Modeling Technological Value Net through Network Contagion: The Case of LED Industry

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***Abstract*--Co-opetition provides a framework from which to identify firms' strategic position and alternatives in any given situations. The value net model is a strategic view of the key relationships that drives any company's ability to compete or cooperate with other players in a business condition. The idea of the value net model can be used in the technological system where the company can identify its technological competitors and complements. This study aims to construct a quantitative method for modeling the technological value net with the help of social network analysis. Patent citations are quantified by social network contagion in order to ascertain what kinds of contagion patterns take place in a technological system. The study employs LED industry as a research samples about 17 LED manufacturers are identified. The 17 manufacturers' patents that are issued in USPTO from 2006 to 2012. The study finds that the technological competitors of players are different in supplier views and customer views. On the other hand, the technological complements of players are different from supplier views and customer views. These findings can help the company to identify technological competitors and complements in the technological system.**

I. INTRODUCTION

Since Brandenberg and Nalebuff [4] introduce an idea called "Co-opetition", many scholars employ this concept to analyze the industry environment, such as, Carayannis [7] analyze the satellite industry, Zhang[21] analyze the partnership of supply chain, Liu[14] discussion about distributor's entrepreneurial orientation and manufacturer's knowledge acquisition, Gurnani[12] emphasis on investment decisions on supply chain, and Gnyawali [11] study the co-opetition between two large firms, Samsung Electronics and Sony, on LCD-TV industry. Most literature are conducted in qualitative methods and there are very few quantitative research like Chen and Chen [8] using the patent citation analysis to analyze co-opetition between two LCD manufactories. Moreover, Chen and Chen [8] use the traditional patent analysis methods, thus they only analyze the behavior of dyadic firms, and they can't analyze the behavior of an industry. Achrol [1][2] suggested that one of the fundamental change in the twenty-first century is from a dyadic perspective of interorganizational exchange relationships towards network perspective. In addition, most literature ignores a very import concept called "value net" of co-opetition. Business researchers Brandenberg and Nalebuff [4] provide a useful tool called the "value net", classifies the players in a company's market into four categories: competitors, complementors, suppliers and customers, to mapping the landscape of the industry and market conditions that create a very complex competitive and cooperative landscape in their book Co-opetition. However, there are very few article discus co-opetition and value net by quantitative methods [13].

Patent citations provide a method for measuring innovation diffusion among the various firms. For example, if patents of firm A is cited by patents of firm B, this implies that the knowledge diffused from firm A to firm B. The innovation diffusion are examined by contagion effects in two different social network models. The cohesion model is based on diffusion by direct communication. The structural equivalence model is based on diffusion by similarity of network position [19].This study employs network contagion to ascertain what kinds of contagion patterns take place in a technological system, and provides a quantitative method to modeling the value net of co-opetition by network contagion.

This study employs LED industry as a research sample in which 17 LED manufacturers are identified. The 17 manufacturers' patents that are issued in USPTO from 2006 to 2012 are collected.

The contribution of this empirical research is twofold. Firstly, it tries to test whether the technological competitors and complements of players are different in supplier views and customer views. Secondly, it can help the firms to identify technological competitors and complements in the technological system.

II. LITERATURE REVIEW

This study employs the social network contagion to examine the value net of co-opetition. This section reviews related literatures concerning the theories regarding value net of co-opetition, and the social network contagion.

A. Theories of Value Net

Möller [15] argues that the manager have to look beyond customer and supplier relationships into web like network such as R&D networks, supplier networks, and competitive coalitions. Moreover, Parolini [16] discussion the value net is a helpful tool for plan the competitive strategy. The direction of the network may horizontal in one dimension or diagonal in multi- dimension [20]. Brandenberg and Nalebuff [4] suggest that the "value net", classifies the actors in a company's market into four categories: competitors, complementors, suppliers and customers. Four key features of this framework as follows:

- A player is your complementor if customers value your product more when they have the other player's product then when they have your product alone.

- A player is your competitor if customers value your product less when they have the other player's product then when they have your product alone.
- A player is your complementor if it's more attractive for a supplier to provide resources to you when it's also supplying the other player then when it's supplying you alone.
- A player is your competitor if it's less attractive for a supplier to provide resources to you when it's also supplying the other player then when it's supplying you alone.

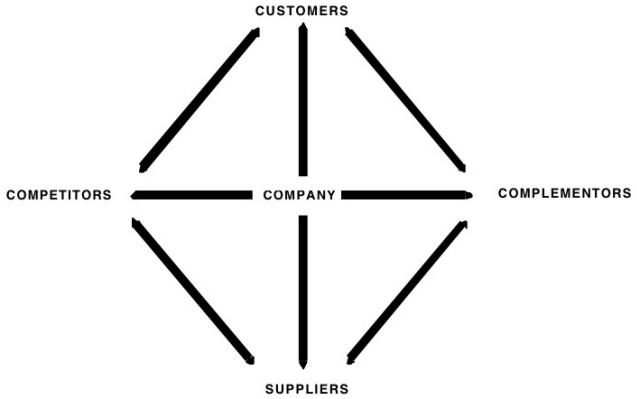

Figure 1 The Value Net [4]

That is, a firm identifying its competitors and complementors should be separated into two perspectives: one is based on supplier views and the other is on customer views. This study employs patent citation network to analyze the structure of value net of co-opetition. For example, if patents of firm A is cited by patents of firm B, this implies that the knowledge diffused from firm A to firm B. Then, this study defines firm A is supplier of knowledge, in other hand, firm B is customer of knowledge.

B. Network contagion *model*

The diffusion mechanisms of new technologies adoption among firms, in particular through contagion effects [19]. Therefore, the technology diffusion model of the technology intensive industry may use the contagion model of social network analysis. Scholars have employed the contagion model to explore the social contagion in the diffusion of technological innovation [5][9]. Scholars employs the cohesion model and the structural equivalence model to examine which social structural circumstances lead an actor's behavior of interpersonal synapse over which innovation is transmitted [19].

The cohesion model focuses on socialization between egos and alter [5]. The more frequent communication between ego and alter, the more likely that ego share the information and benefit with alter. Consequence, a firm tend to cooperate with the firms who have strong links between them. Therefore, this study employs cohesion to identify complementors

The structural equivalence model highlights competition between ego and alter [5].The more similar relations of ego and relations of alter with other actors, the more likely alter could substitute for ego in ego's role relations, and so the more intense that ego's feelings of competition with alter. Therefore, this study employs structure equivalence to identify competitor.

Shih and Chang [18] employed patent citation to examine the network structure of international technology diffusion in terms of embodied and disembodied diffusion networks. Some countries became the consumers of through purchase of goods, and some countries become supplier of knowledge through export goods. Therefore, a group named Source can be seen as a knowledge supplier and a group named Absorber can be seen as a knowledge customer.

Value net of co-opetition is a framework to identify the firm's environment. Therefore, this study employs the patent citation to examine the value net of co-opetition.

III. DATA AND METHODOLOGY

A. Data

Chen and Chen [8] used patent analysis to explore the co-opetition behavior between the two light emitting diode (LED) manufactures, Nichia and Osram. Patent citations have been often interpreted as a proxy of the knowledge diffusing and the knowledge absorb outward from the patents. This study employs LED industry as a research sample in which 17 LED manufacturers (Table 1) are identified. The abbreviation of the firms is given by this study. The 17 manufacturers' patents that are issued in USPTO (United States Patent and Trademark Office) between 2006 and 2012 are collected. The key word of search is combined by white light, red light, green light, light emitting diode, light emitting device and LCD. The result has 476 patents. Then, we built a social network for analysis, the actor of network is firm and linkage is patent citation (Figure 2).

B. Methodology

The sociological classic frequently cited as evidence of social contagion in the diffusion of technological innovation [9].The cohesion and structural equivalence highlighted the empirical circumstances in which they could contradict one another, and Burt [5][6] used them to reanalyze Medical Innovation. A formal theory to derive the predictions of social contagion by cohesion versus structural equivalence, and construct a general equation for this purpose by Burt [5][6]. Shih [19] proposed a formal theory to derive the predictions of social contagion by cohesion versus structural equivalence, and constructed a general equation for analyze ecommerce diffusion among firms. This study employs Shih's [19] social contagion model to examine the network contagion. The equation can be formulated as:

TABLE 1. NAME AND ABBREVIATION LIST OF 17 LCD FIRM

firm's name	abbreviation
Cree, Inc.	*Cree*
Epistar Corp.	*Epistar*
Everlight Electronics	*Everlight*
Intematix Corporation	*Intematix*
LG	*LG Group*
Leuchtstoffwerk Breitungen GmbH	*Leuchtstoffwerk*
Litec GbR (LITEC-LLL GmbH)	*Litec*
Luminus Devices, Inc.	*Luminus*
NICHIA Corporation	*Nichia*
Opto Tech GmbH	*Opto*
OSRAM GmbH	*Osram*
Royal Dutch Philips Electronics Ltd.	*Philips*
Samsung Electronics Co., Ltd.	*Samsung*
Seoul Semiconductor Co., Ltd.	*Seoul*
Sharp Corporation	*Sharp*
Toyoda Gosei Co., Ltd.	*Toyoda*
Tridonic GmbH & Co KG	*Tridonic*

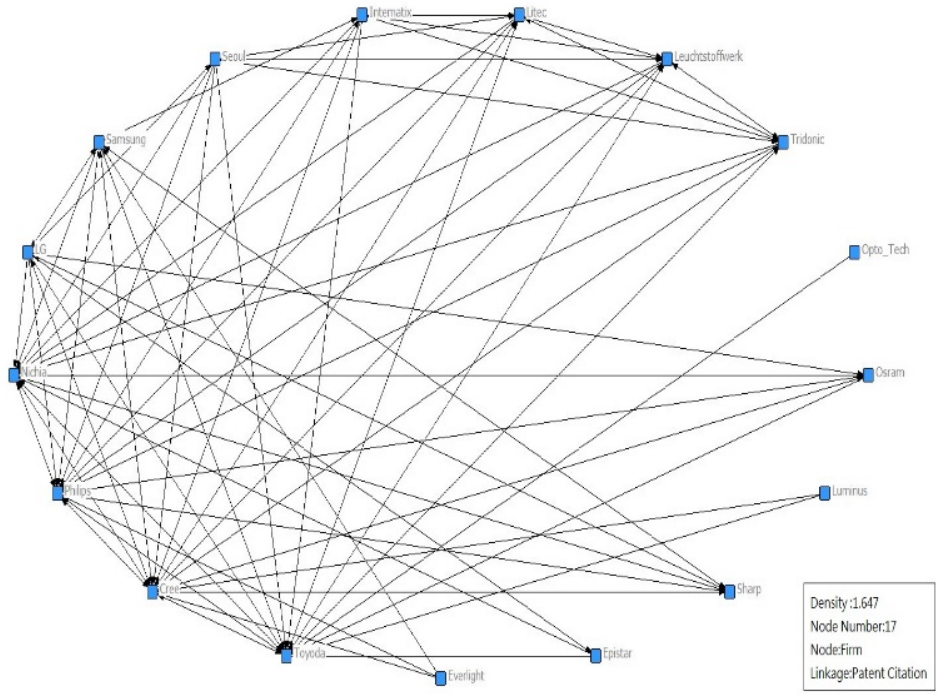

Figure 2 The diagram of 17 LCD manufacture Patent citation Network

$$w_{ij} = \frac{(\text{proximity } i \text{ to } j)^v}{\sum_k (\text{proximity } i \text{ to } k)^v}, k \neq i. \quad (1)$$

$$d_{ij} = \left[\sum_k \left(\frac{Z_{ik}}{R_i} - \frac{Z_{jk}}{R_j}\right)^2 + \sum_k \left(\frac{Z_{ki}}{C_i} - \frac{Z_{kj}}{C_j}\right)^2\right]^{1/2} \quad i \neq j \neq k \quad (2)$$

Where R_i denotes the sum of supplier across actors in row i of the patent citation matrix, and C_i denotes the sum of customer by actor i in column i. This study separate supplier views and customer views, thus, (2) can be formulated as

$$d_{ij}^c = \left[\sum_k \left(\frac{Z_{ki}}{C_i} - \frac{Z_{kj}}{C_j}\right)^2\right]^{1/2} \quad i \neq j \neq k \quad (2.1)$$

$$d_{ij}^s = \left[\sum_k \left(\frac{Z_{ik}}{R_i} - \frac{Z_{jk}}{R_j}\right)^2\right]^{1/2} \quad i \neq j \neq k \quad (2.2)$$

Where d_{ij}^s denotes the Euclidean distance between sectors i and j of supplier across actors in row i of the patent citation matrix, and d_{ij}^c denotes the Euclidean distance between actors i and j of customer by actor i in column i.

This study defined the contagion model as:

$$w_{ij}^{s\_SE} = \frac{\left(d_{Max_i - d_{ij}}^s\right)}{\sum_k \left(d_{Max_i - d_{ik}}^s\right)} \; i \neq j \neq k \quad (3)$$

$$w_{ij}^{c\_SE} = \frac{\left(d^{c}_{Max_i - d^{c}_{ij}}\right)}{\Sigma_k\left(d^{c}_{Max_i - d^{c}_{ik}}\right)} \; i \neq j \neq k \quad (4)$$

$$w_{ij}^{s\_c} = \frac{Z_{ij}}{\Sigma_k(Z_{ik})} \; i \neq j \neq k \quad (5)$$

$$w_{ij}^{c\_c} = \frac{Z_{ji}}{\Sigma_k(Z_{ki})} \; i \neq j \neq k \quad (6)$$

Where $w_{ij}^{s\_SE}$ denote the contagion effect of structure equivalence based on supplier views; $w_{ij}^{c\_SE}$ denote the contagion effect of structure equivalence from customer views; $w_{ij}^{s\_c}$ denote the contagion effect of cohesion from customer views; $w_{ij}^{c\_c}$ denote the contagion effect of cohesion from customer views. d_{max} i denotes the largest distance between actor i and any other actor. The proximity of some actor i to j can be expressed as the extent to which d_{ij} is smaller than $d_{max\,i}$, that is, $d_{max\,i} - d_{ij}$.

Then, this study tests $w_{ij}^{s\_SE}$ and $w_{ij}^{c\_SE}$ with Pearson correlation coefficient to check the difference of competitor in supplier views and customer views; test $w_{ij}^{s\_c}$ and $w_{ij}^{c\_c}$ with Pearson correlation coefficient to check the difference of complementor in supplier views and customer views.

IV. RESULT AND DISCUSSION

The results of (3) show in Table 2(a). Table 2(a) shows the strength of competition degree among the firms, in supplier views. For example, to firm Cree, in the supplier views, the most important competitor is Epistar. Descending order of degree of competition to Gree is: Epistar, Samsung, Toyoda, Seoul, Intematix, Sharp, LG, Leuchtstoffwerk, Litec, Tridonic, Nichia, Philips, Osram, Luminus, Everlight and Opto.

The results of (4) show in Table 2(b). Table 2(b) shows the strength of competition degree among the firms, in customer views. For example, to firm Nichia, in the customer views, the most important competitor is Epistar. Descending order of degree of competition to Nichia is: Leuchtstoffwerk, Litec, Sharp, Tridonic, Toyoda, Intematix, Samsung, Osram, Seoul, Philips, LG and Cree. Firm Everlight, Luminus and Opto haven't competitively behavior with Nichia in customer views.

The results of (5) show in Table 2(c). Table 2(c) shows the strength of cooperation degree among the firms, in supplier views. For example, to firm Toyoda, in the supplier views, the most important complementor is Seoul. Descending order of degree of cooperation to Toyoda is: Seoul, Intematix, Luminus, Philips, Cree, Samsung, LG, Nichia, Epistar, Osram, Leuchtstoffwerk, Litec, Opto and Tridonic. Firm Everlight and Sharp haven't cooperatively behavior with Toyoda in supplier views.

The results of (6) show in Table 2(d). Table 2(d) shows the strength of cooperation degree among the firms, in customer views. For example, to firm Opto, in the customer views, the most important complementor is Toyoda. The others firms haven't cooperatively behavior with Opto in customer views.

This study test table 2(a) and table 2(b) by Pearson correlation coefficient. The result showed in Table3 (a). In this table, for example, this study test the competition degree of Cree between the supplier views, first row of Table 2(a), and customer views, first row of Table 2(b), is correlation or not; then, put the result on the first row and first column. Likewise, put the result of competition degree of Epistar of correlation test between supplier views and customer views in second row and second column.

This study test Table 2(c) and Table 2(d) by Pearson correlation coefficient. The result showed in Table3 (b). In this table, for example, this study tests the cooperation degree of Cree between the supplier views, first row of Table 2(c), and customer views, first row of Table 2(d), is correlation or not; then, put the result on the first row and first column. Likewise, put the result of cooperation degree of Epistar of correlation test between supplier views and customer views in second row and second column.

In Table3 (a), Cree is correlation competitor with Cree, Everlight, Intematix, Leuchtstoffwerk, Luminus, Nichia, Opto, Samsung and Sharp. It means that the competitor of Cree in customer views are similar with the competitor of Cree, Everlight, Intematix, Leuchtstoffwerk, Luminus, Nichia, Opto, Samsung and Sharp in supplier views.

In Table 3(b), Everlight is correlation complementor with Nichia, Osram and Philips. It means that the complementors of Everlight in customer views are similar with the complementors of Nichia, Osram and Philips in supplier views. But the complementors of Everlight in customer views not similar with the complementors of Everlight in supplier views. In addition, the complementors of Cree in customer views are not similar with the complementors of Cree in supplier views. The same situation happens between Intematix and Osram.

To compare the correlation with the same firm, the result listed in Table 4. There are one of 17 firms is correlation between supplier views and customer views in competition. Thus, 94% of the firms have different competitive situation between supplier views and customer views, and 100% of the firms have different cooperative situations between supplier views and customer views.

TABLE 2(A). THE LIST OF $w_{ij}^{s\_SE}$

	Cree	Epistar	Everlight	Intematix	LG	Leuchtstoffwerk	Litec	Luminus	Nichia	Opto	Osram	Philips	Samsung	Seoul	Sharp	Toyoda	Tridonic
Cree	-	0.085862	0.00612	0.078737	0.076215	0.072704	0.072704	0.015441	0.070848	0	0.051709	0.056313	0.084966	0.082288	0.077853	0.084856	0.072704
Epistar	0.0837	-	0	0.0837	0	0.0837	0.0837	0	0.082111	0	0.0837	0.0837	0.0837	0.0837	0.0837	0.080527	0.0837
Everlight	0.033572	0.02052	-	0.02052	0.02052	0.02052	0.02052	0.220951	0.02052	0.220951	0.220951	0.02299	0.0419	0.02052	0	0.02052	0.02052
Intematix	0.079673	0.086889	0	-	0.086889	0.077969	0.077969	0	0.081942	0	0.086889	0.058926	0.027377	0.086889	0.086889	0.077039	0.077969
LG	0.086912	0	0	0.098036	-	0.098036	0.08287	0	0.084052	0	0.078216	0.090177	0.0904	0	0.094205	0.092399	0.098036
Leuchtstoffwerk	0.069404	0.081918	0	0.073543	0.081918	-	0.081918	0	0.079591	0	0.081918	0.079967	0.081918	0.049177	0.081918	0.070925	0.081918
Litec	0.071047	0.083882	0	0.075291	0.071047	0.083882	-	0	0.081494	0	0.083882	0.08188	0.083882	0.038262	0.083882	0.072607	0.083882
Luminus	0.06193	0	0.435242	0	0	0	0	-	0	0.435242	0	0	0	0	0	0.032974	0
Nichia	0.067909	0.080692	0	0.077587	0.070664	0.079914	0.079914	0	-	0	0.074692	0.073233	0.077587	0.074499	0.079914	0.078362	0.079914
Opto	0	0	0.495652	0	0	0	0	0.495652	0	-	0	0	0	0	0	0.005848	0
Osram	0.046044	0.076184	0.076184	0.076184	0.061027	0.076184	0.076184	0	0.069217	0	-	0.061027	0.076184	0.076184	0.076184	0.073315	0.076184
Philips	0.056168	0.085634	0.001161	0.058096	0.078841	0.083587	0.083587	0	0.076218	0	0.068478	-	0.068478	0.082907	0.082907	0.082692	0.083587
Samsung	0.084637	0.085529	0.009947	0.026972	0.078937	0.085529	0.085529	0	0.080664	0	0.085529	0.068395	-	0.085529	0.051794	0.079052	0.085529
Seoul	0.094513	0.098667	0	0.098667	0	0.058867	0.044675	0	0.089239	0	0.098667	0.095488	0.098667	-	0.098667	0.069058	0.044675
Sharp	0.072073	0.07855	0	0.07855	0.075868	0.07855	0.07855	0.008158	0.076572	0.008158	0.07855	0.07634	0.051031	0.07855	-	0.07855	0.07855
Toyoda	0.081804	0.079635	0	0.073419	0.078074	0.071655	0.071655	0.008112	0.078854	0.001343	0.079635	0.079934	0.076518	0.058185	0.082771	-	0.071655
Tridonic	0.070216	0.082888	0	0.074407	0.082888	0.082888	0.082888	0	0.080532	0	0.082888	0.080912	0.082888	0.037828	0.082888	0.071756	-

TABLE 2(B). THE LIST OF $w_{ij}^{c\_SE}$

	Cree	Epistar	Everlight	Intematix	LG	Leuchtstoffwerk	Litec	Luminus	Nichia	Opto	Osram	Philips	Samsung	Seoul	Sharp	Toyoda	Tridonic
Cree	-	0.085433	0.009535	0.068694	0.083058	0.080357	0.080357	0	0.058358	0.085433	0.057819	0.007463	0.069373	0.072293	0.070345	0.081199	0.080357
Epistar	0.072046	-	0.072046	0.072046	0.062857	0.072046	0.072046	0.072046	0	0.072046	0.072046	0.072046	0.072046	0.072046	0.072046	0	0.072046
Everlight	0	0.081356	-	0.081356	0.081356	0.081356	0.081356	0	0.081356	0.081356	0.081356	0	0.039088	0.081356	0.063333	0.081356	0.081356
Intematix	0.065225	0.071579	0.071579	-	0.071579	0.065225	0.065225	0.071579	0.05274	0	0.071579	0.061154	0.067086	0.071579	0.071579	0.05274	0.065225
LG	0.076366	0.062761	0.079702	0.079702	-	0.079702	0.079702	0.079702	0	0.079702	0.030426	0.025227	0.06901	0.062761	0.044551	0.062761	0.079702
Leuchtstoffwerk	0.070009	0.076117	0.076117	0.056022	0.076117	-	0.076117	0.076117	0	0.076117	0.076117	0	0.076117	0.037782	0.076117	0.071868	0.076117
Litec	0.070009	0.076117	0.076117	0.056022	0.076117	0.076117	-	0.076117	0	0.076117	0.076117	0	0.076117	0.037782	0.076117	0.071868	0.076117
Luminus	0	0.077399	0.008696	0.077399	0.077399	0.077399	0.077399	-	0	0.077399	0.077399	0.077399	0.077399	0.077399	0.077399	0.060976	0.077399
Nichia	0.083476	0	0.118396	0.05589	0.044217	0.036578	0.036578	0.009717	-	0.118396	0.075934	0.063269	0.073536	0.080761	0.05589	0.073387	0.036578
Opto	0.071429	0.071429	0.071429	0	0.071429	0.071429	0.071429	0.071429	0.071429	-	0.071429	0.071429	0.071429	0.071429	0.071429	0	0.071429
Osram	0.051752	0.071558	0.071558	0.071558	0.046029	0.071558	0.071558	0.071558	0.047879	0.071558	-	0	0.071558	0.071558	0.071558	0.063547	0.071558
Philips	0.022316	0.110256	0.024635	0.079308	0.065728	0.037976	0.037976	0.110256	0.061693	0.110256	0	-	0.058583	0.096778	0.037976	0.079577	0.037976
Samsung	0.053117	0.083011	0.011165	0.060842	0.068717	0.083011	0.083011	0.083011	0.019119	0.083011	0.083011	0	-	0.083011	0.075519	0.039562	0.083011
Seoul	0.061225	0.086727	0.086727	0.086727	0.063214	0.025577	0.025577	0.086727	0.03085	0.086727	0.086727	0.063665	0.086727	-	0.086727	0	0.025577
Sharp	0.057148	0.074984	0.055203	0.074984	0.045202	0.074984	0.074984	0.074984	0.017748	0.074984	0.074984	0	0.070263	0.074984	-	0.074984	0.074984
Toyoda	0.073481	0.03622	0.075162	0.055332	0.070335	0.073761	0.073761	0.067866	0.06104	0	0.070691	0.064281	0.065738	0.056478	0.075162	-	0.073761
Tridonic	0.070009	0.076117	0.076117	0.056022	0.076117	0.076117	0.076117	0.076117	0	0.076117	0.076117	0	0.076117	0.037782	0.076117	0.071868	-

TABLE 2(C). THE LIST OF $w_{ij}^{s\_c}$

	Cree	Epistar	Everlight	Intematix	LG	Leuchtstoffwerk	Litec	Luminus	Nichia	Opto	Osram	Philips	Samsung	Seoul	Sharp	Toyoda	Tridonic
Cree	-	0	0.021335	0.021335	0.007543	0	0	0.084333	0.007543	0	0.007543	0.039194	0.039194	0.084333	0.007543	0.021335	0
Epistar	0	-	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Everlight	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intematix	0	0	0	-	0	0	0	0	0	0	0	0.19245	0.544331	0	0	0	0
LG	0.053995	0	0	0	-	0	0	0	0	0	0	0	0.431959	0	0.152721	0	0
Leuchtstoffwerk	0.053995	0	0	0.029391	0	-	0.010391	0	0	0	0	0	0	0.379106	0	0.053995	0.010391
Litec	0.053995	0	0	0.029391	0	0.010391	-	0	0	0	0	0	0	0.379106	0	0.053995	0.010391
Luminus	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0
Nichia	0.090622	0.002324	0	0.012075	0.047729	0.004269	0.004269	0	-	0	0.043036	0.047729	0.012075	0.02598	0.004269	0.029973	0.004269
Opto	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0
Osram	0.268957	0	0	0	0.08119	0	0	0	0.095091	0	-	0.08119	0	0	0	0	0
Philips	0.293034	0	0.001783	0.005044	0.019938	0.003276	0.003276	0	0.005044	0	0.052218	-	0.019938	0.005044	0.005044	0.019938	0.003276
Samsung	0.044194	0	0.044194	0	0.353553	0	0	0	0	0	0	0	-	0	0.125	0	0
Seoul	0	0	0	0	1	0	0	0	0	0	0	0	0	-	0	0	0
Sharp	0.044194	0	0	0	0.125	0	0	0	0	0	0	0	0.494106	0	-	0	0
Toyoda	0.02598	0.006573	0	0.034152	0.012075	0.002324	0.002324	0.034152	0.012075	0.002324	0.006573	0.034152	0.01859	0.148719	0	-	0.002324
Tridonic	0.053995	0	0	0.029391	0	0.010391	0.010391	0	0	0	0	0	0	0.379106	0	0.053995	-

TABLE 2(D). THE LIST OF $w_{ij}^{c\_c}$

	Cree	Epistar	Everlight	Intematix	LG	Leuchtstoffwerk	Litec	Luminus	Nichia	Opto	Osram	Philips	Samsung	Seoul	Sharp	Toyoda	Tridonic
Cree	-	0	0	0	0	0	0	0	0	0	0	0.000977	0	0	0	0	0
Epistar	0	-	0	0	0	0	0	0	0.000977	0	0	0	0	0	0	0.000977	0
Everlight	0.000105	0	-	0	0	0	0	0	0	0	0	0.000105	0	0	0	0	0
Intematix	0	0	0	-	0	0	0	0	0.000001	0	0	0	0	0	0	0.000001	0
LG	0	0	0	0	-	0	0	0	0.000006	0	0	0	0	0	0	0	0
Leuchtstoffwerk	0	0	0	0	0	-	0	0	0.000017	0	0	0.000017	0	0	0	0	0
Litec	0	0	0	0	0	0	-	0	0.000017	0	0	0.000017	0	0	0	0	0
Luminus	0.000377	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0.002331	0
Nichia	0	0	0	0	0	0	0	0	-	0	0.002801	0	0	0	0	0	0
Opto	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	1	0
Osram	0	0	0	0	0	0	0	0	0.000079	0	-	0.001677	0	0	0	0	0
Philips	0	0	0	0	0	0	0	0	0.000279	0	0.000002	-	0	0	0	0	0
Samsung	0	0	0	0	0	0	0	0	0	0	0	0.000005	-	0	0	0	0
Seoul	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0.000001	0
Sharp	0	0	0	0	0	0	0	0	0.000001	0	0	0.000017	0	0	-	0	0
Toyoda	0	0	0	0	0	0	0	0	0.000023	0	0	0.000009	0	0	0	-	0
Tridonic	0	0	0	0	0	0	0	0	0.000017	0	0	0.000017	0	0	0	0	-

TABLE 3(A). THE RESULT OF CORRELATION TEST BETWEEN COMPETITION DEGREE OF CUSTOMER VIEWS AND COMPETITION DEGREE OF SUPPLIER VIEWS

Customer view / Supplier view	Cree	Epistar	Everlight	Intematix	LG	Leuchtstoff werk	Litec	Luminus	Nichia	Opto	Osram	Philips	Samsung	Seoul	Sharp	Toyoda	Tridonic
Cree	.587*	-0.205	0.098	0.459	-0.142	-0.112	-0.112	0.093	-0.327	-0.245	-0.075	-0.148	0.149	-0.349	0.032	0.371	-0.112
Epistar	0.37	-0.14	0.039	0.306	-0.391	-0.285	-0.285	0.067	-0.155	-0.19	-0.071	-0.23	0.044	-0.323	0.012	0.282	-0.285
Everlight	-.494*	0.221	-0.077	-0.303	0.121	0.287	0.287	-0.079	0.291	0.207	0.259	-0.038	0.033	0.449	0.17	-0.284	0.287
Intematix	.558*	-0.196	0.309	0.405	-0.299	-0.185	-0.185	0.094	-0.276	-0.206	-0.113	-0.255	0.109	-0.354	-0.022	0.317	-0.185
LG	0.31	-0.23	-0.017	0.218	-0.205	-0.111	-0.111	0.033	-0.076	-0.271	-0.303	-0.462	-0.111	-.525*	-0.217	.541*	-0.111
Leuchtstoff werk	.489*	-0.157	0.137	0.396	-0.346	-0.171	-0.171	0.172	-0.315	-0.106	-0.239	-0.303	0.071	-0.395	-0.147	0.389	-0.171
Litec	0.462	-0.165	0.11	0.37	-0.361	-0.16	-0.16	0.148	-0.312	-0.122	-0.226	-0.325	0.05	-0.412	-0.14	0.386	-0.16
Luminus	-.503*	0.159	-0.177	-0.423	0.347	0.253	0.253	-0.196	0.272	0.147	0.214	0.224	-0.089	0.351	0.117	-0.362	0.253
Nichia	.528*	-0.216	0.197	0.401	-0.349	-0.238	-0.238	0.161	-0.27	-0.181	-0.172	-0.233	0.086	-0.406	-0.085	0.364	-0.238
Opto	-.522*	0.176	-0.136	-0.416	0.331	0.241	0.241	-0.144	0.254	0.164	0.225	0.244	-0.072	0.37	0.116	-0.378	0.241
Osram	0.258	-0.121	0.456	.578*	-0.226	-0.098	-0.098	-0.019	-0.055	-0.175	0.042	-0.464	-0.127	-0.258	-0.017	.511*	-0.098
Philips	0.479	-0.205	0.209	0.383	-0.35	-0.258	-0.258	0.241	-0.326	-0.084	-0.247	-0.148	0.065	-0.452	-0.135	0.361	-0.258
Samsung	.513*	-0.201	0.138	0.356	-0.289	-0.148	-0.148	0.03	-0.203	0.121	-0.175	-0.321	0.114	-0.473	-0.105	0.389	-0.148
Seoul	0.236	-0.102	-0.091	0.318	-.531*	-0.386	-0.386	0	-0.021	-0.182	-0.153	-0.094	-0.046	0.043	-0.091	0.138	-0.386
Sharp	.525*	-0.201	0.201	0.377	-0.343	-0.258	-0.258	0.18	-0.303	-0.203	-0.222	-0.198	0.08	-0.42	-0.095	0.338	-0.258
Toyoda	0.48	-0.238	0.048	0.401	-0.386	-0.219	-0.219	0.102	-0.272	-0.19	-0.283	-0.25	0.014	-0.378	-0.163	0.399	-0.219
Tridonic	0.474	-0.163	0.122	0.379	-0.341	-0.146	-0.146	0.158	-0.322	-0.113	-0.246	-0.32	0.054	-0.408	-0.158	0.391	-0.146

** Correlation significant (two-tailed) at the 0.01 level.
* Correlation significant (two-tailed) at the 0.05 level.

TABLE 3(B). THE RESULT OF CORRELATION TEST BETWEEN COOPERATION DEGREE OF CUSTOMER VIEWS AND COOPERATION DEGREE OF SUPPLIER VIEWS

Customer view / Supplier view	Cree	Epistar	Everlight	Intematix	LG	Leuchtstoff werk	Litec	Luminus	Nichia	Opto_Tech	Osram	Philips	Samsung	Seoul	Sharp	Toyoda	Tridonic
Cree	0.18	-0.077	-0.007	-0.077	-0.118	0.045	0.045	-0.019	-0.118	0.012	0.174	-0.119	0.18	0.012	0.173	-0.045	0.045
Epistar	-0.062	-0.091	-0.091	-0.091	-0.063	-0.091	-0.091	-0.072	-0.063	-0.062	-0.066	-0.063	-0.062	-0.062	-0.066	-0.083	-0.091
Everlight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Intematix	0.28	-0.119	0.145	-0.119	-0.081	0.145	0.145	-0.094	-0.081	-0.081	0.277	-0.082	0.28	-0.081	0.276	0.027	0.145
LG	-0.089	-0.13	-0.037	-0.13	-0.089	-0.13	-0.13	-0.083	-0.089	-0.089	-0.093	-0.09	-0.089	-0.089	-0.095	-0.118	-0.13
Leuchtstoff werk	-0.089	-0.019	-0.019	-0.019	-0.089	-0.13	-0.13	0.073	-0.089	0.063	-0.093	-0.09	-0.089	0.063	-0.095	-0.118	-0.13
Litec	-0.089	-0.019	-0.019	-0.019	-0.089	-0.13	-0.13	0.073	-0.089	0.063	-0.093	-0.09	-0.089	0.063	-0.095	-0.118	-0.13
Luminus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nichia	0.29	-0.065	.743**	-0.065	-0.197	0.068	0.068	0.226	0.242	0.109	0.281	-0.196	0.29	0.109	0.279	-0.08	0.068
Opto_Tech	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Osram	0.185	0.089	.776**	0.089	0.236	0.308	0.308	0.028	-0.114	-0.114	0.197	0.236	0.185	-0.114	0.199	0.294	0.308
Philips	-0.094	-0.071	.648**	-0.071	-0.076	-0.124	-0.124	0.137	0.097	-0.021	-0.098	-0.075	-0.094	-0.021	-0.099	-0.107	-0.124
Samsung	-0.097	-0.142	-0.048	-0.142	-0.097	-0.142	-0.142	-0.092	-0.097	-0.097	-0.102	-0.098	-0.097	-0.097	-0.103	-0.128	-0.142
Seoul	-0.062	-0.091	-0.091	-0.091	-0.063	-0.091	-0.091	-0.072	-0.063	-0.062	-0.066	-0.063	-0.062	-0.062	-0.066	-0.083	-0.091
Sharp	-0.083	-0.121	-0.052	-0.121	-0.083	-0.121	-0.121	-0.081	-0.083	-0.083	-0.087	-0.083	-0.083	-0.083	-0.088	-0.11	-0.121
Toyoda	0.102	-0.15	0.105	-0.15	-0.059	0.032	0.032	-0.139	-0.099	-0.146	0.099	-0.059	0.102	-0.146	0.099	-0.018	0.032
Tridonic	-0.089	-0.019	-0.019	-0.019	-0.089	-0.13	-0.13	0.073	-0.089	0.063	-0.093	-0.09	-0.089	0.063	-0.095	-0.118	-0.13

** Correlation significant (two-tailed) at the 0.01 level.
* Correlation significant (two-tailed) at the 0.05 level.

TABLE 4. SUMMARY OF TABLE 3

Co-opetition / Firms	Competition Supplier view V.S. Customer view	Cooperation Supplier view V.S. Customer view
Cree	0.587**(0.013)	0.18
Epistar	-0.14	-0.091
Everlight	-0.007	0
Intematix	0.405	-0.119
LG	-0.205	-0.089
Leuchtstoffwerk	-0.171	-0.13
Litec	-0.16	-0.13
Luminus	-0.196	0.073
Nichia	-0.27	0.232
Opto	0.164	0
Osram	0.0042	0.197
Philips	0.148	-0.075
Samsung	0.114	-0.097
Seoul	0.043	-0.062
Sharp	-0.095	-0.088
Toyoda	0.399	-0.018
Tridonic	-0.146	-0.13

** Correlation significant (two-tailed) at the 0.01 level.
* Correlation significant (two-tailed) at the 0.05 level.

V. CONCLUSION

In the present study we employ network contagion effect in order to find the model of value net of co-opetition. There is only one firm which has the same competitive situation between supplier views and customer views. The other firms have different situations between supplier views and customer views of both competitors and complementors. This is in line with earlier findings in the literature.

The first contribution of this study results from the fact that we separate the industry technology diffusion network into two parts: one is based on supplier views to indicate the competitive situation with the help of the structure equivalence, and to indicate the cooperative situation by the cohesion; the other one is on the basis of customer views to indicate the competitive situation by the structure equivalence, and to indicate the cooperative situation by the cohesion.

The second contribution of this study comes from the fact that the situation is difference from supplier views and customer views. When a certain firm develops technological strategies must consider both supplier views and customer views to identify technological competitors and complements.

The third contribution relates to our efforts introduce the quantitative method which builds the value net introduced by Brandenberg and Nalebuff [4]. The empirical findings of this study are summarized below:

1. Most of the firms have difference complementor between customer views and supplier views.
2. Most of the firms have difference competitor between customer views and supplier views.
3. When a firm identifies its complementor and competitor in a certain industry, it must separate customer views and supplier views.

From the managerial perspective, our study helps managers on how to improve the efficiency of identifying the competitor and complementor in the industry and on what competitors and complementors to focus in the first. *By providing insights on the relative industry of both views, the method of this study helps managers to prevent from focusing on less important competitors and complementor and wasting considerable resources on these less important actors.*

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