$

The weight vector $\boldsymbol{w}_\mathbf{J}$ of that best-matching input vector is updated by the equation

$$\boldsymbol{w}_\mathbf{J}^{(new)} = \beta(\mathbf{X} \wedge \boldsymbol{w}_\mathbf{J})^{(old)} + (1-\beta)\,\boldsymbol{w}_\mathbf{J}^{(old)} \quad (3.10)$$

And then read another input vector and repeat the matching and reset procedure until all category nodes are committed for all the input data vectors.

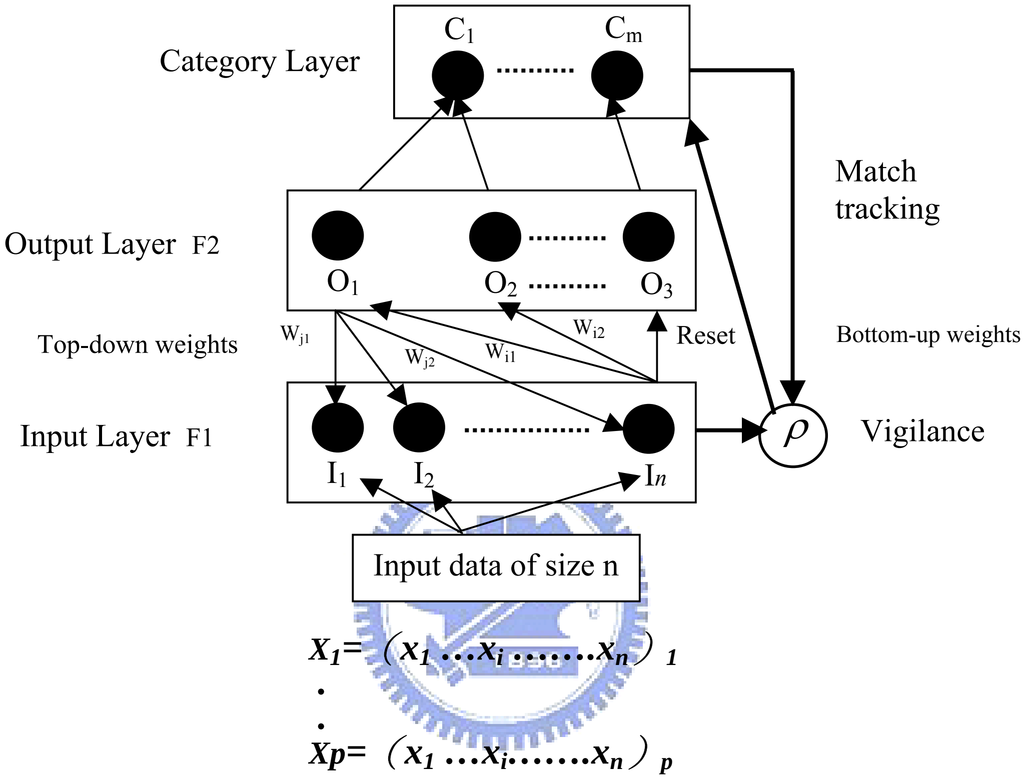


Figure 8. The architecture of FuzzyART network

For the same input vectors data set with the same value for choice parameter and learning rate parameter, a low vigilance value will result in a small number of coarse clusters. On the other hand, a high vigilance value will lead to a large number of finer clusters.

The FuzzyART network allows the researcher to control the degree of similarity for vectors assigned in the same cluster. In vectors presentation, the degree of similarity between a new vector and stored vectors is defined. The ratio of this similarity to vigilance parameter (ρ) is used to ensure whether the new vector is well clustered or not. The other unsupervised learning neural networks that do not employ vigilance parameter may cause a significantly different input pattern to be forced into an inappropriate cluster. In market segmentation task, the network can cluster the data set of customer needs pattern represented as *p* continuous-valued vector $\mathbf{X} = (\boldsymbol{x}_{1,} \boldsymbol{x}_2, \ldots \boldsymbol{x}_i, \ldots \boldsymbol{x}_n)$ into *m* clusters (Figure 8). Different from other cluster methods, a FuzzyART network will not perilously force all input vectors into a cluster if they are not sufficiently similar. This is the reason why the FuzzyART network is employed in this study to cluster the data set collected from the rating scale instrument questionnaires.

3.3.3 K-means Clustering Method

K-means is a non-hierarchical clustering method, which is normally chosen as the benchmarking tool against other clustering algorithms. The K-means algorithm operation requires (1) choosing the number of clusters and (2) choosing an initial cluster center.

In order to divide the input vectors into k clusters, the number of clusters must be known in advance. Most of the nonhierarchical clustering methods differ in: (1) how to select initial cluster seed, (2) the rule used to reassign input vectors into each cluster. Finding from simulation studies, indicated that nonhierarchical clustering technique are sensitive to the selection of initial seed (Shama 1996).

K-means can find a set of k cluster centers which are the local minimum of the total squared Euclidean distance between all input vectors $\mathbf{x}$ and the nearest of k centers c_j. The K-means algorithm is quoted below (Pandys 1996).

Input vector: $\mathbf{x} = (x_1, x_2, \ldots x_i, \ldots x_n)$

Initializing cluster seed: select k as the number of cluster desired, for each of these K clusters choose an initial cluster center or seed: $\{c_1(m), c_2(m), \ldots, c_k(m)\}$. where $c_j(m)$ represents the value of the cluster center at the mth iteration

Cluster assignment：distribute all input vectors to different cluster

$$\mathbf{x}_i \text{ belong to } \boldsymbol{\theta}_j(m) \quad \text{if } \| \mathbf{x}_i - c_j(m) \|_2 < \| \mathbf{x}_i - c_h(m) \|_2 \quad \text{for all } h = 1,2\ldots,k,\ h \neq j \qquad (3.11)$$

$\boldsymbol{\theta}_j(m)$ represents the population of cluster j at iteration m.

$\|\,.\,\|_2$ is the L two-norm, the Euclidean distance

Calculating new cluster centers:

$$c_j(m+1) = \frac{1}{\mathrm{Mj}} \sum_{x_i \text{ in } \boldsymbol{\theta}_j(m)} \mathbf{x}_i \qquad (3.12)$$

where M_j is the number of sample vectors attached to $\boldsymbol{\theta}_j$ during cluster assignment.

Check for convergence:

The condition for convergence is that no cluster center has changed its position during new cluster center formation process.

3.4 EVALUATION CRITERIA IN A MULTIPLE ASSESSMENT SCHEME FOR DATA MINING TASKS

In the integrated KM model a multiple-assessment scheme is proposed to deal with the issue of justification. Three evaluation criteria of the scheme are shown in Table 5.

Table 5. The three evaluation criteria in the multiple-assessment scheme

1.	Does the customer accept the web-based survey approach and render a response sufficient for data mining?
2.	Can data mining technique successfully extract customer knowledge to facilitate NPD?
3.	Which one is the most appropriate, if multiple data mining methods are qualified for clustering customers into segments?

A survey response sample size of 1,000 is assumed to be the sufficient threshold for criterion No.1. As for criterion No. 2, it will deal with (1) how to justify K-means, SOM network, and FuzzyART network as qualified data mining methods for clustering operation in market segmentation. And for criterion No.3, we have to answer: (2) in case that all three methods are qualified for the clustering operation, how to decide which one is the most appropriate?

The first problem that arises is: how to determine the optimal number of clusters or the 'natural' number of clusters. Defining a criterion function that measures the clustering quality of any clustering solution, and finding the cluster solution that presents the extreme value of the criterion function is one approach to solve the problem (Duda 2001). In other words, clustering operations to come up with solution for different numbers of clusters is performed repeatedly in order to compare the value of criterion function for each clustering operation. If there is a 'larger gap' among the values of the criterion function for sequential clustering solutions, then it suggests the existence of a 'natural' number of clusters. Among many criterion functions for cluster analysis, this study chooses R-squared (RS), the ratio of SS_b (between-clusters variation) to SSt (total variation), as the criterion function, and $SS_t = SS_b + SS_w$, while SS_w is the within-cluster variation. Plotting the R-squared values as a vertical axis against the number of clusters as a horizontal axis, an 'elbow' point in the plot indicates the presence of the best clustering solution or the optimal number of clusters (Sharma 1996). The above-mentioned procedure is summarized in the Table 6.

Table 6. The procedure to find the optimal number of clusters

1	Defining a criterion function that measures the clustering quality of any clustering solution.
2	If there is a "larger gap" in the value of the criterion function among sequential clustering solutions, then this suggests a "natural" number of clusters.
3	This study choose R-squared, the ratio of SS_b (between-clusters variation) to SSt (total variation), as the criterion function, and $SS_t = SS_b + SS_w$, while SS_w is the within-cluster variation.
4	Plotting the R-squared values as a vertical axis against the number of clusters as a horizontal axis, an "elbow" point in the plot indicates the best clustering solution or the optimal number of clusters (Sharma 1996).

The second problem will be resolved by adopting the existing market research paradigm: using the most commonly used Cronbach's alpha coefficient to represent the reliability of construct in a rating scale survey instrument (Cronbach 1951, Peterson 1994). Cronbach's alpha is also an estimator of internal consistency for a survey instrument, which is approximately defined by the formula:

$$\alpha = \frac{K \cdot \bar{r}}{1 + (K-1) \cdot \bar{r}} \quad \text{..} \qquad (3.13)$$

or

$$\alpha = \left(\frac{K}{K-1}\right)\left(1 - \sum_{i=1}^{k} \sigma_i^2 \Big/ \sigma_s^2\right) \quad \text{.. ....} \qquad (3.14)$$

where K is the number of items in the survey instrument, $\bar{r}$ is the average inter-items coefficient of correlation among the items. And σ_i^2 is the variance of all values in item i, and σ_s^2 is the variance of the total item values for each customer response.

If the inter-items correlations are high, it can be inferred that the items are measuring the same underlying construct. It also means that the internal consistency or the reliability of the survey instrument is sufficiently reliable for business practical utility.

After market segments is formed by segmentation task, all the survey response will be re-allocated to each segment, and calculate Cronbach's alpha of all the instruments belong to each segment to make sure whether the data mining method is practically useful in real world business environment. The recommendation for the minimally acceptable reliability level expressed by Cronbach's alpha is proposed by researcher as in the Table 7.

Table 7. Recommended reliability levels for rating scale survey instrument

Researcher	Situation	Recommended level
Murphy and Davidshifer (1998)	Unacceptable level Low level Moderate to high level High Level	Below 0.6 0.7 0.8-0.9 0.9 and above

To summarize, the whole procedure for the multiple-assessment scheme is shown in Figure 9. An empirical study described in the Chapter 4 will furnish the field-collected data set to go through the multiple-assessment scheme. Data mining results assessed by the three evaluation criteria will confirm whether or not it is robust to be used in the integrated KM model.

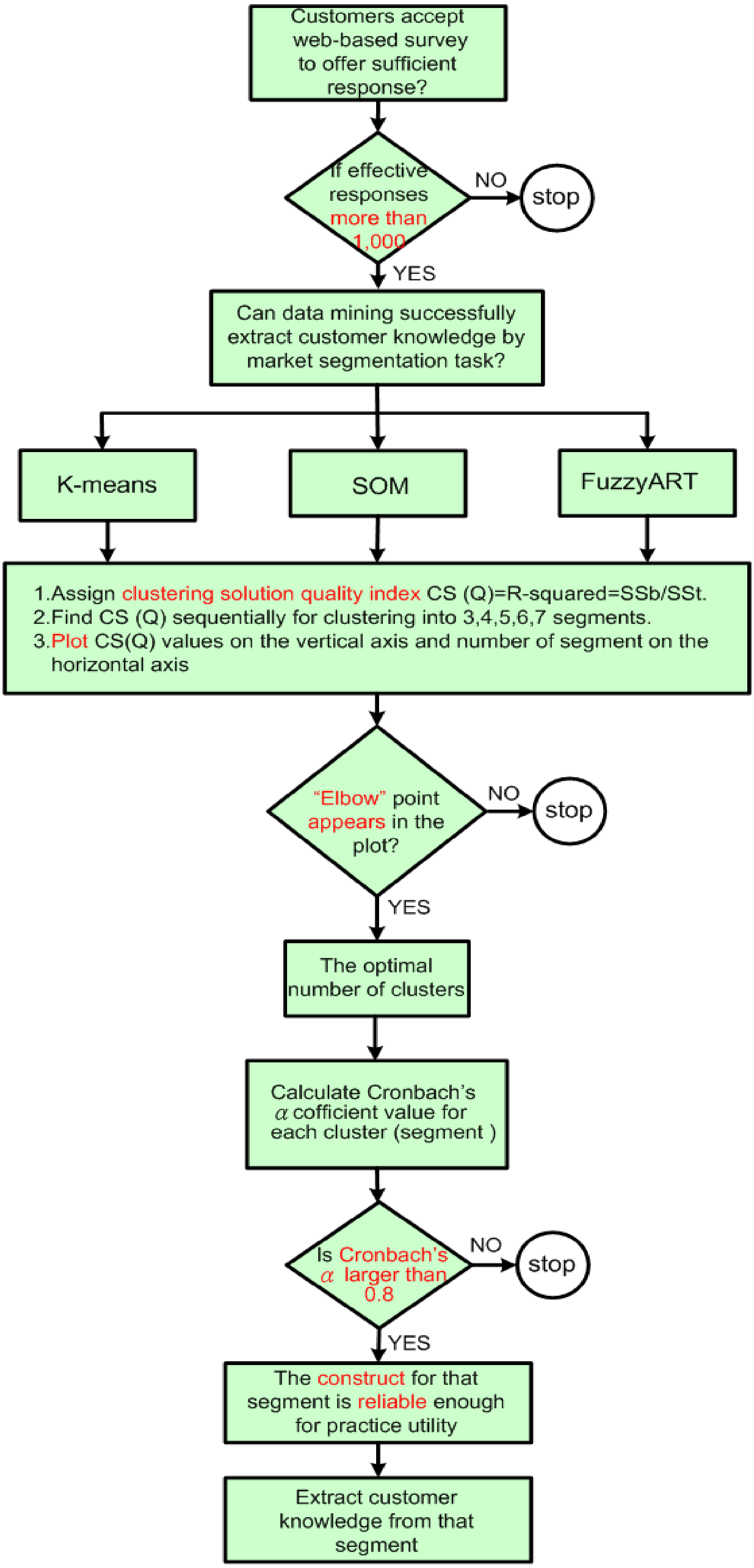


Figure 9. The procedure for the multiple-assessment scheme

CHAPTER 4

IMPLEMENTATION OF THE INTEGRATED KM MODEL

4.1 BACKGROUND ABOUT THE CASE STUDY

To meet future demands on Mobile-commerce, an innovative NPD project was initiated. The objective of this project is to explore the opportunity for Taiwan's hi-tech industry especially the computer and wireless communication hardware manufacturers to penetrate into a new market -- the in-vehicle personal computer market. The vision of this NPD project is to serve perspective users beginning from Taiwan and extending to the greater market coverage in the world by taking advantage of economies of scale and economies of scope. Aiming at project success, the integrated KM model with an empirical study has been implemented in this innovative NPD project, in view of linking customer knowledge with technological product knowledge and dealing with the complexity of product sophistication/market acceptance issues.

4.1.1 Wireless Internet as The Technological Innovation to Support Telematics and Mobile-Commerce

In this era of the digital economy, companies have benefited from the capabilities of the Internet to operate sales and communication channels in order to reach customers in larger geographical regions. This new approach is titled 'Electronic-commerce (E-commerce)' -- selling and buying products/services over the web. In the E-commerce, the connectivity within the fixed user locations in the wired communication infrastructure can be further enhanced by the innovative 'ubiquitous networking' wireless communication technology, to construct the 'Mobile-business (M-business)' or 'Mobile-commerce (M-commerce)' environment under the definition of "M-business = Internet + wireless + E-business" as given by Kalakota (Kalakota 2002).

The computer-based M-commerce platform in a vehicle, namely the automotive Telematics platform, (Telematics is the combination of "***Tele***communication" and "infor***matics***") is regarded as an innovative technology combining wireless communication, an in-vehicle information system, and an in-vehicle multimedia computing system. A Telematics-enabled vehicle is capable of offering customers a variety of benefit and value in the form of new services, namely, the enhancement of safety, security, travel information services, convenience, and entertainment, so as to develop new business models and new markets (Figure. 10). Therefore, Telematics is qualified as a radical innovation enabling technology if taking into account the benefits it renders, the sophistication of its engineering efforts, and the complexity of application in wireless network connectivity. However, a recent report demonstrated that customers within different territories presented heterogeneous needs patterns: the customers in the U.S. have much stronger focus on safety-relevant services, while those in Europe prefer navigation and traffic information services, and customers in Japan accept more entertainment-based Telematics packages (Shahmanesh 2003). This implies that in order to develop a Telematics platform for market success in a particular region, the sophistication of technologies should not be the only issue to deal with, but consideration on the customer side also matters. Therefore, building a M-commerce Telematics product demands innovative technology as well as customer knowledge. It is also worthwhile to note that M-commerce is different from the endeavor of attracting the mass market in E-commerce, scholars have suggested that in M-commerce the emphasis should be put on separate service packages for different specific groups of customers (Kotler 2003).

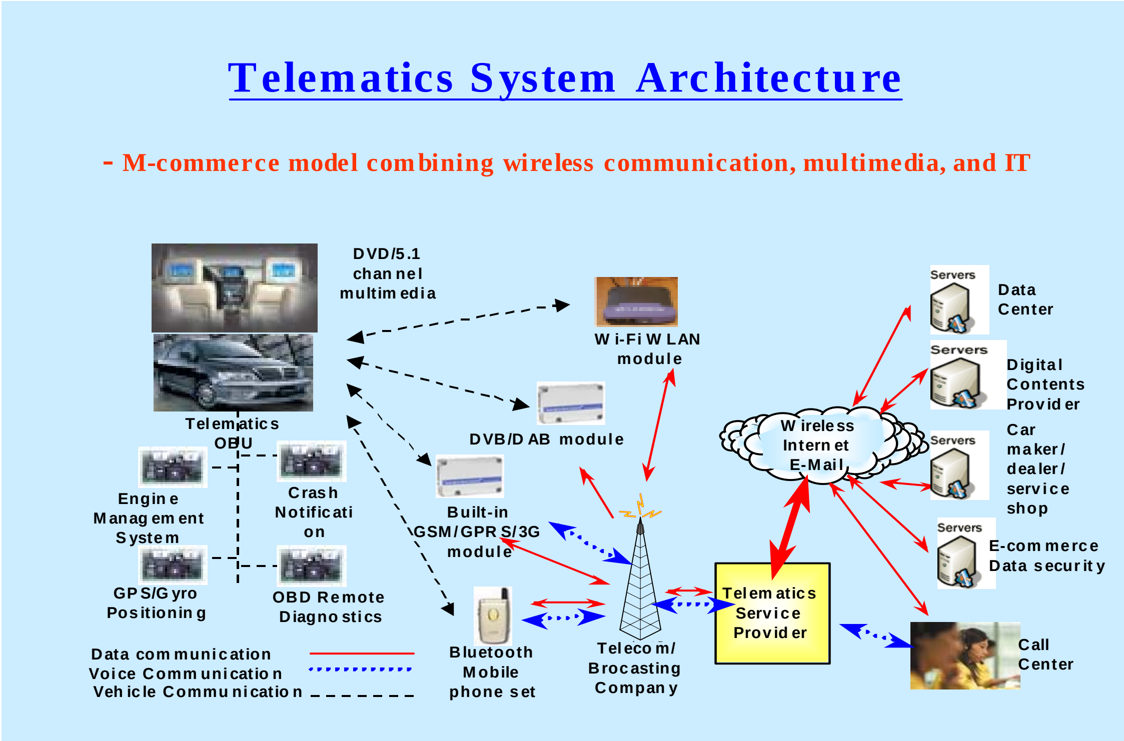


Figure 10. The business model and architecture of Telematics system

4.1.2 The Backbone of M-Commerce – The 'Ubiquitous networking' Technology

To realize M-commerce applications, technology innovation is definitely a must in addition to the elimination of impediments over current E-commerce including data security, legal affairs, commercial settings, cost-benefits, as well as the context for user-friendly application.

Once equipped with wireless Internet access capability, a cellular phone set, a personal digital assistant (PDA) and a portable notebook computer become all qualified devices for M-commerce. They allow users to ubiquitously access the Internet at any time and any way through various wireless networks operating within different distance coverage via a Bluetooth wireless network, the wireless local area network (IEEE 802.11b), the wide area network like GSM (Global System for Mobile Communication), GPRS (General Packet Radio Service), and W-CDMA (Wide Band Code Division Multiple Access) network. Unfortunately, compared to a wired Internet system, wireless devices feature two kinds of drawbacks: the first is the low-bandwidth and high-latency time, the second is usage constraints such as short battery storage capacity, small monitor screen size, and erratic communication reliability under different operating environments, let alone the costly wireless connecting expense.

The battery and screen issue does not happen in a computer-based M-commerce platform in a vehicle, namely, an automotive Telematics in-vehicle platform. (Of course, this is at the expense of sacrificing the mobility of a cellular phone). It is engaged in the perspective of M-commerce by getting the car industry into the Internet era, and reciprocally bringing the Internet into the car by wireless technology (Sommerlatte 2001).

4.1.3 Building An M-Commerce Platform Demands Innovative Technology and Innovative Knowledge

The M-commerce model supported by a Telematics in-vehicle platform demands the application of a variety of high technology. When integrated as a whole the task becomes so sophisticated that many efforts need to be made.

Quoted from Fuchs (2002), the major enabling technologies of Telematics are:

(1) Positioning and location technologies: GPS (global positioning system), digital map.

(2) Telematics service delivery technologies:

- Wireless short-range communication system: Bluetooth, IEEE 802.11x networking family.
- Wide area cellular communication system: GSM, GPRS, CDMA, W-CDMA.
- Communications via satellite.
- Data broadcast: FM subscriber, digital audio broadcast, digital video broadcast.

(3) Networking and protocols

- Telematics protocols.
- Internet protocols.
- WAP (wireless application protocol).

(4) Vehicle communications

- Serial vehicle bus systems: CAN (controller are network), LIN (local interconnect network).
- Multimedia/plug-and-play bus system: MOST (media oriented systems transport) and AMI-C/IDB (automotive multimedia interface collaboration/ ITS data bus)
- Audio and speech processing

(5) Distributed computing

4.2 RESEARCH METHODOLOGY FOR MODEL IMPLEMENTATION

The implementation of the integrated KM model is supported by an empirical study in an innovative Telematics NPD project. It begins with managing product knowledge to facilitate the identification of product benefits, based on which to develop a web-based market research for customer knowledge management. Research methodology involves data mining by statistical and neural network approaches that are employed to extract knowledge of customers in marketplace, as well as a multiple-assessment scheme that is used to justify research outcomes in this dissertation.

4.2.1 Product Knowledge Management for Telematics NPD Project

The sophistication of innovative technology involved in Telematics NPD project has been revealed in section 4.1.3, the confidential nature of related product knowledge prevent itself from being further disclosed. Therefore, in this chapter we play down the detailed discussion of product knowledge management and rather put emphasis on the aspect of customer knowledge management.

4.2.1.1 Organizational Learning

It is certain that no business entity can afford the possession of all the above-mentioned knowledge and technologies to alone conduct an automotive vehicle-installed Telematics NPD project. Given that all the technologies become available, there is still no opportunity to secure market viability if perspective customers turn down the offerings by judging them as premature. It is obvious that aside from the working knowledge on innovative technologies, the NPD team should create measures of how to exploit knowledge hoarded in value chain partners and measures of how to penetrate the market.

Organizational learning is required for knowledge sharing and knowledge generation among team partners at many interfaces. 'Hierarchical interface learning' scheme is employed in this project to tackle the demand that learning must occurs at the interface between marketing and product design, the interface among value chain stakeholders, the interface among heterogeneous technologies, and so on. From product technology viewpoint, 'hierarchical interface learning' may start from areas such as the interface between the wireless communication modules and computer main board; interface among vehicle electronic harness, control console, operating software; and interface between human-machine interaction and driving safety.

4.2.1.2 Value Chain Collaboration

The players, technologies, and activities involved in the framework of M-commerce consist of two domains with three processes in each domain. In the contents domain, the processes are: (1) contents formats: text, hyper-text and graphic, audio and video, (2) contents presentation: media editing and presentation, value-added website set-up, (3) contents for commercialization: contents and services providing, mobile wireless portals for commercial practice. On the other hand, in the infrastructure domain, the processes are (1) mobile wireless transmission technologies and telecommunication companies, (2) mobile services/delivery support: Internet connection, server platform, payment system, and security measures, (3) mobile interface/application: application based on embedded operating system device hardware, firmware, and software (Pierre 2001). The device to activate the transaction is through portable computer, PDA, or even a mobile phone.

In case of in-vehicle Telematics application, aside from the above-mentioned M-commerce activities, additional customer-attractive functions and vehicle-related services become indispensable to satisfy car drivers with specific demands. Therefore, the first thing is to organize a cross-industry collaboration NPD team to develop a car-installed Telematics platform, and then the next step will be the establishment of conciliation among value chain stakeholders to find out how to do business.

The 'collaborative engineering' approach enables the distribution of within-organization and between-organization tacit knowledge among NPD team partners to facilitate the generation of new knowledge in how to construct the building blocks of this innovative product, and the resolution out of consensus will be codified for application and for reuse in the future. An example of generated knowledge is the application difference between personal computer operating system such as Window 2000 and embedded operating system such as WinCE.Net, to affect the wireless Internet connectivity capability.

4.2.1.3 Technology Transfer

As a consequence of collaborative engineering, the practice of modular design as an existing knowledge and technology in the computer industry has been transferred. It alerts the NPD team to conjecture whether a full-featured new Telematics product is likely to be judged as premature if customers perceive it as too costly, too sophisticated, and too inconvenient. Therefore, the NPD team makes a proposal to apply the knowledge of product 're-configurability' that can be embedded in the 'modular design'.

To implement the 'modular design', each party in the NPD collaboration team transfers only the technology that is required at the interface of different domain knowledge to let NPD product comes into being. The 'hierarchical interface technology transfer' scheme provides the appropriate solution for technology transfer at interfaces of different product module or platform. The codified product knowledge is used to make up the 'value chain knowledge/technology architecture' as the blueprint to guide NPD team in accomplishing all the necessary knowledge/technology transfer.

4.2.1.4 Product Feature Realization–The Outcome of Product Knowledge Application

The NPD collaboration team adopted herein a multi-layered architecture to accommodate all the features of Telematics platform. Presented here only for demonstration is an oversimplified two-layered architecture example. At the system level, a 2 x 1-DIN (Deutsch Industry Norm) size box or 2-DIN size box is designated as two alternatives for the first layer configuration. In the second layer subsystem, there are four main building blocks: wireless communication module, multimedia module, GPS navigation module and HMI: human-machine-interface including a 7-inch TFT (thin film transistor) display and control panel either with or without voice-command hand free phone capability.

The presumed full-scale system is the whole of wireless, multimedia, GPS, and HMI modules. In case of control panel without voice-command hand free phone capability, product variants become available by a combination of: (wireless + HMI), (multimedia + HMI), (GPS + HMI), (wireless + multimedia + HMI), (wireless + GPS + HMI), (multimedia + GPS + HMI) and (wireless + multimedia + GPS + HMI). Each variant has specific features and cost structure to meet the demand of particular customer group, and each also conserves the possibility of re-configurability when technology evolves in the future. At this stage, knowledge realization comes true.

4.2.2 Customer Knowledge Management for Telematic NPD Project

This part is the main focus of this dissertation, backed up by a web-based survey.

4.2.2.1 Product Benefits Identification

At first, the NPD project team generates and delivers product knowledge 'for' customers. Customer knowledge generation starts from transforming by NPD team the Telematics product's features into 'benefits perceived by customers', paving the way to understand customers' response toward benefits that those features bring out. The typical benefits of the Telematics platform for the vehicle drivers are: safety, security, information, convenience, entertainment and M-commerce application. Table 8 is a summarized but not exclusive list describing features that Telematics platform has, benefits it offered and the technologies involved. At this stage, a bi-directional communication channel like E-mail or company's website is appropriately used to reach customers.

Table 8. Telematics platform's features, benefits offered and technology involved

Features	Technology Used	Benefits Offered
Crash notification	GSM, GPRS	Safety
Emergency services	GSM, GPRS	Safety
Roadside assistance	GSM, GPRS	Safety
Hand-free mobile phone call	GSM, GPRS Bluetooth	Safety, Convenience
Voice command phone dialing	GSM, GPRS , pattern recognition	Convenience, Safety
Stolen-vehicle tracking	GPRS or GPS	Security
Vehicle location change alert	GPRS or GPS	Security
Vehicle tow service	GPRS or GPS	Security
Automatic navigation guidance with electronic map	GPS, TFT LCD Embedded Operating System	Convenience, Information
Gasoline station and parking lot guidance	GSM, TFT LCD Embedded operating system	Convenience, Information
Internet access E-mail	GPRS, Bluetooth. TFT LCD, embedded operating system	Information, Convenience. Mobile-commerce
Tourist information	GSM, GPRS, Bluetooth, Wi-Fi (IEEE 802.11b)	Information, Convenience
Traffic condition report	GPRS, Bluetooth, Radio broadcasting	Information, Convenience, Safety
Vehicle status diagnostics	CAN networking, sensors, TFT LCD.	Information, Safety
Personal information Management (calendar, Phone and address	Embedded OS, Software component, TFT LCD touch panel	Information, Convenience
AM/FM MP3	Radio broadcasting, Data compression: MPEG Layer 3	Information, Entertainment. Convenience
DVD and DVB 5.1 channels audio	Data compression: MPEG2 and MPEG4 Digital broadcasting	Information, Entertainment. Convenience

In this study, sampling plan for web-based survey is based on the following assumption:

(1) Because Telematics features are complementary and supporting devices for a vehicle, only vechicle drivers to be the potential customers of the Telematics platform.

(2) Only customers those are used to IT application such as E-mail, Internet surfing and on-line conversation, to be the perspective customers of the sophisticated Telematics platform.

(3) Only customers with enthusiasm about high technology stuff are interested to answer the web-based survey, their response toward Telematics platform will be more optimistic than the average customers.

Under the assumption, the sampling plan is prepared by a random selection from the current customer database to form a target roster, by which to send out an e-mail soliciting the recipient to answer a self-administered questionnaire posted on the website www.question.sine.com.tw. On the front page of that website appears a thank-you letter, followed by a detailed instruction describing the procedure how to answer the questions. The first part of the questionnaire is pertinent to customers' demographic and personal information such as age, gender, profession, education background, income, marital status, and number of children. The second part of the questionnaire in the survey instrument consists of 29 items of Telematics features that deliver certain benefits to customers. All 29 items are arranged into eight groups, customer will answer item by item how they need these features. The third part is to collect the information of customers' perceived monetary value on certain Telematics features.

The contents of the questionnaire are shown in Appendix A. The feedbacks toward this survey instrument provide responses from customers about their needs, attitudes, and perceived values toward a Telatatics platform's features with benefits offered. The total of the customers' responses, collected in the form of analog-valued data will be arranged as the 'customer response database'. This procedure creates an opportunity to identify that the customers have already acquired product knowledge about the product features and benefits they may offer, thus NPD team has delivered knowledge 'for' customers.

4.2.2.2 Customers' Needs Categorization

From the total of customers' response collected via Internet, 1,742 effective questionnaires became available. All data were processed by a MySQL database management system installed on an Apache web server running under the Linux operating system. The aggregate of the data collected from all customers in the study first undergoes a data cleaning process and a data transformation process to constitute a data set as the database ready for data mining task that follows the categorization of customers' needs. At this stage, the web-based survey activity generates knowledge 'about' customers by understanding customers' demographic background, needs and preference attitude toward benefits that product features offered.

To obtain an overall understanding on how marketplace needs Telematics features, an aggregate needs categorization can be done by calculating the percentage proportion of customers that select 'not so needed' plus 'moderately needed' as the category of 'low degree of needs' and that select 'strongly needed' plus 'extremely needed as the category of 'high degree of needs'. Percentage proportion of customers selecting 'just needed' is regarded as the category 'neutral' for ease of observation. In this study, the descriptive statistics of needs categorization derived from web-based survey is shown in Appendix B. 15% constituents difference among needs categories for certain Telematics feature indicates the dominant needs status. The aggregate needs categorization can help NPD team to observe the comprehensive market intelligence in favor of the perspective product development planning. Because the sample customers those participate the web-based survey are all car user, they are the selective potential customers that are most apt to utilize the Telematics product when it is brought out in the market.

From the survey results, it shows that safety and security related features are much needed; travel-assisted information and entertainment are also needed. On the contrary, IT related items are much weakly demanded. Although the statistical outcome displays a needs categorization as a whole, the hidden customer knowledge is not yet extracted. Therefore, besides the descriptive needs categorization presentation, the data mining technique is also employed to cluster all the customers in the study based on their needs patterns into groups of similar propensity, so that customer knowledge in each segment can be readily extracted, because segmentation scheme based on benefit/needs is appropriate to convert tacit customer knowledge into useful explicit knowledge.

Through communication with customers, the NPD project team is able to utilize knowledge 'for' customers and knowledge 'about' customers to conduct the appropriate market segmentation task.

4.2.2.3 Data Mining for Market Segmenting to Convert Tacit Customer Knowledge into Codified Knowledge

In this study, three data mining methods are used to cluster customers that participated in a web-based survey into homogenous groups. One of them is a popular multivariate method, the K-means algorithm; the other two are of artificial neural networks - SOM network and FuzzyART network. For the business practical utility, data mining in the integrated KM model has to fulfill the criteria of the multiple-assessment scheme.

4.2.2.4 The Result of Research - Tested by The Multiple-Assessment Scheme

- **Does customer accept the web-based survey?**

The first criterion: "Does the customer accept the web-based survey approach and render a response sufficient for data mining?" has been achieved by 1,472 effective responses in the survey, it is more than the threshold of 1,000 response examples.

- **Determining the best clustering solution–the optimal number of 'natural' cluster**

From the pragmatic standpoint of need-based segmentation, selecting as the number of cluster from between three to seven enables marketing people consider it as manageable in business practices (Haley 1985). So cluster by SOM network, FuzzyART network and K-means algorithm respectively the data set from 'customer response database' into clustering solutions for three, four, five, six and seven segments, and then compute the R-squared value corresponding to each clustering solution. Table 9 to Table 11 lists up parameters and resultant R-squared values for these three different data mining methods.

Table 9. Parameters and R-squared values for different clustering solutions using Self- Organizing Feature Map network

No. of Segment	No. of Epoch	Initial No. of Neighborhood	Initial Weight	Initial Learning Rate	Final Learning Rate	R-Squared
3	5,000	2	0.3	0.5	0.0001	0.3882
4	5,000	3	0.3	0.5	0.0001	0.4219
5	5,000	4	0.3	0.5	0.0001	0.4558
6	5,000	5	0.3	0.5	0.0001	0.4572
7	5,000	6	0.3	0.5	0.0001	0.4886

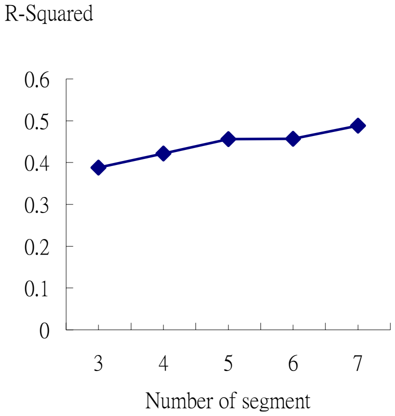
Table 10. Parameters and R-squared values for different clustering solutions using FuzzyART network

No. of Segment	No. of Epoch	Choice Parameter	Learning Rate Parameter	Vigilance Parameter	R-Squared
3	1	0.1	0.98	0.14	0.1406
4	1	0.1	0.99	0.16	0.1221
5	1	0.1	0.99	0.18	0.2269
6	1	0.1	0.99	0.20	0.1797
7	1	0.1	0.98	0.21	0.1637

Table 11. Parameters and R-squared values for different clustering solutions using K-means Algorithm

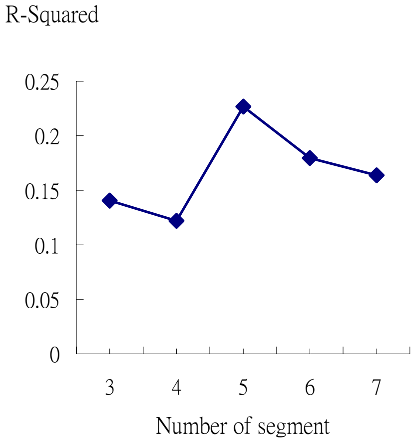
No. of Segment	R-Squared
3	0.3877
4	0.4221
5	0.4552
6	0.4662
7	0.4810

Plotting R-squared values as vertical axis against the number of cluster as horizontal axis, if there appears an ‘elbow’ point in plot it indicates the occurrence of the best clustering solution or the optimal number of cluster (Shama 1996). Figure 11 to Figure 13 are plots used to show whether or not an ‘elbow’ point makes presence.



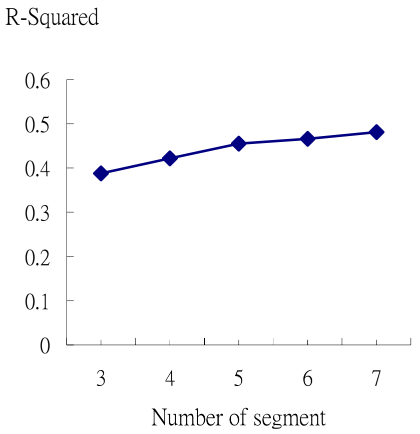
No. of Segment	R-Squared	Difference
3	0.3882	
4	0.4219	0.0337
5	0.4558	0.0339
6	0.4572	0.0014
7	0.4886	0.0314

Figure 11. Clustering solutions for SOM network



No. of Segment	R-Squared	Difference
3	0.1406	
4	0.1221	-0.0185
5	0.2269	0.1047
6	0.1797	-0.0472
7	0.1637	0.0160

Figure 12. Clustering solutions for FuzzyART network



No. of Segment	R-Squared	Difference
3	0.3877	
4	0.4221	0.0344
5	0.4552	0.0331
6	0.4662	0.0110
7	0.481	0.0148

Figure 13. Clustering solutions for K-means algorithm

The “larger gap” in the value of R-squared happens at five as the optimal number of cluster for all three data mining methods. Based on the data set in the ‘customer response database’ of this study, it qualifies the formation of five ‘natural’ clusters or five market segments

- **Determining which one is the most appropriate data mining method?**

Although all the SOM network, FuzzyART network and K-means clustering method result in five segments as the same number of ‘natural’ clusters, another issue takes place as to how reliable are these clustering methods? Because the clustering operation in this study is based on the aggregate needs pattern collected from the rating scale instrument via web-based survey, for the attitude construct of a particular segment to be valid and possess practical business utility, it must be justified as reliable by meeting a minimally acceptable level expressed by Cronbach’s alpha coefficient, i.e. 0.9 and above as high acceptance reliability level; 0.8-0.9 as moderate to high acceptance level; while 0.7 as low reliability level and 0.6 as unacceptable level (Murry 1988). Therefore, the sub-data set out of customers’ response in these five segments must subject to scrutiny. Table 12 to Table 14 shows the values of Cronbach's alpha coefficient for different clustering solutions done respectively by SOM network, FuzzyART network and K-means algorithm.

Table 12. Cronbach's alpha for clustering solutions done by SOM network

Cronbach's Alpha for Different Clustering Solutions							
	1st segment	2nd segment	3rd segment	4th segment	5th segment	6th segment	7th segment
Clustering into **3** segments	0.7947	0.5864	0.8408				
Clustering into **4** segments	0.7582	0.3148	0.4193	0.8030			
Clustering into **5** segments	0.7786	0.5752	0.6387	0.4439	0.7954		
Clustering into **6** segments	0.7910	0.6230	0.5624	0.4354	0.5141	0.7145	
Clustering into **7** segments	0.8027	0.6134	0.4992	0.4987	0.4902	0.4124	0.7189

Table 13. Cronbach's alpha for clustering solutions done by FuzzyART network

Cronbach's Alpha for Different Clustering Solutions							
	1st segment	2nd segment	3rd segment	4th segment	5th segment	6th segment	7th segment
Clustering into **3** segments	0.9270	0.9389	0.9098				
Clustering into **4** segments	0.9475	0.9600	0.9640	0.9319			
Clustering into **5** segments	0.8531	0.8031	0.9142	0.9287	0.9280		
Clustering into **6** segments	0.9178	0.8932	0.8953	0.8816	0.8825	0.9400	
Clustering into **7** segments	0.9314	0.9013	0.9371	0.8934	0.8627	0.9359	0.9313

Table 14. Cronbach's alpha coefficient for clustering solutions done by K-means

Cronbach's Alpha for Different Clustering Solutions							
	1st segment	2nd segment	3rd segment	4th segment	5th segment	6th segment	7th segment
Clustering into **3** segments	0.5812	0.7921	0.8454				
Clustering into **4** segments	0.6921	0.6630	0.8075	0.8494			
Clustering into **5** segments	0.4673	0.5745	0.6430	0.8013	0.7835		
Clustering into **6** segments	0.6128	0.5043	0.7231	0.7940	0.7819	0.5762	
Clustering into **7** segments	0.5666	0.5149	0.5539	0.8182	0.6810	0.7552	0.6026

The Cronbach's alpha coefficient shown from Table 12 to Table 14 indicates that only clustering solutions performed by FuzzyART network can meet the moderate to high reliability level. Both SOM network and K-means clustering algorithm are qualified as appropriate methods to find out the number of 'natural' clusters though, unfortunately they fail in providing the reliable construct for each segment.

After adequate segments are formed, each segment's needs patterns toward Telematics product's features is also well delineated, and then different characteristics of each segment is further investigated and analyzed by NPD team, in order to make strategic decision for product variant line-up or to reposition the revised market offerings. At this stage, tacit customer knowledge hoarded within each customer segment is excavated and converted into explicit customer knowledge in a codified form to be used by the NPD project team.

Data mining outcomes have achieved the requirement of the three criteria in the multiple-assessment scheme to justify the integrated KM model, as presented by: (1) 1,472 effective survey response sample size exceed 1,000 -- the presumed threshold for criteria No.1, (2) the SOM network, the FuzzyART network and the K-means algorithm are all qualified data mining methods for clustering operation, and (3) among these three data mining methods, FuzzyART network is the most appropriate one for the clustering operation to implement market segmentation, its result presents the best construct reliability for each market segment.

4.2.2.5 Segment Needs Pattern Extraction

Once the segmentation task is done, the characteristics of customers' needs patterns in each segment are also studied to extract the customer knowledge hoarded in each segment as the knowledge 'from' customer. In this study, market segmentation done by FuzzyART neural network comes up with five segments as the optimal solution. Data mining facilitates the needs pattern hidden in each market segments thus to be extracted as shown in Table 15. For the sake of easy visualization, legend '●●' stands for features extremely needed, '●' stands for features highly needed, '△' stands for features just needed and '✕' stands for features not so needed.

The No. 5 segment is named as the 'early adaptor' segment, as customers in this segment care their property and driving experience so as to prefer car tracking, roadside assistance and information pertinent to driving. Besides, they also are apt to try new idea so as to like IT related application in car without showing any hesitation. The No.4 segment is named as the 'majority' segment, because customers in this segment consists of 65.15% of sample size in this study, and like most people in the society they prefer what are really useful in using a car. The No. 3 segment is the 'pragmatist' segment , they don't need functions that can be handled in office or at home if time sensitiveness is not an issue. The No. 2 segment is named as the 'skeptic' segment, although customers would like to rely on GPS navigation guidance in traveling, they show no intension to use IT-related applications in car, perhaps except for electronic game they doubt the benefits the technology innovation brings out. The No.1 segment is named as 'prudent citizen', as they have hesitation to utilize anything that is not so conventional.

Looking into the distinction of needs pattern among these five segments makes NPD team identify what to attract customers, this finding provides valuable knowledge 'from' customer. An interesting finding arouses our attention: features pertaining to M-commerce are not so needed at this point of time! From the viewpoint of technological innovation, NPD team foresees the emergence of M-commerce era, but contemporary customers reject this innovative technology and its application, how to untangle the dilemma? A 'portable' rather than an 'embedded' wireless configuration may work.

Table 15. The needs pattern in each segment as the explicit customer knowledge

Segments in marketplace	Segment No.1	Segment No.2	Segment No.3	Segment No.4	Segment No.5
Description about segment	**Prudent Citizen**	**Skeptic**	**Pragmatis**	**Majority**	**Early Adopter**
Segment size and Proportion	153 10.39 %	34 2.31 %	101 6.86 %	959 65.15 %	225 15.29 %
Feature item	The extent of needs				
Group 1: Automatic route guidance functions					
1.GPS navigation with electronic map	△	●	△	△	●
2. Shortest path search	△	●	△	△	●
3. Turn and branch prompt	△	●	△	△	●
4. Gas station / parking lot position	●	●	●	●	●
Group 2: Traffic Information					

5. Periodic radio broadcasting	△	△	△	△	△
6. Real time information access	●	●	●	●	●
Group 3: Emergency services					
7. SOS message in emergency	●	●	●	●	●
8. Vehicle tow notification	●	●	●	●	●
9. Stolen vehicle tracking	●	●●	●●	●●	●●
10. Roadside assistance services	●	●●	●	●	●●
Group 4: Travel information					
11. Tourist information guide	△	△	△	△	△
12. Travel route information	●	●	●	●	●
13. Flight, train, bus schedule	△	△	△	△	△
Group 5: Lifestyle/ information access					
14. Shopping, on-sales information	×	×	×	×	△
15. News, stock, sports, weather, medicine	△	△	△	△	△
16. Concierge service	×	×	△	△	△
17. Calendar, organizer, address note	×	△	△	△	△
18. Voice recording	×	×	△	△	△
19. Data synchronization with PDA or Notebook computer	×	×	△	●	●
Group 6: Mobile commerce					
20. In-vehicle ticket reservation	×	×	×	△	△
21. In-vehicle on-line shopping	×	×	×	×	△

22. E-mail / short message transceiver	×	×	△	△	△
23. Internet web browsing	△	×	△	△	△
Group 7: In-vehicle entertainment					
24. DVD, CD, MP3, TV enjoyment	●	●	●	●	●
25. Electronic game playing	×	●	×	×	△
26. Karaoke singing device	×	×	△	△	△
Group 8: Human-machine interface					
27. By voice command for hand free phone	×	×	△	●	●
28. By touch screen	△	×	△	△	△
29. By joystick	△	△	△	△	△

When NPD team looks into the customers' demographic data, income, profession, and education level in each segment, more customer knowledge can be extracted. The analysis of major segment characteristics is shown in Appendix C. Further investigation by hypothesis test and correlation analysis will lead to the excavation of deeper knowledge. A brief observation indicates that profession and education level are the main influential factors for perspective customers to accept the innovative M-commerce features in Telematics platform.

The newly codified customer knowledge is transferred to NPD team for aiming at the right target market segments and making appropriate strategic business decisions in product variants realization. It helps the NPD team to revise the original product definition thanks to the product's re-configurability capability, to set priorities for product features to add on, to enhance the functionality of the attractive product elements, and to rule out product features that customers have no interest towards. At this stage, customer knowledge realization comes true to help the NPD project team in reducing market risk and creating a product having attraction.

4.2.2.6 The Outcomes of Customer Knowledge Application

Based on the extracted customer knowledge from each segment, NPD team plan a offering for each segment:

Early Adaptor: Wireless + Multimedia + GPS + HMI of voice-command hand free phone.

Majority: Wireless + Multimedia + HMI of voice-command hand free phone.

Pragmatist: Wireless + Multimedia + HMI

Skeptic: Multimedia + GPS + HMI.

Prudent Citizen: Wireless + Multimedia + HMI

The Telematics platform configuration for 'Pragmatist' segment and "Prudent citizen' segment looks the same, however, the deeper product knowledge generated in collaboration enables NPD team to further differentiate contents within a specific configuration. The reason is that there is several alternatives to achieve the configuration customers need, for example, both DVD and DVB can meet the 'multimedia' configuration requirement, and GSM and GPRS can also meet wireless configuration requirement.

Cost performance, affordability, real usage demand are some of factors that affect customers' final buying decision. Customer knowledge generated from the first part of the web-based survey questionnaire about customers' demographic and personal information such as age, gender, profession, education background, income, marital status, and number of children, as well as from the third part of the web-based survey questionnaire about customers' perceived monetary value on certain Telematics features, enables the NPD team to do further research on how to offer segment-specific affordable attractive product that customers desire to buy.

CHAPTER 5

DISCUSSION

5.1 THE GENERAL DISCUSSION ABOUT THIS STUDY

New product development out of technological innovation plays an important role in the pursuit of organizational competitive advantage for business success. It is supposed to be a knowledge intensive task that requires many different types of knowledge. However, innovative product introduction inevitably runs the risk of unfavorable market reception leading to a company's financial adversity. Congruently managing product knowledge and customer knowledge enables the NPD team to exploit the existing knowledge and generate new knowledge for application in creating value and reducing risk. The importance of knowledge management in technological innovation and NPD has been critically recognized as drawing many research efforts in this area. However, the influential potential of customer knowledge management is not so much emphasized.

The research objectives of this study are: (1) Addressing the imperativeness of managing product knowledge and customer knowledge in an innovative NPD project, by proposing an integrated KM model, (2) Setting up the process and the methodology for extracting knowledge of the customers in marketplace to facilitate the NPD project, by an empirical study, (3) Justifying the robustness of this integrated model by web-based survey and data mining technique to meet the three evaluation criteria of a multiple-assessment scheme. With the result of the empirical study, all of research objectives have accomplished by applying the integrated KM model in an innovative Telematics NPD project. The outcomes of both customer knowledge and product knowledge application are modular-designed Telematics products of a re-configurable nature to cope with the demands of customers in different market segments. Additionally, the significant part of this dissertation is that, in the integrated KM model a well-structured procedure has been established to identify a product's features and benefits so as to communicate with the customer by providing knowledge 'for' customers, to utilize IT infrastructure in acquiring knowledge 'about' customers' background and their needs categorization, to use data mining technique to extract knowledge 'from' customers in different segments about their needs patterns towards specific product features. Pinpointing the propensities of customers in a certain segment enables an NPD project team to bring out attractive products to delight customers in order to facilitate business success.

It is worthwhile to notice that without the support of information technology, carrying out the activities of customer knowledge management will take much more efforts. Sending e-mail to customers by using e-mail addresses registered in a company's customer database provides a convenient way of customer access. Posting an electronic market survey instrument on the web offers a direct data collection route to convert customers' response into the database for data mining operation. Data mining via a statistical computing package and soft computing algorithm such as an artificial neural network presents a robust approach to form 'natural' potential market segments. A data mining technique by following a structured procedure finds its way to codify hidden customer knowledge into explicit knowledge. Finally, we confirm the reliability of the results exercised by data mining.

For market survey using a rating scale instrument to collect the primary data, computing the classical Cronbach's alpha coefficient to check the reliability of customer's attitude construct for a specific segment, is an appropriate approach to ensure its business practical utility. Cronbach's alpha is used to validate customers' needs construct that will guide the development of new product variants. All of the above reconfirm the usefulness of information technology in an integrated KM model.

On the other hand, the contribution IT makes to product knowledge in NPD is interpersonal communication, design tools such as CAD/CAE and simulations, collaboration tools such as product data management systems and groupware like video conferencing and web-mail, and tailor-made KM software packages for decision support and knowledge codification. The NPD team first works out the product definition through knowledge sharing on technological forecasting, knowledge generation about product configuration and knowledge codification in the form of preliminary features setting. Then the products feature items are used in acquiring customer knowledge. IT facilitates the management of customer knowledge by data mining via the web-based survey to present what customers need and want in certain segment. In case that knowledge 'from' customers on the product has conflict with the original product planning, it provides the timely alert to the NPD team to alter the product definition. In this study the application of the integrated KM model in Telematics NPD project, IT application does help the team to switch 'embedded wireless approach' to a low cost 'portable wireless approach' to prevent product offering that customers desire not for the time being, however, reserve the possibility of M-commerce application in the future.

5.2 THE COMPARISON ON RESULTS OF THREE DATA MINING METHODS

5.2.1 The Determination of The Best Clustering Solution

The number of 'natural' cluster is resulted from the best clustering solution in data mining operation. In academic literatures (Shama 1996, Duda 2000), the 'larger gap' in the value of criterion function among sequential clustering solutions as well as the 'elbow point' in the plot of R-squared vs. cluster number, have been recognized for long time as the means to identify the optimal number of clusters. In this study all three data mining methods unanimously results in five market segments as the best clustering solution, despite that the 'elbow' shape presented individually by SOM and K-means in Figure 11 and 13 doesn't distinguish itself so well if compared with that of FuzzyART network in Figure 12. On the contrary, the value of Cronbach's alpha coefficient for the best clustering solution when using K-means and SOM, demonstrates that they are unable to come up with a reliable customers attitude constructs for each five market segments.

5.2.2. The Refinement in Data Mining Steps for Better Clustering Result

Except K-means and SOM, the results of data mining by FuzzyART in this study has already fulfilled the requirement of multiple-assessment scheme by meeting three evaluation criteria to indicate that the best clustering solution as the optimal five segments. The reliability of customer's attitude constructs in these five segments represented by Cronbach's alpha coefficient value are all larger than 0.8 in Table 13, a moderate to high reliability level, justifies their practicality as the reliable customer knowledge. However, other researchers recommended that 0.9 to 0.95 as the reliability level for applied research (Peterson 1994). Therefore, refinement on data set at the stage of 'data transformation' in data mining steps can be done trying to upgrade the construct reliability level by better segmentation result. For K-means and SOM, data refinement is also expected to increase the value of Cronbach's alpha coefficient.

5.2.3. The Challenge of Forming Uniform-Size Market Segments

Clustering customer's response toward web-based survey questionnaire into 3, 4, 5, 6 and 7 market segments has been accomplished in this study by data mining techniques with K-means, SOM network and FuzzyART network respectively. The values of Cronbach's alpha coefficient for survey construct for those segments are listed in Tables 12, 13 and 14. Although only Cronbach's alpha coefficients of clustering solutions by

FuzzyART are larger than 0.8 to present real world business practice utility, on the other hands, clustering by K-means and SOM results in more uniform segments size, compared with that of clustering result by FuzzyART. In case of five segments, the segment size in each segment is: K-means (404, 250, 303, 267, 248), SOM (251, 278, 293, 395, 255) and FuuzyART (153, 34, 101, 959, 225). In business practice it will be desirable to have more uniform segment size for each segment, taking into account the efforts to develop the product variant to serve that segment. Thus, there exists a demand for taking advantage of the respective unique clustering characteristics in K-means, SOM and FuzzyART so as to explore the opportunity of applying the hybrid segmentation scheme.

5.3 THE CONTRIBUTION AND CONSTRAINT OF THIS STUDY

The major contribution of this dissertation lies in three aspects. The first is the fusion of product knowledge management with customer knowledge management to create attractive products for customers and also to reduce project risk. The second is the justification of the integrated KM model which incorporating information technology into an emerging CKM model, for this model exploits the synergy of a data-driven CRM management tool and people-oriented KM process. The third is the verification of a data mining-oriented market segmentation scheme through the intervention of a well-established business research paradigm, i.e. the survey construct reliability presented as Cronbach's alpha coefficient. The approach disclosed here and the outcome of knowledge management application in this study does transcend the research fruit of the academic community onto a concrete methodology of a business practice, making a consequential positive impact definitely foreseeable.

This study also shows that the hybridization of conventional market research methodology with a data mining approach is feasible and effective in practical business application. More contribution may take place in the area where the application of the integrated KM model is realized in the domain of other components of technology management, namely, product knowledge, industry knowledge, operations knowledge, supplier knowledge, and competitor knowledge.

Although the outcome of knowledge application in this study is satisfactory, some inherent limitations must be noted. First, it focused on a product innovation in the automotive industry. The benefits offered by the innovative product concern only car users, rather than the general public. Second, the findings in this study relies on a quantitative assessment via the needs pattern of an aggregate customers' response. Therefore it must be assumed that the feedback of sample customers does represent the needs pattern of all the customers registered in the customer database. Third, the outcome of the customer knowledge application should be supported by a successful clustering method. Instead of using a conventional measurement criteria to determine the most appropriate clustering result, this study employs a multiple-assessment scheme such as R-Squared and Cronbach's alpha coefficient for making a decision, so as to better justify the validity of the application result. Fourth, although the third part of the web-based survey questionnaire is about customers' perceived monetary value on certain Telematics features, enables the NPD team to study how to offer segment-specific affordable attractive product that customers desire to buy. Becacuse it features the commercial confidential nature, nothing should be disclosed. Fifth, the optimal segment number is five, however; for small size segment such as 'skeptic' segment, company must have the double thought to see whether it is necessary to serve this particular segement.

This new approach should be subjected to further investigation, because the above limitations constrain the generality of the integrated KM model for use in other industries and other product contexts.

CHAPTER 6

CONCLUSION

This study begins with the argument that (1) product innovation must link with the knowledge of customers' needs, (2) the results of knowledge application should be discussed more fully, (3) information technology such as CRM, web-based survey approaches and data mining techniques may facilitate the knowledge process. In order to address the importance of customer knowledge in innovative product development, we propose a target marketing-oriented integrated KM model, by presenting the taxonomy of customer knowledge, namely, knowledge 'for' the customer, knowledge 'about' the customer and knowledge 'from' the customer, as well as the process of how to create customer knowledge in each stage.

A point of interest is the application of the IT-based procedures, such as web-based survey and data mining for a real world innovative NPD project, in the attempt to diminish the 'knowing-doing gap' that has been criticized by major KM research articles. In addition three evaluation criteria are also proposed to scrutinize the robustness of data mining result in this integrated KM model.

The empirical data collected from a web-based market survey provides considerable support for the integrated KM model, taking into account the evaluation result based on some of the criteria. It is evident that from the results, the methodology proposed in this study can be successfully applied in a business practice by linking NPD with customer knowledge. The approach discussed in this study clearly delineate the process and activities of the integrated model, it offers the application perspective in the real business environment.

This dissertation also proposes the incorporation of a data-mining technique into the integrated KM model. The integrated KM model with a well-structured process and implementation procedure has broken ground on a new methodology in the field of research on product and customer knowledge management. However, the approach of methodology hybridization from different disciplines is in the stage of incubation, which calls for sustainable input from researchers of related fields to collaboratively explore more possibilities in the future.

Further research is recommended in several directions:

(1) To investigate the impact of data refinement on clustering results, measures such as selection of appropriate initial seed for K-means, fine tuning in advance by supervised learning toward nodes on SOM network, and training FuzzyART network several times by presenting the input data set in different ordering sequence, are recommended for future research that aims at better data mining outcomes.

(2) To explore the relationship between 'elbow shape' and the rating scale construct reliability in market segmentation research.

(3) To justify the effectiveness of hybrid segmentation scheme such as using FuzzyART to perform the Post hoc segmentation to get a better clustering solutions in terms of Cronbach's alpha coefficient, and then feed the cluster centers as the initial seed of K-means algorithm to perform the A priori segmentation. The expectation of using this hybrid segmentation approach is to obtain a clustering solution with uniform segments size and at the same time, to secure reliable customer attitude construct for each segment in order to develop the right product variants.

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APPENDIX A. THE CONTENTS OF WEB-BASED SURVEY QUESTIONNAIRE

A.1 Data Collection and Data Cleaning

The NPD project team prepared a roster of customers selected from the car manufacture's current customer database, and then sent e-mail to solicit them answering a survey instrument posted on a web site. All response data were processed by a MySQL database management system installed in the Apache web server running under the Linux operating system environment. After data cleaning 1,742 effective questionnaires became available.

A.2 Questionnaire Used in The Survey Instrument

In the front page of the website appeared a brief letter to thank the customers for taking part in the survey, followed by a detailed instruction describing the procedure how to correctly answer the questions. The first part of the questionnaire is pertinent to customers' demographic and personal information such as:

Age: (1) younger than 20 years old, (2) between 20 to 30 years old, (3) between 30 to 40 years old, (4) between 40 to 50 years old, and (5) above 50 years old,

Gender: (1) male and (2) female

Profession: (1) manger in hi-tech industries (2) managers in conventional industries, (3) managers in service industry, (4) employee in hi-tech industries (5) employees in conventional industries, (6) employee in service industry, (7) farmer, (8) military or police personnel, (9) government institution or education institution employee, (10) private business owner, (11) house keeper, (12) student.

Education level: (1) below high school, (2) high school, (3) college graduate, (3) university graduate, (5) above graduate school.

Annual income: (1) no income, (2) below NTD 200,000, (3) between 200,000 and 500,000, (4) between 500,000. and 800,000. (5) between 800,000. and 1,200,000., (6) between 1,200,000. and 1,500,000, and (7) above 1,500,000.

Marital status: (1) married, (2) unmarried.

Number of children: (1) none, (2) one, (3) two, (4) three, (5) four or more than four.

To make it easy in answering the web-based questionnaire, on the instrument numerical data are arranged in the increasing order of certain predetermined ranges, for example:

Age ● under 20, ● 20 to 30, ●30 to 40, ●40 to 50, ● over 50

The small circle in front of each range is for a customer to " click " by mouse and so choose exclusively an option within a question item.

The second part of the questionnaire in the main survey instrument consists of 29 items of Telematics features that deliver certain benefits to the customers. All of the 29 items are arranged into eight groups or dimension, and each item is presented in the format shown in Table A.2.

Table A.2 The main part of the questionnaire: multiple rating list scale for web-based survey on customer needs about Telematics features

Feature items \ the extent of needs	Not much needed	Moderately needed	Just needed	Strongly needed	Extremely needed
Group 1: Automatic route guidance functions					
1. GPS navigation with electronic map	●1	●2	●3	●4	●5
2. Shortest path search	●1	●2	●3	●4	●5
3. Turn and branch prompt	●1	●2	●3	●4	●5
4. Gas station / parking lot position	●1	●2	●3	●4	●5
Group 2: Traffic information					
5. Periodic radio broadcasting	●1	●2	●3	●4	●5
6. Real time information access	●1	●2	●3	●4	●5
Group 3: Emergency services					
7. SOS message in emergency	●1	●2	●3	●4	●5
8. Vehicle tow notification	●1	●2	●3	●4	●5
9. Stolen vehicle tracking	●1	●2	●3	●4	●5
10. Roadside assistance services	●1	●2	●3	●4	●5
Group 4: Travel information					
11. Tourist information guide	●1	●2	●3	●4	●5
12. Travel route information	●1	●2	●3	●4	●5
13. Flight, train, bus schedule	●1	●2	●3	●4	●5
Group 5: Lifestyle and information access					
14. Shopping, on-sales information	●1	●2	●3	●4	●5
15. News, stock, sports, weather	●1	●2	●3	●4	●5
16. Concierge service	●1	●2	●3	●4	●5

17. Calendar, organizer, address note	●1	●2	●3	●4	●5
18. Voice recording	●1	●2	●3	●4	●5
19. Data synchronization with PDA or notebook computer	●1	●2	●3	●4	●5
Group 6: Mobile commerce					
20. In-vehicle ticket reservation	●1	●2	●3	●4	●5
21. In-vehicle on-line shopping	●1	●2	●3	●4	●5
22. E-mail and short message transmission	●1	●2	●3	●4	●5
23. Internet web browsing	●1	●2	●3	●4	●5
Group 7: In-vehicle entertainment					
24. DVD, CD, MP3, TV enjoyment	●1	●2	●3	●4	●5
25. Electronic game playing	●1	●2	●3	●4	●5
26. Karaoke singing device	●1	●2	●3	●4	●5
Group 8: Human-machine interface					
27. By voice command	●1	●2	●3	●4	●5
28. By touch screen	●1	●2	●3	●4	●5
29. By joystick	●1	●2	●3	●4	●5

The third part collects the information of customers' perceived value on certain Telematics function/feature. Some major function/feature items are presented with five monetary value options. Customer clicks the small circle in front of one option to complete the selection task on a particular item to disclose his/her perceived value or the monetary value he or she is willing to pay. Because this part is of commercial confidential nature, it will not be shown here.

A.3 Data Transformation and Data Processing

The data set in the database consists of 1,472 records of needs patterns, each needs pattern is composed of 29 fields, element in each field is the one and only one of continuous-valued variable among the variable set of (0.1, 0.3, 0.5, 0.7, 0.9). The value 0.1 represents 'not so needed', 0.3 represents 'moderately needed', 0.5 represents 'very much needed', 0.7 represents 'strongly needed', and 0.9 represents 'extremely needed'.

SAS statistical software package is used to carry out the K-means clustering operation, NeurolShell2 software package is employed to perform clustering by SOM neural network, while clustering by FuzzyART network is through ART GALLERY, a software package developed by Dr. Lars Hasso Linden of Boston University, U.S.A.

The reason to transform the needs pattern of each sample customer is that FuzzyART software accepts only continuous-valued variable between 0 to 1.0, therefore, representing a customer need pattern with the (0.1, 0.3, 0.5, 0.7, 0.9) spectrum from the 5-interval multiple rating list scale customer feedback response.makes upa data vector, and the aggregate customer response data set becomes the database, readily available for data mining operation.

APPENDIX B. THE AGGREGATE NEEDS CATEGORIZATION

Feature items \ the extent of needs	High degree of needs	Neutral	Low degree of needs
Group 1: Automatic route guidance functions			
1.GPS navigation with electronic map	**46.33 %**	22.96%	30.71%
2. Shortest path search	**48.64 %**	23.91%	27.45 %
3. Turn and branch prompt	**47.55 %**	25.41%	27.04 %
4. Gas station / parking lot position indication	**63.72 %**	19.16%	17.12 %
Group 2: Traffic Information			
5. Periodic radio broadcasting	35.94 %	31.59%	32.47 %
6. Real time information access	**61.07 %**	22.35%	16.58 %
Group 3: Emergency services			
7. SOS message in emergency	**75.48 %**	14.87%	9.65 %
8. Vehicle tow notification	**72.15 %**	17.12%	10.73 %
9. Stolen vehicle tracking	**83.63** %	9.98%	6.39 %
10. Roadside assistance services	**77.85 %**	14.68%	7.47 %
Group 4: Travel information			
11. Tourist information guide	45.86 %	27.99%	26.15 %
12. Travel route information	**54.01 %**	27.19%	18.8 %
13. Flight, train, bus schedule	38.93 %	31.93%	29.14 %
Group 5: Lifestyle/ information access			
14. Shopping, on-sales information	22.76 %	24.48%	52.76 %
15. News, stock, sports, weather, medicine	34.10 %	27.99%	37.91 %
16. Concierge service	28.13 %	26.90%	44.97 %
17. Calendar, organizer, address note	27.17 %	26.57%	**46.26 %**

18. Voice recording	23.85 %	28.39%	**47.76 %**
19. Data synchronization with PDA or Notebook computer	33.63 %	24.18%	42.19 %
Group 6: Mobile commerce			
20. In-vehicle ticket reservation	25.48 %	26.01%	**48.51 %**
21. In-vehicle on-line transaction	19.50 %	24.52%	**55.98 %**
22. E-mail and short message transceiver	32.34 %	26.08%	41.58 %
23. Internet web browsing	34.38 %	24.45%	41.17 %
Group 7: In-vehicle entertainment			
24. DVD, CD, MP3, TV enjoyment	**53.53 %**	23.85%	22.62 %
25. Electronic game playing	27.58 %	26.56%	**45.86 %**
26. Karaoke singing device	33.42 %	24.94%	41.64 %
Group 8: Human-machine interface			
27. By voice command	33.63 %	24.18%	42.19 %
28. By touch screen	34.10 %	28.94%	36.96 %
29. By joystick	38.25 %	32.33%	29.42 %

(What in boldface is the dominant needs category)

APPENDIX C. THE ANALYSIS OF SEGMENT CHARACTERISTICS

Segment Characteristics	Segment No.1	Segment No.2	Segment No.3	Segment No.4	Segment No.5
Age					
20-30 year old	47.7%	47%	58.4%	51.3%	48.9%
30-40	31.4%	41%	17.8%	35.2%	36.4%
elder than 40 years old	9.8%	11.8%	5.9%	7.9%	5.8%
Others	11.1%	0.2%	17.9%	5.6%	8.9%
Gender					
Male	80%	94%	85%	83.5%	80%
Female	20%	6%	15%	16.5%	20%
Profession					
Industry employee	25.5%	64.7%	36.6%	51.6%	52%
Industry manager	40.5%	23.5%	23.8%	22.7%	30%
Military & police	13.1%	5.9%	9.9%	10.0%	3.5%
Government personnel	3.9%	5.9%	2.0%	4.0%	3.5%
House wife	6.5%	0%	18.8%	5.0%	1.1%
Student	8.5%	0%	8.9%	5.0%	1.1%
Others	2.0%	0%	0%	1.7%	8.8%
Education					
High school & college	59.5%	70%	52.4%	47.3%	50%
University &graduate	39.2%	29.4%	45.5%	51.6%	50%
Others	1.3%	0.6%	2.1%	1.1%	0%
Annual income (NT Dollars)					
200,000-50,000	14.4%	17.6%	10%	7.7%	6.7%
500,000-80,000	75.8%	76.5%	79%	80.2%	82%
800,000-1,200,000	8.5%	5.9%	9%	6.9%	10%
Others	1.3%	0%	2.0%	5.2%	1.3%
Marital status					
Married	63.4%	76.5%	54%	64.2%	70%
Unmarried	26.6%	23.5%	46%	35.8%	30%