

Data Mining the Data Processing Technologies for Inventory Management

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Abstract—This research applied various data mining approaches to investigate the innovations of data processing technologies for inventory management based on the database of the United States Patent and Trademark Office. The first objective of data mining in this study is to find the core technologies by evaluating patent citation matrix and patent strength. This information can help companies to choose suitable tools through the understanding of the most essential innovations. A total of 63 core technologies were identified from 949 patents under the US patent class of 705/28. Besides, a network of patent development paths was also derived to illustrate the correlations of core advancements. Finally, this study adopted the method of nonhierarchical clustering analysis to identify key groups of technologies through the symmetrical matrix of relative correlation strength. Enterprise can refer the findings of clustering to recognize the trend and characteristics of data processing technologies for their strategic technology management.

Index Terms—data mining, patent analysis, inventory management, data processing

I. INTRODUCTION

Data processing of inventory management involves with electrical apparatus and its corresponding method that performs operations with significant data change or calculations in the processing of inventory records [1]. Due to the complexity and importance of inventory control in the age of globalization, new innovations have been proposed to enhance the computerized procedures for establishing, maintaining, or updating inventory records. For example, an inventory management system can automatically determine which items in the Just-in-Time inventory may need replenishment most likely [2]. Another computer system uses a linear programming engine to choose the priority of customer orders and arrange limited inventory accordingly [3]. Empirical studies have also shown that applications of advanced inventory-related systems not only help the maintenance of service level but also save enormous amount of inventory costs, which can be allocated for other business

improvement projects [4][5]. Hence, how to apply advanced technologies for better inventory control and management is crucial for enterprise to develop a competitive advantage that is difficult to match [6].

Nevertheless, understanding of the advanced inventory management technologies is a daunting task for business practice because there are too many alternative solutions and knowledge bases in the market. Among the knowledge bases of technological advances, patent information is one of the most objective resources for “competitor monitoring, technology assessment, research and development (R&D) portfolio management and identification of potential sources for the external generation of technological knowledge” [7]. Thus, this study applied various data mining approaches to investigate the patent database of the United States Patent and Trademark Office (USPTO) regarding the data processing technologies for inventory management. The first goal of data mining in this study is to find the core technologies by evaluating patent citation matrix and patent strength. This information can help companies to choose suitable tools through the understanding of the most essential innovations. Besides, a network of patent development paths was also derived to illustrate the correlations of core advancements. From the perspective of R&D, knowledge of development paths is also critical for plagiarism prevention and industrial improvements. Furthermore, this study adopted the method of nonhierarchical clustering analysis to identify key groups of technologies through the symmetrical matrix of relative correlation strength. The clustering results can help enterprises not only to look for opportunities of future innovations but also to recognize the trend and characteristics of data processing technologies for their strategic technology management. In the remainder of this paper, we describe the technology development for inventory management through literature review in Section II. The applied data mining methodology and data collection source of this study are explained in Section III. In Section IV, the analysis results of data

mining are presented and discussed. Finally, we conclude this study and future researches in Section V.

II. TECHNOLOGIES AND INVENTORY MANAGEMENT

Due to the innovative advances of information and communication technology (ICT) since the 1990's, companies have invested ICT solutions for the improvement of inventory operations. Studies have illustrated the close relationships between ICT implementation and supply chain performance. For example, an empirical finding showed that Toyota Production System can reduce inventory in the manufacturing sector [4]. Cheng and Chou [5] proposed a real-time inventory decision support system that not only decreases the inventory costs but also helps to maintain the service level greater than 90% for various demand patterns. Generally speaking, ICT can allow supply chain partners to share demand and inventory data quickly and economically [8].

From the perspective of inventory-related technologies, Yang, Ng and Cheng [9] described the application of vendor-managed inventory (VMI) system, where suppliers take full responsibilities for maintaining inventory levels through the information shared by buyers. Performances of supply chain such as inventory holding cost, stock-out ratio, service level, and demand distortion are supposed to be benefited from the adoption of VMI systems. Meanwhile, technology of electronic data interchange (EDI) is the structured transmission of standardized electronic documents between entities. Study of Cachon and Fisher [8] suggested that information sharing through EDI can reduce supply chain costs, the gap between traditional information policy cost, lead time, and batch size. In the study of Lindau and Lumsden [10], automatic data capture systems are applied to control shipments and keep track of work-in-process. In addition, bar-code is another technology used to meliorate the accuracy of information and speed the transmission of data. In the case study of Manthou and Vlachopoulou [11], bar-code technology was deployed to automate daily transactions for the reduction of cost and human error during data entry operations. Their study also indicated that bar-code application can offer accurate inventory control and replenishment for uncertainty reduction at the store level. Meanwhile, the optimization of inventory and supply chain operations can be achieved by the approaches of two-way radio frequency (RF) transmission, where operational records are collected automatically in real-time. Furthermore, through the integrations of RF systems, automatic identification systems (AIS), bar-code systems, automatic data capture (ADC), enhancing EDI and quick response (QR) systems, the manufacturing and distribution firms are able to better control inventory operations with enhanced data processing technologies [12]. Study of Fleisch and Tellkamp [13] also indicated that automatic identification technologies such as radio frequency identification (RFID) not only can be used to solve the problem of inventory inaccuracy caused by theft but also reduce the level of out-of-stock and supply

chain cost. To deal the compatibility requirement of data standard from globalization, enterprises are trying to enhance competence by seeking effective ways to integrate resources with the demand for information exchange. For example, the 96-bits RFID electronic product code (EPC) system was successfully implemented by several pilot projects to exchange data supported by GS1 association, which provides widely-used standards for supply chain activities. Hence, the RFID-enabled pull-based supply chain can effectively decrease total inventory cost and increase inventory turnover rate through the support of object visibility from RFID [14]. In the study of Martinez-Sala et al. [15], active RFID was applied on the tracking of returnable packaging and transport units in the grocery supply chain. Their findings show that active type of RFID tags not only prevents tag redundancy like general RFID tags but also has the capability of reusability and long-range reading. Although previous studies described the main technologies for inventory management, related investigations on core innovations as well as technical trend and characteristics were addressed little. Therefore, further examination on this class of technologies has its importance.

III. METHODOLOGY AND DATA COLLECTION

A. Data Mining

To understand the context of data processing technology development regarding inventory management, the approaches of patent citation matrix, patent strength, and network of patent development paths were utilized first in this study to identify the core technologies and their correlations. Then nonhierarchical cluster analysis was analyzed by a symmetrical matrix of relative correlation strength to understand the trend and characteristics of technological advances. Details of the above approaches are describes as follows.

Patent information of data processing technologies was retrieved as the data source of data mining. In this study, patent citation matrix was examined to represent the relationships between patents. Suppose that the indexes of cited patent and citing patent are l and l' respectively. We denote $C_{ll'}$ the citation relationship between patent Z_l and $Z_{l'}$. If $C_{ll'} = 0$, it implies that patents Z_l and $Z_{l'}$ are isolated. If $C_{ll'} = 1$, it says that patents Z_l and $Z_{l'}$ have a direct citation relationship. Meanwhile, patents Z_l and $Z_{l'}$ have an indirect citation relationship if $C_{ll'} \neq 1$, $C_{lk} = 1$, and $C_{kl'} = 1$, where patent $Z_{l'}$ did not directly cite patent Z_l , but patent Z_k cited patent Z_l and patent $Z_{l'}$ cited patent Z_k directly. Hence, a patent citation matrix can be constructed from the above configurations.

Because the core technologies have no clear definition or criterion, patents that are cited (directly and indirectly) most may be considered as the candidates of core technologies in practice. Suppose that β ($0 \leq \beta \leq 1$) represents the importance of an indirect citation. According to the study of Chang et al. [16], the formula of citation strength for patent W can be calculated by

$$V(W) = n + \beta \sum_{i=1}^n V(Z_i), \text{ if } n > 0, \quad (1)$$

$$V(W) = 0, \text{ if } n = 0,$$

where n is the number of patents (Z_1, \dots, Z_n) that directly cite patent W . If a patent Z_i is an end node in a patent citation network, it implies that no patent cites Z_i and therefore $n = 0$ and $V(Z_i) = 0$. If $\beta = 0$, function V only calculates the direct citation effect. If $\beta = 1$, the indirect effect is equal to the direct effect. We included those patents that are ranked among the top 20 influential technologies from the measurements of citation strength when $\beta = 0$, $\beta = 0.3$, and $\beta = 0.5$. In addition to the application of citation strength, this study also employed the method of three standard deviations (three S.D.) to select those latest patents that have strong direct citations but relatively weak indirect citations. The core technologies are then determined by the union of patents extracted from the approaches of citation strength and three S.D.

The next step is to calculate the relationships of core patents. Suppose that W and Y are two core technologies derived from the above methods. The lineal linkage coefficient of W and Y can be estimated by

$$R(W, Y) = \sum_{j=1}^m \alpha^{\text{link}(j)}, \text{ if } m > 0, \quad (2)$$

$$R(W, Y) = 0, \text{ if } m = 0,$$

where m is the number of paths from Y to W , $\text{link}(j)$ denotes the number of intermediate patents in the j th path from Y to W ($j = 1 \dots m$), and α ($0 \leq \alpha \leq 1$) represents the decline effect of intermediate patents [17]. If patent Y cites patent W directly and there is no other paths from Y to W , then $R(W, Y) = 1$. If there is no path from Y to W , then $R(W, Y) = 0$. While α is increasing, the effect of the intermediate patents becomes smaller and the indirect relationship between W and Y becomes larger. Here in this study, α was set to 0.5 to imply that the lineal linkage of two patents is 0.5 if there is an intermediate patent in the path of these two patents. If a patent is not related to the other patents from the evaluation of (2), this patent was excluded for further analysis. For those patents that have lineal relationships with the other patents, a network of patent development paths and cluster analysis were conducted upon them.

To classify the categories of data processing technologies for inventory management, the approach of nonhierarchical cluster analysis was applied in this study. Because the input data should be a symmetrical correlation matrix and the domain values of the matrix should be between -1 to +1 or 0 to 1 for our cluster analysis, we transferred the relationship measurement of (2) to another measurement called relative correlation strength [16]. Suppose that $\text{Max}(R(W, \cdot))$ is the maximum value of $R(W, X)$ for all patents X in our data set. The relative correlation strength between patent W and patent Y can be formulated as

$$R'(W, Y) = \sqrt{R(W, Y) / \text{Max}(R(W, \cdot))}, \text{ if } W \neq Y, \quad (3)$$

$$R'(W, Y) = 1, \text{ if } W = Y.$$

The purpose of the division in (3) is to constrain the domain value between 0 and 1, and the square root in (3) is to exclude the occurrence of small values.

Once obtained the symmetrical matrix of relative correlation strength by (3), nonhierarchical cluster analysis was applied to classify the core patents of data processing technologies in inventory management. Suppose that there are K clusters given the data of core technologies. The first step of the clustering algorithm used in this study is to place K initial group centroids into the space represented by the objects that are being clustered. Then the second step is to associate each core patent to the cluster that has the closest centroid. When all core patents have been assigned, step 3 is to recalculate the K new centroids. We have to repeat Steps 2 and 3 until the locations of K centroids no longer change. According to the results of nonhierarchical cluster analysis, we further analyzed the characteristics of each technological cluster and evaluated the trend of data processing advances since 1990.

B. Data Collection

The patent data were collected from the United States Patent and Trademark Office (USPTO) database, which is the largest patent database in the world. Our analysis is based on the patents from the Subclass 28 (Inventory management) of the Class 705 (Data Processing: Financial, Business Practice, Management, or Cost/Price Determination). Accordingly, a total of 1,116 related patents can be found from the 705/28 class since 1947 to 2009. Because this study focused on the investigation of recent technological advances during the past two decades, we collected 949 patent records that issued after January 1, 1990 until December 31, 2009 for further data mining analysis.

IV. FINDINGS OF DATA MINING

Before identifying the core advances for the data processing technologies in inventory management, we first constructed a patent citation network for the 949 patents. This network can help us to estimate the citation strength for each patent from the perspectives of direct citation and indirect citation. By letting β be equal to 0, 0.3, and 0.5, we selected the patents as the core technologies if patent's citation strength is ranked in the top 20 list. Because this selection approach is likely to ignore new influential patents, we also included those patents which have citation strength higher than the upper bound of three standard deviations in their issued year. As a result, a total of 71 patents were identified as the core technologies from the 949 patents.

The next analysis of this study is to estimate the relationships of core technologies from (2). There are eight patents that were found not related to the other patents. These isolated core technologies are Patent No. 6006196 (Method of estimating future replenishment requirements and inventory levels in physical distribution networks), No. 6032125 (Demand forecasting method, demand forecasting system, and recording medium), No. 6260024 (Method and apparatus for facilitating buyer-driven purchase orders on a commercial network system), No. 6463420 (Online tracking of delivery status information over a computer network), No. 7292904 (Method for sizing production lot starts within a linear system programming environment), No. 7308330 (Dynamic order swapping in BTO environment), No. 7340420 (Method and system for providing information on industrial wastes, server and terminal for providing the information, recording medium for recording computer-readable program, and program allowing computer to execute process), and No. 7385529 (Dynamic and predictive information system and method for shipping assets and transport). Accordingly, these eight patents were deleted and the relationship matrix became to 63 by 63. The distribution of 63 core technologies by issued year is illustrated in Fig. 1, where 42% of core technologies were issued between 1997 and 2000. In addition, the network of patent development paths for these 63 core technologies is shown as Fig. 2, where node denotes patent and arrow represents the development direction of forward citation. The importance of individual patent can be recognized by its number of direct paths and indirect paths from the other patents. For example, Patent No. 7218980 (Prediction based optimization of a semiconductor supply chain using an adaptive real time work-in-progress tracking system) only has one direct path from patent 6049742 (Projected supply planning matching assets with demand in microelectronics manufacturing). Besides, it has no

indirect paths from the other patents. This core technology is relatively less important than the others because it's a new patent which is issued in 2007. The network shown in Fig. 2 not only displays the importance of individual core patent, but also traces the development routes of core technologies.

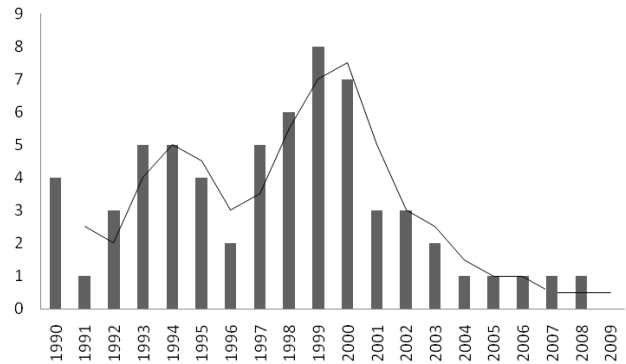


Figure 1. The distribution of core technologies by issued year.

To further identify the categories of data processing technologies for inventory management, we need to transfer the input data from the matrix of $R(W,Y)$ to the symmetrical matrix of relative correlation strength $R'(W,Z)$ for the following cluster analysis. The diagonal of $R'(W,Z)$ is set to 1 because the relationship of oneself is equal to 1. After we conducted the nonhierarchical clustering analysis, the 63 basic patents were classified into two groups as shown in Table I. According to the characteristics of major patent technologies in the group, Group 1 (G1) is named inventory management systems, which has 40 technologies. Meanwhile, Group 2 (G2) is named inventory monitoring methods and systems, which has 23 patents only. Among the 40 advancements in Group 1, the first issued technology was on April 4, 1990 and the last issued patent was on May 27, 2008. Generally speaking, the distribution period of issued

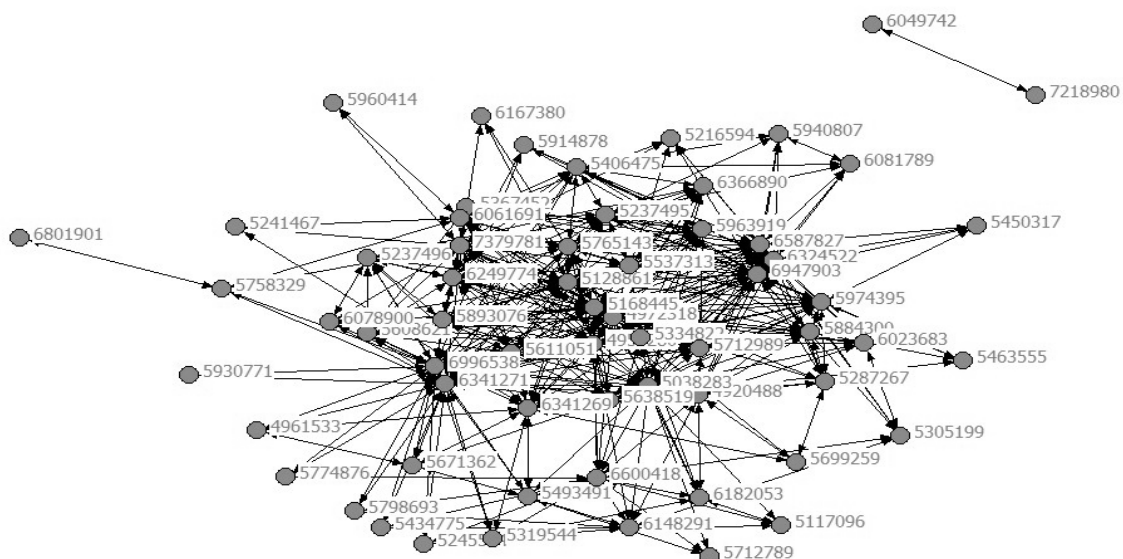


Figure 2. Network of patent development paths for core technologies.

technologies in Group 1 is longer than those in Group 2. It implies that the development of technologies of inventory management systems is normally longer than the technologies of inventory monitoring methods and systems.

TABLE I.
SUMMARY OF NONHIERARCHICAL CLUSTERING ANALYSIS

Group	Volume	First issued date	Last issued date	Major technologies
G1	40	1990.04.24	2008.05.27	Inventory management systems
G2	23	1990.10.09	2007.05.15	Inventory monitoring methods and systems

The citation relationship for the clustered patents is expressed in Fig. 3. Gray nodes denote patents in Group 1 while black nodes denote patents in Group 2. The citation relationship shows that most patents in Group 2 cite patents from Group 1. It means that the technologies of inventory management systems are relatively mature advances than the technologies of inventory monitoring methods and systems. For example, Patent No. 5319544 (Inventory monitoring and verification system and method) of group 2 cited Patent No. 5237496 (Inventory control method and system) of group 1. Patent No. 5463555 (System and method for integrating a business environment with a process control environment) of group 2 cited Patent No. 5287627 (Consumable supplies monitoring/ordering system for reprographic equipment) of group 1. Accordingly, our findings show that most technologies of inventory monitoring methods and systems depend on the technologies of inventory management systems.

The characteristics of inventory management systems are shown in Table II, which includes the detailed information of issued date, patent number, technology name, number of direct citation, and number of indirect citation. Table II indicates that most of the patents in Group 1 were issued during 1990 to 2002. The year that has the peak issued volume is 1999, in which six related technologies of inventory management systems announced. The technology of just-in-time requisition and inventory management system (No. 5712989) issued in 1998 has most direct citations in Group 1. A total of 70 patents (include the non-core technologies) has cited Patent No. 5712989 directly for their innovation developments. Through these 70 patents, the just-in-time requisition and inventory management system was also cited indirectly by 234 patents. The patent that has the second most direct citations is No. 5765143 (Method and system for inventory management), but its number of direct citations shows a big gap to No. 5712989. Besides, the technology of shipping method (No. 5038283) issued in 1991 has most indirect citations (303 patents). Other technologies such as order entry and inventory control method (No. 4972318), inventory control method and system (No. 5128861), and automatic ordering system and method for allowing a shop to tailor ordering needs (No. 5168445) also have indirect citations over 200 times. However, latest technologies such as No. 6947903 (Method and system for monitoring a supply-chain), No. 6996538 (Inventory control system and methods), and No. 7379781 (Constraint based order optimization system and available to promise system) generally have no indirect citations from the other technologies. This summary table of Group 1 technologies can help companies to

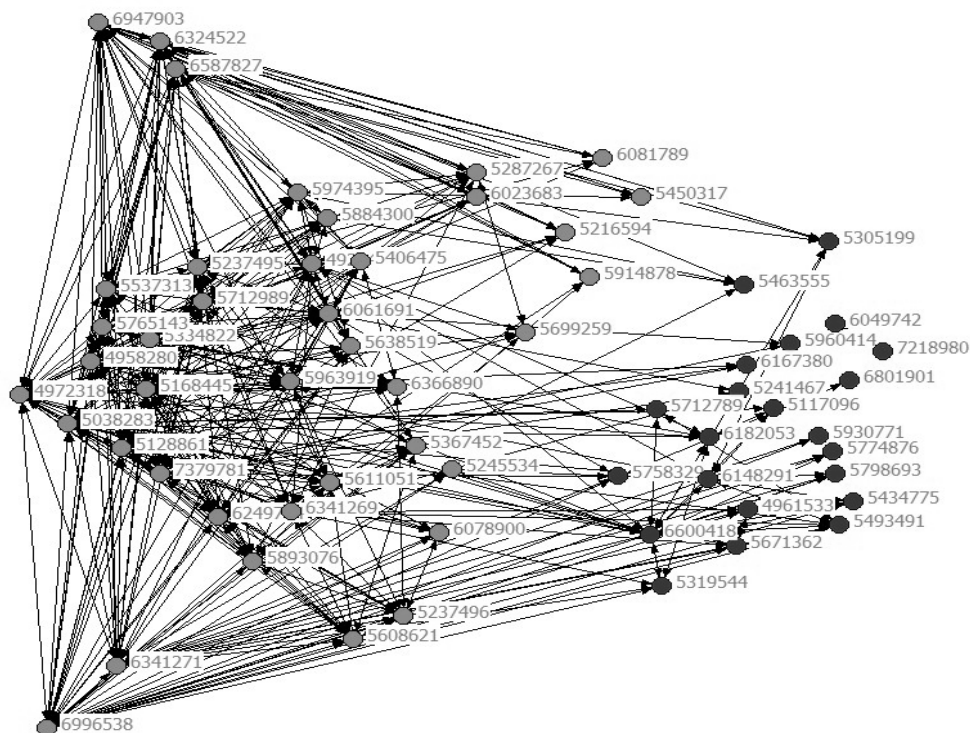


Figure 3. The citation relationship for the clustered patents.

understand the trend of innovations and the key patents for the future development of inventory management systems.

TABLE II.
CHARACTERISTICS OF INVENTORY MANAGEMENT SYSTEMS

Year	Patent	Technology name	Direct citation	Indirect citation
1990	4920488	Physical inventory system	13	155
	4958280	Apparatus and method for satisfying disposable contact lens prescriptions	8	123
	4972318	Order entry and inventory control method	21	247
1991	5038283	Shipping method	38	303
1992	5128861	Inventory control method and system	21	251
	5168445	Automatic ordering system and method for allowing a shop to tailor ordering needs	30	273
1993	5216594	Method of inventory management for footwear and last manufacture	8	58
	5237495	Production/purchase management processing system and method	9	62
	5237496	Inventory control method and system	16	130
1994	5287267	Consumable supplies monitoring/ordering system for reprographic equipment	15	77
	5334822	Method and system for inventoring a distributed plurality of items on a supply	13	155
	5367452	Mobile merchandising business management system which provides comprehensive support services for transportable business operations	7	44
1995	5406475	Data processing network having a plurality of independent subscribers	4	61
	5450317	Method and system for optimized logistics planning	18	72
1996	5537313	Point of supply use distribution process and apparatus	12	142
1997	5608621	System and method for controlling the number of units of parts in an inventory	16	123
	5611051	Point of supply use distribution process and apparatus	16	95
	5638519	Electronic method and system for controlling and tracking information related to business transactions	23	126
	5699259	Inventory control procedure	17	13
1998	5712989	Just-in-time requisition and inventory management system	70	234
	5765143	Method and system for inventory management	44	162
	5884300	Inventory pipeline management system	24	43
1999	5893076	Supplier driven commerce transaction processing system and methodology	20	30
	5914878	Raw materials ordering system	12	46
	5940807	Automated and independently accessible inventory information exchange system	9	51
	5963919	Inventory management strategy evaluation system and method	33	30

	5974395	System and method for extended enterprise planning across a supply chain	26	13
2000	6023683	Electronic sourcing system and method	20	33
	6061691	Method and system for inventory management	13	5
	6078900	Method for estimating stock levels in production-distribution networks with inventory control	21	42
	6081789	Automated and independently accessible inventory information exchange system	19	36
2001	6249774	Method for owning, managing, automatically replenishing, and invoicing inventory items	16	12
	6324522	Electronic information network for inventory control and transfer	26	31
	6341269	System, method and article of manufacture to optimize inventory and merchandising shelf space utilization	14	21
2002	6341271	Inventory management system and method	29	23
	6366890	Product inventory category management and variety optimization method and system	15	3
2003	6587827	Order fulfillment processing system	11	4
2005	6947903	Method and system for monitoring a supply-chain	6	0
2006	6996538	Inventory control system and methods	4	0
2008	7379781	Constraint based order optimization system and available to promise system	3	0

Similarly, Table III describes the characteristics of Group 2 technologies. The year that has the peak issued volume is 1998, in which four related technologies of inventory monitoring methods and systems announced. The technology of container and inventory monitoring methods and systems (No. 6148291) issued in 2000 has the most direct citations (31 times). Comparing to the top performers of Group 1 regarding direct citations, the top performers of Group 2 generally have significantly fewer direct citations. The main reason of this phenomenon is probably because the average issued year of Group 2 is younger than the one of Group 1. Although the technology of electronic locating systems (No. 5798693) was cited directly by 12 patents only, it has the most indirect citations (77 times) via these 12 direct citations. Patents like system for controlling and monitoring the distribution of goods (No. 5117096), space management system (No. 5241467), managing an inventory of devices (No. 5434775), and system for managing customer orders and method of implementation (No. 5758329) also have indirect citations over 60 times. These technologies may have the potentials for further development. Meanwhile, latest technology No. 7218980 (Prediction based optimization of a semiconductor supply chain using an adaptive real time work-in-progress tracking system) has no indirect citations from the other technologies. As there is only one core technology of Group 2 issued after the year of 2005, further investigation is needed to

understand whether this brand of technologies may not need to refer other patents for their developments.

TABLE III.
CHARACTERISTICS OF INVENTORY MONITORING METHODS AND SYSTEMS

Year	Patent	Technology name	Direct citation	Indirect citation
1990	4961533	Inventory control system	15	46
1992	5117096	System for controlling and monitoring the distribution of goods	9	70
1993	5241467	Space management system	16	66
1994	5305199	Consumable supplies monitoring/ordering system for reprographic equipment	18	44
	5319544	Inventory monitoring and verification system and method	13	41
	5434775	Managing an inventory of devices	17	76
1995	5463555	System and method for integrating a business environment with a process control environment	9	44
1996	5493491	Method of ordering, shipping and merchandizing goods and shipping/display assembly therefore	6	50
1997	5671362	Materials monitoring systems, materials management systems and related methods	15	31
	5712789	Container monitoring system and method	17	37
1998	5758329	System for managing customer orders and method of implementation	27	63
	5774876	Managing assets with active electronic tags	21	53
	5798693	Electronic locating systems	12	77
1999	5930771	Inventory control and remote monitoring apparatus and method for coin-operable vending machines	13	43
	5960414	Method for monitoring excess inventory	17	28
	6049742	Projected supply planning matching assets with demand in microelectronics manufacturing	17	18
2000	6148291	Container and inventory monitoring methods and systems	31	49
	6167380	System and method for allocating manufactured products to sellers	16	10
2001	6182053	Method and apparatus for managing inventory	13	15
2003	6600418	Object tracking and management system and method using radio-frequency identification tags	11	2
2004	6801901	Systems and methods for building and improving the quality of inventory load configurations	4	1
2007	7218980	Prediction based optimization of a semiconductor supply chain using an adaptive real time work-in-progress tracking system	3	0

To compare the citation trend of these two core groups, we summarize their citation volumes (include the non-core technologies) from 1990 to 2009 in Table IV. The volume of Group 1 technologies generally shows an increasing pattern since 1992. Particularly, the citation volumes of these two groups increase significantly since

2005. Our findings indicate that both groups of technologies are still emerging. In addition, latest data processing technologies for inventory management are dependent on the foundations of core technologies.

TABLE IV.
TREND ANALYSIS OF TECHNOLOGICAL GROUPS

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
G1	0	0	3	5	10	3	9	15	18	54	
G2	0	0	0	0	0	4	0	3	4	26	
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
G1	40	30	45	51	14	72	104	120	84	98	775
G2	29	18	26	28	9	27	43	45	37	30	329

V. CONCLUSIONS

Because inventory management is critical for supply chain participants, understanding and monitoring the development trend and context of data processing technologies for inventory management would benefit participants to enhance their competitive advantage. This study applied various data mining techniques to investigate the data processing innovations for inventory management through the investigation of USPTO database. We applied the approaches of citation strength and three S.D. to extract 63 core patents from 949 patents. The correlation strength between core patents was estimated through the lineal linkage coefficients and expressed by their correlation strength diagrams. Finally, the approach of nonhierarchical cluster analysis was used to reveal the trend and characteristics of core data processing technologies. Our results show that the data processing technologies for inventory management can be classified into the category of inventory management systems and the category of inventory monitoring methods and systems. The technologies inside the group of inventory management systems are generally mature innovations and thus they may be considered as the indicator techniques. Meanwhile, the patents inside the cluster of inventory monitoring methods and systems are relatively new and thus still have more rooms for development in the future.

Some possible future researches related to this work are described as follows. First, our analysis only focuses on the data mining of USPTO 705/28 class. However, there are other subclasses related to the technologies of inventory management under Class 705. Extended investigations on these subclasses can help companies to evaluate technological development from different angles. Second, the patents of data processing techniques for inventory management are issued continuously. More recent records can be collected for further analysis to see whether new core technologies can be identified.

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