THE COOPERATION AND COMPETITION OF TECHNOLOGICAL DEVELOPMENT: THE CASE OF TFT-LCD

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ABSTRACT

The study aims to find the players of technological cooperation and competition from the perspective of ego firms. The research applies the method of Network Constraint Index to analyze the network of technological diffusion. The higher the constraint value of a certain firm is, the more constraint it would stop the linkage from technological connection. On the other hand, the lower the constraint value of a certain firm is, the less connection it is with the others, which means more chance to obtain the intermediate benefit. The firm with constraint trait might be the bridge the connection of the others and control the important resources and advantages among other firms. By this way, the purpose of this study is to identify the players of technological cooperation and competition for firms and help them to make a complete portfolio of technology development.

Keywords—Competition, Cooperation, Patent, Constrain, TFT-LCD

1.INTRODUCTION

Patents are the fight weapons behind the business of the industry. It is not only as the core threat arms but also the last defend walls. Because patents are regarded as the core products on research and development, it is the competitive battlefield since always until now. Many world-known research institutions, such as International Institute for Management Development (IMD) and World Economic Forum (WEF), view patents as a key indicator in evaluating a national research and development (R&D) position. Patent are an important intangible asset of the firms, it not only regards as the core competiveness but also enable firms to generate revenue by selling them.

The study focuses on TFT-LCD industry to explore the changes and developments of the technology. From the end of the 1960's, the technology of LCD (Liquid Crystal Display) used to be initially applied by U.S. Radio Corporation of America (RCA). On account of the characteristics for thin and power-save, TFT-LCD becomes the main applied products on display industry. Once when the Japan firm TOSHIBA employed TFT-LCD on the Notebook screen, it has spread widely on consuming electronic product like GPS, digital camera, NB, etc. It is to say that TFT-LCD is on behalf of progress on technology market that is due to the technology of TFT-LCD has reached the maturity period and could be explained for the developing history. By exploring patents analysis is the way to overview.

The traditional method only could regard from the bilateral side to overview the relationship and even have no way to understand the ego side, and the clusters side of the variety within them. As the rapidly change of the technology, the innovation process becomes much complex, the product life cycle comes to be terminate, and the demand of the market turns the environment competitive. There is much important to possess the up-to-date, the correct, and the abundant patent information to make the complete patent portfolio for the companies to fight against. There are few researches on both patent transaction and patent citation together at the same time. The research constructs the transaction matrix and citation matrix to discuss the characteristics they act. Under the cost and capability conditions, how to acquire the advantage by technology transferring is the important issue that business needs to conquer to. Focus on the case TFT-LCD industry, this study aims to develop a method to identify a certain company's cooperation and competition from the ego perspective to help its decision-makers for a better strategy making.

2. LITERATURE REVIEW

2.1 Technology Market

As the progress of the technology, the fast time the products launch, the short term the product life cycle changes. For many businesses, the new products and service are much important for the companies especially for the technology-imploded firms [1]. In order to launch the competitive products, business usually put lots of efforts on the innovation technology. However, for limitation of the resource, they focus on the development capability

they are expert in and acquire those not much important technology from the other firms. Meanwhile, they might gain profits by offering their technology-owned capability to the others reversely. Business eager for the most profits that they provide their own technology and acquire the external technology at the same time.

Technology transfer means the process of technology exports and imports between the nations, the regions, the industries, and the organizations. Ryan [2] denoted from the aspect of management, business first consider what resource and capability should acquire, and how to transfer the merits to the allies when entering the technology market. The complete mechanism on technology market makes an important influence for the activities in the market. That is to say the high efficiency of technology market plays the key character [3]. If the information is not as ample as the normal standard, there may occur to the asymmetric transaction when searching the cooperation. Implied three characteristics of the market: the market safety which influences the trust of the anticipants and the authenticity of the products; the market thickness that relates whether the both sides efficiently interact or not in the market; and the lack of congestion for urging the transaction activities process with the reasonable speed. Therefore, the patent system fulfills the demand of the market safety that makes technology information open without caring the imitation by the others. In other words, the implement of patent rights is the key factor decided on the licensing and effectiveness in the technology [4]. Due to the rebuild feature for transferring and delivering that patent makes the professional technology be current in the market [5]. The key for business to enter technology market or not is based on the process of buy and sell [6]; therefore, not only the patents and technology of products but also the approach of transferring and the interaction of players are the important factors influence the technology market.

2.2 Co-opetition

Brandenburger & Nalebuff [7] discussed business is cooperation when it comes to creating and competition when it comes to dividing it up. In other words, business is war and peace occurring at the same time. The former CEO of Novell, Ray Noorda created the word “co-opetition” which is contained cooperation and competition together in the nineteen century. The combination makes for a more dynamic relationship than the words “competition” and “cooperation” suggest individually. In fact, there are some concepts about the above relationship: strategic alliance, joint venture, game theory, and etc. By estimating the strategy arrangement, it is urged to find the suitable respond under the competition.

The early topic for competition is about the zero-sum game, the benefit to one side is from the deficit of the other side. Furthermore, the theory game is separated into two parts: the rule-based games and the freewheeling games. That the freewheeling games emphasized on how to create the added value but not focus on how much profit it takes from the others. This kind of game must need the most power gathering everyone’s efforts together to enhance the whole value of all that is respect to the early cooperation. Subsequently, the world known theory “Prisoners Dilemma” brought out by Nash [8] interpreted that there’s may be the relationship of cooperation and competition simultaneously for the both sides as long as when they reach the equilibrium point.

The research on the TFT-LCD industry faces much difficult and seeks for strategic alliance that would help each other share resource and increase their core competitiveness. The main idea is to combine the specific advantage of each other for the complementary and make the best synergy of all. Contractor & Lorange [9] indicated the demand-poverty might gain the prior position if cooperated with the local business partners from the research on strategic alliance and joint venture. The strategic alliance is the embeddedness of the organization in the network [10] that extends the cooperation and competition in the free market. The main categorizations of strategic alliance are the embeddedness of interdependence which is similar like the citing and cited relationship in the network and the cross-organization. Gulati [11] denoted there are three types of embeddedness: the embeddedness of relationship which is symbolized the cohesion in the network that means the interconnection between people and people; another one is the embeddedness of structure that is corresponded to the structural equivalence in the network focused on the opposite side is on the same structure place as it is; and the other one is the embeddedness of position which is according to the base of centrality degree that regarding the role-player it is in the social network.

The concept of cohesion is about the clusters that implies the actors with the strong, direct, frequent relationship in the network. Festinger & Kelly [12] defined cohesion is the result that forming the most power to maintain the clusters. That is meant the high degree of the cohesion is much consistency than the low degree one. Cook & Whitmeyer [13] considered the social structure is the mechanism of the relationship between the egos.

And the ego side could exchange the tangible objects and intangible information and profits as in the strong cohesion network. As for structural equivalence is another concept explaining the process of the society. That is meant if the two actors substitute with each other without changing the structure of the whole network that it is to regarded the two as the equal relationship. Burt [14] considered that the players in the same cluster might act as the similar as they are for the likely conducts and behaviors. Moreover, the firms with structural equivalence are by observing and imitating with each other to decline the risk when developing the technology and even to cost down for the higher profits.

3. METHODOLOGY

The research focuses on the TFT-LCD industry and selects some specific firms as the research objects to find out the interaction and qualification within the all. As the technology change rapidly, all the firms pay much attention on how to get the priority power and status in the competitive environment. In order to acquire the full information about the relationship of the firms in the TFT-LCD industry, this study adopts Social Network Analysis method to make an observation for the patents.

3.1 Research Data

USPTO (United States Patent and Trademark Office) is the branch organization under the United States Department of Commerce to manage the patents application and offer the service on searching the patents. It makes open to the public of the full-text search service of patents. The database update once every Tuesday [15] The database involves patents from 1976 to now. Most of the countries establish the organization for controlling the intellectual property. For instance, Japan for JPO (Japan Patent Office), Korea for KIPO (Korean Intellectual Property Office) and China for SIPO (State Intellectual Property Office of the People's Republic Office). While U.S. has the most market and connect with almost every country all over the world that the USPTO symbolize the important index as the source to research retrieval.

The way to categorize the data is by UPC (Universal Product Code). Owing to it is the represented for the U.S. and also has the better complete information than the IPC (International Patent Classification). Moreover, within the 122 patent players list, the data come from US up to 59 firms that even almost be the half of all.

The research uses the tool PatentGuider2008 by LearningTech Corp. to collect the data from USPTO (U.S. Patent and Trademark Office). For the research objective refers Hsieh's analysis [16] word strings on the technology interaction and connection of the TFT-LCD firms. The searching word strings are: ABST(tft or lcd or tfr-lcd or "thin film" or "liquid crystal")and not ABST (tn or stn or st or "twisted nematic" or "super twisted nematic" or "super twisted" or "supertwisted" or "supernematic"). ABST means the scope of the patent. There are three kinds of the LCD monitors: Twisted Nematic:TN), (Super Twisted Nematic; STN) and (Thin Flim Transistors; TFT). The development of LCD monitors comes from the beginning period TN-LCD to the later period TFT-LCD, and for its improvement on contrast ratio and resolution ratio, the TFT-LCD becomes the universal types in today's market. Therefore, the search removes the two exclusive types on TN-LCD and STN-LCD. In addition, the research data duration is from announced date 1976/01/01 to 2012/12/31. By this way filtered out 59855 data for patents of all.

3.2 Indicators

Burt [17] denoted that if some nodes situated as the linked points in different clusters which also play an important roles to be the brokers, it is to say the node defines the "structural holes" characteristic. This kind of relationship between two players represent "unredundant" linkage that means the node on the position could control the benefit as the brokerage role between unrelated clusters. Structural hole enables break through the constraint within the networks and obtain distinct information so that it might create much possibility for the innovation. Structural hole in the network has the qualification for variety and non-repetitiveness [18].

Hierarchy. For the most popular is Constraint which means a node owns the power in the network. This research is using structural hole the patent data and try to find out whether being as broker could control much resource that is meant it is owns decision-making power than the others and additionally benefit from them.

In the case of notebook, Hargadon & Sutton [19] showed that if the central firm as the structural hole positions that link with others on the unrelated linkage could get the profit from each other. That because in other firms could only get information from its own, and the broker shows up to connect the individual ones and earn from them. Cao and Nee [20] found that by the power conversion thesis in market transform case, it is known the politicians use the advantage in information to obtain the self-profit. That's the example of owning the control

power by structural holes.

The research adopted Constraint Index as the measurement, and the equation Network Constraint Index for Structural hole is below:

$$C_B(n_i) = \sum_{j=1}^{l} \sum_{k=1}^{l} \frac{g_{jk}(n_i)}{g_{jk}} \quad 、 \ i \neq i \neq k \ ，i \ 、j \ 、k \ 、l = 1 \ ，2 \ldots$$

It's the sum value that denotes the degree links to other node from the ego side. Network Constraint Index is the directly or indirectly closeness degree of one firm with others. The more constraint degree means the more linkage that the firm is hard to control the flows within other firms and there is appearing much constraint between each other. In the other hand, the less constraint degree the firm is, it is located the overlapped position over the others and has more power to control the connection from each other. That's the brokerage makes profit earned from in this kind of structural holes characteristic network.

4. RESULTS

In order to figure out that the problem only could regard from the bilateral side to overview the relationship, Burt [21] denoted the concept of Structural Holes that would solve the above difficulty and it has the characteristic to look through with over the three actors' network relationships. The study is from the ego perspective to explore the phenomenon of structural holes. Structural holes implies on the market position as the mediator between the unconnected one with each other; so that it might get profits for being as broker or gatekeeper. Comparing with others, the actors with structural hole is much possible to contact the diversity message and create more innovation by absorbing the information it obtains.

The research applies the method Network Constraint Index to discuss the network. It is to know the higher the constraint value is, the much constraint it would stop the linkage from connecting that would lost the power of controlling. This is meant the firm connects densely with others then it shares the information within the linked ones and might prevent the new ideas from entering in. On the other hand, the much lower the constraint value it is, the little connection it is with the others that might appearing the chance to obtain the intermediate benefit. On account of being the overlap position the most firms they are, they would be lack of the linkage with others and without any interaction. The firm with constraint trait might be the bridge to connect the side to side and control the important resource and advantage for the intermediator of all.

4.1 From the View of Citation Matrix

In citation matrix, the most great constraint value is 0.94 for JNC, which is meant it is located on the multi-connected place. Though it links with others much densely and duplicated for obtaining technology easily, it would not appear the phenomenon of structural hole so does not have the chance to get profit from the position-advantage. On the other hand, the least constraint value is 0.156 for ROCKWELL_TECH, which it could get much benefit from the others linked with each other much and be with overlapped without interactions.

4.2 From the View of Transaction Matrix

In transaction matrix, the most great constraint value is 0.992 for TOPPOLY, which is meant it is located on the multi-connected place. Though it links with others much densely and duplicated for obtaining technology easily, it would not appear the phenomenon of structural hole so does not have the chance to get profit from the position-advantage. On the other hand, the least constraint value is 0.243 for INDUSTRIAL, which it could get much benefit from the others linked with each other much and be with overlapped without interactions.

4.3 Co-opetition

The study expects to find out the players of cooperation and competition from the ego perspective to help the decision-maker for a better strategy. Because there are two kinds of matrix of citation and transaction, the research sets up a four-grid standard for measurement. The analysis model is below:

Table 1 The co-opetition model

		TRANSACTION	
		CO	OPETITION
CITATION	CO		
	OPETITION		

The operation is to fill the overlapped firm into the columns for four parts, the both sited at transaction with cooperation and citation with cooperation, transaction with cooperation and citation with competition, transaction with competition and citation with cooperation, and transaction with competition and citation with competition.

By this way, the purpose is to distinguish whether the other players is on the side as the ally or the competitor and help to make a complete patent portfolio for the management.

Above all, the study would select some players out for the advanced analysis that for the international players, the Taiwan local players, the players as legal entity, and the players as patent trolls. As the DisplaySearch Institution shows that LG PHILIPS and INNOLUX are the represented firms on the TFT-LCD industry that the study takes them as the analysis examples. Furthermore, player HITACHI is with the most degree centrality of all that is suitable for the discussion. For the legal entity, player UNIV_TOKYO is represented the international firms in Japan while INDUSTRIAL is as the Taiwanese target. In Taiwan, the player CHIMEI and are the benchmarking to be considered as the examples for the study analysis. There is still one kind of the player called patent troll, which is the identity to earn the profits from the others by the patent litigation while always being calling into questions for the proper behaviors. According to the report *Exploring the Business Model of IP Holding Company in the U.S.* of Ministry of Economic Affairs shows there are two companies- ACACIA and GUARDIAN as the patterns to be the patent troll examples.

Table 2 The International representatives-HITACHI

HITACHI		TRANSACTION	
		CO	OPETITION
CITATION	CO	CANON/FUJITSU	FUJITSU/MATSUSHITA/ TOSHIBA
	OPETITION	CANON	MATSUSHITA

The player HITACHI is the greatest of both in-degree and out-degree that it is taken as the example for the analysis. That is to know all the players within the relationship with HITACHI are all come from Japan, so does HITACHI. For CANON, FUJITSU, MATSUSHITA that they are with the cooperation and competition with HITACHI; only the player TOSHIBA toward HITACHI is cooperation in citation while is competitive in transaction. It is the important task for HITACHI to understand the condition and make the best solutions to confront theses key players with different roles in the both competition and cooperation.

Table 3 The International representatives-LG_PHILIPS

LG_PHILIPS		TRANSACTION	
		CO	OPETITION
CITATION	CO	CHIMEI/ CHISSO/ HANNSTAR/ INDUSTRIAL/ KONINKLIJKE /MATSUSHITA/ ROCKWELL_TECH/ TDK/ TOSHIBA	CHIMEI
	OPETITION	ROCKWELL_SCIENCE/CHIMEI/ INDUSTRIAL/MATSUSHITA	CHIMEI

LG_PHILIPS is the international business comes from Korea, and it is made up with the business LG from Korea and PHILIPS from the Netherlands together while is now under the patent company LG since 2008. From the analysis result is denoted that the player CHIMEI is the most influential one for LG_PHILIPS over all. On account of CHIMEI is the key business in Taiwan and LG_PHILIPS represents the Korea business as well. These two players are both focus their resource on TFT-LCD manufacturing around the world that they might be the rival and ally at the same time.

ROCKWELL_SCIENCE, INDUSTRIAL, and MATSUSHITA are still the players that LG_PHILIPS should take care of that they are all with cooperation in citation and transaction while with cooperation in transaction and with competition in citation. There is much easier to cope with the key actors like CHIMEI in every phase; however, the instances like INDUSTRIAL or MATSUSHITA are difficult to confront that they sometimes as the ally while being as the rival at the other hand immediately.

Table 4 The Taiwanese representatives-CHIMEI

CHIMEI	TRANSACTION	
	CO	OPETITION

CITATION	CO	CHISSO /HANNSTAR/INDUSTRIAL /KONINKLIJKE/LG_PHILIPS /MATSUSHITA /ROCKWELL_TECH /TDK/TOSHIBA	HANNSTAR/LG_PHILIPS/IN DUSTRIAL
	OPETITION	HANNSTAR/INDUSTRIAL/ROCK WELL_SCIENCE	HANNSTAR/ INDUSTRIAL

CHIMEI is once as the "Panel Five Tigers"[1] in Taiwan in the 2002 though it is emerged into INNOLUX now. From the analysis results are shown the player HANNSTAR, and INDUSTRIAL are occupied the whole possibilities with competition and cooperation in citation and transaction; furthermore, the two players are both come from Taiwan that so does CHIMEI. HANNSTAR was the member of Panel Five Tigers that CHIMEI was as well that they came through the tough stage being ally and rival with each other since always till now. Another example INDUSTRIAL is the institution set up by Ministry of Economic Affairs in Taiwan. Though it connects with CHIMEI such frequent that they are not as the same relationship with each other as HANNSTAR with.

Table 5The Taiwanese representatives-INNOLUX

INNOLUX		TRANSACTION	
		CO	OPETITION
CITATION	CO	ADV_TECH/ HIMAX/ INNOCOM	
	OPETITION	DAEWOO	

INNOLUX is the key firm in the later stage as the Taiwanese representative. It makes the more cooperation with ADV_TECH, HIMAX, and INNOCOM in both transaction and citation while faced to DAEWOO, the Korean company, it changed to become competitive with it in citation network. For the result, it is indicated that INNOLUX is suitable to seek more cooperation opportunity than set the rivals fight against for.

Table 6 The Legal Entity representatives-UNIV_TOKYO

UNIV_TOKYO		TRANSACTION	
		CO	OPETITION
CITATION	CO	SKC	
	OPETITION		

UNIV_TOKYO is an academic institution in Japan that is regarded as the legal entity. For the characteristic of the university, it is less possible to struggle the resource like ordinary business do that the analysis result agrees with the statement. There is only one player SKC for the both cooperation in citation and transaction. Therefore, UNIV_TOKYO could find the assistance from SKC as the matter when it has the necessary in the future.

Table 7 The Legal Entity representatives-INDUSTRIAL

INDUSTRIAL		TRANSACTION	
		CO	OPETITION
CITATION	CO	CHIMEI/CHISSO/ HANNSTAR/ KONINKLIJKE /MATSUSHITA/ ROCKWELL_TECH/TDK/ TOSHIBA	KONINKLIJKE/CHIMEI
	OPETITION	HANNASTAR/ KONINKLIJKE/ ROCKWELL_SCIENCE/ TOSHIBA/ XEROX	KONINKLIJKE

The player INDUSTRIAL is the institution set up by Ministry of Economic Affairs in Taiwan that it is not seeking the chance to conduct battle with others but focusing on the possibility is could enhance the development of the industry in Taiwan. As the result appeared, KONINKLIJKE is the influential player toward INDUSTRIAL

over all in the network. KONINKLIJKE is for Koninklijke Philips Electronics in the Netherlands organization that would like to collect useful information to strengthen its capability that might be conflict with INDUSTRIAL.

Table 8 The Patent Troll representatives-ACACIA

ACACIA		TRANSACTION	
		CO	OPETITION
CITATION	CO	HOECHST	
	OPETITION		

For ACACIA which is considered to be the patent troll that it prevents from seizing the resource directly but using another roundabout way. It is shown that ACACIA do not with any competitive relationship with the others while only being cooperation with the player HOECHST. This is the peace way for ACACIA by unnecessary losing too much cost to obtain its final purpose.

Table 9 The Patent Troll representatives-GRARDIAN

GUARDIAN		TRANSACTION	
		CO	OPETITION
CITATION	CO		
	OPETITION	MITSUBISHI	TPO

Different form ACACIA, GUARDIAN would like to take the fierce artifice to acquire the advantage. In the condition that cooperation in transaction and competition in citation corresponds to the player MITSUBISHI which is indicated GURARDIAN would fight against with MITUSBISHI in the citation phase while seek to be cooperated with MITUSBISHI when taking the transaction behavior. On the other hand, player TPO is the most menace toward GRARDIAN that no matter on citation or transaction TPO is on the competitive relationship with GUARDIAN. For this crisis, GUARDIAN should be careful for the strategy that TPO would take.

5. CONCLUSION

The ego network could analyze from the multi-sides that help explore the position and advantage of each individual while the traditional CHI could not get the point. The research applies the method Network Constraint Index to discuss the network. It is to know the higher the constraint value is, the much constraint it would stop the linkage from connecting that would lost the power of controlling. This is meant the firm connects densely with others then it shares the information within the linked ones and might prevent the new ideas from entering in. On the other hand, the much lower the constraint value it is, the little connection it is with the others that might appearing the chance to obtain the intermediate benefit. On account of being the overlap position the most firms they are, they would be lack of the linkage with others and without any interaction. The firm with constraint trait might be the bridge to connect the side to side and control the important resource and advantage for the intermediator of all.

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The study expects to find out the players of cooperation and competition from the ego perspective to help the decision-maker for a better strategy. Because there are two kinds of matrix of citation and transaction, the research sets up a four-grid standard for measurement. The operation is to fill the overlapped firm into the columns for four parts, the both sited at transaction with cooperation and citation with cooperation, transaction with cooperation and citation with competition, transaction with competition and citation with cooperation, and transaction with competition and citation with competition. By this way, the purpose is to distinguish whether the other players is on the side as the ally or the competitor and help to make a complete patent portfolio for the management.

In conclusion, there are various kinds of the relationships between cooperation and competition in citation matrix and transaction matrix. By the analysis method this study brings out is help explore the deeper implications that provides the useful references for the decision-makers. With different characteristics for the four parts:

international, Taiwanese, legal entity, and patent trolls could analyze each special conditions they are.

By the each column could provide something important information for the further discussion; moreover, put the two models together for the comparison is much effective exploring the whole network. Look at the example of CHIMEI and LG_PHILIPS, they are almost reaching the same situation; on the side of CHIMEI, it could be found there are two columns corresponded with LG_PHILIPS while for LG_PHILIPS that there are the whole four columns accorded with CHIMEI. By contrasting the former one and later one helps to consider the next step following from both the self-side and the counterpart. The duality relationship of each one is the good analysis method for the advanced suggestion for the management.

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