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Exploring technology diffusion and classification of business methods: Using the patent citation network

Shann-Bin Chang [a,*], Kuei-Kuei Lai [b], Shu-Min Chang [c]

[a] Ling Tung University, Department of Commercial Technology & management, Taichung 40852, Taiwan
[b] National Yunlin University of Science and Technology, Dept. Business Administration, Douliou, Taiwan
[c] Nan Kai Institute of Technology, Department of Industry Engineering & Management, Nantou, Taiwan, PhD Program of BA at National Yunlin University of Science and Technology, Douliou, Taiwan

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ABSTRACT

Among the many technology forecasting indicators, patents and patent citations are useful and important indicators. The more frequently a certain patent is cited by subsequent patents, the more the related technology can be said to be diffused, implying that the technology is more widely applied and thus more valuable. This paper analyzes the business methods technology which retrieves patents from the USPTO database. There are two purposes of this paper: 1. establish the indicators for finding basic patents and measure the relationship of these basic patents; 2. classify the basic patents and explain the groups of technology diffusion. Finally, this study identifies the two mainstreams in business method technology: one is focused on marketing technology, and the other one stresses on data security. Both are important for Internet data processes or e-commerce activities.

1. Introduction

In the face of rapidly changing technologies, the capability of an enterprises to keep ahead of new technologies, monitor technological development, and acquire and apply the most appropriate new technologies is critical to competing successfully. Among the many technology forecasting indicators, patents are a mature and objective indicator. In a patent document, an inventor must describe the prior art of the invention, which is usually presented by citing former patents or previous literature. The more frequently a certain patent is cited by subsequent patents, the more the related technology can be said to be diffused, implying that the technology is more widely applied and thus more valuable. Therefore, patent citations not only imply the importance of a patent, but they also regarded as tracing the spread of technology. Through patent citation, people can explore the technologies diffusion of a certain technology domain.

Since Internet technology began sweeping the world, almost every company has come to view it as a new stage with which to compete in the 21st century. Business methods based on network technologies have become weapons in this battle for success. Following the announcement of the *Examination Guidelines for Computer-Related Inventions* by the United States Patent and Trademark Office (USPTO) in 1996 [1], a Business Methods Patent White Paper titled *Automated Financial or Management Data Processing Methods* was published in 2000 [2]. Additionally, several legal precedents in the U.S. Court of Appeals for the Federal Circuit (CAFC), such as State Street Bank & Trust Co. v. Signature Financial Group, Inc. and Amazon.com v. Barnes & Noble, clearly illustrated that business methods can be patented. These phenomena have made competition for patenting business methods very intense. Therefore, this study focuses on business methods technology and draws upon the largest patent database in the world, the USPTO, as its source of information.

Because patent citations are related to technology diffusion, this study uses a patent citation network to satisfy two purposes. The first is to establish two indicators to find basic patents from numerous patents and to measure the relationship of these basic

* Corresponding author.
E-mail address: stephen.22@hotmail.com (S.-B. Chang).

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patents. The second is to by using the above indicators classify the basic patents by hierarchical cluster analysis and to explain the meanings of each group of technology diffusion.

As to measuring the patent citation, this study establishes an indicator which uses the lineal relationship that combines direct and indirect citations. This method was applied to literature analysis by Chang et al. [3] and the results were successful. The rest of this paper is organized as follows. Section 2 reviews some relevant literature; Section 3 introduces the methodology; Section 4 includes the data analysis; and Sections 5 and 6 are the discussion and summary, respectively.

2. Literature review

The domain literature related to this paper can be divided into three parts: technology change and technology life cycle; technology diffusion and patents citation; and basic patents. They are discussed in the following subsections.

2.1. Technology change and technology life cycle

In past studies, scholars have often classified technology change into two types: incremental and radical. Incremental change means that people use existing knowledge or technologies to develop a new technology, which is an enhancement of product technology [4]. According to Foster in 1986, if investment in R&D is depicted on the *x*-axis, and the technical effectiveness indicator is the *y*-axis, then the relationship follows an 'S'-like curve [5]. This kind of technology change is incremental and is referred to as enhancing 'efficiency'. On the other hand, if people cannot use the existing knowledge or technologies to develop the new technology, then the existing knowledge can be replaced, and this will be a radical change in technology. This kind of change is called competence destroying [6]. Foster described it as radical development by technology discontinuity [5]. This change produces another discontinuous S-curve and is a type of 'effectiveness' development.

There are many models which discuss the reasons for enterprises experiencing incremental and radical development, such as the viewpoints of Schumpeter [7], the innovation model of Abernathy–Clark [8], and the Henderson–Clark [9] model [9]. These models belong to the static model classification of innovation theory. Dynamic models describe the process of the new technology from its appearance to its disappearance. These models include the Utterback–Abernathy [10] dynamic model[10], the Tushman–Rosenkopf [11] technology life-cycle model [11], and the Scurve. The dynamic model takes into consideration that technology is generated by people using their knowledge. Therefore, these dynamic models have the characteristics of a life cycle. The present study recognized the technology life cycle. This life cycle can be divided into four phases: emerging, growth, mature, and saturation phases [12]. If depicted by using an orthogonal coordinate, the *x*-axis represents the investment of R&D (such as time, cost, and efforts) and the *y*-axis stands for the effectiveness of technology (such as speed, capacity, and volume) or proxy indicators (such as patents or technical reports). The technology life cycle of the four phases will be illustrated as a sharp S-curve.

2.2. Technology diffusion and patent citation

Diffusion is a process in which an innovation is spread through some specific paths in a social system [13]. One popular diffusion model is the Bass [14] diffusion model which has been modified into many different versions [15], especially when applied to the marketing field. The development of the theoretical foundation of the Bass diffusion model is combined with two diffusion models, Fourt and Woodlock [16] and Mansfield [17]. The former thought that the diffusion process was mainly affected by the mass media. This diffusion process can be viewed as an external effect. The latter thought of the diffusion process as being mainly affected by "word of mouth" related to the number of people who used it in the early stages, which is an internal effect. Based on the Bass model, Rogers used the symmetrical concept of normal distribution to classify technology consumers into five categories: innovators, early adopters, early majority, late majority, and laggards [13]. Extending the concept of Rogers, Moore proposed the technology adoption life cycle (TALC) concept, in which innovative firms build up different marketing strategies at different stages on the basis of the characteristics of the consumers [18].

As for the technology diffusion model, the only difference from the above models is that the diffusion object changed from product to technology. Geroski sorted technology diffusion models into four categories: epidemic, probit, density dependent growth, and information cascades [19]. Additionally, Bocquet, Brossard and Sabatier separated technology diffusion models into three theoretical approaches: epidemic, rank, and game theory approaches [20]. The most commonly used is the epidemic model, which builds on the premise that what limits the speed of usage is the lack of information available about the new technology, how to use it, and what it does. The rank approach is like a probit model which follows from the premise that different firms with different goals and abilities are likely to want or adopt the new technology at different times. With regard to other approaches, including density dependent growth, information cascades models, and game theory approach, they were merely discussed in past literature.

There are many methods for technology diffusion in the industries. In practice, product exhibitions or expositions, technology conferences, and technology licensing and transfers are possible ways to diffuse technologies. However, the diffusion effect of the above methods cannot be observed or measured clearly. A patent is a medium for the disclosure of technology. In the content of a patent, the "prior art" illustration is a critical element. The meanings of prior art is to clearly explain the developmental trace of the technology of the invention. The prior art is presented in words and through citing linkages, such as patents, journals, or other literature. From another aspect, the more a patent is cited, the wider the technology is diffused, and it implies that the applications and values of the patent are higher [21–24]. The process of patent citation is like the epidemic model of technology diffusion.

Patent citation analysis can be used to combine social network theory or bibliometrics methods. There are many studies in the literature integrating patent citations and social networks [25,26]. Lai and Wu [27] and Daim et al. [28] also combined bibliometrics with patent analysis to classify semiconductor technology and to forecast emerging technologies, respectively. Furthermore, Lai and Chang used patent citation to fit the Bass diffusion model, and found that direct citation of a patent had a mass media effect, while indirect citation had a "word of mouth" effect. These results indicate that technology diffusion can be observed or measured by patent citation, including direct and indirect citation [29].

In addition, Chang et al. established an indicator which uses the lineal relationship that combines direct and indirect citation to analyze literature on patent analysis [3]. The results of Chang et al. are better than those of another study by Lai et al. which employed bibliometrics methods [30]. Therefore, this study uses the patent citation network method as generated by Chang et al. [3] to explore the technology diffusion trajectories and to classify basic patents.

2.3. Basic patents

There is no a clear definition of a basic patent in the literature, and there are no objective criteria to examine a basic patent. In practice, if a certain patent is at a critical position in its field of technology, and most technologies following need to cite that certain technology, then that patent can be called as a basic patent. However, the basic patent in a certain field of technology is not unique and depends on the method of classification and search [31]. The role of the basic patent in a diffusion model is similar to the origins of an epidemic infection or mass media in the Bass model. Lai and Chang [29] used three criteria to examine the basic patent: 1. the frequency with which a patent was cited; 2. the number of companies citing the patent, and 3. the number of categories to which the patent can be applied. If these indicators are higher, then the patent being called a basic patent is better qualified.

Although Lai and Chang [29] used direct and indirect citations to fit the Bass diffusion model, their paper did not use indirect citation to qualify the basic patent. Furthermore, their study did not discuss the position of basic patents in the process of technology development. Therefore, our study will use the patent citation network to find the position of basic patents. This method is similar to, but not the same as the social network analysis [32]. This study not only establishes an indicator to measure basic patents, but it also calculates the relationships between basic patents.

3. Methodology

This section describes the methodology framework for our study of how to retrieve US patents; how to establish an indicator of basic patents; and how to formulate the relationships of basic patents.

3.1. Retrieve U.S. patents

This study focuses on the field of business methods technology and draws upon the largest patent database in the world, the USPTO, as its source of information. There are two criteria for retrieving US patents:

(1) "Current US Class" of patents must include US Class 705. The title of Class 705 is "Data Processing: financial, business practice, management, or cost/price determination". Class 705 was designed for the Business Methods Patent White Paper (2000) titled *Automated Financial or Management Data Processing Methods*.
(2) The "Issued date" of the patents must be between January 1, 1993 and June 30, 2006. This study focuses on business method technologies which are based on Internet or e-commerce. The year 1993 is of particular significance because it was the year the first business browser Mosaic was born and the emergence of e-commerce. Therefore, the patents selected were those issued after Jan 1, 1993 until June 30, 2006.

3.2. Establish indicator of basic patents

Before establishing the indicator of basic patents, this study discusses the concept of the patent citation network. If there are 10 patents that are sorted by date applied, and named A, B….J, respectively, the relationships of these patent citations are checked and drawn as the network in Fig. 1.

Using the same data, the relationship with the patent citation matrix C_{ij}, is described as shown in Table 1. For example, Patent C was cited by F, G, H, and therefore, $C_{3,6}=C_{3,7}=C_{3,8}=1$, and $C_{3,j}=0$ for $j=1,2,3,4,5,9$.

These patents are sorted by date, so the citation relationship must be that newer patents cite older patents. Therefore, all cells of the lower triangle of the patent citation matrix C_{ij} are 0. Additionally, if a patent is isolated, such as Patent I, all the cells on the row and column of I are 0, and therefore the row and column of I can be deleted.

Before continuing, some specific terms need to be defined:

a. Lineal relationship: This relationship is like father and son, or grandfather and grandson. The former is called a direct citation; while the latter is called an indirect citation. Both of them are measured in this study, and Table 1 is used to describe them as follows.
   - Direct citation: If $C_{ij}=1$, it says that patents i,j have a direct citation relationship. Refer to Table 1, $C_{1,3}=1$, it says that patent A and C have a direct citation relationship.

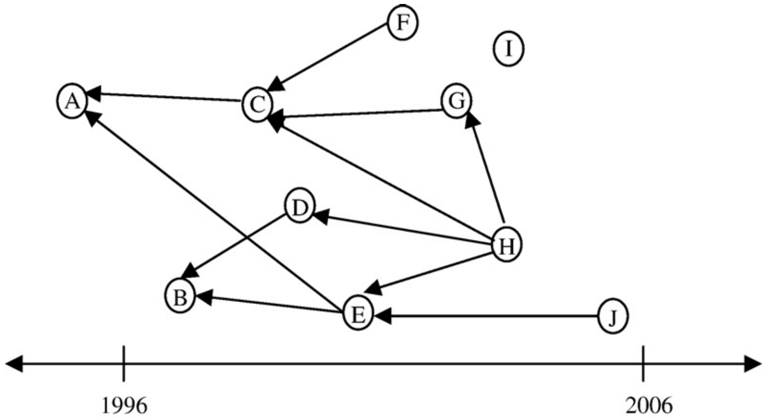

Fig. 1. Patent citation network.

- Indirect citation: If $C_{ij} \neq 1$, but $C_{ik}=1$, $C_{kj}=1$, it says that patents *i,j* have an indirect citation relationship. For example, Patent F did not directly cite Patent A ($C_{1,6} \neq 1$), but Patent F cited Patent C ($C_{3,6}=1$), and Patent C cited Patent A ($C_{1,3}=1$). So, it says that Patents F and A have an indirect citation relationship.

b. Collateral relationship: This relationship is like between brothers, or between uncle and nephews. Bibliographic coupling and co-citation are typical methods which apply a collateral relationship. This relationship is not used in this study.

Both direct and indirect citations impact technology diffusion. Lai and Chang treated direct citation as an innovative adopter of the diffusion model and indirect citation as an imitative adopter of the diffusion model, and they used the Bass model to examine the diffusion process [29]. The resulting goodness of fit was found to be very high. Therefore, this study combines direct and indirect citation in a lineal relationship for the following analysis.

Define the indicator *V* for measuring basic patents as Eq. (1).

$$V(P) = n + \beta \sum_{i}^{n} V(Q_i), \text{ if n>0} \qquad (1)$$
$$V(P) = 0, \text{ if n} = 0$$

V is a strength indicator of a Patent *P*, which was named the Literature Strength Coefficient by Chang et al. [3] The constant *n* is the number of patents directly citing Patent *P*, and these patents are represented by Q_i ($i=1\ldots n$). If a patent Q_i is an end note in a patent citation network, like F, H, J in Fig. 1, then that means that no patent cites Q_i and $n=0$, and then $V(Q_i)=0$. The parameter β ($0 \leqq \beta \leqq 1$) represents the importance of an indirect citation. Letting $\beta=0$, *V* only calculates the direct citation effect; while if $\beta=1$, the indirect effect is equal to the direct effect. This study lets $\beta=0$, 0.3, 0.5 to calculate the indicator *V*(*P*) and select basic patents.

3.3. Formulate the relationships of basic patents

In order to measure the relationships of basic patents, this study establishes an indicator *R*(*P*, *Q*) to calculate the lineal linkage of two patents *P* and *Q* as Eq. (2). This indicator was named the Lineal Linkage Coefficient by Chang et al. [3]

$$R(P,Q) = \sum_{i=1}^{n} \alpha^{\text{link}(i)}, \text{ if n>0} \qquad (2)$$
$$R(P,Q) = 0, \text{ if n} = 0$$

Table 1
Patent citation matrix

Cited	Citing	A	B	C	D	E	F	G	H	J	Sum
A				1		1					2
B					1	1					2
C							1	1	1		3
D									1		1
E									1	1	2
F											0
G									1		1
H											0
J											0

The constant n is the number of paths from Q to P, and link(i) represents the number of intermediate patents in the ith path from Q to P ($i=1\ldots n$). If patent Q cites patent P directly and there are no other paths from Q to P, then $R(P,Q)=1$. If there is no anyone path from Q to P, then $R(P,Q)=0$. The parameter α ($0<\alpha\leqq 1$) represents the decline effect of intermediate patents. If α is larger, then the decline effect of the intermediate patents is smaller, and the indirect relationship between P and Q is larger. In this study, we always set α equals to 0.5. This means that if one patent is within the path of two other patents, the lineal linkage of the two patents is 0.5.

4. Data analysis

This section presents the study data analysis divided into four sequential steps: business methods patent retrieval; select basic patents; calculate the lineal linkage of the basic patents; and cluster analysis.

4.1. Business methods patents retrieval

Based on the criteria in Section 3.1, the "Current US Class" field of patents was set to include US Class 705 (as previously discussed) and the "Issued date" field was set to be between January 1, 1993 and June 30, 2006. These selection criteria retrieved 10,386 entries of patents from the USPTO database. Table 2 includes the descriptive statistics of patents from 1993 to 2006. The mean and standard deviation (S.D.) will be discussed in Section 4.2. This study used the relationships of the "patent number" and the "US ref" fields to build the 10,386 by 10,386 patents citation matrix (like Table 1) which is the input data for Eqs. (1) and (2).

4.2. Select basic patents

In Eq. (1), this study lets β be equal to 0, 0.3 and 0.5 to calculate the strength indicator $V(P)$, respectively. The patents ranks of $V(P)$ are in the top 50 for each β, and these patents are set as the basic patents. Based on experience in patent analysis, these patents are older and their rate of citation is higher. Referring to the results of $V(P)$, most of the basic patents are older. Exactly, all of the basic patents were issued before 1999 if only Eq. (1) only is used to select the basic patents.

In order to include any of the younger patents that had the characteristics of basic patents but were not be included in the top 50 of $V(P)$, this study added another condition of selecting the younger patents as basic patents. This means that those patents are selected that have a higher citation rate than the upper bound of three standard deviations in its issued year. For example, if a patent was issued in 2002, and the patent was cited more than 14.07 times, then that patent was designated as a basic patent. (See the Table 2)

Combining these two methods, this study selected 161 patents as basic patents from the 10,368 patents. The numbers of basic patents which were generated by two methods are listed in Table 3. Only two patents in 1997 of the 3 S.D. method are not covered by the $V(P)$ method before 1999. This result means that the $V(P)$ method is a more complete method for finding older patents, and that the 3 S.D. method is suitable for younger patents.

4.3. Calculate the lineal linkage of basic patents

Based on the 10,386 by 10,386 patents citation matrix, Eq. (2) was used to calculate the lineal linkage of these patents, and to generate a 10,386 by 10,386 relationship symmetrical matrix $R(P,Q)$. From the 10,386 by 10,386 matrix $R(P,Q)$, this study only

Table 2
Description statistics of business method patents from 1993 to 2006

Year	Number of patents	Cited frequency equal to 0	Cited frequency not equal to 0	Citation mean	Citation S.D.	3 S.D. upper bound
1993	250	14	236	21.52	25.91	99.25
1994	268	8	260	18.77	22.90	87.47
1995	201	15	186	19.03	23.32	88.98
1996	273	15	258	17.45	21.34	81.47
1997	381	32	349	16.73	20.80	79.14
1998	741	49	692	15.93	22.43	83.24
1999	1003	86	917	11.36	13.38	51.49
2000	1059	128	931	7.41	7.59	30.17
2001	879	199	680	5.15	6.36	24.22
2002	881	281	600	3.25	3.61	14.07
2003	941	511	430	2.23	1.98	8.18
2004	993	770	223	1.58	1.14	5.00
2005	1446	1358	88	1.14	0.51	2.66
2006	1070	1069	1			
Total	10,386	4535	5851			

Note: Mean and S.D. only calculated from the patents that cited frequency not equal to 0.

Table 3
Year distribution of basic patents by two methods

Method	93	94	95	96	97	98	99	00	01	02	03	04	05	Total
$V(P)$	19	19	12	6	9	13	4	0	0	0	0	0	0	82
3 S.D.	3	9	6	5	10	13	24	18	13	8	9	7	2	127
Both	3	9	6	5	8	13	4	0	0	0	0	0	0	48
Total	19	19	12	6	11	13	24	18	13	8	9	7	2	161

retrieved the relationships of 161 basic patents. This means that the 161 by 161 submatrix was built from the full relationships matrix. Additionally, the cells of the 161 by 161 matrix were examined and four patents were found that were not related to the others. These four patents were then deleted and the matrix became to 157 by 157.

Why was the 161 by 161 basic patents citation matrix not used directly to build the relationship matrix $R(P,Q)$? Because, as with other patents there can be intermediate patents between basic patents. Therefore if non-basic patents are excluded to calculate the lineal linkage strength, then part of the indirect relationships of the basic patents will be lost. Using the retrieved basic patents and Eq. (2), a 157 by 157 symmetrical matrix $R(P,Q)$ was generated where the cells of the matrix represent the lineal linkage strength of the basic patents. The 157 by 157 matrix was then used as the input data for classifying the basic patents in the next step.

4.4. Cluster analysis

There are many methods for classifying basic patents, like factors analysis, MDS or cluster analysis. This study utilized the hierarchical cluster analysis to classify these basic patents. The reasons are twofold: 1. hierarchical cluster analysis can record the process of the cluster; and 2. the concept of the hierarchical cluster analysis implies the collateral relation that can compensate the lineal linkage.

In general, the input data for hierarchical cluster analysis is a symmetrical correlation matrix or a similar matrix. The domain values of the matrix are between −1 to +1 or 0 to 1. In this study, the maximum value of matrix $R(P,Q)$ is 29.3 and the minimum value of matrix is 0. In order to make cluster analysis suitable, the matrix $R(P,Q)$ was transferred to a new matrix $NewR(P,Q)$ by Eq. (3).

$$\begin{aligned} \mathrm{NewR}(P,Q) &= \sqrt{R(P,Q)/\mathrm{Max}(R(P,Q))} \quad &&, \text{ if } \quad \mathrm{P}\neq\mathrm{Q} \\ \mathrm{NewR}(P,Q) &= 1 &&, \text{ if } \quad \mathrm{P}=\mathrm{Q} \end{aligned} \tag{3}$$

where the $\mathrm{Max}(R(P,Q))$ is the maximum value of matrix $R(P,Q)$ or 29.3. The purpose of the division is to transfer the domain value between 0 and 1, and the purpose of the square root is to decline the bias of tiny values. This study set 1 to diagonal of NewR (P,Q) meaning that the relationship of oneself is equal to 1.

How many groups are suitable when using hierarchical cluster analysis? There are no absolute rules. In general, the suitable groups are between 3 and 8, or the sample sizes are 20 times the group number [33]. Finally, hierarchical cluster analysis was used with Ward's method and the squared Euclidean distance to classify 157 basic patents into 8 groups. The number of groups agrees with the above rules.

5. Results and discussions

The eight groups of patents were generated by cluster analysis. This paper lists the summary of the cluster analysis in Table 4 and discussions are provided below. (Appendix lists the 157 basic patents' number by groups)

Table 4
Summary of cluster analysis

Group	Volume	First Issued date	Last Issued date	US 705 sub-class	Major technologies
G1	12	1993.02.09	2005.01.04	14,16	Distribution or redemption of coupon, or promotion program; POS or electronic cash register
G2	10	1993.03.30	1996.09.17	56,57,65,67,68,69,77	Usage protection of distributed data files; secure transaction
G3	24	1993.04.13	2004.01.06	14,26,27,39,74,75	Distribution and promotion; electronic shopping; finance; transaction verification
G4	22	1993.04.20	1998.04.14	51–59	Usage protection of distributed data files
G5	61	1993.08.17	2004.09.28	5, 10, 26, 27	Reservation, check-in, or booking, electronic shopping
G6	10	1998.03.03	2003.01.07	26, 75, 77	Protection of data transfer; secure transaction; electronic shopping
G7	16	1999.06.08	2004.02.24	54	Usage protection of distributed data files
G8	2	2002.05.07	2003.12.02	54	Usage protection of distributed data files

5.1. Eight groups discussion

There are 12 patents in Group 1. Although the number of patents is not large, the distribution of years from 1993 to 2005 is the longest among all groups. The major technologies of Group 1 are "distribution or redemption of coupon or promotion program" and "POS or electronic cash register". The first patent in Group 1 is US 5,185,695 named "Method and system for handling discount coupons by using centrally stored manufacturer coupons in place of paper coupons". Based on that patent, the followers invented new technologies for the distribution or redemption of the coupon, while some other patents combined the coupon with promotion action in 1999 and 2000.

There are only 10 patents in Group 2, and the distribution years from 1993 to 1996 are the shortest. The major technologies are entirely different from Group 1; "protection of distributed data files" and "secure transaction". This group is another starting point of business method technologies. There have not been significant assignees in Group 2, but the last patent US 5,557,518 by Citibank was very important in influencing the technologies of Group 6 [34].

There are 24 patents in Group 3; but the distribution time from 1993 to 2004 was less than Group 1. The number of patents increased gradually from 1993 to 2000 indicating that these technologies developed in a stable manner. The representative firms are Bell Communications Research and Amazon.com, major technologies that are expanding widely and are focused on "distribution and promotion", "electronic shopping", "finance", and "transaction verification". Some of the technologies overlap those in Group 1.

There are 22 patents in Group 4, and the distribution time from 1993 to 1998 was similar to Group 2. The major technologies include "protection of distributed data files", which is also similar to Group 2, but the representative firms, Digital Equipment Corporation, Citibank, and Xerox, are different from those in Groups 2. There are some interactions of technologies between Groups 2 and 4, and therefore these two groups will be merged in the next phase. This also shows that most firms were heavily involved in developing a technology for the protection of data transfer during this stage.

Group 5 is the largest group, with 61 patents and a distribution time from 1993 to 2004, with a peak from 1999 to 2000. The major technologies of Group 5 are "reservation, check-in or booking"; and "electronic shopping". These technologies are in the mainstream of business methods. Some technologies are overlapping with Group 3, and the distribution time is also similar to Group 3. Therefore these two groups will be merged in the next phase. The representative firms are IBM and Walker Asset Management.

There are 10 patents in Group 6, and the starting time is later than the previous five groups. The first patent of this group US 5,724,424 cites the last patent of Group 2, US 5,557,518, which means that this group was generated from Group 2. If we focus on the characteristics of technologies, the major technology was "protection of data transfer" and "secure transaction" before 1996. However after 1998 this group emphasized the business methods of "electronic shopping".

There are 16 patents in Group 7. It was surprising that 13 patents of this group belong to InterTrust Technologies Corp., implying that the technologies of this corporation are highly concentrated. This group was developed later and its technologies are similar to those of Groups 2 and 4, but are not grouped together. It is fair to say that Group 7 attempted to find methods for "protecting data transfer" different from Groups 2 and 4, and discontinued its technology change after 1998.

There are only two patents in Group 8, which was the last group to be developed among the 8 groups. The major technologies of this group are similar to those of Group 7, and thus these two groups will be merged in the next phase.

The technology diffusion curves of these 8 groups are illustrated in Fig. 2.

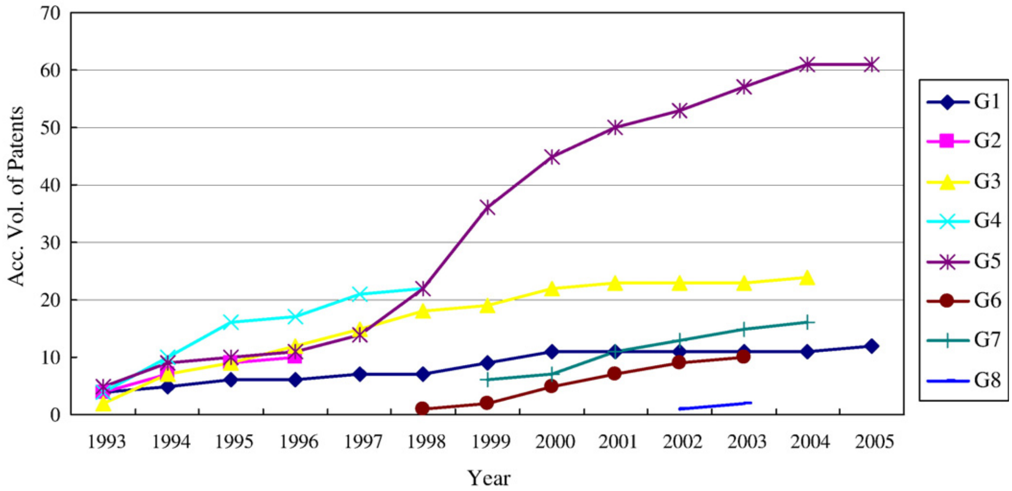

Fig. 2. Issued year distributions of basic patents based on eight groups.

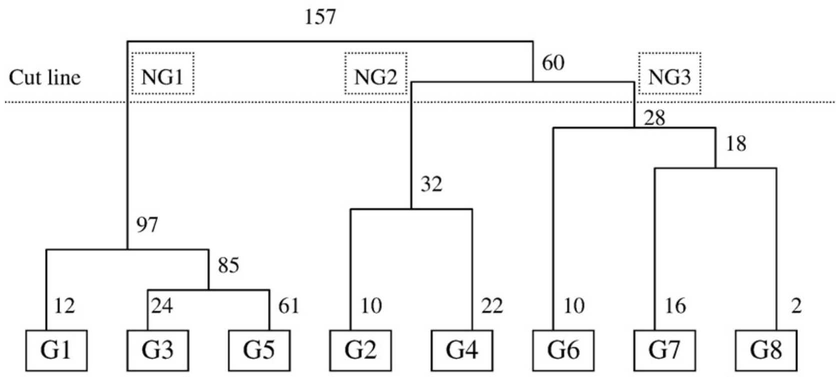

Fig. 3. Dendrogram for the hierarchical cluster analysis.

5.2. Merging groups discussion

From the above analysis, we find that there are some overlapping technologies between the eight groups. If we make an in-depth examination of the results of the hierarchical cluster analysis, then one can draw the hierarchical figure in Fig. 3 shown below. Based on the discussion in Section 5.1 and the cut line of Fig. 3, this study combined these 8 groups into 3 new groups: NG1 combined Groups 1, 3, 5 and was named Marketing group; NG2 combined Groups 2 and 4 and was named Data Security group; and NG3 combined Groups 6, 7, 8 and was named 2nd generation Data Security group. The characteristics of the three new groups are discussed below.

(1) NG1 contains the most important technology of business methods. This group is the largest group, involving 97 patents and the distribution time spans the full range of this study. The technologies of this group are to build new business methods of marketing, such as coupons, promotion programs, POS, reservations, check-in, and booking. The purpose is to increase opportunities for businesses and create wealth for enterprises, so it is called the NG1 Marketing group.

(2) NG2 is another threshold for business methods. The technologies were invented for protecting transaction security and increasing the consumer's trust in e-commerce. Citibank had 5 basic patents in this study, and 4 of the 5 belong to NG2. This group started with NG1 quickly developed further. That does not mean that NG2's technologies are less important than those of NG1, because their technologies were transferred to NG3 after 1998.

(3) NG3 started in 1998 and was a continuation of NG2. One can see that the technology categories of NG3 are similar to those of NG2, and that the assignees of NG2 are concentrated in Intertrust Technologies Corp. Intertrust develops and licenses intellectual property for Digital Rights Management (DRM) and Trusted Computing. The former DRM is a new issue, and was merely discussed prior to 1998, while Trusted Computing is an extension of NG2. From NG2 to NG3 most likely involved a radical change of the technology [5]. The technologies of these two groups are used in the same domain but not closely related. This kind of change is called competence destroying [6]. Therefore, they are called NG2 Data Security group and NG3 2nd generation Data Security group.

(4) If the cut line is shifted up, then there remain two groups in Fig. 3. NG2 and NG3 are merged into one group, and the NG3 line will shift to the dotted line following the NG2 line in Fig. 4. This means that there are two mainstreams of business method technology; one focused on marketing technology, and the other one stresses on data security. The former is creating a new business model while the latter is improving the transaction security. Both of them are important for e-commerce. According to Foster's technology diffusion viewpoint, these two mainstreams developed their own technology in parallel and merely cross others. They are two independent S curves that have stable growth.

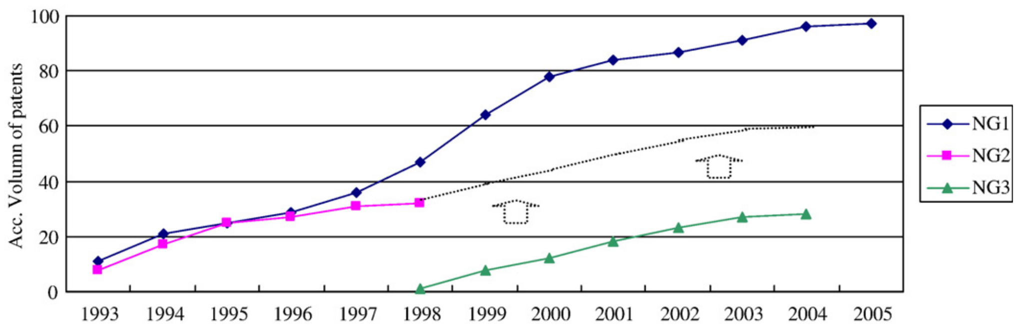

Fig. 4. Distributions and merging of basic patents based on new groups.

6. Summary

This study established two indicators for selecting the basic patents and for calculating the relationship of patents. It used the hierarchical cluster analysis to classify these basic patents and discussed the meanings of each group. This following section draws the conclusions and lists the contributions of this study.

7. Conclusions

This study proposed four conclusions:

(1) Establishing the indicator and method for finding basic patents

This study used lineal citation relationships to establish an indicator for finding basic patents. This method not only considers the importance of direct citation, but also takes into account the influence of indirect citation. Different values (0, 0.3, 0.5) were given to the parameter β to calculate the strength of the patents. As to the newer patents, another criterion was selected to filter the basic patents where the number of direct citations had to be larger than the upper bound of three standard deviations in the same year. Finally, this study retrieved 10,386 business method patents from the USPTO database and found 157 basic patents.

(2) Establishing another indicator to measure the lineal linkage of basic patents

This study established another indicator to measure the lineal linkage of basic patents. This method not only considers the direct relationship but also accounts for the influence of indirect relationship. The parameter $\alpha(0<\alpha\leqq 1)$ represents the decline effect of intermediate patents, and this study set α equal to 0.5. Finally, the lineal linkage equation was used to build a 157 by 157 relationship matrix which was the input data for the cluster analysis.

(3) Classifying the basic patents

This study used hierarchical cluster analysis to classify 157 basic patents into eight clusters. The major technology, representative firms, and distribution time of each group were analyzed, and then illustrated with the technology diffusion curves in Fig. 2. Because there were some technological overlaps between the different groups, a more in-depth analysis was carried out to explore and further clarify the technology diffusion.

(4) Merging relevant clusters and explaining the technology diffusion

Because this study employed hierarchical cluster analysis, a dendrogram was used to clearly show the merging of the clusters. Finally, this study found two mainstreams of business method technology; one focused on marketing technology, and the other stressing data security. The former creates new business models, such as coupon, promotion program, POS, reservation, check-in, or booking; and the latter improves transaction security and increases the consumer's trust in e-commerce. Both of them are important for Internet data processing and e-commerce activities.

7.1. Contributions

There are three clear contributions from this study as follows.

(1) For the academic research

Radical technology change is like the science revolution by Kuhn [35]. Inventing a basic patent will give rise to a paradigm shift in science revolution. This study used patent citation to find basic patents, and then classified these basic patents to explore the group characteristics and their technology diffusion. The result of this study not only provides scholars with a deeper understanding of the value and function of patents, but it also brings new empirical evidence to support the theories of technology change and diffusion.

(2) For the industrial experience

There is no clear definition of a basic patent in the literature, and there are no objective criteria to examine a basic patent. This study combined two methods to retrieve basic patents: one was to aim at older patents by an indicator $V(P)$, the other one was to use the 3 S.D. method for younger patents. In practice, R&D managers can use this indicator for measuring the strength of patents as the value of the patents. This indicator can provide the trade for patent pricing, licensing, or mortgaging. Furthermore, finding basic patents earlier can help business managers to formulate R&D strategies and improve their decisions for technology planning.

(3) For the business methods domain

Since Internet technology became popular, the concept of industry has changed and its boundaries have become blurred. This phenomenon is referred to as digital convergence [36]. Business methods are typical technologies of the Internet era; they are applied to many industries, such as computer software, hardware, communication, finance, retailing, entertainment. This study found two mainstreams of business method technology; one focused on marketing technology, the other one stressing data security. Enterprises can develop their business method strategies from these two mainstreams based on their own competence or endowment, and find potential competitors or partners in a more convenient and correct way by means of the patentees of each group.

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Appendix A. The list of 157 basic patents by eight groups

G1	G2	G3		G4		G5				G6	G7	G8
5185695	5199066	5202826	5671279	5204897	5453601	5237157	5758328	5948040	6236971	5724424	5910987	6385596
5245533	5220501	5224162	5677955	5218637	5455407	5237496	5794207	5950173	6236975	5948061	5915019	6658568
5249044	5247575	5283829	5699528	5222134	5457746	5237499	5794210	5970475	6260024	6016504	5917912	
5256863	5247578	5287268	5715314	5260999	5473692	5239462	5794219	5974396	6285987	6029150	5943422	
5353218	5276736	5321751	5757917	5283731	5509070	5243515	5835896	6009410	6341271	6141653	5949876	
5380991	5305200	5326959	5809144	5297031	5621797	5297032	5848396	6014643	6345256	6205437	5982891	
5687322	5319705	5351186	5960411	5305195	5629980	5309355	5862223	6017157	6460036	6282522	6112181	
5857175	5416840	5383113	6029141	5339239	5634012	5319542	5890138	6021397	6532451	6338050	6185683	
5970469	5440634	5465206	6047067	5341429	5638443	5375055	5897622	6058379	6571339	6345263	6237786	
6014634	5557518	5537314	6125352	5351293	5740549	5408417	5905975	6061660	6609101	6505177	6240185	
6055513		5590038	6233565	5410598		5502636	5918213	6064979	6657702		6253193	
6839682		5590197	6675153	5438508		5644727	5924082	6134548	6697702		6363488	
						5664110	5933811	6151582	6705517		6389402	
						5664115	5933816	6154738	6708155		6574609	
						5710887	5940504	6226618	6798997		6587837	
						5724521					6697948	

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Shann-Bin Chang is currently an associate professor at Ling Tung University in the Department of Commercial Technology and Management, Taiwan. His research areas include patent analysis, Internet intellectual property management, technology forecasting, and e-commerce. His research papers have been published at Journal of Management, Journal of Technology Management, The Journal of American Academy of Business, and The Business Review.

Kuei-Kuei Lai is currently a professor at National Yunlin University of Science and Technology in the Department of Business Administration, Taiwan. His research areas include technology management, patent analysis and technology forecasting. His research papers have been published at Information Processing and Management, Journal of Management, Journal of Technology Management, and Management & System.

Shu-Min Chang is an instructor at Nan Kai Institute of Technology in the Department of Industry Engineering and Management, Taiwan. She is currently a doctoral student at National Yunlin University of Science and Technology in the Department of Business Administration. Her research is on patent analysis and technology forecasting. Her research papers have been published at Journal of Technology Management, and The Journal of American Academy of Business.