行政院國家科學委員會專題研究計畫　成果報告

需求鍊知識探勘應用於協同設計與新產品開發之研究

計畫類別：個別型計畫
計畫編號：NSC94-2416-H-032-001-
執行期間：94 年 08 月 01 日至 95 年 07 月 31 日
執行單位：淡江大學經營決策學系

計畫主持人：廖述賢

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報告類型：精簡報告

處理方式：本計畫可公開查詢

中　華　民　國 95 年 10 月 11 日

Mining demand chain knowledge for new product development and marketing

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Abstract

Many enterprises devote a significant portion of their budget to new product development (NPD) and marketing to make their products distinctive from those of competitors and better fit the needs and wants of consumers. Hence, knowledge and feedback on customer demand and consumption experience has become an important information and asset for enterprises. However, failing to obtain such data directly from customers, the NPD and marketing departments end up having fragmented understandings and biased perspectives of customers' needs. This paper investigates the following research issues in a world leading bicycle brand/ manufacture company, GIANT of Taiwan: What exactly are the customers' "functional needs" and "wants" for bicycles? Does knowledge of the customers and the product itself reflect the needs of the market? Can product design and planning for production lines be integrated with the knowledge of customers and market channels? Can the knowledge of customers and market channels be transformed into knowledge assets of the enterprises during the stage of new product development (NPD)? The Apriori algorithm is a methodology of association rule for data mining, which is implemented for mining demand chain knowledge from channels (sales and maintenance) and customers. Knowledge extraction from data mining results is illustrated as knowledge patterns and rules in order to propose suggestions and solutions to the case firm for NPD and marketing.

Keywords: New product development; Marketing segmentation; Demand chain management; Data mining; Association rule; Knowledge extraction.

1. Introduction

In manufacturing and business processes, the transmission between information flow, money flow and logistics flow generally follows Supply Chain Management (SCM). SCM focuses on using the above information to optimize the material flow

through the successive steps of inbound logistics, operations and outbound logistics across the supply chain [27]. Essentially, SCM is a set of practices aimed at managing and coordinating the supply chain from raw material suppliers to the ultimate customer [18]. Upstream firms in a supply chain usually face a higher degree of order fluctuations than downstream firms, which are closer to the end customers. This is the so-called bullwhip effect [45], and it is one of the most problematic characteristics in supply chains [27]. Hence, industrial dynamics and management of the bullwhip effect are the main system issues in SCM [18]. However, with rising living standards and advances in production capacity, the traditional 'mass production' mode of operation can no longer effectively meet the needs of customers, who are looking for uniqueness, innovation and novelty. In other words, the purchase of a product should not only serve the physical needs, but should also bring satisfaction to the customers' emotional wants. The motivation behind a purchase originates from the affective domain and goes beyond the mere desire for the functional purpose of the product. Therefore, to satisfy customers, who are both rational and sentimental, product developers and suppliers on the one hand must maximize production efficiency; and on the other hand, must enhance product design to cater to the customer preferences. It seems that customer requirements increasingly drive the performance of the overall supply chain [26, 42]. Thus, a demand chain is a supply chain that emphasizes market mediation more than ensures efficient physical supply of the product [48].

In the demand chain, the focus is clearly customer-centered, as defined early by Brace [7], in explaining the concept of a demand chain as "…the whole manufacturing and distribution process may be seen as a sequence of events with but one end in view: it exists to serve the ultimate consumer." Demand chain management (DCM) can be defined as "extending the view of operations from a single business unit or a company to the whole chain. Essentially, DCM is a set of practices aimed at managing and coordinating the whole demand chain, starting from the end customer and working backward to raw material suppliers [50]." The information and communication infrastructure development has resulted in the continual evolution of the demand chain concept with a shift away from supply chains towards demand chains and DCM. The main stimulus behind this has been the shift in power away from the supplier and towards the customer [46]. Striking a

balance between good customer satisfaction and supply chain efficiency begins with understanding the situation and needs of distinct customer segments [18]. Thus, DCM is the management of supply production systems designed to promote higher customer satisfaction levels through electronic commerce (EC) that facilitates physical flow and information transfer, both forwards and backwards between suppliers, manufacturers, and customers [53]. The generation of consumer-product ideas is usually "manufacturer-active", rather than "customer-active" [20]. Demand chain management tries to obtain more reliable and detailed information about (prospective) consumers [27], which is the practice that manages and coordinates the supply chain from end-customers backwards to suppliers [15,18,51]. Accordingly, demand chain management focuses not only on generating drawing power from customers to purchase merchandises on the supply chain; but also on exploring satisfaction, participation, and involvement from customers in order for enterprises to understand customer needs and wants. Thus, customers in the demand chain change their position and assume a leading role in bringing more benefit for enterprises.

In addition, as an enterprise asset, the customer has an important position. Most of the parties involved in the production chain, such as the manufacturers, suppliers and retailers, are aware of the importance and need for enterprises to acquire and share better customer knowledge. But this is easier said than done since customers' knowledge is concealed in the customers. It is available but not accessible, and there is little possibility of exploring the full volume of data that should be collected for its potential value. Inefficient utilization would render the data collected useless, causing databases to become 'data dumps' [24]. How to effectively process and use data is becoming increasingly important. This calls for new techniques to help analyze, understand or even visualize the huge amounts of stored data gathered from business and scientific applications [31]. Among the new techniques developed, data mining is the process of discovering significant knowledge, such as patterns, associations, changes, anomalies and significant structures from large amounts of data stored in databases, data warehouses, or other information repositories [22,24]. Customer knowledge extracted through data mining can be integrated with product and marketing knowledge from research and be provided to up stream suppliers as well as downstream retailers. Thus it can serve as a reference for product development,

product promotion and customer relationship management. When effectively utilized, such knowledge extraction can enable enterprises to gain a competitive edge through production of customer-oriented goods that provide better consumer satisfaction [43].

Accordingly, this paper investigates the following research issues in a leading international bicycle brand/manufacture company, GIANT of Taiwan: What exactly are the customers' "functional needs" and "wants" for bicycles? Are knowledge of the customers and the product itself reflected in the needs of the market? Can product design and planning for product lines be integrated with the knowledge of customers and market channels? Can the knowledge of customers and market channels be transformed into knowledge assets of the enterprises during the stage of new product development (NPD)? In addition, regarding the marketing channels and methods, apart from the conventional supply chain marketing model, the demand chain marketing model can also be considered to ensure that the products manufactured are customer-oriented. The Apriori algorithm is a methodology of association rules for data mining, which is implemented to mine demand chain knowledge from channels (distribution and maintenance) and customers for NPD and marketing. Knowledge extracted from data mining results is illustrated as knowledge patterns and rules in order to propose suggestions and solutions to the case firm for NPD, marketing, and knowledge management. The rest of this paper is organized as follows. In Section 2, we present the background of the case firm and its problems and suggestions from the perspective of supply chain and demand chain. Section 3 introduces the proposed data mining system, which includes system framework, relational database design, E-R model, logical database design, and physical database design. Section 4 presents the data mining process, including Apriori algorithm, knowledge extraction process, results analysis and electronic catalog design for NPD and marketing. Discussions and future works are presented in Section 5; and Section 6 presents a brief conclusion.

2. NPD of case firm

2.1. Case firm

There is intense competition in the bicycle industry, and product development is among the essential processes for success, survival, and renewal of organizations, particularly for firms in fast-paced or competitive markets [9]. In the case of product change, it is well known that incremental product innovation is well managed by the

cooperation between marketing knowledge and technology knowledge [21,47]. In Taiwan, the bicycle industry includes upstream, mid-stream, and downstream firms. The case firm, GIANT, began as a downstream original equipment manufacturing (OEM) factory, and has grown to become the largest bicycle manufacturer in the world with the capabilities of order design manufacturing (ODM) and order brand manufacturing (OBM). It is the considered best brand in both Taiwan and Mainland China, the second in the USA, and a widely popular brand in Europe, Japan and Australia. It has factories in Taiwan, Mainland China and the Netherlands. Its annual production amounts to 1.1 billion bicycles, around 5% of the global bicycle production. GIANT has over 10,000 marketing and distribution outlets providing fast and comprehensive service to customers. Forbes selected it as one of the most successful small-scale enterprises in 2002. In 2002, GIANT produced 13% of all bicycles exported by Taiwan, comprising 31% of the total bicycle export value. Moreover, the Taiwan External Trade Development Council (TAITRA) has ranked it as the 7th among the top 10 Global Brands with brand value estimated to be about US $ 250 million in 2004.

2.2. NPD of the case firm

As mentioned above, the case firm originally manufactured and sold bicycles in the downstream of supply chain system of this industry. Apart from the production of parts and accessories, it is now mainly involved in new product development. For new products designed by its research & development (R&D) team, the parts and accessories are manufactured by collaborating firms in the upper and middle streams, and are then assembled and delivered to the distribution outlets for sale worldwide (Figure 1).

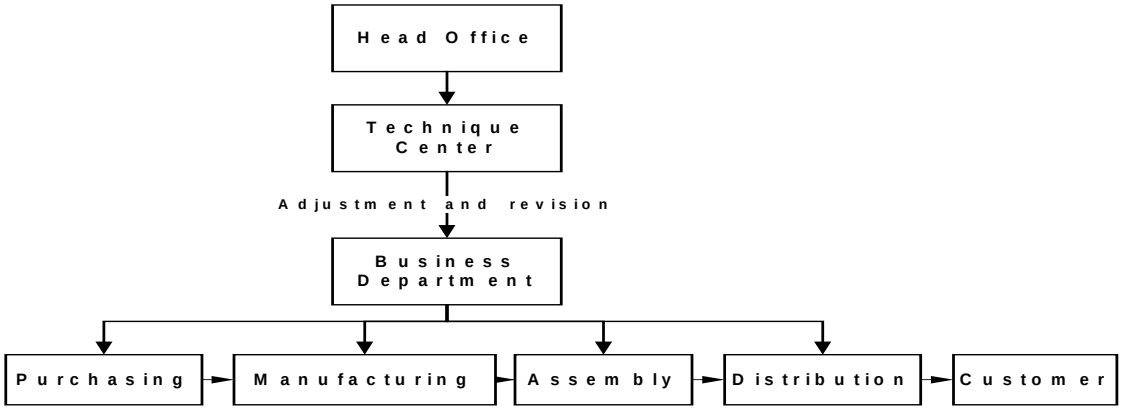

Figure 1 Case firm's product design and manufacturing process

Bicycle manufacturing is a traditional labor-intensive industry. Ongoing NPD or slight modifications of the design are necessary because competition is keen and the competitors are adept at imitation. In general, the NPD process involves five stages, namely idea conception, product design and development, manufacturing and market testing, commercialization and product launch, market development [38]. According to interview data with the CEO from the case firm headquarters in Taiwan, its NPD process and problems through the abovementioned five stages are described as follows.

A. Idea conception stage

Novel ideas come mainly from the industry and academia. The industry includes the bicycle manufacturing sector, the collaborating and related factories, as well as the suppliers of the production equipment and raw materials. Academia includes universities and higher education institutions as well as related research development centers. However, both sources of innovations will represent the preferences of the manufacturers, rather than the needs of the customers.

B. Product design and development stage

Over 200 R&D engineers at the head office of the case firm brainstorm and work on new product design and development. At this stage, the customers still have no involvement because the decision-making is mainly in the hands of the enterprise owner, the R&D engineers or other members of the supply chain system. This situation is not unique to the case firm, and is also prevalent among its competitors. Although the supply chain system of the bicycle manufacturing industry has been well integrated all along, the relocation of its production base to Mainland China to take advantage of its cheap and abundant labor has forced Taiwan to transform its role from OEM to order design manufacturing (ODM) and order brand manufacturing (OBM) in order to survive and remain competitive. Bicycle manufacturing is a prominent example of the many industries that have undertaken such transformation.

C. Manufacturing and market testing stage

Since the previous stages involve only internal knowledge of the enterprise, the creation of innovative products and manufacturing process may be slow. Taiwan has lost its former advantage of inexpensive labor to Mainland China and now must seek advances in better production and technology to maintain its competitive edge.

D. Commercialization and product launch stage

A limited supply of newly designed products is launched for market sales. Depending on the demand in different regional markets, the factories then began mass production. At this stage, cheap and poor-quality imitations will also enter the market. Due to the lack of comprehensive protection of intellectual property rights, the case firm has to engage in ongoing production development or make slight modifications in design in order to outbid the imitators and stay competitive.

E. Market development stage

To develop products clearly distinct from those of competitors is neither possible nor desirable since customers have pre-set knowledge of the products which is hard to overcome. When faced with new innovations, customers may not be able to note their distinctive features. Hence, substantial resources must be devoted to marketing in order to attract the customers' attention to new products.

2.3. NPD and marketing problems of case firm – from supply chain perspective

Concerted efforts of various departments involved in the various development stages from idea conception to marketing of new products is needed to order achieve success in NPD. In order for the new products developed to be well accepted by customers, and hence be profitable, efforts must be made to explore the real value felt by the customers of the products since it is this value that forms the basis of consumption and satisfaction.

Traditional NPD involves professional engineers and designers responsible for exploring novelty in manufacturing processes and product designs. However, their

emphasis is more on enhancing the functionality of the products to meet customers' needs, and much less attention has been paid to the use and maintenance of the newly designed products. As a result, these innovations may fall short of meeting the practical tastes and wants of customers. When customers buy a certain product or use a certain service, they may have some purposes to achieve or some experience to realize through such consumption. Hence, to tap into such hidden agendas of consumption can narrow the gap between new products developed and the expectations of potential customers. Thus, techniques such as data mining are much needed and can be of significant help to both R&D and marketing departments. Problems encountered in bicycle manufacturing can broadly be divided into two categories: technical and marketing. Technical problems are mainly the lack of manpower in R&D and technical design as well as the inaccessibility of key technology; while marketing issues originate from severe price-cutting due to competitors and legal proceedings involved in dumping cases, which are beyond the scope of discussion in this paper.

The above-mentioned phenomena have led to the following problems:

(1) NPD is solely the responsibility of the R&D engineers who develop innovations from existing data of the enterprise, new raw materials available and novel techniques discovered. The whole development process has not considered the needs and wants of customers and is more concerned with the product functionality than with the customer experience [41]. Hence, to the customers, the newly designed products closely resemble those of competitors available on the market. In particular, most of the products, though new, are modeled from current designs and are hardly distinctive or distinguishable to the consumers.

(2) In bicycle manufacturing, the preferences and expertise of the enterprise owner play a decisive role in new product design. Inadequate professional knowledge or poor decisions on future market development will subject the new products to high risk or great chance of failure.

(3) Knowledge for marketing decision support can come from three major sources — customer knowledge from the retailer, consumer knowledge from market research, and market knowledge from third-party data providers [43]. Understanding of the customers is also an important asset of an organization [4].

Failure to incorporate the knowledge generated from the customer use of the products into new design process will cause new products not to meet the customers' real needs.

(4) The product itself, rather than the customer, forms the basis of traditional marketing strategy. Most traditional marketing personnel believe that product superiority is the key to success in sales and see that their job lies solely in making high-quality goods available to target customers through proper channels. With too much emphasis on the functions and intrinsic worth of the products, traditional marketing lacks concepts that can account for the image and imaginative qualities that a product may provide.

(5) As pointed out by Schmitt [41], an enterprise faces two types of customers: (1) individual consumers who use the products in their daily life; and (2) corporate customers, including firms involved in logistics, wholesale and retail aspects. GIANT offers regular training courses for its retail sales/marketing representatives so that they are equipped to provide good and timely service to customers. Nevertheless, the practical retailing experience of the sales/marketing representative accumulated over the years is neither included in the firm's knowledge database nor fully utilized.

(6) The current marketing mode of the bicycle manufacturing industry defines a customer as either an individual or a single transaction and fails to consider the changing needs of consumers over time. Hence, the completion of a transaction implies the end of the customer relationship, which is refereed to as the revolving-door effect. Thus, in a highly competitive market, it is important to increase the retention rate among existing customers [3, 39].

To counteract these problems, it is important to first establish a customer database, which can provide assistance and support for NPD and marketing. Analysis made using data mining can also help improve performance of the case firm by exploring necessary information or knowledge from demand chain.

2.4. Innovative thinking of the case firm – from the demand chain perspective

In a survey of over one hundred U.S. managers in 2002, Schmitt [41] identified customer focus as the single most important differentiator between the best and worst companies in an industry. To focus on customers would imply providing the right product and service to the right customer at the right time through the right channel.

(1) Who are our customers?

As mentioned above, in traditional bicycle marketing, a customer is defined as either an individual or a single transaction. Upon completion of a transaction and without the need of after-sales service or maintenance, the customer will have no more contact with the case firm. In this research, the customer unit is a household, and over time, the household may have different needs that demand different products. Providing appropriate products and services to meet the changing needs of customers over time can help sustain the transaction relationship and maintain interaction.

(2) How can customers contribute to product design?

Enterprises need to consider the opinions of customers. Through data mining, the consumption experience of the customers can be transformed into knowledge that is stored in the database, thus forming a valuable asset of the enterprise. In the past, feedback from customers was mainly collected by the service department, which handles complaint calls from customers. In other words, the enterprises played a passive role in waiting for feedback from customers. Hence, enterprises should be more active in soliciting the opinions of customers. Storing knowledge related to the needs and consumption experience of the customers in the database can enable the enterprise to produce products and services that meet the demand of the customers.

(3) How can customers contribute to product development?

The database containing knowledge with respect to customers, marketing, and technologies must be constantly updated so that users of such knowledge, such as the marketing as well as R&D departments, can keep abreast of the latest information and market trends.

(4) What are the advantages acquired by the customers?

Consumers often view innovation in terms of whether a new products, services or communication helps them improve how they live [41]. Hence, to involve customers in the design of new products can make the newly designed products better meet the customers' expectations and needs. Quality products and services obtained through proper marketing channels and tailor-made to fit customer needs can be distinctive in the view of the customers.

(5) What are the advantages acquired by the case firm?

Since internal information of this industry mainly concerns changing the market demand and cost consideration, NPD made on the basis of such information is not likely to result in much innovation but rather greater competition. In contrast, input from academic research can lead to new developments and revolutionary changes in products and manufacturing techniques. This can lead to breakthroughs in key technology for NPD without infringing on the patent rights of competitors.

Previous collaborative designs have only integrated knowledge from the supply chain partners. Adding customer knowledge to NPD can result in distinctive products and services that can ensure greater profits. Involving customers in the design stage can foster knowledge exchange; while involving them in the marketing stage can ensure that needs of different customer segments are met, bringing in greater profits.

Figure 2 displays the information and knowledge flow within the case firm. As can be seen, there are two tiers of data source on demand chain. One is data from customers comprising their experience of product or service usage; and the other is data from channels and maintenance stores regarding results of market research. In this paper, customer data are obtained via questionnaire survey; and knowledge is then extracted using data mining and association rules. As summarized in Fig.2, through information and data processing, knowledge is organized, integrated and finally distributed to R&D and marketing departments for applications, while feedback from these applications can refresh and adjust the organization of knowledge.

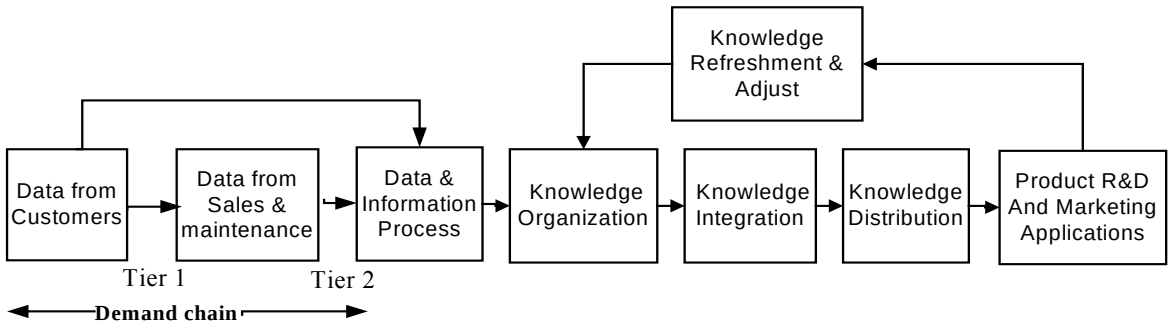

Figure 2 Demand chain information and knowledge flow

3. Data mining system

3.1. System framework

In a changing industrial and commercial society, one of the most important tasks of enterprises is to efficiently and effectively incorporates customer needs in the NPD process. However, internal forecasts made by an R&D department may not accurately reflect the tastes and preferences of customers. In order to provide better reference for NPD, this paper proposes the association rule for data mining to extract product and market knowledge on customer preferences and sales/maintenance records from channels and maintenance stores. Knowledge extracted from this analysis can serve as useful input for a CEO or the analysts of R&D and marketing departments. Figure 3 presents the data mining system framework.

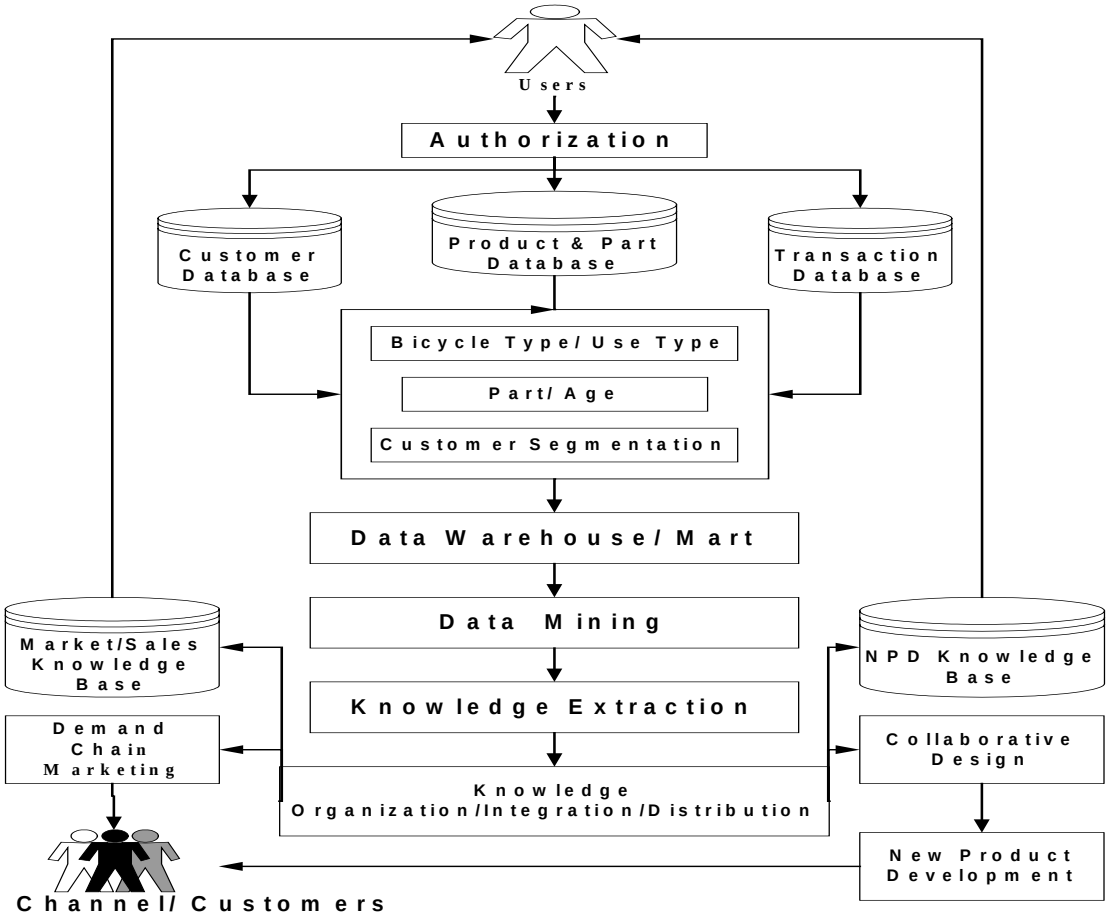

Figure 3 System framework

3.2. Relational database design

The concept of relational database was first developed in the 1970s by Codd, representing interrelated data in the form of a table [10]. The representation of data in the interrelated table hence becomes the main characteristic of the relational database Relational databases organize data as a collection of tables in which all data relationships are represented by common values in related tables. They can relate data stored in one table to data in another, as long as the two tables share a common data element. The tables appear similar to flat files, but the information in more than one file can be easily extracted and combined with Structured Query Language (SQL), which is the standard data manipulation language for relational database management system [28]. Many organizations maintain relational databases, and since relational patterns reliably portray patterns embedded within a database, relational patterns can be beneficially utilized by organizations to support a variety of efforts for building their database management systems [49]. Some research articles have shown that association rules of relational databases can provide a useful method for mining knowledge on different application areas [2,5,8,31,32,34]. The structure of the relational database design in this paper is described in Figure 4. Once the relational database design has been completed, this paper begins to mine demand chain knowledge by using association rules. This research established relational tables on MS Access 2002 and transferred them on an MS SQL Server within an OBDC environment in order to implement data table on SPSS Clementine.

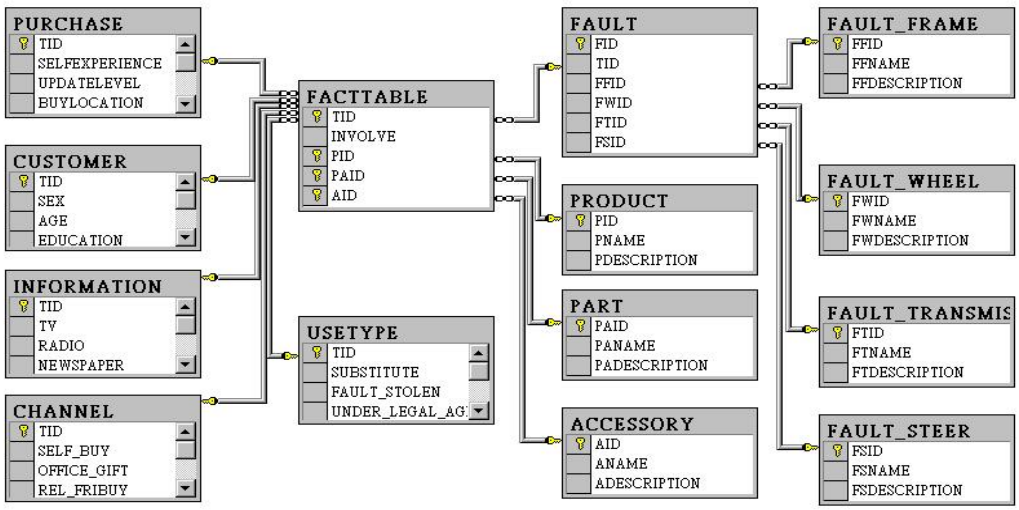

Figure 4 Relational database design

4. Data mining

4.1 Data mining tasks and methods

In the literature, there are many data mining tasks such as classification, estimation, predictive modeling, clustering/segmentation, affinity grouping or association rules, description and visualization as well as sequential modeling. Similarly, there are also many application methods, including Apriori algorithm, Artificial neural networks, Decision trees, Genetic algorithm, Regression, K-means clustering, etc. [4,14,16,22,35,36,49].

4.2 Data source

Data is collected from customers and channel/maintenance stores based on NPD and marketing questionnaire design, including (1) Customer/Channel basic data table; (2) Customer product involvement data table; (3) Customer product preference data table; (4) Customer behavior and attitudes data table; (5) Maintenance data table; (6) Customer complaint data table; (7) Sales experience data table; (8) Product, part and accessory data table; and (9) Transaction data table. Customer data was collected by interviewing customers who have purchased bicycles with help from channel/maintenance stores. Channel data is gathered by collecting questionnaire replies from channel/maintenance stores as well. Data collection was then conducted between May to August 2004 on channel/maintenance locations in 23 counties of Taiwan. A total of 1019 customers and 329 channel/maintenance stores participated in completing questionnaires, and relational database construction was completed in October 2004.

4.3 Association rule and Apriori algorithm

Association rules have been widely employed in different disciplines to explore the relationships between data in the database. If $L = \{l1, l2, \ldots, ln\}$ denotes the set of customers' knowledge and demand in the database, and both X and Y represent decision variables which are subsets of L and independent, an example of an association rule is an implication of the form: $X \rightarrow Y$, where $X \subsetneq L$, $Y \subsetneq L$ and $X \cap Y = \varnothing$. Each association rule has two measurement standards: support and confidence [52]. The support of a rule, denoted by Sup (X), is the percentage of transactions in

the database that contain the itemset X∪Y. All itemsets which satisfy the support threshold, called minimum support, are called large itemsets. During the core phase of the algorithm, all large itemsets are generated. The confidence of a rule, denoted by Conf (X→Y), is the percentage of transactions which contain X that also contain Y [1,49]. In practical investigations, these rules are usually regarded as "interesting" only if the support and confidence exceed certain threshold values [11]. According to Agrawal et al. [1], the problem of mining association rules can be decomposed into two steps. The first step is to detect a large item set whose support is greater than $Min\sup$ and the second step is to generate association rules, using the large item set. Such rules must satisfy two conditions:

1. $Sup(X \cup Y, D) \geq Min\sup$

2. $Conf(X \rightarrow Y) \geq Minconf$

Moreover, the judgment standard is called the lift, which is defined as: Lift = Confidence (X→Y) / Support(Y)) [52]. The best-known strategy for association rule mining is called Apriori [1,25,52]. Apriori algorithms read the recorded data in the database repeatedly and generate large itemsets after each reading. Only the support for candidate itemsets is calculated in order to reduce the calculation load and enhance efficiency.

4.4 Data mining process

How the consumption behavior of the customer affects product sales can be observed from the records in the database. In customer relationship management, care must be taken not to focus solely on a single consumption act, or ignore potential customers hidden behind a particular customer e.g. their family members. By selecting the different information needed to make decision variables analysis, and after using the data investigation process (process, organization integration, distribution) it can then become a very useful knowledge group. Furthermore it can be separated into product knowledge and marketing knowledge, which then can be used by the R&D and marketing departments (Figure 5).

R&D Department: The database is accessed to receive or search for the product knowledge needed in the NPD process. Consumer opinions or experiences should be included so that the R&D department can utilize its current material knowledge,

mechanical knowledge, etc., and then combine those aspects with the rational knowledge, to bridge the perceptual knowledge gap like "consumer experience". In other words, this can bring consumer views into the design phase, and thus add them into the NPD process, so new products can be according to the consumer's personal needs and in harmony with the consumer's and family member's feelings. Consumer experiences or feedback information should be continually collected, and repeatedly added into the database for future use.

Marketing Department: The database is accessed to receive or discover the marketing knowledge for different consumers, provide different consumers with personalized information and make exclusive catalogues. There should be appropriate differentiation to provide the appropriate information. Thus, when a consumer is buying the firm's product or receiving its service, they can maintain contact with the service centers, and thus avoiding increased marketing costs due to loss of contact with the consumer. Also, in order to maintain contact with consumers, we can make use of the service, maintenance, product upgrades, etc., for informing new marketing information during the transfer period for subsequent product releases. This can lower marketing costs, increase the effectiveness of marketing and reduce consumers' attention to other similar products, thereby reducing consumer loss.

Knowledge extraction, verification, distribution, storage, and re-use are all essential elements in retailing for decision-making or problem-solving with expert consultant functions or to accumulate knowledge from customers and the market to be used by managers in sales problems [31]. Major customer problems can be therefore identified through customer feedback [54]. Especially in the NPD stage, understanding the voice of the customer during new product development (NPD) can lead to the development of superior products that meet customer needs better than those of competitors [6,17].

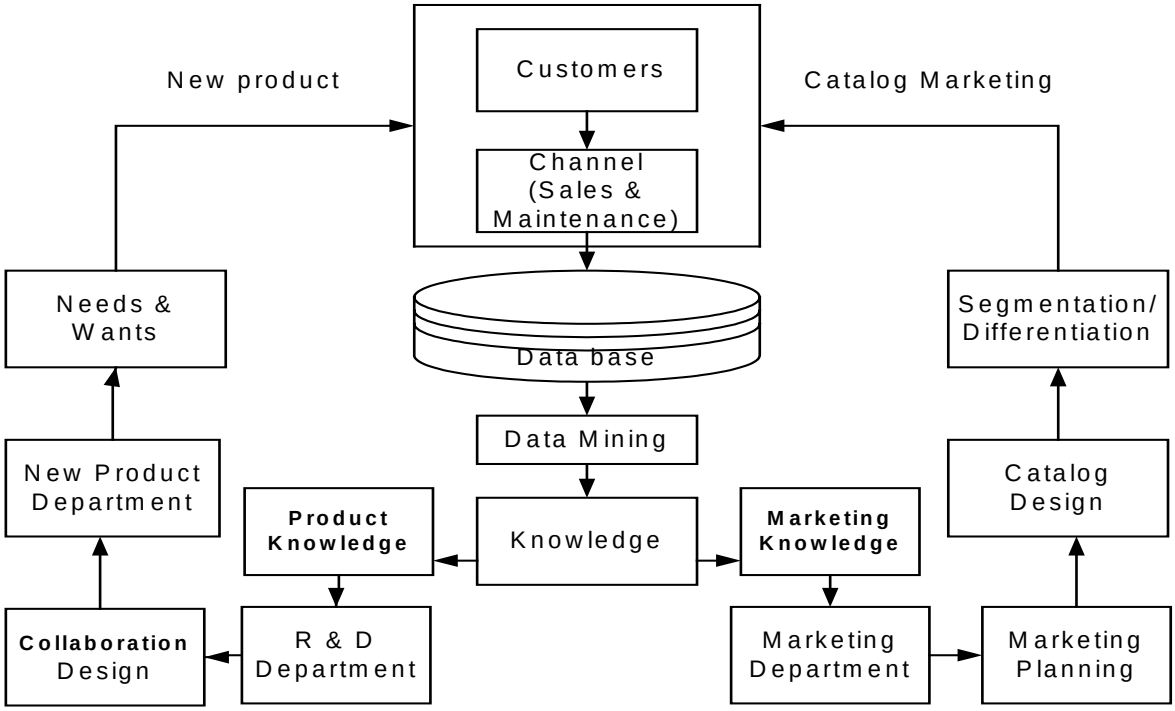

Figure.5 Demand chain data mining and NPD/marketing process

4.5 Mining knowledge for NPD

These are developed by choosing various decision variables (such as, Customer age + Customer residential area + Product involvement + Product style + Bike fault condition), integrating consumers' product experiences, (e.g. usage preferences), and any malfunctions during or after usage. The analysis lift value should be set at greater than one; while the minimum support and confidence values are set at least 9% and 50% respectively, and then adjusted accordingly if necessary during the analysis process. Four different selections are presented for the bicycle problems: Frame, Wheel, Transmission, and Steering. Among these, the one that appears least frequently, a total of 74 times, is the "bicycle frame-rear part", which accounts for 9.23% of the frames in total, therefore the minimum support value is set at that, and the minimum confidence value is set at greater than 50%. At the same time, if association rule A is one type of association rule B's arrangement compositions, then association rule A is unnecessary [44]. This means that the association rule emphasizes the ability to include all the large item association rules. Therefore, this research presents and analyzes the large itemsets that make up all the decision variables.

(1) Frames part (Pattern A):

Table 1 shows the results for minimum support (min sup) = 9 %, and minimum confidence (min conf) = 50 %. In the bicycle item association rule, consumers' experience is based on people aged 20~29 years, who are women's bike users from the northern area with lower involvement levels, where the level of cushion chair shaft damage is the most frequent. Here the lift value is up to 1.17, and confidence value is 50.00. From this it can be predicted that the group of consumers that damage the frames the most are the women's bike users from the northern area, with less involvement in the product, and ages ranging from 20~29. Therefore, inspecting the cushion chair shaft of the women's bike is the most important task to prevent consumers from being injured because of problems with parts. The association graph in Figure 6 shows the association relationships between all the decision variables. The combinations of all the decision variables can be shown with this type of graph. All the lines in the graph represent the sign on records of the customers in the database; the thickness of the lines represents whether the extent of the relationship between the two decision variables is high or low.

Table 1 Frames part association rule (min sup = 9%; min conf = 50%)

Rule	Lift	Sup	Conf	Consequent	Antecedent			
R_{A1}	1.17	11.50	50.00	Saddle & Seat post	Area= North	Low product involvement	Age = 20~29	Women's Bike

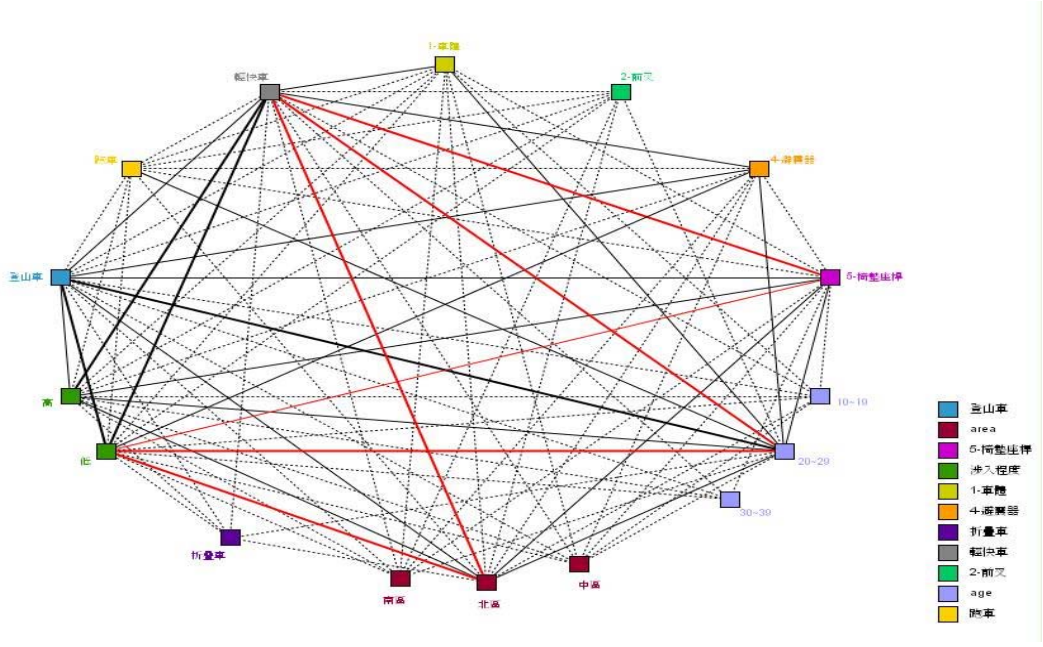

Figure 7 Bike fault-frames association diagram

(2) Wheel part (Pattern B):

For the wheel part, in consumers whose families own both the MTB and the women's bike, the chances of incurring interior and exterior wheel damage lift value is up to 1.12. From these patterns it can be seen that most of these are customers from the northern area. So, when problems with the interior and exterior wheel occurs frequently, and the firm does not pay more attention to this family, then the entire customer family will eventually give low evaluations to the company, consequently leading to negative effects (MTB + women's bike) to the family members. No matter what the level of involvement, wheel faults will occur, and the relationships between the patterns will be stronger, so it is necessary to increase our attention towards the product material or the purchasing source of the wheels (Table 2).

Table 2 Wheel part association rule (min sup = 12%; min conf = 70%)

Rule	Lift	Sup	Conf	Consequent	Antecedent		
R_{B1}	1.12	12.70	75.40	Tires/Inner tubes	Mountain Bike	Lower product involvement	Women's Bike
R_{B2}	1.10	13.50	74.60	Tires/Inner tubes	Higher product involvement	Mountain Bike	Women's Bike
R_{B3}	1.10	13.80	74.40	Tires/Inner tubes	Area = North	Mountain Bike	Age= 20~29
R_{B4}	1.10	14.30	73.90	Tires/Inner tubes	Mountain Bike	Age= 20~29	Women's Bike
R_{B5}	1.08	14.80	72.70	Tires/Inner tubes	Higher product involvement	Age = 20~29	Women's Bike
R_{B6}	1.06	15.80	71.70	Tires/Inner tubes	Area = North	Age= 20~29	Women's Bike
R_{B7}	1.05	16.20	71.20	Tires/Inner tubes	Area = North	Lower product involvement	Women's Bike

(3) Transmission part (Pattern C):

In the transmission part, a pattern can be established only for chain faults in whereas the other items (chain wheel, freewheel, derailleur gear units, derailleur gear inner wire) are all not established. Consumers who come across these problems mostly live in the northern area, mostly have women's bikes, have less involvement in the product, and are between 20~29 years old. Also, the MTB consumers who live in the northern area have lower involvement and are between 20~29 years old. Thus according to the pattern it can be seen that more chain faults are likely to occur, but

these relationships are weaker than the women's bike consumers (Table 3).

Table 3 Transmission part association rule (min sup = 9%; min conf = 75%)

Rule	Lift	Sup	Conf	Consequent	Antecedent			
R_{C1}	1.20	10.90	80.60	Chain	Area= North	Lower product involvement	Age= 20~29	Women's Bike
R_{C2}	1.13	9.60	75.80	Chain	Area= North	Mountain Bike	Lower product involvement	Age= 20~29

(4) Steering part (Pattern D):

In the steering part, the most significant relationships are in the higher item groups, showing three patterns. The highest lift value is up to 1.32 with the ages ranging from 20~29, there is higher product involvement and for consumers who use a women's bike, the damage part is the brake. For models like the MTB and the women's bike, common problems that occur to the brake are the brake cable snapping or wearing and this is especially serious for women's bikes. Therefore in order to overcome these two faults there must be more careful design and manufacturing process inspections or a high rate of examination and repair to prevent consumers from being injured from using these products (Table 4).

Table 4 Steering part association rule (min sup = 13%; min conf = 55%)

Rule	Lift	Sup	Conf	Consequent	Antecedent		
R_{D1}	1.32	15.30	63.70	Brake	Higher product involvement	Age= 20~29	Women's Bike
R_{D2}	1.24	13.60	60.00	Brake	Higher product involvement	Mountain Bike	Women's Bike
R_{D3}	1.19	14.20	57.40	Brake	Mountain Bike	Age= 20~29	Women's Bike

(5) Bike faults (Pattern E):

The four sections above individually discussed the relationship between the user and each of the damaged parts. This section observes whether or not a fault in one the four items will affect other items. Among these the highest lift value is 1.28 (Saddles + brake + chain + tires/inner tubes). It can be recognized that when either the saddles chair shaft and the brake, or the brake cable and the brake fail simultaneously this will cause great pressure on the tires/inner tubes. Also, when the above problems occur

simultaneously, then there should be more attention paid to the chain (Table 5).

Table 5 Bike fault association rule (min sup = 15%; min conf = 80%)

Rule	Lift	Sup	Conf	Consequent	Antecedent		
R_{E1}	1.28	18.10	83.30	Tires/Inner tubes	Saddle Tube	Brake	Chain
R_{E2}	1.26	16.30	82.30	Tires/Inner tubes	Saddle Tube	Brake Inner Wire	Chain
R_{E3}	1.21	18.50	81.60	Chain	Saddle Tube	Brake	Tires/Inner tubes

Since customers are affected most directly by damaged parts, the psychological or physical injuries they suffer are the deepest. We should take more initiative to discover problems and remedy them, also reviewing why they occurred so that customers will be more loyal to the GIANT brand and products. After quality has stabilized, marketing activities to the customers should follow and these should be activities that will encourage the customers to continue using this product, so they can use their influence on others to join in purchasing.

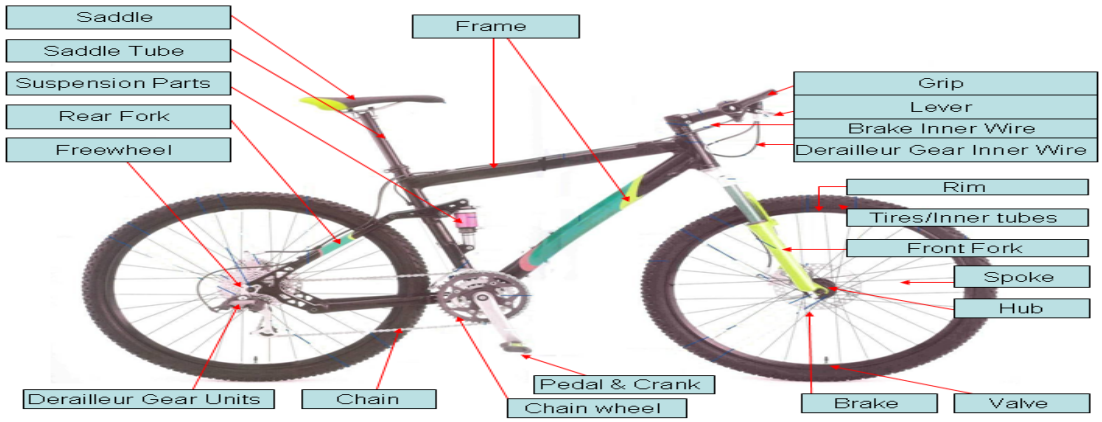

Figure 8 New product development

As shown in Figure 8, after data mining for NPD has been done, the case firm can design and develop a type of bicycle based on the mined knowledge through Pattern A to Pattern F by using sixteen knowledge rules. By doing so, GIANT has more capability to improve its NPD by extracting and implementing channels and customer knowledge on the demand chain. In addition, this demand chain knowledge mining could bring the case firm closer to the market from the side of manufacture on

the supply chain.

4.6 Mining knowledge for marketing

By choice there are various decision variables (such as, Customer age + Customer live area + Product involvement + Product style + purchasing criteria + components, accessories + current price + preferred price), used to understand the criteria that customers consider when purchasing different products, and the components, or accessories that they wish to add. Integrating these two decision variables can influence customers' impressions of this product and stimulate their needs and wants.

(1) Customer's satisfaction (Pattern F):

The price of the products that customers use now represents the price that customers are willing to pay before they purchase the product. This is because before using the product customers tend to give product evaluation in advance, and together with the price that they are willing to pay, this will be the price that customers are currently willing to pay to use the product. The price that customers are willing to pay in the future depends on the current experience that the customers gain from using the product (Table 6). This includes the good side (e.g. an enjoyable family bike riding experience) and the bad side (e.g. part breakdowns that occur repeatedly), and after all of these weightings they will have a new evaluation for the product.

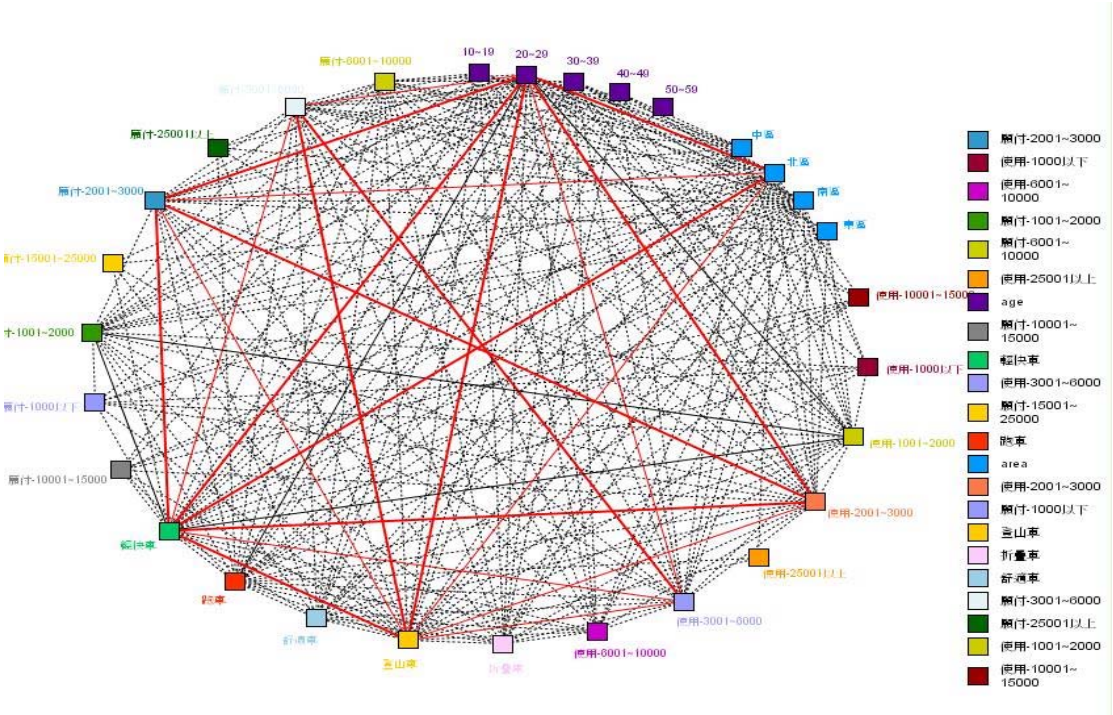

Figure 9 Customer satisfaction association web diagram

Customers for the mountain bikes and women's bikes all tend to have paid a relatively low price for their current product, and price that they will be willing to pay for their next product will also be low. This means that the current products used can only fulfill the current users' wants, therefore if the company wishes to increase the selling price of similar products or ask the customer to increase their spending for similar products, then the company might face a rapid decline in sales or a great loss of customers (Figure 9).

Table 6 Customer satisfaction association rule (min sup = 10%; min conf = 60%)

Rule	Lift	Sup	Conf	Consequent	Antecedent		
R_{G1}	1.97	10.60	73.10	Current price NT 3001~6000	Preferred price NT 3001~6000	MTB	Women's Bike
R_{G2}	1.94	11.70	72.30	Current price NT 3001~6000	Preferred price NT 3001~6000	Age = 20~29	Women's Bike
R_{G3}	1.77	13.50	70.80	Preferred price NT 2001~3000	Current price NT 2001~3000	MTB	Age = 20~29
R_{G4}	1.70	13.40	67.60	Preferred price NT 2001~3000	Current price NT 2001~3000	Age = 20~29	Women's Bike
R_{G5}	1.69	10.50	67.30	Preferred price NT 2001~3000	Current price NT 2001~3000	MTB	Women's Bike
R_{G6}	1.66	11.80	68.30	Preferred price NT 3001~6000	Current price NT 3001~6000	MTB	Age = 20~29

R_{G7}	1.22	10.10	69.90	Age = 20~29	Area = North	MTB	Women's Bike
R_{G8}	1.13	11.20	64.90	Age = 20~29	Preferred price NT 2001~3000	Area = North	Women's Bike
R_{G9}	1.12	10.80	60.00	MTB	Preferred price NT 2001~3000	Area = North	Age = 20~29
R_{G10}	1.11	14.90	63.80	Age = 20~29	Preferred price NT 2001~3000	Current price 2001~3000	MTB
R_{G11}	1.05	10.40	60.40	Age = 20~29	Preferred price NT 2001~3000	MTB	Women's Bike

(2) Product involvement and used price effect (Pattern G):

Customers from the northern area have less involvement with their bicycle products, and customers with the same conditions from the southern area have higher involvement. Overall, the customers are between 20~29 years old, the price of the products they use ranges from NT 2001~6000 dollars, and they tend to have higher product involvement. The Pattern G model used only 7% of the original database and achieved 100% effectiveness, saving up 93% or the data collection and analysis cost (Table 7).

Table 7 Product involvement and used price effect association rule (min sup = 5%; min conf = 65%)

Rule	Lift	Sup	Conf	Consequent	Antecedent		
R_{J1}	1.59	8.20	75.00	Higher product involvement	Area = South	current price NT 2001~3000	Age= 20~29
R_{J2}	1.47	5.10	69.20	Higher product involvement	Current price NT 3001~6000	Current price NT 2001~3000	Age= 20~29
R_{J3}	1.29	7.90	67.90	Lower product involvement	Current price NT 1001~2000	Area = North	Age= 20~29
R_{J4}	1.24	7.60	71.40	Age= 20~29	Current price NT 1001~2000	Area = North	Lower product involvement
R_{J5}	1.16	5.30	66.70	Age= 20~29	Current price NT 3001~6000	Current price NT 2001~3000	Higher product involvement
R_{J6}	1.16	8.50	66.70	Age= 20~29	Current price NT 2001~3000	Area= North	Lower product involvement

R_{J7}	1.16	9.30	66.30	Age= 20~29	Area = South	Current price NT 2001~3000	Higher product involvement

(3) Peripheral effect factor (Pattern H):

From Pattern H, it can be seen that most customers are from the southern area and are between 20~29 years old. In addition, customer service personnel's attitude, the interior design of selling stores, product pricing, and the products on display in the store are what customers consider when purchasing the products; and these indirectly affect the buying decisions and other factors. This customer group has higher product involvement, but the price of the current products used ranges only between NT 2000~3000 dollars (Table 8).

Table 8 Peripheral effect factor association rule (min sup = 5%; min conf = 70%)

Rule	Lift	Sup	Conf	Consequent	Antecedent			
R_{K1}	1.96	6.20	80.60	Customer service personnel's attitude	Area = South	Current price NT 2001~3000	Higher product involvement	Age= 20~29
R_{K2}	3.61	6.20	77.40	Interior designs of selling stores	Area = South	Current price NT 2001~3000	Higher product involvement	Age= 20~29
R_{K3}	1.23	6.20	72.60	Product pricing	Area = South	Current price NT 2001~3000	Higher product involvement	Age= 20~29
R_{K4}	1.32	6.20	71.00	Products on display	Area = South	Current price NT 2001~3000	Higher product involvement	Age= 20~29

(4) Market channel (Pattern I):

The product distribution method of the company in this research is through 329 sale/maintenance stores for serving customers, so that customer contact with the actual products is mostly through the products on display in the stores. This young consumer group (ages 20~29) has lower product involvement and pays much attention to the product price; in addition they are all familiar with purchasing by the Internet. So the method to effectively influence this young group of customers can be by releasing discount offers, new product information, exchange of opinions, etc., these

are all which the case firm should pay attention to (Table 9).

Table 9 Market channel association rule (min sup = 30%; min conf = 80%)

Rule	Lift	Sup	Conf	Consequent	Antecedent	
R_{L1}	1.07	34.40	94.80	Internet	Age = 20~29	Product pricing
R_{L2}	1.05	32.10	93.20	Internet	Products on display	Age = 20~29
R_{L3}	1.04	31.40	92.10	Internet	Lower product involvement	Age = 20~29
R_{L4}	1.04	34.40	91.90	Internet	Products on display	Product pricing
R_{L5}	1.02	31.50	90.60	Internet	Lower product involvement	Product pricing

Figure 10 Catalog marketing

As shown in Figure 10, after data mining for marketing, the case firm designed an electronic catalog according to specific user segmentation for cross selling based on the mining knowledge through Pattern G to Pattern I by using twenty-seven knowledge rules. By doing so, GIANT is better able to develop its marketing segmentation planning and its marketing tools, using paper/electronic catalogs to specific channel and customer. In addition, demand chain knowledge mining could bring the case firm deeper into the market to understand and react the customers' needs and wants.

5. Discussions and future works

(1) Human needs are states of felt deprivation. For example, physical needs for food,

clothing, shelter, and safety. Individual needs seek for knowledge, esteem, and self-expression. These needs were not created by manufactures or marketers; they are a basic part of the human makeup. Human wants are the form human needs take as they are shaped by culture and individual personality. They are shaped by one's society and are described in terms of objects that will satisfy needs. Therefore, manufactures or marketers can seek what object of customers' wants in order to satisfy their needs. In this regard, how to find the object of customers' wants becomes a critical task for businesses. Bicycle is an object of some customers' wants due to different individual needs. Thus, this paper investigates what functionalities and style are the customers' functional needs and wants for bicycles by extracting specific knowledge pattern and rules from customers. By doing so, this article demonstrates a knowledge extraction approach in order to examine that knowledge of the customers and the product itself reflects the needs of the market.

(2) In addition, this paper describes a case study of NPD on a bicycle enterprise by implementing data mining approach and integrating different source of demand chain knowledge. By doing so, this paper presents an example that product design and planning for production lines can be integrated with the knowledge of customers and market channels. Also, the knowledge of customers and market channels can be transformed into knowledge assets of the enterprises during the stage of new product development. This might be not a new approach on NPD or marketing. However, this research suggests that case firm should consider both inside and outside sources of knowledge in order to investigate its operation, product/service, market, customers, suppliers, competitors, etc. from different aspects. By doing so, a knowledge resource could be an intellectual asset and competence to the case firm.

(3) Demand chain management is increasingly being used to meet the needs of enterprises, such as: automotive retailing, UK manufacturers and services, aerospace firms, UK lighting manufacturers, logistics/distribution business, multi-echelon spare parts supply chain, etc. [12,15,18,19,23,53,]. Demand chain management, including customer satisfaction, involvement, and customization, is attained through identifying specific needs of groups of customers and developing appropriate offers to certain groups of customers or market segments on products

and service. [18]. This paper suggests that the case firm should extract customer and channel knowledge from the demand chain and place them as a knowledge resource on its supply chain. This integration of demand chain and supply chain management might not only have better capabilities on understanding its market, but also enhances its manufacturing and product innovation capabilities on extending its product lines. By doing so, the case firm might have better competitive advantage in the worldwide bicycle market.

(4) In addition, knowledge management is an example of database implementation by an organization in order to enhance its competitive advantages [13,29,30,31,33,37,]. Knowledge extraction, verification, distribution, storage, and re-use are all essential elements in industries for decision-making or problem solving. This paper focuses on the stage of knowledge extraction. However, once knowledge extraction has been done, how to store, distribute, verify, re-use, and update are continuous tasks for the case firm. Therefore, knowledge management framework and architecture are future work to manage its knowledge. On the other hand, different data mining methodologies, such as, genetic algorithms, neural nets, decision trees, regression, etc. should be implemented by the case firm in order to enhance data analysis capabilities for classification, clustering, and prediction analysis.

(5) On the other hand, once customer knowledge been extracted from channels or the Internet, different marketing strategies and tactics might be implemented by the case firm. For example, direct marketing might be an option to the case firm. Could paper/electronic catalog marketing become one kind of direct marketing approach for marketers or salespersons in the case firm when their groups of customers and needs of product are targeted? Thus, this means that the case firm might design paper/electronic catalog according to customers' knowledge to sell and promote its products and service both on channel and via Internet. In addition, electronic catalogs may become another kind of mobile marketing method for the case firm to mine customer knowledge regarding specific groups of customers who are accepting catalogs and coupons from their mobile phones, PDA, and computers.

(6) Generally, enterprises do not collect customer data for a database in order to make market analysis. Because information technology investment and manipulation are

a threshold not only to small and medium enterprise, but also to some large enterprises unless business owners can be aware that it is really helpful to their businesses. The case firm has not yet built its data warehouse. This research suggests that case firm should build warehouse integrating some other information technology solutions in order to provide a well-structured database platform on its domestic and abroad system environment. By doing so, all of data can be integrated together and implement for analysis. On the other hand, this research uses Taiwan Giant as an example for implementing relational database and data mining approach for NPD and marketing. However, this paper suggests that the case firm should extend this experience to its all branches to examine if GIANT could really release a new product to market and gain profits in the future.

(7) Does the case firm accept this data mining approach and results? Indeed, the case firm is actually doing the data mining method proposed in this paper. For example, mining specific groups of customers who would like to provide their data (including their friends and family) constantly via Internet and join a customer club so that they can purchase custom-make bicycles. In addition, discounts for products from the electronic catalog are dynamically designed, depending on customers' transaction frequency, spending amount, and purchase patterns. Electronic catalogs are mailed to customers according to customer and market segmentation and paper catalogs are mailed to new customers or presented to general customers in the sales/ maintenance stores. Thus, this paper not only presents the practical development of a data mining system, but it is also an academic study to explore the bicycle industry through new product development and marketing based on database technology and data mining methodology.

(8) Finally, this paper proposes some uncompleted tasks. First, a more coherent conceptual model for analysing the supply chain problems on the case firm should be continued to study. By doing so, we can find more new product development problems on the case firm's product design and manufacturing process. Second, some core problems on problem analysis, such as: Is there a dominant role of entrepreneur? What is the product focus? Is the case firm lack of using retail knowledge? Is there any cause and effect factors existing in the case firm's supply chain problem? These problems can be considered to analyze on the next research stage. Third, entrepreneurship is a critical issue to the case firm in terms of

examining problems from entrepreneurial operation perspective. All of these uncompleted tasks should be continue to investigate on the future works.

6. Conclusion

Consumer needs and wants are sensitive and complicated, and if a firm can understand them and make efforts to fulfill their wants and provide friendly service, then the customers will be more supportive to the enterprise. During the process of developing from the product concept to the actual product itself, the customer can only passively receive new information, and can only select from the products that are currently on sale in the market. No matter which type of product, the consumer cannot individually come up with a product concept and then develop it. Furthermore, buying what is available on the market does not mean that customers are satisfied with the current product, because the customers' experiences were not considered in developing the product so they can only accept the product as it is. As a result, the enterprise has responsibility to develop products that fulfill the customer needs and wants, as this will increase the enterprise's competitiveness and it is an essential criterion to earning higher profits. This paper proposes the Apriori algorithm as a methodology of association rule for data mining, which is implemented for mining demand chain knowledge from channels (sales and maintenance stores) and customers. Knowledge extraction from data mining results is illustrated as knowledge patterns and rules in order to propose suggestions and solutions to the case firm for NPD and marketing and knowledge management. This research process and results could serve as an example for other enterprises or academic research.

Acknowledgements

This research was funded by the National Science Council, Taiwan, Republic of China, under contract No. NSC 94-2416-H-032 -001.

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