A Study of Influencing Factors of Patent Value Based on Social Network Analysis

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***Abstract*--This study proposes a different angle to evaluate patent value, namely regarding patent value as a combination of static characteristics and dynamic relationship. On one hand, a majority of patent static characteristics are fixed in their application, which means these characteristics are controlled by the owner of patent; on the other hand, the dynamic citation relationship is formed by forward citation and backward citation, which means not controlled by the owner. If a patent takes an important position in other citation relationships, this implies the patent has more chance to gain and control technology and knowledge, and to have an important influence on subsequent patents. In other words, this patent is valuable. This study applies social network analysis to carry out the research purpose, regarding patent as a node and citation as the connection between nodes to build patent citation network. This study can provide a thinking mode based on social network analysis for companies; offer a more rational way to evaluate patent value from the perspective of dynamic development; construct an effective early warning mechanism for patent litigation.**

I. INTRODUCTION

Light Emitting Diode (LED) is a kind of material that transforms electric energy to luminous energy. Compared to the traditional illuminant such as electric incandescent lamp and neon lamp, LED products which has the advantages of energy conservation, small volume, strong shock resistance ability, high-brightness, eco-friendly, long operating life are attractive to the world's attention particularly in display and lighting fields. In order to maintain competitiveness in LED industry, it is important for leading manufacturers to master core technologies of LED products. In this case, owing the exclusive right of patent is an appropriate mean to build up legal entry barriers and reduce competitions. Therefore, acquiring patents is the top priority for LED manufacturers to prevent other rivals entering relevant field of technology.

Patent is considered as an intangible asset for companies, not only an isolating mechanism excluding competitors, but also a strategic instrument to enhance competitiveness and increase the value of companies. Although patent brings great potential value for the companies, it costs a company a lot to acquire the patent or authorization of it. Such as R&D costs, application fee, maintenance cost after authorization, litigation expense. The cost-income principle make a company with limited resource impossible to widely apply for patents in order to protect its innovation, thus evaluating patent value and building up a proper patent portfolio become an important issue for the company.

Prior researchers have developed ways to evaluate patent value, mostly based on patent characteristics and statically discussed determinants of patent value. However, patent value is not only depends on its static attributes, but also the citation relationship with other patents, which reflects the flow of technology knowledge and determines patent's position of technology-knowledge evolving network. Moreover, citations from followed patent to previous patent would bring changes from time to time. Therefore patent value should be considered as dynamic developing. Above all, patent value depends on both static and dynamic attributes, patent characteristics and citation relationship.

This study proposes a different angle to evaluate patent value, namely regarding patent value as a combination of static characteristics and dynamic relationship. On one hand, a majority of patent static characteristics are fixed in their application, which means these characteristics are controlled by the owner of patent; on the other hand, the dynamic citation relationship is formed by forward citation and backward citation, which means not controlled by the owner. If a patent takes an important position in other citation relationships, this implies the patent has more chance to gain and control technology and knowledge, and to have an important influence on subsequent patents. In other words, this patent is valuable.

This study applies social network analysis to carry out the research purpose, regarding patent as a node and citation as the connection between nodes to build patent citation network. This study can provide a thinking mode based on social network analysis for companies; offer a more rational way to evaluate patent value from the perspective of dynamic development; construct an effective early warning mechanism for patent litigation.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

A. Social network theory

A social network is a method of studying the dynamic relationship between multiple entities that made up of a set of nodes and connections. Each node defines an actor, and each connection defines the interactive relationship between nodes [1], then nodes connected in a certain relationship draw a relation network map. Actor and relationship are the basic elements of social network. Actors represent different research objectives, such as individual, organization or technology. Relationships between actors can be friendship of

individuals, transaction relationship of organization or citation relationship between technologies.

The research of network analysis is very extensive, social network researchers give a lot of attention to relationship, network structure and position. Interaction of actors forms relationship between actors, then complex relationship makes the network structure, finally network structure gives features to the network and makes each actor occupy certain position. Structure and position of network provide a wealth of information about behavior, perception and attitude of individual actors, which helps to make reasonable prediction and explanation for actor's behavior.

The original utilization is mainly in the research of dynamic relationship between people, Collins and Clark [2] explored the relation between human resource practice and firm performance from the perspective of social network relationship in top management team, the result reveals social network relationship of top management team has moderating effect. Social network analysis has been applied more often in the research of nonhuman relationship, such as communication and alliance of organization and enterprise [3], generation and diffusion of innovating knowledge [4, 5], evaluation of journals influence [6].

B. The analysis of patent value determinants

On the analysis of patent value determinants, in order to identify the determinants of the patent value and find out most valuable patents, former researchers have developed various models, mainly categorized independent variable into four different classes: patent characteristics (number of forward citations, number of backward citations, IPC categories and number of inventors etc.), patent ownerships (co-application, cross-border ownership, patent portfolio scale and market size etc.), insider information (motivation of application and background of inventing etc.) and filing strategies (number of patent claims and number of patent priority etc.) [7]. From these variables, we can obtain various valuable information such as the technological importance [8], the existing technological background, the linkage between innovation and basic research [9], the technological scope [10], research effort [11], the legal breadth of the protection [12] and so on.

Patent value index can be divided into two categories: based on market and based on patent itself [7].The best-known patent value index based on market are Tobin's q, market value of shares (enterprise level) and royalties, inventors & managers' evaluation of patent and acquisition activity (patent level). In contrast, index based on patent are of more diversification. It can be categorized into five classes: technique importance (forward citation), geographic importance (patent family), length (renewal), authorization decision (authorized patent), and legal dispute (litigation probability and opposition probability). It has been proven that these five indexes are positively related to patent value [7].

By different choices of patent value index and determinants, researchers have done various empirical researches to predict patent's potential value. Allison, et al. [13] finds that valuable patents contain more claims, forward citation and backward citation. Allison, et al. [14] discovered the features of litigated patent, then concluded that litigated patents are of higher value than those have not been litigated. Chang, et al. [15] derived a new variables called earn plan ratio, indicating the extent of how a company's internal strategies result its external reputation, moreover they built the regression model by taking compensation for damages as dependent variable, demonstrating that patent family strength reflect the value of the patent itself [16]. The foregoing researches consistently demonstrated that forward citation, patent family, renewal, legal dispute and application strategy are positively related to patent value; however relationship between the other determinants and value is blurry [7]. This demands further studies focus on a new perspective.

In spite of effective ways are provided from the prior researches to evaluate patent value, the characteristic of chosen index brings limitation of using patent characters to predict litigation possibility, or evaluate patent value. This is because firstly, all of the indexes merely static evaluate and explain patent value and litigation. Only when patent characteristics are identified, its value can be evaluated [17]; secondly, although forward citation is seen as effective index to predict potential litigation [18, 19], we find that patent with less or no forward citation gets involved in litigation as well, which means patent characteristic perspective is not sufficient, so we need more dynamic way.

With the interdisciplinary usage of social network analysis, researchers also combine the method with patent analysis to offset the disadvantage of traditional patent analysis methods. Wang, et al. [17] studies the effects of brokerage or closure position on patent quality in technology evolving, by drawing patent citation picture, regarding patent as node, citation as connection. Clarkson [20] used patent citation network to propose an objective way to identify patent thicket by comparing the density of patent pool and the density of patent space around the pool. Chang, et al. [21] proposed a way to explore fundamental patent index and to evaluate relationship between fundamental patents, also classify fundamental patents and elaborate technology diffusion, by building patent citation network to analyze patent business methods.

Social network analysis not only helps to identify the relationships between patents, but also helps to identify the relationships between patent owners. Kim and Song [22] connected the two sides involved in lawsuit by building patent litigations network, divided companies into four classes based on the level of initiative and passive according to the centrality of companies, and then judged the roles played by the companies in the specific technology field accordingly, as well as future development direction. Therefore, this study applies social network analysis to evaluate patent value. However, it is important for practitioners in the LED industry to understand this relationship. Hence, this paper attempts to fill this research

gap research gap.

C. Network centrality and patent value

Network centrality is the index to evaluate the ability of node to access and control resources, which means that node with higher network centrality is more directly or indirectly connected to other nodes, it influences other nodes more. Therefore, node with higher centrality occupies higher relative importance, affecting other nodes more and being affected less by other nodes. Here we introduce two indexes to evaluate centrality, which are widely used in social network analysis, and then we explain the index and develop the hypotheses.

1) Degree centrality

Degree Centrality evaluates the number of other nodes that directly connected to one node, reflecting the local centrality of the node. So nodes with higher degree centrality are connected to more nodes, possess more informal rights and influence, as the consequence, they can exert influence on the whole network through the nodes connected to them, and get more chance to get access to resources.

Patent applicant need to list the cited patents or scientific literature, these backward citations constitute the technical basis of the patent. Connecting all the patents in order by the citation relationship, from which we can draw a dynamic picture of technology evolving network. Since patent citation network is an ordered network, it requires to simultaneously considering in-degree centrality and out-degree centrality.

Out-degree centrality represents how many relationships started from one node to the other nodes, it means how many patents are cited by one patent or one patent's backward citation. Generally speaking, fundamental patents focus on basic research, so they do not have many patents or scientific literatures to cite, resulting a lower out-degree centrality. However, fundamental patents are the basis of subsequent techniques, then they have a strong influence on the subsequent, moreover Lanjouw and Schankerman [19] found that the backward citation is negatively correlated to patent litigation, which means patent with lower out-degree centrality may value more.

On the other hand, backward citation evaluates the extent of technological spillovers [23-25], a patent which is based on a large number of previous researches can fuses the previous technology knowledge and cover multiple technological fields or dig deep in a specific technology field, possessing higher technology breadth or depth, so patent with higher out-degree centrality is of higher technological degree of fusion. According to Allison, et al. [13] showed that litigated patents have much more citations than those not get involved. In terms of average, litigated patents averagely cited 14.2 patents, and 8.6 patent citations for those not involved. Thus patent with high out-degree centrality could have more value.

In-degree centrality represents how many relationships one node gets from the other nodes; it means how many patents have cited this patent or number of forward citations. Only when the technology knowledge contained by a patent is necessary or provides reference for subsequent innovation, this patent would be cited by the subsequent patent, so studies on forward citation usually see forward citation as the evaluation of patent technological quality, economic value of one technique to another [23, 26-29]. More forward citation of one patent reflects that the unique technique of this patent is core or critical in this technology field, effecting the subsequent more and attracting more contenders. Therefore, patent of higher in-degree centrality values more in technique and economics, here this study proposes the following hypothesis:

H1: Litigated patent has higher or lower out-degree centrality than those not being litigated.

H2: Litigated patent has higher in-degree centrality than those not being litigated.

2) Closeness centrality

Closeness centrality computes the sum of all the shortest distance between one node to all the other nodes, then it reflects the extent how an actor can avoid being controlled, explains efficiency and independence [30]. Efficiency shows the least steps an actor will take to get another actor, while independence means the actor can connect with others with less dependence on intermediary personnel. Hence, higher closeness centrality means higher efficiency and independence of the actor. Since patent citation network is ordered network, it's required that in-closeness centrality and out-closeness centrality be distinguished. The meaning of in-closeness centrality is the reciprocal of the sum of shortest distance a patent to be cited indirectly or directly, it reflects the extent how the patent effects the subsequent patents while not interfered by the mediator. Out-closeness centrality evaluates the reciprocal of the sum of shortest distance for one patent to cite all the patents it needed, reflecting its initiative proximity or its ability to absorb technical knowledge from the previous patents. Because patent value mainly consists in technological value and economic value, technological value means reference basis for the subsequent patents, and economic value means the profitability of patent commercialization. However, profitability of patent largely depends on its technological value that is reflected in forward citations. Therefore this study only considers in-closeness centrality. As all said above, patent with higher in-closeness centrality affects the subsequent patents more. Here this study proposes the following hypothesis:

H3: Litigated patent has higher in-closeness centrality than those not being litigated.

D. Network position and patent value

Social capital can be acquired from two kinds of network positions: structural holes and network closure. Participating and controlling information diffusion are the basis of social capital that brought by structural holes. Theory of structural hole contends that social capital is a kind of intervening

opportunity, the non-redundant relationship between two relevant privies. Structural hole provides a cushion in the network, while people around structural holes cycle in the different information flow, so structural hole bridges the different information flows and controls people that bilateral. For example, there are three nodes of A, B and C in the network, with B and C connected to A while B and C not connected to each other, this made A occupies the central position, namely structural hole position, B and C can only be associated via A. In a word, node on the position of structural hole possesses better mediation, which makes it the critical path connecting different node, more effectively controlling the flow of resource and information [30].

As indicated by Burt [31], node located on the structural hole disseminates information or allocates resource among the different groups or nodes, creating the communication and exchanging between nodes which not connected directly. This makes it possible for the node on the structural hole to create value. In patent citation network, mediators transfer technological knowledge to patents in different fields. By connecting patents in different fields, the mediators can easily result in new technique and promote technological development. Additionally, since mediators plays an important role in connecting relevant patents, they can be deemed as the strategic tools to quickly block contenders entering the market [32]. Therefore, patent in the structural hole tends to value more.

Network closure is often highly correlated to network density. The definition of network density is the average level of interaction among members of the network, and higher density means more connections of the members [33]. Network closeness reaches the highest level when every node is connected to one another directly or indirectly. With nodes closely connected and actors frequently exchanging information in the closed network, closed network reduces the heterogeneity in the group, which consequently promotes reliance and collaboration, strengthens knowledge sharing, and improves group performance. Every actor establishes its own reputation in the network, which makes them linked more closely and forms the closed network [17].

Therefore, frequent contacts among the members of the network makes it easier to produce similar views, establish common belief and reach an agreement, leading to stronger cohesion and a more profound effect from group norms to the network, which in turn reduces the heterogeneity of the network members. In patent citation network, technological knowledge of high concentration and overlapping information communication helps to deeply comprehend and absorb specific technological knowledge, thus deepens the R&D and continuous improves the existing technologies. Besides, closed network structure can efficiently lower the technological risk, increase opportunities of cooperation with analogous technology, and improve the communication efficiency of homogeneous technologies.

However, closed network can even more limit one node from the relationships of adjacent nodes, exposure one node under the risk of being controlled and replaced. To be more specific, assume that node A, B and C are all connected to each other, thus the relationship between A and B contains redundant information, which means B may be connected to C by A while B and C can directly exchange information, thus the control by A to B and C is weakened. That is, network of high closeness restrains A to the relationship of A, B and C, bringing the network higher embeddedness. Therefore, high closeness of patent indicates that the patent is focusing on a certain specific field, causing redundant information between the patent and patents adjacent to it. Owing the homophyly with adjacent patents, subsequent patents do not have to cite this patent, and the adjacents can potentially replace it, thus the patent may no longer have a significant impact on the subsequent.

Structural hole and network closeness are the two side of a same network position, and we can use effect size to evaluate the position of node. The definition of the effect size is difference between individual network scale and network redundancy, i.e., actual size of non-redundant network, reflecting the non-redundant information existing in the relationship of the node and adjacent nodes [34]. Bigger the effect size of node, lower degree of duplication and greater intermediary.

By all the above, this study proposes the following hypothesis:

H4: Litigated patents are of higher or lower efficient scale than those not being litigated.

III. METHODOLOGY AND MEASUREMENT

A. Sample and data collection

The data for this study comes from the database of Thomson Innovation, we retrieve all the literature information of US authorized patents up to 31th of May, 2011. Technology fields are retrieved includes epitaxial growth, LED chip making and LED chip package, but end product application technology. After a preliminary retrieval, 40330 patents are selected, and then by manual screening, we get 7164 patents belonging to this study's relevant technology fields. To confirm appropriate LED technology fields, this study organizes the depth interview of ten senior experts respectively who have participated in R&D projects and more than ten years' experience in LED industry. By the interview, keywords for retrieval are determined, as well as analysis data. We further remove isolated patents which are not cite or cited by other patents, left 4650 suitable patents. Then we adopt Westlaw database to check up whether sample patents are litigated or not by their patent number. Finally we obtain a sample set consist of 59 litigated patents and 4159 patents not get involved.

B. Measurement

Litigated/Non-litigated patents: The dependent variable is a categorical variable and is coded as 1 if a patent has ever been litigated and 0 if a patent has never been litigated. This

study used "litigated patent" as the proxy variable for a "patent value". The data comes from Westlaw, we can make sure whether a patent has been litigated or not.

Out-degree centrality: times the number of patent *i* cites the other patents or number of patent *i*'s backward citations. It's defined by $d(i) = \sum_j m_{ij}$, if patent *i* cites patent *j*, m_{ij}=1.

In-degree centrality: times the number of patent *i* cited by the other patents or number of patent *i*'s forward citations. It's defined by, $d(i) = \sum_j m_{ji}$, if patent *i* is cited by patent *j*, m_{ji}=1.

In-closeness centrality: reciprocal of the sum of shortest distance taken by all the other patents to cite patent *i* directly or indirectly. It' defined by $c(i) = \sum_j d_{ji}$, where d_{ji} is the shortest distance from patent *j* to *i*.

Effect size: the difference between individual network scale and network redundancy or factors other than redundancy of network. It's defined by $ES = \sum_j \left(1 - \sum_q p_{iq}\, m_{jq}\right), q \neq i,j$, where *j* represents all the nodes connected to *i*, and *q* are the nodes except *i* and *j*; $p_{iq}m_{jq}$ represents the redundancy between patent *i* and *j*, and p_{iq} represents the proportion of the relationship input from patent *i* to *q*.

C. Control variables

Patent inventors: amount of all the inventors. It describes patent's technological complexity and research effort that needed. Generally speaking, bigger amount means higher technological complexity and more research effort, which makes the patent more likely value more. This study defines patent inventors as the amount of patent inventors. Data comes from the Patent Full-Text and Image Database established by USPTO.

Technology scope: it measures how for the field of patent technology could possibly reach, and it's mainly reflected by the number of technology classifications, such as IPC (International Patent Classification) or UPC (United States Patent Classification). Patents of more technology classifications are of wider technology scope. Prior studies indicated that patent technology scope has a positive correlation with patent value: with more scope get involved, more valuable inventions are created [10, 35, 36]. Here in this study, technology scope is defined as the sum of patent's second order sub-classification number without repetition or the sum of four-digit IPC code.

Patent claims: this variable defines the scope of protection covered by the patent and one or more patent rights under a certain condition, including independent claims and dependent claims. Based on patent application, patent claims states the technical features, working to make it clear that patent is infringed or not. For the patentee, more claims means wider scope of patent protection [37], helping companies to identify potential infringers or authorize in some specific fields. Lanjouw and Schankerman [19] found that if patent claims increases by 10%, the count of patent litigations in their sample increases by 1.4% accordingly. Therefore, more patent claims represent wider protection scope, which makes patents value more. Number of patent claims here is defined as the sum of independent and dependent claims. The data comes from Patent Full-Text and Image Database by USPTO.

Patent family: collection of applications of the same patent in different countries or collection of different subsequent patents from the same patent. It shows the company's attention to technology and market, by applying patents in several important countries for protection, the company can set barriers for opponents who attempts to imitate their technology and undermine the company's competence and market shares. It costs more for the company to expend patent family by more patent applications. We can see that only when the patent technology brings more profit than the application expense, the company will do the investment to expend patent family. Thus company's potential sales market can be predicted from the patent family layout, since the amount of patent family reflects the importance of technology and future market, patent family positively effects patent value [27, 38, 39]. Number of patent family is defined as the patent amount of the focus patent. Database sampled in this study, is the database from INPADOC (International Patent Documentation Center) in the website esp@cenet.

IV. RESULTS

A. Descriptive statistics

The descriptive statistics of all the variables are shown in Table 1, including minimum, maximum, mean value and standard deviation. Standard deviations of variables are relatively small except variables of effect size (EffSize), out-degree centrality (OutDegree) and in-degree centrality (InDegree). Overall, the distributions of the variables are relatively centralized.

TABLE 1 DESCRIPTIVE STATISTICS

Variables	Min.	Max.	Mean	S. D.
1. OutDegree	0	134	2.97	7.84
2. InDegree	0	292	2.97	7.36
3. InCloseness	0.021	0.028	0.021	0.0003
4. EffSize	0	288.51	5.48	10.31
5. PatInventor	1	15	2.92	1.85
6. IPC4	1	13	1.66	0.95
7. Claim	1	169	17.35	14.70
8. PatFamily	1	330	8.83	21.12

TABLE 2. CHARACTERISTICS OF LITIGATED AND NON-LITIGATED PATENTS (RESULT OF T-TEST)

Variables	Litigated patent	Non-litigated patent	t-value
1. OutDegree	11.76	2.86	2.93**
2. InDegree	6.02	2.94	2.37**
3. InCloseness	0.02	0.02	0.94
4. EffSize	16.42	5.34	3.67**
5. PatInventor	3.25	2.92	1.41
6. IPC4	1.95	1.66	1.80*
7. Claim	23.49	17.28	3.23**
8. PatFamily	26.71	8.61	2.80**

Note: **p<0.05, *p<0.1

B. Analysis for the difference between litigated and non-litigated patent characteristics

This study applied a t-test in order to compare the mean of litigated patents variable with that of non-litigated patents. As reported in Table 2, under the significant level of 5%, regarding the mean of OutDegree, InDegree, EffSize), IPC4, Claim and PatFamily, litigated patents have significant larger values than that of non-litigated patents. However, Table 2 shows that the mean of InCloseness and PatInventor of litigated patents are not significantly larger than that of non-litigated patents.

C. the result of logit regression

Regarding Litigated Patent as dependent variable, OutDegree, InDegree, InCloseness and EffSize as independent variable, PatInventor, IPC4, Claim and PatFamily as control variable, this study builds logistic regression model. The empirical results are in Table 3.

The results in Table 3 indicate that, under the significant level of 5%, the coefficients of OutDegree, InDegree and EffSize respectively are 0.23, 0.22 and -0.21, indicating that OutDegree and InCloseness has significant positive effects to patent value, whereas EffSize has significant negative effects to patent value. There H1, H2, H4 are supported in this study. However, in-closeness centrality doesn't have significant effects to patent litigation probability. H3 isn't supported in this study.

D. Conclusions and discussion

What this study tries to discuss is determinants of patent value, for this reason, this study utilizes social network analysis to build patent citation network and do empirical analysis. First, through the T-test of litigated and non-litigated patents, we find that out-degree centrality, in-degree centrality and effect size of the two kind patents are significantly different, whereas in-closeness is not significantly different. Then, this study makes logistic regression, it turns out a significant and positive relationship between out-degree centrality, in-degree centrality and patent value, while effect size has negative relationship significantly with patent value, and in-closeness centrality doesn't significantly affect patent value.

Since out-degree centrality positively affects patent value significantly and out-degree centrality is the number of patent backward citations, showing the fusion of patent technological foundation and knowledge, this study suggests that in filing patents, companies should firstly fully excavate previous researches in relevant technology fields, by having a strong understanding of development path and cutting-edge of the technical field, acquiring adequate technical knowledge and laying down a solid theoretical foundation, then innovate, develop and finally improve patent value, based on previous patents.

In-degree centrality is the amount of patent forward citations, reflecting the extent of how a patent attract to subsequent innovators and competitors, this indicator not only reflects knowledge spillover, but also market value of companies. The results shows in-degree centrality positively affects patent value significantly, suggesting that, in filing patents, company should take account of how the unique technology contained by the patent could affect subsequent and attract more competitors, which can bring the company a higher reputation from outside, improve the market value in the competition of sales market and eventually increase patent value.

TABLE 3 RESULT OF LOGISTIC REGRESSION

Variables	
Intercept	-0.73
Independent variables	
OutDegree	0.23**
InDegree	0.22**
InCloseness	-219.34
EffSize	-0.21**
Control variables	
PatInventor	0.03
IPC4	0.13
Claim	0.007
PatFamily	0.009**
-2 Log Likelihood	584.43

Note: **p<0.05, *p<0.1

Effect size is the factor other than redundancy in the network, reflecting the non-redundant information in the relationship of patent and the adjacent nodes. Smaller effect size of patent means higher repeatability and closeness of the network in which the patent is. The results of this study indicate that effect size negatively affects patent value significantly, suggesting that companies make their patents occupy the closed position of the network, which can increase the opportunity to corporate with similar techniques and improve the efficiency of communication with homogeneous techniques, as a result, creating the closed network. Once the closed network is established, it will deepen the R&D and continuous improvement of existing techniques, lower the risk of technology development, and finally increase the value of patent.

Besides, companies can apply this model to evaluate the value of opponent's patents to choose the target patent, and then obtain the right to use patent through acquisition or authorization. Meanwhile, companies can also use social network analysis to build patent citation network to detect technology development path, so the companies can identify the key patents in the development and positions where the companies themselves and their opponents locate, and they can analyze and compare the layout strategies of themselves and their opponents to formulate appropriate strategies for competing and cooperating.

At last, this model provides the companies a set of early warning mechanisms for patent litigations. With this model, companies are able to make a judgment about the litigation probability of their patents. Since patent citation network dynamically develops as time goes, it's suggested that the companies dynamically update patent database according to the model. By doing this, companies can monitor the change of litigation probability in real time, identify the patent may get involved in litigation in advance, and prepare for the patent litigation, reducing the enormous cost and uncertainty when facing the litigation in the future.

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