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## RESEARCH ARTICLE

# Investigating Knowledge Structure and Future Directions in IT-Based Business Methods Using Hierarchical Main Path Approach

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**ABSTRACT** Business method (BM) has been recognized as a key factor for business innovation. BM patents are widely used to analyze and understand BM domains. However, previous studies have not considered the significant characteristics of the BM domain and patents, such as relative weight for knowledge flows and various knowledge interrelations among sub-domains. This study employed a hierarchical main path analysis that considered the relative difference in knowledge inheritances and identified the knowledge structure in the BM domain. In addition, the knowledge unconventionality metric was adopted to optimize knowledge diffusion in the last layer for forecasting further developmental directions. The empirical analysis showed that the BM domain consists of eight sub-domains, and each sub-domain has a high interrelationship with other sub-domains. Most dominant knowledge was invented based on different types of knowledge in different sub-domains. In particular, the overall trajectories and future directions were analyzed according to the changes in relative importance of sub-domains. The dominant patents, trajectories, and future directions for each sub-domain were analyzed based on the high knowledge persistence and end-node information of the main paths.

**INDEX TERMS** Business method, business model, hierarchical main path, knowledge inheritance, knowledge structure, knowledge trajectories, patent citation network.

## I. INTRODUCTION

Information and communication technology (ICT) is one of the most significant drivers for change and evolution in the business environment [1], [2], [3], [4], [5]. The emergence of ICT-based business methods (BMs) has enabled new types of businesses and business models [6], [7], for example, Airbnb. Airbnb, one of the largest companies in the hotel and hospitality sector, offers accommodations to travelers. However, this company does not own any lodging properties but only operates an online rental platform. Airbnb's business model is completely different from traditional business models in the

hotel sector, and ICT, as an enabler for business communication, processing, and transactions, makes this possible [4], [8], [9], [10], [11]. As ICT has become an essential component for BMs, BMs have been considered patentable subject matter since 1998 [12], [13], [14], [15], [16] and widely applied to various industries, including service sectors such as finance, retailing, and entertainment [17]. In fact, many significant Internet business operations, such as online auctions (e.g., Priceline.com), online one-click ordering (e.g., Amazon.com), and online shopping carts (e.g., Open Market), are also covered by specific BMs.

BM patents - software-based commercial techniques for conducting business using computers, the Internet, mobile devices, and so on [18] - have been used as useful

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data to analyze and understand business model innovations and evolutions [19], [20]. Unlike other technology domains (TDs), BM patents have different characteristics that need to be carefully considered. First, BM patents generally inherit a great volume of knowledge for later development [8], [16], [21], [22]. Therefore, equal weighting for every knowledge flow can cause inappropriate identification of major knowledge streams, necessitating the need to calculate the relative inheritance weight of knowledge flows. Second, the knowledge interrelationships among the sub-domains within the BM domain are much higher than those of other TDs [23]. Each BM patent concerns a software-based method or process for a specific function. Even a single business or service operation requires multiple sub-functions. Software-based methods can easily be applied to other applications for various purposes. Therefore, sub-domains within the BM domain are highly interrelated, and considerable knowledge is transferred across the sub-domains [23], [24]. Because knowledge recombination is the fundamental mechanism for new knowledge creation [25], [26], [27], [28], [29], [30], [31], [32], knowledge flows among different sub-domains are often key clues to understanding further developments and should be carefully analyzed. In particular, the BM domain has various complex knowledge flows across sub-domains; thus, hierarchical knowledge structuring (or knowledge decomposition) is essential for investigating BM patents.

Some studies have analyzed knowledge flows, diffusions, or trends in the BM domain using BM patents. Chang et al. [33] analyzed BM patents to identify basic patents and explain knowledge diffusion situations in the BM domain. No et al. [16] suggested a framework for investigating knowledge flows in BM patents using patent citations and textual information. Lee and Sohn [3] analyzed emerging trends in financial BM patents using a topic-modeling technique. However, most studies did not consider the knowledge structure under the BM domain to understand knowledge combinations/diffusions among sub-domains and the relative difference in knowledge inheritance. Therefore, this study employed the hierarchical main path approach [24] to objectively understand the underlying knowledge structure, dynamic developmental flows, and future directions in the BM domain. The hierarchical main path approach automatically decomposes a TD into an optimized number of sub-domains and generates technological trajectories from the overall TD perspective and each sub-domain perspective simultaneously. In addition, the hierarchical main path analysis is based on the concept of knowledge persistence – the metric to measure how much knowledge of a patent is retained and its technological contributions to recent development and inventions – and forward-backward path analysis for minimizing searching paths [34]. Thus, the method can consider different weights for each knowledge flow and show the knowledge interrelations among sub-domains with minimized network complexity [24]. In particular, this study used

the knowledge unconventionality (KU) metric [35] to minimize knowledge diffusions usually occurring in the last layer of the generated hierarchical main paths and to characterize future developmental directions.

The remainder of this paper is organized as follows. Section II reviews the background knowledge for this research. Section III describes the method, Section IV describes the results and implications of the empirical analysis, and finally, Section V concludes the paper.

## II. THEORETICAL BACKGROUND

### A. BUSINESS METHOD PATENTS

The business model is the design of the organizational structure and rationale for generating a firm's profits. It explains how companies create, deliver, and capture value in the context of market economies and society [2], [4], [13], [15]. Because a substantial number of business models have been implemented by ICT in the recent digital era, BM patents have been considered significant data for analyzing and understanding business models and innovation.

BM patents can be defined as methods of administering, managing, or operating an organization, and techniques used in conducting business [2]. Although a business model cannot be protected by a patent, specific BMs for the business model are patentable. BM patents have a long history with the patent system (Table 1), but it has not been long since BM patents were considered common and regular patentable inventions. The actual root of BM patents lies in the State Street Bank and Trust Company vs. Signature Financial Group, Inc. case in 1998. The Federal Circuit decided that a software patent for valuing mutual funds was valid; BMs have been patentable since then [36]. Unlike other technology domains, BM patents are directly linked with business and service fields; thus, BM patents are a valuable data source for identifying opportunities for technology-based services [9].

**TABLE 1. Early business method related patents (www.uspto.gov, Business methods white paper).**

Patent number	Filing date	Title
US 209,827	1878.11.12	Ticket printing and recording machine
US 915,090	1909.03.16	Cash register
US 1,710,691	1929.04.30	Combined sorter and tabulator
US 2,594,865	1952.04.29	System for making reservation

In patent classification systems, BM patents are classified into relatively clear classes and sub-classes. International patent classification (IPC) or Cooperative patent classification (CPC) G06Q and United States patent classification (USPC) 705 are the classifications for BMs; IPC/CPC G06Q is defined as “Data processing systems or methods, specially adapted for administrative, commercial, financial,

**TABLE 2. Patent classification for business methods.**

Patent system	Class	Sub-class (or Main group)	Definition		
CPC	G06Q		Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purpose		
		G06Q-10/00	Administration; Management		
		G06Q-20/00	Payment architectures, schemes or protocols		
		G06Q-30/00	Commerce		
		G06Q-40/00	Finance; Insurance; Tax strategies; Processing of corporate or income taxes		
		G06Q-50/00	Systems or methods specially adapted for specific business sectors		
		G06Q-90/00	Systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not involving significant data processing		
		G06Q-99/00	Subject matter not provided for in other groups of this subclass		
		G06Q-2220/00	Business processing using cryptography		
		G06Q-2230/00	Voting or election arrangements		
		G06Q-2240/00	Transportation facility access		
		G06Q-2250/00	Postage metering systems		
		USPC	705		Data processing: financial, business practice, management, or cost/price determination
				705/1.1	Automated electrical financial or business practice or management arrangement
705/50	Business processing using cryptography				
705/80	Electronic negotiation				
705/400	For cost/price				
705/500	Miscellaneous				
705/901	Digital rights management				

managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes” with 11 sub-classes, or main groups in the CPC system (Table 2). USPC 705 is defined as “Data processing:

financial, business practice, management, or cost/price determination” with six subclasses (Table 3). Although both patent classification systems for BMs seem to have clear structures, almost all BM patents are generally classified into multiple subclasses under CPC G06Q or USPC 705; thus, each subclass, or even lower-level class, cannot be a specific group representing a homogeneous service or operational function. The defined classes, or lower-level classes, are difficult to use directly, and a clustering method for effectively isolating the sub-domains is required to identify meaningful knowledge flows within the BM domain.

In addition, BM patents have a much larger volume of knowledge flow than other technological domains. Patent citations are widely considered to be knowledge flow or inheritance from citing to the cited patent [34], [37], [38]. The number of backward citations of BM patents is far greater than that of other TDs. The simple statistics of the average number of backward citations clearly show that the average number of backward citations of BM patents is 31.05, while that of other patents, except software- and healthcare-related patents, is 13.95 (tested by authors using the entire U.S. patents from 1976 to 2020). Thus, knowledge flows can be critical information for analyzing the BM domain; however, careful consideration of the peculiar characteristics derived from complex and vast knowledge flows is essential. Therefore, this study adopts the hierarchical main path approach to consider the characteristics of BM patents.

**B. HIERARCHICAL MAIN PATH ANALYSIS**

Hierarchical main path analysis is a method for identifying the overall and specific knowledge trajectories within a TD by structural decomposition. Main path analysis, which reduces network complexity and identifies the major knowledge streams, has been widely used in various studies on technological innovation.

Hummon and Doreian [39] first suggested search path-based metrics, such as search path link count (SPLC), search path node pair (SPNP), and node pair projection count (NPPC), to identify the main path in a large citation network. Although a search path-based main path approach has been applied to many innovation studies [39], [40], [41], [42], [43], it has some critical limitations for analyzing “technological” domains: singular trajectory, high network complexity, and omission of key knowledge. In order to solve these limitations, Park and Magee [34] suggested a knowledge persistence-based main path approach. This approach is based on knowledge recombination theory and the characteristics of knowledge inheritance. Novel knowledge is created by a recombination of existing knowledge; thus, a proportion of knowledge in the cited patent is incorporated in the citing patent. Based on this concept, knowledge persistence (KP) quantifies how much of a patent has been retained in recent developments based on the structural and topological position of the patent in a citation network [34]. KP-based main paths first identify high KP patents as key nodes for main paths,



actually explored, is determined by dividing the number of patents from the first patent dataset that align with the patent classification code by the sum of all patents gathered in the first patent dataset. Third, we chose CPCs and UPCs combinations which showed the most elevated MPR value to establish a TD search query.

### B. TECHNOLOGY STRUCTURING BY TECHNOLOGICAL SPACE DECOMPOSITION

We created a minimum overlap classification (MOC) [46] to divide the BM domain into sub-domains. MOC consists of the deepest class combinations of different patent classification systems. Thus, MOC is the most specific technological space created by the classification overlaps. Hierarchical clustering was applied to find groups of meaningful size and independence as sub-domains. Hierarchical clustering is performed based on knowledge distance, and the knowledge distance is calculated using the patent overlap-based distance (PODist) and class hierarchy-based distance (CHDist) [46]. Because a patent includes multiple classification codes rather than a single classification code, MOCs that include the same patent can be determined as a similar technology space. The PODist converts MOCs into vectors and calculates the distances between the MOCs:

$$\text{CostDist}(MOC_i, MOC_j) = 1 - \frac{MOC_i \cdot MOC_j}{\|MOC_i\| \|MOC_j\|},$$

where  $MOC_i$  is a vector of MOC,  $MOC_i \cdot MOC_j$  is an inner product,  $\|MOC_i\|$  is the Euclidean distance of  $MOC_i$ , and the distance ranges from 0 to 1. However, high skewness similarity does not produce distinguishable values, and the value needs to be reduced. Therefore, we applied a logistic function to reduce the difference in the MOC distances. The PODist is expressed as follows:

$$\text{PODist}(MOC_i, MOC_j) = \frac{1}{1 + e^{-10(\text{CostDist}(MOC_i, MOC_j) - 0.5)}}.$$

The CHDist is calculated using the hierarchical structure of the patent classification system. We transformed the patent classification system into a hierarchical tree network. Nodes are composed of classification codes and edges are the relationships of hierarchical structures based on patent classification systems. The similarity between classes is calculated using a class hierarchy-based distance, such as link length-based semantic distance (LLDist) approach [46]:

$$\text{LLDist}(Class_i, Class_j) = 1 - \frac{2 \cdot d(LCS(Class_i, Class_j))}{d(Class_i) + d(Class_j)},$$

where  $Class_i$  is the specific patent class in CPC, UPC, or IPC,  $d(Class_i)$  is the number of edge from the section in the focal classification to  $Class_i$ , and  $LCS(Class_i, Class_j)$  is the least common subsumer of  $Class_i$ , and  $Class_j$  under the patent classification system' hierarchical structure. The LLDist ranges from 0 to 1. The two deepest level of classes of two different patent classifications generate the MOC, and the

CHDist is calculated according to the patent classification system constituting the MOC. The CHDIS formula is as follows:

$$\text{CHDist}(MOC_i, MOC_j) = \frac{\text{LLDist}(CPC_i, CPC_j) + \text{LLDist}(USPC_i, USPC_j)}{2}.$$

Finally, knowledge distance is calculated as the PODist and CHDist. The formula used is as follows:

$$\text{MOCDis} = \text{PODist} \times \text{CHDist}$$

Next, we perform hierarchical agglomerative clustering based on the technological similarity among MOCs [46]. In hierarchical agglomerative clustering, MOCs are clustered from the highest value of technological similarity. The final clustering denotes the entire domain. Thus, sub-domains with lower technological similarity are composed of sub-domains with higher technological similarity. The cutoff can be further subdivided according to the purpose of the analysis. We evaluated the cut-off that sets the sub-domains in each clustering process. The cutoff criterion can be the independence of the sub-domain and the number of patents in the sub-domain. In this study, the cutoff level is set when the cutoff satisfies both the size and independence at the same time.

### C. DEFINITION OF SUB-DOMAINS USING DOMAIN SPECIFIC TERMS

We extracted domain-specific terms (DSTs) for each sub-domain to define the name of each sub-domain. DSTs can be a single word or noun phrase and should have relative importance only in a specific sub-domain. In particular, most meaningful terms are noun phrases rather than single words. Therefore, it is important to extract noun phrases as DSTs. This study adopted a stopword-based tokenizing approach to consider noun phrases [47] and identified DSTs by comparing the term frequency distribution between each sub-domain and the entire domain. The extraction process is as follows. First, the entire patent text is tokenized by stop words, and the weights of the tokenized words are scored by word frequency and degree. The DST candidates are extracted by the ratio of word degree to word frequency, and the cutoff is usually set as a third of the total text. Second, DSTs are quantitatively identified based on the relative essentiality of the terms at different boundaries [46]. The formulation for calculating the domain-specific score (DSS) is as follows.

$$\text{DSS}_{ij}(k) = \frac{\text{edf}_i(k)^2 / n_i \cdot \text{rdf}_i(k)}{\text{edf}_{\bar{i}}(k)^2 / n_{\bar{i}} \cdot \text{rdf}_{\bar{i}}(k)}, \quad (i \neq j)$$

where  $k$  is a specific keyword,  $\text{rdf}(k)$  is the referenced document frequency of  $k$  and is defined as the number of documents having  $k$  as the candidates, and  $\text{edf}(k)$  is the extracted document frequency of  $k$ .  $i$  is a specific sub-domain under the focal domain, and  $j$  is the upper set of  $i$ , that is, the entire domain.  $\bar{i}$  is a complementary set of  $i$ , and  $n_i$  is the number of documents in  $i$ .

### D. MAIN PATH IDENTIFICATION

We applied the concept of knowledge persistence (KP) to represent technologies that contain significant knowledge. KP quantitatively calculates the rate at which knowledge is transferred between a patent citation relationship and is an indicator that measures the amount of knowledge duration or the impact on technological development. The KP-based main path analysis identifies high-KP patents in the knowledge network and shows their development. The KP calculation method is as follows: First, a patent citation network was constructed. Second, the longest citation edge was found by the start and endpoint of the patent citation network. Third, the patent citation network was rearranged based on the layer of the longest citation edge. Fourth, KP calculated the ratio of the number of backward connections to the layer immediately preceding the endpoint. Fig 3 illustrates how KP is calculated. The formula for KP is as follows [34]:

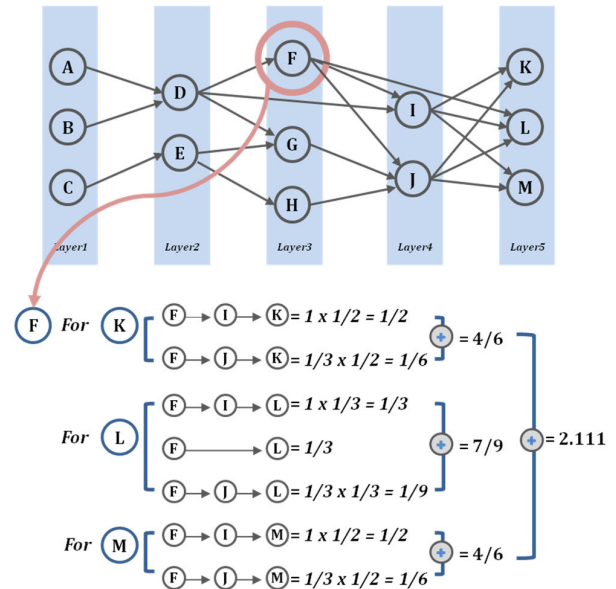
$$KP(P_A) = \sum_{i=1}^n \sum_{j=1}^{m_i} \prod_{k=1}^{l_j-1} \frac{1}{BWDCit(P_{ijk})},$$

When  $P_A$  represents a patent associated with A,  $P_{ijk}$  stands for the k-th patent in the j-th backward path that begins from  $P_i$  to ends at  $P_A$ ;  $BWDCit(P_{ijk})$  is used to indicate the number of backward citations from  $P_{ijk}$ . This is done while disregarding the citations made by patents that fall between layers t and t-1, specifically when  $P_A$  is situated under layer t. The  $l_j$  is used to designate the totality of patents present along the j-th backward path, starting from  $P_i$  to  $P_A$ . The variable  $m_i$  is the entirety of viable backward paths from  $P_i$  to  $P_A$ , i is the count of patents in the final layer that hold indirect links with  $P_A$ .

We identified the important patents in a knowledge network using KP normalization from the global or local perspective. The global-perspective persistence (GP) was evaluated by normalizing it using the highest KP value in the knowledge network. The layer-perspective persistence (LP) was evaluated by normalizing it using the highest KP value for each layer. In general, citation-based metrics cannot measure recent patents as important ones because of time bias [34]. KP was also calculated as a citation-based metric and is weighted on relatively old patents, but the LP metric solves the time effect bias. Based on [34], this method determines the high-KP patents with GP greater than or equal to 0.3 or LP greater than or equal to than 0.8, as the important patents. To find the main paths, we applied the backward and forward search mechanism for the paths of high-KP patents. This mechanism identifies the multiple main paths well-connected from the starting points to the endpoints [24], [48].

### E. GENERATION OF HIERARCHICAL MAIN PATHS

We applied the KP-based main path analysis for the entire domain and sub-domain. The generated KP-based main paths for each sub-domain are located in their respective sections on a main path network, and all main paths are linked by



**FIGURE 3. Knowledge persistence calculation. Notes: Layer denotes overall knowledge structure defined by knowledge flows and inheritances in a TD; The size of layers is determined by the longest citation flow; Each node on the network is assigned to its corresponding layer; the ratio of knowledge inheritance is defined as 1/the number of knowledge in-flows through citations.**

integrating the main paths for the entire domain with the main paths for all sub-domains; the overlapped patents between the entire domain and sub-domains are used as integration points. For better understanding of trajectories, all nodes are rearranged by application year. This method uncovers the role and development of sub-domain knowledge in the entire domain knowledge development [24].

### F. FUTURE DIRECTION ANALYSIS

This step minimizes the hierarchical main-path network on the last layer using the KU metric. The KU metric is fundamentally based on knowledge recombination theory [25], [26], [27], [28], [29], [30], [31], [32]. Innovative knowledge, which has a high possibility of becoming a future knowledge flow, is usually created by the recombination of atypical knowledge. The KU metric is defined as follows [35].

$$KU_p = \sum_j^{n_p} DC_j / n_p; CPC_{p_j} \neq CPC_p,$$

where  $DC_j$  represents the count of different classifications in patent p, which cites patent j;  $DC_j$  is counted when main class of CPC (Cooperative Patent Classification) codes  $CPC_{p_j}$  of patent j is not assigned to patent p.  $n_p$  is the number of patents cited patent p on the main paths. Based on the KU scores of patents at the endpoints, the patents with the highest KU scores are being continued or prioritized for further analysis.

## IV. CASE STUDY

### A. DATA

We collected the BM patent set using classification overlap method (COM). The patent search queries are presented

in Table 3. The patent classifications used in COM are listed in Table 4.

TABLE 3. Data overview.

Search query	Num. of patents	Data range	Relevancy
G06Q and 705	48,562	US-granted patents from 1990.01.01 to 2021.01.01 (Application date)	96%

TABLE 4. Business method related patent classification for data collection.

Classification	Descriptions
CPC G06Q	Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes
USP C 705	Data processing: financial, business practice, management, or cost/price determination

B. RESULT

First, we extracted the MOC from the collected BM patent set and identified eight sub-domains using technological similarity-based hierarchical clustering. To define each of the identified sub-domains, keywords were extracted by applying the domain-specific score (DSS) to the titles and abstracts of patents in the sub-domains. The name for each sub-domain (Table 5) is qualitatively defined mainly based on the extracted domain-specific keywords and key-phrases (Table 6).

Next, we generated KP-based hierarchical main paths for the entire domain and sub-domain. By integrating the generated main paths, the development trajectories and interrelationships among sub-domains are well identified. However, this method effectively reduces the complex network and identifies each main path. Concerning network size, the BM domain generally has a significant number of knowledge flows, resulting in a large and complex knowledge network. However, this method can effectively reduce the network size and find major knowledge flows from a complex citation network. The summary of the hierarchical main path analysis results is presented in Table 7.

1) OVERALL TRAJECTORIES

As can be seen in Figs. 4, 5, and 6, the important developments in the BM domain in the 1990s began with Managerial Computing Systems, Advertising Systems, E-commerce, and Financial Data Processing. As the offline market transitioned

TABLE 5. Sub-domain definition.

Sub-domains	Definition
Financial Data Processing	Methods and systems for financial, stock, and insurance transactions with a focus on banks and securities companies
Payment System	Methods and Systems for companies and customers through the bank
Healthcare	Methods and systems for customer payments in the network
E-commerce	Methods and systems for patient information, medications, medical information, patient management, and hospital management
Managerial computing system	Methods and systems for sale and Web system in E-commerce
Business Processing system	Method and systems for efficiently supporting companies in especially insurance and inventory management
Advertisement system	Methods and systems for handling data-driven demand forecasting, optimal efficiency, and department management
Security system	Methods and systems for promoting a company's products and services to customers
	Methods and systems for protecting data passing over networks

to an online market due to digitalization, the corresponding BM patents developed. Among them, knowledge in the E-commerce sub-domain was adopted by Advertisement Systems and Financial Data Processing. In the Advertisement System, methods (e.g., 1057 and 923) that converted offline customer channels into initial online channels were mainly invented.

From Period 3 (2001-2005) in Fig. 6, new sub-domains emerged, and knowledge interactions actively occurred. The significant implication in this period is the growth of E-commerce and Payment Systems. User interfaces, such as electronic shopping carts for customer convenience, and various systemic methods for attracting customers (e.g., 18534, 21162, and 31278), were mainly developed in the E-commerce sub-domain. The emergence of new sub-domains, Business Process Systems and Security Systems, is also highly related to E-commerce and Payment Systems. Key knowledge in Business Process Systems (e.g., 13752 and 25345) became more general BMs for business activities, such as demand forecasting systems and product price optimization, by using customer information from e-payment. The BMs for Security Systems, such as transaction stability (e.g., 11751 and 13216), were required and developed.

In Period 4 (2006-2010) in Fig. 6, various sub-domains became important. The environment for customers and users changed because of the emergence of smartphones.

TABLE 6. Top 15 extracted domain-specific terms for each sub-domain.

Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Financial Data Processing	Payment system	Healthcare	E-commerce	Managerial computing system	Business process system	Advertisement system	Security system
trading system	electronic payment	health care	electronic commerce	insurance policy	business process	online ad	digital signature
financial instrument	payment transaction	medical record	shopping cart	health care	supply chain	advertising system	digital certificate
market data	payment system	patient data	product information	payment system	historical data	advertisement information	second part
financial data	authorization request	medical information	purchase order	financial account	computer implemented method	advertising content	first part
financial institution	account number	social networking	web site	payment transaction	time period	targeted advertisement	public key
financial account	payment information	medical condition	purchase transaction	financial institution	data structure	advertising campaign	private key
financial transaction	credit card	system use	various embodiment	management system	control system	content item	encryption key
account information	electronic transaction	information management	web page	financial transaction	management system	web page	line transaction
insurance policy	transaction processing	medical care	computer network	account information	data related	user profile	electronic transaction
credit card	transaction information	medical procedure	service provider	credit card	program product	search result	smart card
payment transaction	financial transaction	monitoring device	first user	service provider	determined based	user interaction	electronic payment
data processing system	card reader	patient information	system allows	system also	computer program product	search engine	digital content
payment system	purchase transaction	electronic medical record	communication network	computer system	graphical user interface	user based	account number
account number	financial account	medical device	social network	information regarding	user interface	location information	authorization request
transaction information	account information	healthcare provider	system receives	social network	user input	web site	Credit card

Consequently, the previous sub-domains all changed. The BM patent (e.g., 47491) of the Managerial Computing System is about a big data-based order processing method. The Advertising System’s patents (e.g., 46295, 46621, and 46629) developed methods of targeting advertisements by acquiring information on customers’ real-time locations and channels. The Security System’s BM patents (e.g., 46481 and 46502) were mainly about methods to enhance security in the payment process.

TABLE 7. Summary of main paths.

Sub-domain	Name of Sub-domain	Number of patents	Citation network		Main path	
			Number of nodes	Number of edges	Number of nodes	Number of edges
1	Financial data	15,396	13,223	145,534	31	27
2	Payment system	10,695	8,987	90,925	24	20
3	Healthcare	5,661	3,453	11,485	29	37
4	E-commerce Managerial	14,728	12,084	96,638	67	73
5	computing system	18,668	14,861	105,594	44	66
6	Business process system	6,866	5,046	19,442	63	72
7	Advertisement system	5,308	3,897	20,805	40	42
8	Security system	5,559	3,178	14,790	24	40
-	Entire-TD	48,562	43,401	537,506	61	109

In Period 5 (2011-2015) in Fig. 6, the Managerial Computing System, whose patents were not selected as major nodes on the main paths and so the sub-domain disappeared for Periods 3 and 4, was identified again. The potential reason could be the change in the consumer payment environment to a mobile environment (e.g., 37947, 38263, and 41136). Based on this, knowledge in the Managerial Computing System was actively adopted by Security System and Payment System. Security System’s BMs (e.g., 34521, 37931, 42553, and 42611) were mainly about stable information transactions and cryptograms in a virtual environment. Payment System’s BMs (e.g., 42616, 35470, and 38863) focused on mobile wallet-related technology. To enable efficient payments, it was important to improve customer personal information security and user convenience by separately storing user information and only opening the address for it.

From Period 6 (2016-2020) in Fig. 6, knowledge flows were not as strong as before. The crucial reason is that the timing for patent disclosure and the time from application to registration takes approximately 990+ days (2.7 years). Because the patent examination period for BM patents usually takes about 1300+ days (3.6 years), this period inevitably has weak knowledge flows.

Similar to previous periods, Advertisement Systems will continue to play a vital role in the BM domain in the future. Key BM patents (e.g., 49136, 48669, and 48676) for this sub-domain focused on customized advertisements using real-time customer transaction information. Companies specializing in advertising will evolve BM patents in connection



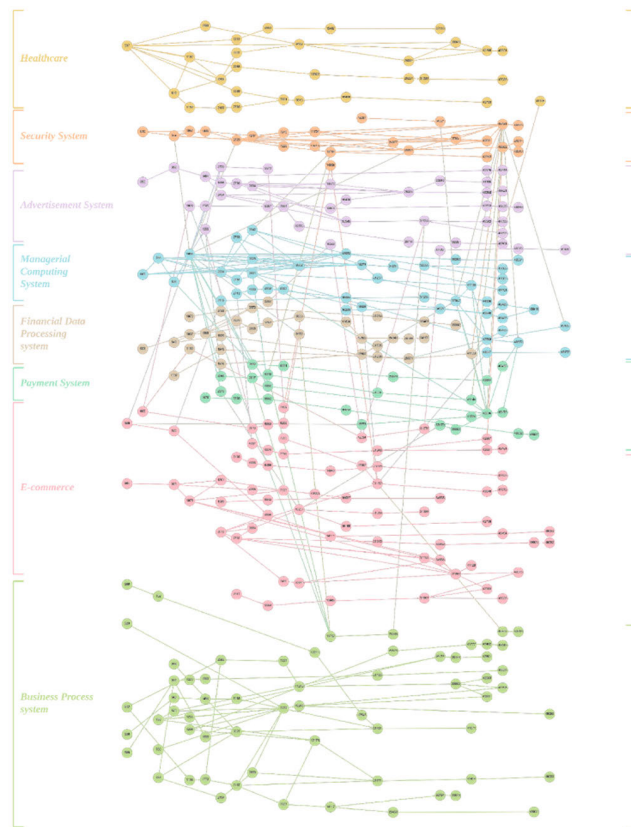


FIGURE 4. KP-based hierarchical main paths for BM domain. (High-quality figure is attached in S1 file.)

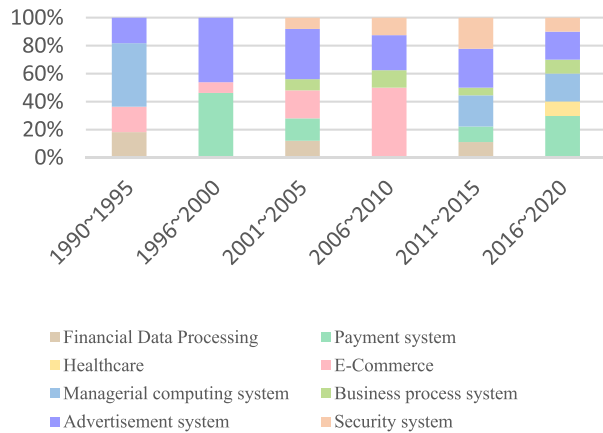


FIGURE 5. Ration of high KP patents for each sub-domain in specific periods.

with companies that have substantial financial and customer information to acquire customer data. The BM patent (e.g., 48673) for the Security System was developed with multiple tokenization to strengthen authentication. Based on this knowledge, the patents (e.g., 48672 and 49135) of Managerial Computing Systems have developed as methods that can be utilized in social media and platforms. As such,

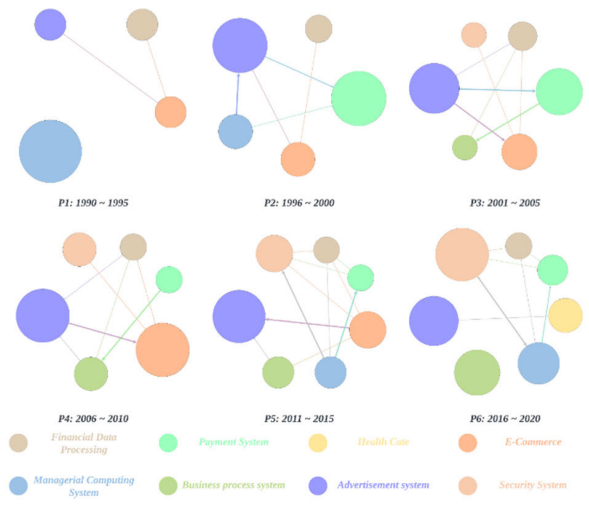


FIGURE 6. Knowledge flow network for each sub-domain by moving average period.

they will be developed according to changes in the security system environment. The increase in financial and personal data/information will lead to the development of enhanced security systems.

Meanwhile, there have been no innovations in E-commerce knowledge since 2016. The E-commerce development process has evolved according to changes in customers' accessibility to digitalization, networks, and wireless communication devices. As there have been no environmental changes, BMs of E-commerce have become common knowledge. However, if the Metaverse becomes popular, companies will focus on developing new E-commerce methods or systems for the new customer environment. In addition, this paper has discovered a new sub-domain, Healthcare, for the development of the BM domain. Healthcare's BM patent (e.g., 49106) provides customized compensation based on customer information in the insurance field. Considering social needs and trends, Healthcare will grow more, and various BMs (e.g., for insurance or remote healthcare) will be actively developed.

Technologies have developed through the recombination of knowledge from previous technologies. In particular, key technologies were generally invented when knowledge from several fields, rather than the knowledge of one field, was combined. We found that the development process of the BM domain also supports the innovation theory (Table 8). The key node, for instance, 13752 (Business process system) was invented based on node 1056 (Managerial computing system), 3517 (Payment system), and 9472 (Financial data processing). Node 1056 is about a system for managing customer information utilization, purchase, and delivery in the network. Node 3517 could facilitate the purchase activity by providing incentives to customers based on real-time product purchase information. Node 9472 helps customers

**TABLE 8. Example patents related to cross-domain knowledge combination.**

L	Patent Number	Application Year	Sub-domain	KP	# of forward citations	Title	Assignee
1056	US 5724426	1995	Managerial computing system	1219.347	643	Digital active advertising	Open Market
3517	US 62912787	1999	Payment system	272.9427	264	Method and system for generating incentives based on substantially real-time product purchase information	Incentech
9472	US 7689502	2002	Financial data processing	53.5495	35	System and method for establishing or modifying an account with user selectable terms	JPMorgan Chase Bank
1381	US 8175905	2004	Business process system	42.4414	15	Systems and methods for constructing and utilizing a merchant database derived from customer purchase transactions data	JPMorgan Chase Bank

easily access and use financial products. Based on these BM patents, node 13752 acquires seller information using customer purchase information data. This BM patent predicts information about the current seller’s profit and market share based on the information obtained.

2) TRAJECTORIES FOR SUB-DOMAINS

Next, we analyzed the trajectories for the sub-domains.

Initially, BM patents for Financial data processing were methods and systems for transacting financial instruments in a network. In the 2000s, the BM was advanced as an automated system and method for financial product transactions. In the 2010s, BMs for improving data security or user convenience (e.g., 41133 and 38902) were actively developed.

Payment system has been developed based on the growth of E-commerce. BM patents (e.g., 3592 and 3360) for Payment system in the 1990s were usually about methods for payment in a network environment. Based on this, an online payment system (e.g., 21501) was developed using a NFC-enabled mobile communication device. In addition, a personal address system (e.g., 35470) was developed to increase customer convenience and security. Since 2010, the BMs for mobile device-based payment systems changed with the introduction of smartphone and wearable devices as a new customer’s payment environment. The virtual payment account or system for mobile or wearable devices (41144 and 48852) were critical BMs. From this trajectory, it is predictable that companies will continuously focus on developing a new BM system for newly developed payment environments or devices.

In the entire main paths, the Healthcare BM patents were first identified in 2018. However, the Healthcare sub-domain had previously had BM patents. In the 1990s, BM patents were applied to systems for patient management (e.g., 537 and 1159) and methods for insurance claims (e.g., 2956 and 3222). Based on this, BM patents for prescription benefit management for medical services (e.g., 12922) and systems for drug management (e.g., 28564) were developed.

In the 1990s, E-commerce BM patents started as a catalog system for E-commerce (e.g., 923 and 820) and systems for overall operation (e.g., 559 and 1901). In the 2000s, based on the previously important operation systems, BMs focused on a system method (e.g., 5029 and 7205) to maximize the network processing speed and management efficiency of E-commerce and product placement methods applying a statistical modeling method (e.g., 10469 and 14111). In the 2010s, web-based interfaces (e.g., 42597, 43648, and 46936) for customer convenience or methods for proposing customized products by securing customer data (e.g., 47373 and 48675) were significant. Recently, BM systems (e.g., 49025) for cryptocurrency payments in e-commerce have been developed.

BM patents (e.g., 1056 and 2712) in Managerial computing systems started with the development of the company’s overall infrastructure in the network. With the growth of E-commerce, BM patents (e.g., 16295 and 24691) of the Managerial computing system have focused on optimizing delivery and software management to increase customer convenience and corporate efficiency. Since the 2010s, BM patents (e.g., 47491) have developed an order management system (OMS) and methods of locating and selling items at attended delivery using big data analysis methods.

In the 1990s, BM patents for Business process systems (e.g., 523 and 580) developed methods such as an automatic manufacturing costing system and a workflow management and elimination system to facilitate the operation of their companies. In the 2000s, based on the previous trajectory, BMs (e.g., 12214, 10246, and 18543) on demand forecasting for distribution management and monitoring for outsourcing companies were significantly invented. In 2010, BM patents (e.g., 39933, 38144, and 4391) were developed using data-based statistical analysis methods.

Advertisement system has the highest number of KP patents in the overall development of the BM. Initially, the BM patents of the Advertisement system were developed as systems (e.g., 1029, 1595, and 1996) for advertising to customers on the Internet. Based on the previous developments, BMs related to a system that utilizes customer data to increase the effectiveness of advertisements (e.g., 16436 and 13970) were developed. BM patents (e.g., 38351, 35843, and 46444), which are systems for diversified advertising channels that customers can access, were developed.

With the increasing volume of customer data and the development of analytic methods, BM patents (e.g., 46701 and 48676) on more customized advertisements were developed.

Because the BM domain operates in a network environment, the sub-domain of the Security system is especially important. Initially, BM patents (e.g., 1445 and 2820) were about methods for secure transactions in payment systems. With the development of network and security technologies, BM patents (e.g., 11751 and 13216) in the 2000s strengthened security with real-time authentication, such as mobiles. Recently, according to BM patents (e.g., 48673, 48721, and 42553), credit card companies operate customer-customized network configurations and account identifier systems for safe security.

## V. CONCLUSION

We applied the hierarchical main path analysis for understanding the knowledge structures, dynamic development flows, and future directions of the BM domain. The hierarchical main path analysis is a method that automatically decomposes TDs into an optimal number of sub-domains and simultaneously generates descriptive trajectories from both the overall TD view and each sub-domain view. This study found eight sub-domains under the BM domain (Financial data processing, Payment system, Healthcare, E-commerce, Managerial computing system, Business process system, Advertisement system, and Security system), identified BM patents of dominant knowledge, and confirmed the knowledge trajectories and development direction between sub-domains in BM development. The empirical results provide rich information to better understand the BM domain.

Managerial computing systems, E-commerce, Advertisement systems, and Financial data processing began in the development of the BM domain. Over time, Payment system, Healthcare, Business processing systems, and Security systems sub-domains were created and composed of knowledge from various sub-domains. In the sub-domain, the Advertisement system has the highest number of KP patents, as company profit/sales are directly related. The E-commerce sub-domain played an important role until 2015, but there has been no significant development after that. E-commerce has radically developed with changes in the Internet and smartphone environment. To date, innovative BMs of E-commerce have not been developed due to the lack of system and environment changes. However, with the current development of VR and metaverse, the development of E-commerce could be restarted. Security systems are growing continuously owing to the importance of personal information and security issues for companies. The Healthcare sub-domain was not initially found in the main path of the BM domain but was recently identified. However, given the mega-trends, including COVID, well-being, aging society, and so on,

the Healthcare sector will become a key sub-domain in the BM domain.

Although this study provides novel implications and is helpful for the fundamental understanding of the BM domain, there are some limitations to be addressed in further work. First, since most knowledge flows, especially forward citations, occur within the BM domain, this paper focuses on the knowledge flows within the domain. However, there are many knowledge in-flows from outside the BM domain. Most of the knowledge in-flows are from software patents, and BM patents are usually classified in the class for software patents as well. So, there is no credibility problem in the results. But, various knowledge in-flows can be signals for better understanding the knowledge sources and originality of inventive ideas. Further work will include all knowledge in-flows and out-flows in the dataset. Second, there are many companies in many TDs in the BM domain. This is because, unlike other TDs, the BM domain is about 'systemic methods for doing any business'. Even though different TDs have different BMs, all BM patents are classified into the same patent classification. However, this fact contains the clue that the BM domain can be used for cross-domain analysis. Therefore, further works will consider this fact and focus on analyzing knowledge relationships among different sectors. Third, as mentioned in Theoretical background, the BM domain has relatively many citations and produces a large knowledge network. Therefore, the size of main paths, particularly KP-based hierarchical main paths, is inevitably large. This network complexity is always a serious issue for a main path analysis. The basic concept/purpose of a main path analysis is to reduce network complexity without the omission of key knowledge flows. So, a complex main path network should be revised or improved. One potential solution is to redefine the knowledge inheritance mechanism for KP. The current mechanism gives the same weight to each backward citation of the target node. But the same weight clearly cannot reflect the real world. This weight mechanism can be improved by considering the similarity between the backward citation and the focal node. In addition, the backward-forward searching also has the possibility to identify many major knowledge flows if the KP values around the high-KP patents are the same. Therefore, the algorithmic improvement of the backward-forward searching can be a possible solution.

## APPENDIX FOOTNOTES

Number footnotes separately in superscripts numbers.<sup>1</sup> Place the actual footnote at the bottom of the column in which it is cited; do not put footnotes in the reference list (endnotes). Use letters for table footnotes (see Table 1).

<sup>1</sup>It is recommended that footnotes be avoided (except for the unnumbered footnote with the receipt date on the first page). Instead, try to integrate the footnote information into the text.

Label	Patent Number	Application Year	Class	KP	Title	Label	Patent Number	Application Year	Class	KP	Title
512	US5237495	1991	6	85.36	Production/purchase management processing system and method	1070	US5704045	1995	1	190.91	System and method of risk transfer and risk diversification including means to assure with assurance of timely payment and segregation of the interests of capital
523	US5249120	1991	6	108.89	Automated manufacturing costing system and method	1079	US5845265	1995	4	656.2	Consignment nodes
530	US5381332	1991	6	119.16	Project management system with automated schedule and cost integration	1103	US5689652	1995	1	512.28	Crossing network utilizing optimal mutual satisfaction density profile
537	US5301105	1991	3	341.84	All care health management system	1159	US5918208	1995	3	79.17	System for providing medical information
559	US5383113	1991	4	1271.86	System and method for electronically providing customer services including payment of bills, financial analysis and loans	1197	US5835897	1995	3	69.7	Computer-implemented method for profiling medical claims
564	US5231566	1991	4	737.25	Method and apparatus for producing a catalog	1198	US5611051	1995	6	88.48	Point of supply use distribution process and apparatus
580	US5301320	1991	6	106.43	Workflow management and control system	1208	US5712985	1995	6	112.5	System and method for estimating business demand based on business influences
589	US5241465	1991	6	82.72	Method for determining optimum schedule in computer-aided scheduling system	1255	US5615109	1995	6	98.02	Method of and system for generating feasible, profit maximizing requisition sets
599	US5305197	1992	7	393.97	Coupon dispensing machine with feedback	1323	US5615121	1995	6	84.26	System and method for scheduling service providers to perform customer service requests
609	US5283731	1992	4	1914.05	Computer-based classified ad system and method	1445	US6029150	1996	8	66.87	Payment and transactions in electronic commerce system
618	US5247578	1992	8	379.76	Process for exchange of rights between microprocessor cards	1456	US5923552	1996	6	55.55	Systems and methods for facilitating the exchange of information between separate business entities
652	US5424938	1992	1	196.19	Method and apparatus for providing access to a plurality of payment networks	1555	US5822737	1996	7	583.85	Financial transaction system
669	US5283829	1992	5	1132.51	System and method for paying bills electronically	1560	US5848395	1996	6	48.62	Appointment booking and scheduling system
738	US5521813	1993	6	122.96	System and method for the advanced prediction of weather impact on managerial planning applications	1565	US5905974	1996	1	207.44	Automated auction protocol processor
760	US5459656	1993	6	117.41	Business demand projection system and method	1595	US5948061	1996	7	508.18	Method of delivery, targeting, and measuring advertising over networks
762	US5630069	1993	6	110.45	Method and apparatus for creating workflow maps of business processes	1599	US5867821	1996	3	154.66	Method and apparatus for electronically accessing and distributing personal health care information and services in hospitals and homes
768	US5465206	1993	5	803.66	Electronic bill pay system	1600	US5963911	1996	6	97.75	Resource allocation
783	US5325292	1993	6	128.38	Tour/schedule generation for a force management system	1654	US5848396	1996	7	782.66	Method and apparatus for determining behavioral profile of a computer user
804	US5596642	1994	5	551.4	Network settlement performed on consolidated information	1676	US5794219	1996	2	491.2	Method of conducting an on-line auction with bid pooling
810	US5557514	1994	3	238.6	Method and system for generating statistically-based medical provider utilization profiles	1772	US5946662	1996	6	136.54	Method for providing inventory optimization
814	US5557518	1994	8	522.79	Trusted agents for open electronic commerce	1901	US6058379	1997	4	189.64	Real-time network exchange with seller specified exchange parameters and interactive seller participation
820	US5715314	1994	4	463.94	Network sales system	1920	US6128603	1997	1	111.27	Consumer-based system and method for managing and paying electronic billing statements
849	US5644727	1994	1	440.09	System for the operation and management of one or more financial accounts through the use of a digital communication and computation system for exchange, investment and borrowing	1946	US6021397	1997	1	195.97	Financial advisory system
873	US5774868	1994	6	117.8	Automatic sales promotion selection system and method	1976	US6119103	1997	1	98.47	Financial risk prediction systems and methods therefor
902	US5467268	1994	6	119.32	Method for resource assignment and scheduling	1989	US6119101	1997	4	143.13	Intelligent agents for electronic commerce
923	US5451998	1994	4	796.64	Home shopping video catalog	1996	US6119098	1997	7	192.36	System and method for targeting and distributing advertisements over a distributed network
956	US5504675	1994	7	688.76	Method and apparatus for automatic selection and presentation of sales promotion programs	2012	US5970475	1997	4	233.72	Electronic procurement system and method for trading partners
982	US5548506	1994	6	104.81	Automated, electronic network based, project management server system, for managing multiple work-groups	2060	US5899980	1997	2	500.6	Retail method over a wide area network
999	US5416694	1994	6	101.16	Computer-based data integration and management process for workforce planning and occupational readjustment	2065	US6151582	1997	6	68.15	Decision support system for the management of an agile supply chain
1007	US5592379	1994	1	202.46	Method and apparatus for pooling and distributing bond dividends	2109	US6006191	1997	3	60.7	Remote access medical image exchange system and methods of operation therefor
1029	US5740549	1995	7	615.02	Information and advertising distribution system and method	2115	US5960411	1997	5	118.03	Method and system for placing a purchase order via a communications network
1037	US5710889	1995	1	400.35	Interface device for electronically integrating global financial services	2134	US5953707	1997	6	112.19	Decision support system for the management of an agile supply chain
1056	US5724424	1995	5	1219.35	Digital active advertising	2135	US5903878	1997	7	405.78	Method and apparatus for electronic commerce
1057	US5671280	1995	8	130.22	System and method for commercial payments using trusted agents	2206	US5915241	1997	3	96.71	Method and system encoding and processing alternative healthcare provider billing
						2224	US5956700	1997	5	265.85	System and method for paying bills and other obligations including selective payor and payee controls
						2315	US6029141	1997	2	152.05	Internet-based customer referral system
						2454	US6009410	1997	7	278.34	Method and system for presenting customized advertising to a user on the world wide web

2458	US594 0812	1997	1	204.85	Apparatus and method for automatically matching a best available loan to a potential borrower via global telecommunications network	4953	US746 4040	2000	3	10.72	Apparatus and method for processing and/or for providing healthcare information and/or healthcare-related information
2712	US632 4522	1998	5	186.72	Electronic information network for inventory control and transfer	4955	US713 6835	2000	2	49.56	Credit card system and method
2731	US613 1087	1998	4	142.55	Method for automatically identifying, matching, and near-matching buyers and sellers in electronic market transactions	5029	US706 9235	2000	4	14.34	System and method for multi-source transaction processing
2753	US633 9766	1998	5	92.78	Electronic payment system employing limited-use account number	5255	US710 3565	2000	1	37.66	Initial product offering system
2765	US622 6620	1998	3	18.7	Iterative problem solving technique	5263	US717 7833	2000	1	115.04	Automated trading system in an electronic trading exchange
2796	US648 7538	1998	7	105.6	Method and apparatus for local advertising	5314	US658 7835	2000	2	296.08	Shopping assistance with handheld computing device
2820	US632 7578	1998	8	108.63	Four-party credit/debit payment protocol	5387	US689 5387	2000	7	48.8	Dynamic marketing based on client computer configurations
2917	US626 6649	1998	4	109.13	Collaborative recommendations using item-to-item similarity mappings	5502	US708 9208	2000	2	54.83	System and method for electronically exchanging value among distributed users
2922	US640 5180	1998	1	81.01	Automated exchange for matching bids between a party and a counterparty based on a relationship between the counterparty and the exchange	5564	US678 5671	2000	4	35.62	System and method for locating web-based product offerings
2956	US634 3271	1998	3	48.09	Electronic creation, submission, adjudication, and payment of health insurance claims	5573	US659 4644	2000	7	56.21	Electronic gift certificate system
3027	US627 5812	1998	6	79.87	Intelligent system for dynamic resource management	5688	US690 7401	2000	4	46.23	Portal switch for electronic commerce
3164	US628 9322	1998	5	97.18	Electronic bill processing	5942	US644 6045	2000	4	42.56	Method for using computers to facilitate and control the creating of a plurality of functions
3186	US657 8005	1998	6	53.3	Method and apparatus for resource allocation when schedule changes are incorporated in real time	6456	US685 0899	2000	4	28.04	Business process and apparatus for online purchases using a rule-based transferable shopping basket
3187	US620 5431	1998	6	114.07	System and method for forecasting intermittent demand	6993	US766 8761	2001	5	16.18	System and method for ensuring order fulfillment
3196	US612 8600	1998	4	75.56	Electronic shopping system and method of defining electronic catalogue data therefor	7075	US787 7286	2001	6	7.26	Subset optimization system
3222	US620 8973	1998	3	68.62	Point of service third party financial management vehicle for the healthcare industry	7190	US792 5513	2001	4	4.56	Framework for processing sales transaction data
3337	US626 6645	1998	3	45.08	Risk adjustment tools for analyzing patient electronic discharge records	7205	US724 9044	2001	4	25.1	Fulfillment management system for managing ATP data in a distributed supply chain environment
3360	US626 0024	1998	2	125.56	Method and apparatus for facilitating buyer-driven purchase orders on a commercial network system	7223	US708 0026	2001	6	33.47	Supply chain demand forecasting and planning
3369	US601 8713	1998	3	50.44	Integrated system and method for ordering and cumulative results reporting of medical tests	7229	US666 2166	2001	8	20.44	Tokenless biometric electronic debit and credit transactions
3517	US629 2786	1999	2	272.94	Method and system for generating incentives based on substantially real-time product purchase information	7333	US681 3612	2001	4	27.8	Remote bidding supplement for traditional live auctions
3572	US623 3566	1999	1	117.66	System, method and computer program product for online financial products trading	7409	US737 3314	2001	4	42.58	Unified product purchasing method
3592	US644 9599	1999	2	23.94	Network sales system	7490	US691 5275	2001	4	9.55	Managing customization of projects prior to manufacture in an electronic commerce system
3601	US663 6833	1999	5	95.15	Credit card system and method	7801	US716 5221	2001	3	18.17	System and method for navigating patient medical information
3613	US651 0418	1999	4	107.95	Method and apparatus for detecting and deterring the submission of similar offers in a commerce system	7864	US740 6434	2001	7	58.71	System and method for improving the performance of electronic media advertising campaigns through multi-attribute analysis and optimization
3628	US717 7836	1999	5	77.91	Method and system for facilitating financial transactions between consumers over the internet	7915	US717 7849	2001	8	25.17	Method for validating an electronic payment by a credit/debit card
3664	US706 9234	1999	4	34.69	Initiating an agreement in an e-commerce environment	7927	US655 3352	2001	6	34.49	Interface for merchandise price optimization
3684	US690 7566	1999	7	53.59	Method and system for optimum placement of advertisements on a webpage	8221	US720 3658	2001	2	10.92	Methods and apparatus for processing order related messages
3809	US691 0017	1999	6	42.13	Inventory and price decision support	9208	US737 0011	2001	4	68.43	Financial information portal
3908	US659 4643	1999	1	84.41	Automatic stock trading system	9472	US768 9504	2002	1	53.55	System and method for establishing or modifying an account with user selectable terms
3942	US609 8053	1999	5	115.33	System and method for performing an electronic financial transaction	9482	US698 5870	2002	3	23.57	Medication delivery system
4096	US640 5176	1999	4	34.13	Method for processing multiple electronic shopping carts	9502	US758 7363	2002	5	36.47	System and method for optimized funding of electronic transactions
4160	US646 3345	1999	5	66.61	Regenerative available to promise	9633	US743 7325	2002	1	35.92	System and method for performing automatic spread trading
4247	US685 3987	1999	8	20.31	Centralized authorization and fraud-prevention system for network-based transactions	9813	US775 6723	2002	3	6.36	System and method for managing patient bed assignments and bed occupancy in a health care facility
4268	US634 3273	1999	4	39.13	Computerized, multimedia, network, real time, interactive marketing and transactional system	10237	US759 9856	2002	4	14.41	Detection of fraudulent attempts to initiate transactions using modified display objects
4397	US658 7827	1999	4	35.91	Order fulfillment processing system	10246	US810 3538	2002	6	1.67	Method and system for forecasting demand of a distribution center and related stores
4846	US698 0962	2000	4	40.27	Electronic commerce transactions within a marketing system that may contain a membership buying opportunity	10469	US718 1419	2002	4	27.93	Demand aggregation system
4938	US717 7825	2000	5	43.35	Integrated system for ordering, fulfillment, and delivery of consumer products using a data network	10770	US777 8872	2002	7	19.46	Methods and apparatus for ordering advertisements based on performance information and price information
						11279	US758 4116	2002	6	10.48	Monitoring a demand forecasting process

11751	US770 7120	2003	8	23.85	Mobile account authentication service	21162	US892 4269	2007	4	25.42	Consistent set of interfaces derived from a business object model
12178	US737 9890	2003	6	30.57	System and method for profit maximization in retail industry	21208	US778 3571	2007	1	15.07	ATM system for receiving cash deposits from non-networked clients
12214	US727 5039	2003	6	20.69	Workflow management software overview	21214	US800 5740	2007	1	9.82	Using accounting data based indexing to create a portfolio of financial objects
12680	US706 9243	2003	4	17	Interactive remote auction bidding system	21257	US840 1936	2007	5	1	Architectural design for expense reimbursement application software
12922	US715 5397	2003	3	21.79	Apparatus and method for managing prescription benefits	21461	US824 9905	2007	6	3	Methods, systems, and computer-readable media for providing future job information
13216	US703 9611	2003	8	5.95	Managing attempts to initiate authentication of electronic commerce card transactions	21501	US835 2323	2007	2	14.01	Conducting an online payment transaction using an NFC enabled mobile communication device
13752	US817 5908	2004	6	42.44	Systems and methods for constructing and utilizing a merchant database derived from customer purchase transactions data	21505	US824 9965	2007	1	15.05	Member-supported mobile payment system
13754	US799 6324	2004	8	15.48	Systems and methods for managing multiple accounts on a RF transaction device using secondary identification indicia	21519	US789 0416	2007	4	1	Systems and methods for providing a trading interface
13906	US741 8407	2004	4	10.32	Method for electronic gifting using merging images	21771	US801 0404	2007	6	6.77	Systems and methods for price and promotion response analysis
13970	US751 6086	2004	7	11.01	Business rating placement heuristic	21815	US824 4590	2007	4	24.39	Software system for decentralizing ecommerce with single page buy
14036	US780 5383	2004	8	55.06	Price planning system and method including automated price adjustment, manual price adjustment, and promotion management	21948	US878 8278	2007	4	4.4	Consumer database loyalty program for a money transfer system
14111	US737 6572	2004	4	10.69	Return centers with rules-based dispositioning of merchandise	23118	US868 9124	2007	4	4.08	Method, medium, and system for simplifying user management of products during online shopping
14117	US801 0399	2004	6	6.17	Methods, systems, and articles of manufacture for analyzing initiatives for a business network	24691	US859 5077	2008	5	1	Architectural design for service request and order management application software
14470	US789 5077	2004	7	11.47	Predicting inventory availability and prioritizing the serving of competing advertisements based on contract value	24946	US832 1323	2008	1	4.5	Interprogram communication using messages related to order cancellation
14940	US716 2443	2004	4	15.04	Method and computer readable medium storing executable components for locating items of interest among multiple merchants in connection with electronic shopping	24977	US821 9489	2008	8	4.52	Transaction processing using a global unique identifier
15359	US736 4086	2004	7	56.61	Dynamic discount card tied to price curves and group discounts	25345	US878 1881	2008	6	21.78	Merchant benchmarking tool
15407	US782 2622	2004	3	1	System and method for medical appointment and examination sequence planning	25575	US815 5996	2008	6	7	System and method for customer care complexity model
15945	US810 3545	2005	7	13.4	Managing payment for sponsored content presented to mobile communication facilities	25674	US767 3791	2008	2	19	Method and apparatus for creating and exposing order status within a supply chain having disparate systems
15953	US812 1944	2005	5	10.9	Method and system for facilitating network transaction processing	26456	US823 9245	2008	6	3	Method and apparatus for end-to-end retail store site optimization
16007	US758 4123	2005	4	8	Systems for dynamically allocating finite or unique resources	28004	US836 4540	2009	7	8.41	Contextual targeting of content using a monetization platform
16092	US782 2688	2005	2	30.19	Wireless wallet	28071	US840 3211	2009	1	8.4	System, program product and methods for retail activation and reload associated with partial authorization transactions
16169	US781 3963	2005	4	1	Interactive electronic desktop action method and system for executing a transaction	28165	US897 7565	2009	1	3	Interprogram communication using messages related to groups of orders
16295	US814 0592	2005	5	13	Delivery operations information system with route adjustment feature and methods of use	28221	US804 6242	2009	3	3.33	Systems and methods for verifying prescription dosages
16408	US870 6515	2005	3	4	Methods, systems, and apparatus for providing a notification of a message in a health care environment	28564	US863 9525	2009	3	7	Drug labeling
16436	US777 8873	2005	7	18.65	System and method of providing advertisements to Wi-Fi devices	28861	US878 8429	2009	8	5.4	Secure transaction management
16584	US787 0077	2005	5	19.95	System and method for buying goods and billing agency using short message service	30714	US840 1897	2009	7	4.33	System and method of displaying ads based on location
17836	US757 7600	2005	1	10.59	System and method for regulating order entry in an electronic trading environment	31052	US934 2835	2010	7	20.06	Systems and methods to deliver targeted advertisements to audience
18274	US782 2682	2006	5	12.63	System and method for enhancing supply chain transactions	31159	US819 6811	2010	4	8.54	Multiple criteria buying and selling model
18281	US777 8456	2006	8	42.7	Automatic currency processing system having ticket redemption module	31230	US835 5987	2010	5	8.13	Systems and methods to manage information
18326	US839 6749	2006	5	12.29	Providing customer relationship management application as enterprise services	31278	US835 5948	2010	4	26.19	System and methods for discount retailing
18373	US848 9067	2006	2	21.52	Methods and systems for distribution of a mobile wallet for a mobile device	31283	US868 8468	2010	3	1	Systems and methods for verifying dosages associated with healthcare transactions
18405	US773 4533	2006	1	11.03	Method and system for electronic trading via a yield curve	31386	US806 0435	2010	4	0	Systems and methods for providing a trading interface
18534	US768 9469	2006	4	60.57	E-commerce volume pricing	31861	US827 5590	2010	4	4.94	Providing a simulation of wearing items such as garments and/or accessories
18543	US804 1616	2006	6	9	Outsourced service level agreement provisioning management system and method	32550	US867 6706	2010	5	3	Online check register using check imaging
18602	US790 9246	2006	1	7.11	System and method for establishment of rules governing child accounts	33461	US816 5948	2010	1	5	System for selecting and purchasing assets and maintaining an investment portfolio
18862	US765 7466	2006	4	14.4	Systems and methods for providing personalized delivery services	34159	US963 6791	2010	1	0	System for and a method of transmitting data in a central trading system
21150	US820 0520	2007	6	4	Methods, systems, and apparatuses for automated confirmations of meetings	34484	US967 9299	2011	7	11.46	Systems and methods to provide real-time offers via a cooperative database
						34521	US822 9851	2011	8	43.11	Methods and systems for exchanging/transferring gift cards

34535	US820 4770	2011	4	0	Computer-implemented systems and methods for resource allocation	42640	US104 45682	2014	5	4.18	Systems and methods for parcel delivery to alternate delivery locations
34586	US827 1332	2011	4	4.55	DAS predictive modeling and reporting function	42700	US944 9296	2014	3	6	Management of pharmacy kits using multiple acceptance criteria for pharmacy kit segments
34714	US827 1313	2011	6	4	Systems and methods of enhancing leads by determining propensity scores	42738	US108 25007	2014	4	0	Remote transaction processing of a transaction server
34859	US896 5788	2011	4	15	Search page topology	42801	US103 54264	2014	6	0	Contact recommendations based on purchase history
34927	US871 2923	2011	5	11	Computer system for routing package deliveries	42983	US102 35686	2014	6	0	System forecasting and improvement using mean field
35470	US811 2353	2011	2	16.46	Payment service to efficiently enable electronic payment	43047	US104 30753	2014	5	0.5	System and method for international merchandise return service
35843	US913 5632	2011	7	1	Methods and systems for ad placement planning	43648	US989 8767	2014	4	1	Transaction facilitating marketplace platform
36784	US830 6850	2011	6	1.67	System and method for strategizing interactions with a client base	43733	US100 68057	2014	3	0	Systems and methods for integrating, unifying and displaying patient data across healthcare continua
37116	US841 7548	2011	3	0	Medical service support apparatus	43911	US105 40621	2014	6	0	Inventory mirroring
37931	US970 4155	2012	8	9.49	Passing payment tokens through an hop/sop	44106	US988 6705	2014	7	0	Advertisement opportunity bidding
37947	US857 7803	2012	5	48.76	Virtual wallet card selection apparatuses, methods and systems	44336	US969 1105	2014	5	0	Analyzing calendar to generate financial information
37983	US849 4914	2012	4	3.67	Promoting offers through social network influencers	45482	US104 45667	2014	6	1	System and method of work assignment management
38045	US899 0099	2012	3	6	Management of pharmacy kits	45502	US103 18993	2014	7	1	Cross-channel personalized promotion platform
38144	US862 6563	2012	6	1	Enhancing sales leads with business specific customized statistical propensity models	46295	US895 9146	2014	7	1	Media properties selection method and system based on expected profit from profile-based ad delivery
38263	US931 7835	2012	5	3	Populating budgets and/or wish lists using real-time video image analysis	46444	US103 90101	2015	7	0	Advertisement rotation
38351	US972 1262	2012	7	0.5	Systems and methods for providing time-sensitive communications of targeted advertisements to mobile devices	46448	US112 44264	2015	6	0	Interleaving surprise activities in workflow
38683	US909 2776	2012	2	21.23	System and method for managing payment in transactions with a PCD	46453	US953 0131	2015	5	0	Transaction processing using a global unique identifier
38902	US856 6224	2012	1	0	Systems and methods to create, compare, customize, promote, track, optimize and shop for index or theme based portfolios of securities	46456	US110 23890	2015	2	0.33	Identification and verification for provisioning mobile application
39519	US844 2854	2012	6	2	System and method for estimating residual lifetime value of a customer base utilizing survival analysis	46476	US100 26087	2015	2	0.33	Data passed in an interaction
39933	US825 5266	2012	6	1.17	Forecasting demand for products	46481	US984 6878	2015	8	2.45	Payment account identifier system
41128	US966 5874	2013	4	0	Systems and methods for tailoring marketing	46485	US104 10165	2015	5	0.5	Systems and methods for facilitating shipping of parcels for returning items
41133	US952 4501	2013	1	22.63	Method and system for correlating diverse transaction data	46486	US104 10164	2015	5	0.5	Systems and methods for facilitating shipping of parcels
41136	US983 0595	2013	5	25.12	System and method of providing tokenization as a service	46494	US100 02341	2015	4	1	Systems and methods for returning one or more items via an attended delivery/pickup location
41144	US935 5393	2013	2	14.69	Multi-directional wallet connector apparatuses, methods and systems	46502	US105 10055	2015	8	2	Ensuring secure access by a service provider to one of a plurality of mobile electronic wallets
41224	US862 0754	2013	2	8.18	Remote transaction processing using authentication information	46531	US973 4294	2015	3	0	Management of pharmacy kits
41271	US922 4114	2013	6	0	Methods, systems, and computer-readable media for generating a report indicating job availability	46621	US950 8089	2015	7	0	Method and systems for directing profile-based electronic advertisements via an intermediary ad network to visitors who later visit media properties
41414	US965 2776	2013	6	1	Visual representations of recurring revenue management system data and predictions	46629	US103 80631	2015	7	1	Systems and methods to provide advertisements for real time communications
41777	US925 1484	2013	6	4	Predicting likelihood of on-time product delivery, diagnosing issues that threaten delivery, and exploration of likely outcome of different solutions	46695	US983 6743	2015	7	7	Systems and methods to register merchants for data processing in an electronic transaction system
42531	US102 23730	2014	4	3	E-wallet store injection search apparatuses, methods and systems	46701	US102 82797	2015	7	0	Inference model for traveler classification
42553	US111 64176	2014	8	1	Limited-use keys and cryptograms	46752	US956 9781	2015	6	1	Methods for providing cross-vendor support services
42576	US946 6074	2014	7	6	Advertising impression determination	46833	US957 8071	2015	6	0	Context aware interaction
42585	US103 95237	2014	4	0	Systems and methods for dynamic proximity based E-commerce transactions	46936	US104 82517	2015	4	0	Providing a simulation of wearing items such as garments and/or accessories
42597	US971 0807	2014	4	3	Third-party value added wallet features and interfaces apparatuses, methods and systems	47068	US995 9532	2015	5	0	Secure element authentication for remote deposit capture compatible check image generation
42604	US111 64142	2014	2	0	Multi-entity management of a node in a wireless node network	47069	US995 9533	2015	5	0	Secure element authentication for remote deposit of check images received from payors
42608	US110 55710	2014	5	4	Systems and methods for verifying and processing transactions using virtual currency	47086	US101 85926	2015	3	0	Component based aggregation of medication orders
42611	US105 10073	2014	8	2	Methods and systems for provisioning mobile devices with payment credentials	47196	US106 50344	2015	6	0	Inventory mirroring in a heterogeneous fulfillment network
42616	US103 66387	2014	2	7.49	Digital wallet system and method	47373	US101 69802	2015	4	0	Data refining engine for high performance analysis system and method
42623	US102 62340	2014	7	1	Method and apparatus to allocate and recycle telephone numbers in a call-tracking system	47491	US106 85319	2015	5	0	Big data sourcing simulator

47523	US102 82777	2015	4	0	Recently viewed items display area
47599	US103 80646	2015	7	0	Platform for providing customizable user brand experiences
48481	US100 02380	2015	4	0	Beacon service method and device
48669	US103 80637	2016	7	0	Systems and methods to provide voice connections via local telephone numbers
48672	US109 90967	2016	5	0	Method of distributing tokens and managing token relationships
48673	US105 52828	2016	8	0	Multiple tokenization for authentication
48675	US106 64883	2016	4	0	System and method for monitoring activities in a digital channel
48676	US103 39554	2016	7	1	Systems and methods to provide messages in real-time with transaction processing
48681	US102 68891	2016	5	0	Retrieving product information from embedded sensors via mobile device video analysis
48710	US105 46283	2016	8	0	Mobile wallet as a consumer of services from a service provider
48721	US105 46284	2016	8	0	Mobile wallet as provider of services consumed by service provider applications
48852	US961 9794	2016	2	1	Systems and methods for providing compensation, rebate, cashback, and reward for using mobile and wearable payment services, digital currency, NFC touch payments, mobile digital card barcode payments, and multimedia haptic capture buying
48914	US985 8605	2016	6	0	Methods and apparatus for generating a unique virtual item
49015	US107 83488	2017	5	0	Systems and methods of locating and selling items at attended delivery/pickup locations
49025	US104 97037	2017	4	1	System and method for managing cryptocurrency payments via the payment request API
49027	US111 64167	2017	2	0	Systems and methods for virtual currency exchange at a mobile event
49031	US109 02445	2017	6	0	Location evaluation
49080	US111 82833	2018	6	0	Estimating annual cost reduction when pricing information technology (IT) service deals
49082	US108 39386	2018	4	0	Stored value smart contracts on a blockchain
49090	US112 76033	2018	6	0	System and method for fine-tuning sales clusters for stores
49093	US108 32296	2018	4	0	Transaction management system, transaction management method, and program
49106	US110 49130	2018	3	0	Integrating custom benefits into an in-use communication transmission exchange
49135	US110 74218	2019	5	0	Multi-source, multi-dimensional, cross-entity, multimedia merchant analytics database platform apparatuses, methods and systems
49136	US106 28842	2019	7	0	Systems and methods to communicate offer options via messaging in real time with processing of payment transaction
49172	US111 20451	2019	5	0	System and method for mobile express return of products

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