Innovation Intermediary of Technological Alliance

Calvin S. Weng[1], Hsien-Che Lai [2]
[1]Takming University of Science and Technology, Taiwan, R.O.C.
[2]National University of Tainan, Taiwan, R.O.C

Abstract--**Technological alliances play an important role in generating innovations but face effective matchmaking in finding suitable partners in "open innovation" among networks of innovating firms. Intermediaries are external mechanism/institutions that can appropriately support companies in their innovative activities. They are frequently used to build a bridge between different competency constraints among companies. Thus, the purpose of this paper tries to understand the role of a firm's alliance network in view of exploration? What do innovation intermediaries of collaborative partner do?**

Based on the "Strategic Alliance Database" established by the National Science Council (NSC) in Taiwan, this paper empirically explores the brokerage roles in the alliance that intermediaries facilitate technological innovation and innovation process especially the relationship between cooperation networks. By using the technique of 2-mode network analysis of social network analysis, this research focuses on the question of which the capabilities a technological alliance creates a platform for firms that execute matchmaking for new and/or relevant technologies. The results of this paper reveal the fact that brokerage roles can be used to develop collaborations. The strategic positions of intermediary can activate different resources from the ones embedded within alliance network.

I. INTRODUCTION

Traditionally, industrial firms developed their own new products or explore new technologies internally [1-4]. In other word, most companies adopted relatively closed innovation strategies, and with limited interactions with the outside environment. In recent decades, competition among firms turns more intensive. The pace of technological development is increasing and the product life cycles are shortening than before. In response to these competitive pressures, firms start to look for alternatives to in-house R&D. Thus, the R&D strategies have begun to change as firms may gain access to complementary capabilities across industries or acquire external technologies to complement their internal knowledge bases by inter-firm R&D collaboration, such as strategic alliances which involves acquiring the right to use external knowledge [5, 6].

Therefore, the concept of open innovation has recently gained widespread attention [7]. This phenomenon could recently be observed from high technology companies or innovation intensive sectors. Firms across industries started to actively commercialize their technological knowledge through strategic alliances where allow firms to use some technology of external partners, or by extensive use of external knowledge sourcing and external paths to commercialization. In "open innovation" environment, firms interact extensively with their environment, leading to a significant amount of external knowledge exploration and exploitation [7, 8]. Indeed, few companies are self sufficient in their own resources. A deficiency in one or more strategic resource drives firms for seeking mutual collaboration. Cooperation is attractive as partners have a good understanding of the relevant issues at hand. And the rationale for alliance and/or teaming up with collaborative partners is motivated by possibilities to obtain complementary know-how and/or to speed up the R&D process in industries where time-to-market is crucial. The formation of alliance is naturally an alternative decision for balancing exploration and exploitation of firm.

The alliances enable a rapid diffusion of knowledge among partners, enhancing the efficiency and speed of cooperation [9]. Traditionally, alliances act as "pipelines" function for diffusion of existing information and knowledge for exploitation between firms. This raises the question: What a different role of a firm's alliance network is? How alliances act as "brokerage" (or bridge) for firms with recombination potential for new knowledge creation or diverse technologies?

The above conditions connect with March's category of exploration in which environment is in highly uncertainty and the focus is on the discovery and experimentation of new technologies [2]. Existing literature has largely ignored this role of alliances for novelty creation and is therefore unable to explain the development of new knowledge and competencies [10-12]. To descript the brokerage role in innovation process, Howells [13] termed it as 'intermediaries' to present actors within complex realm who perform a variety of tasks within the innovation process. Studies have also pointed that the role of intermediary of organizations creates the necessary linkages between the many actors in innovation networks [14].

In sum, technological alliances play an important role in generating innovations but face effective matchmaking in finding suitable partners in "open innovation" among networks of innovating firms. Intermediaries are external mechanism/institutions that can appropriately support companies in their innovative activities. They are frequently used to build a brokerage between different competency constraints among companies. Thus, the purpose of this paper tries to understand the role of a firm's alliance network in view of exploration? What do innovation intermediaries of collaborative partner do? We select the empirical data of technological alliance from the "Strategic Alliance Database" established by the National Science Council (NSC) in Taiwan. By using the technique of 2-mode network analysis of social network analysis, this research focuses on the question of

which the capabilities a technological alliance creates a platform for firms that execute matchmaking for new and/or relevant technologies. The paper is structured as follows: In section 2, we elaborate our literature reviews. Then, in section 3, we present details about the data and methodology. In section 4, the main findings are presented. Finally, in section 5, we provide a discussion of the results, the main conclusions and some indications for further research.

II. INNOVATION INTERMEDIARY AND ALLIANCE

What is the role of collaborative partner in view of exploration? The different roles that these actors play within the innovation process have been variously described, such as knowledge broker [15-17]; bridge [18, 19], technology transfer [20]. What is the role of brokerage? Marsden defines "brokerage" as a process "by which intermediary actors facilitate transactions between other actors lacking access to or trust in one another."[21, p.202] Thus, according to the definition of Gould and Fernandez [15, p.91]:

> *"any brokered exchange can be thought of as a relation involving three actors, two of whom are the actual parties to the transaction and one of whom is the intermediary or broker"*

However, a key role who fostering the necessary linkages and aligning different actors with diverging interests in order to enable innovation is still lack of a clear definition. In response of this, Howells termed it as "intermediary ", and put forward a broad definition of an innovation intermediary as follows [13, p.720]:

> *"an organization or body that acts as an agent or broker on any aspect of the innovation process between two or more parties. Such intermediary activities include: helping to provide information about potential collaborators, brokering transactions between two or more parties; acting as mediator, or go-between, bodies or organisation that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations."*

This definition points to a different role of a firm in alliance network in view of exploration. Traditionally firms pursue closed innovation strategies. Firms generally keep R&D activities internally within their familiar or closed boundaries. In other words, firms don't frequently interact with outside environment so that other firms also cannot get chance to know their innovations beforehand. Therefore, firms need to utilize intermediaries to search and solve innovation problems as well.

Firms engage in so called exploration that can be characterized by the terms such as search, variation, risk taking, experimentation, play, flexibility, discovery and innovation [2]. In response of uncertainty, firms tend to form technological alliances to overcome their potential technological problems [22-24]. This implicates in open environment with uncertainty one of collaborative partners in alliance network plays a crucial role of innovation intermediary and helps others to break with an existing dominant design and shifting away from existing rules, norms, routines and activities, in search of novel combinations [12]. Therefore, in this paper we argue that the innovation intermediary in alliance can be characterized by helping other collaborative partners in three-fold. First, to break away from the established way of doing things [25]. Second, the novel recombination of diverse technologies or knowledge in a firm [26]. Third, the discovery and experimentation of new technologies [2, 25].

Therefore, in relation to open innovation environment and the brokerage role that collaborative partners play as intermediaries, strategic alliance can : (1) promotes a diversity of range of channels of knowledge transfer; (2) a good opportunities for organizational learning; (3) a channel for diffusion of existing information and knowledge for exploitation; (4) and technological proximity for influencing innovative performance. In sum, innovation intermediaries of alliance partnership are organizations or firms within alliance network that work together to enable innovation, either directly by enabling the innovativeness of one or more firms, or indirectly by enhancing the innovative capacity of ideas, knowledge, or technologies.

III. METHODOLOGY AND DATA

A. Data

We select empirical alliance data from the "Strategic Alliance Database" established by the National Science Council (NSC) in Taiwan, which contains information on 673 cooperative agreements among 248 firms with the period of 2000-2009. Firms which listed on the Taiwan Stock Exchange (TSE) and Taiwan Over-the-Counter Securities Exchange (TOSE) are selected. The empirical data are focus in the Electronic and Information Technology sector. The reasons why we choose Taiwanese electronic and information technology firms as an empirical context are as follows. First, this sector is the most technology-intensive in industry. Second, these firms often upgrade their capabilities and access external technological knowledge through technological alliance. The sample of Taiwanese electronic and information technology firms are thus appropriate for examining the arguments presented in this study. This study refers to these firms as "focal firms" to distinguish them from the alliance partners. In the later social network analysis, "focal firms" and "alliance partners" were treated as "actor" and "event", respectively.

B. Methodology

Social network analysis in innovation and invention studies has gained considerable attention [27-29]. In social network analysis, the term "mode" refers to a class of entities. In the 1- mode case, the mode typically called actors or nodes whose members have social ties with other members. In the

2- mode case, actors with members of another class. In the other words, 1-mode analysis examines the relationships between the same set of persons or entities. On the contrary, 2-mode analysis looks at equally the relations between two different sets of persons or entities [30]. In this paper, the methods utilized to analyze the empirical network data was developed by Borgatti and Everett [30]. All of social network measures and figures are derived using the software program UCINET 6.0 [31].

1. 2-mode network

The network data set can be presented as a matrix form. A matrix is 2-mode if the rows and columns refer to different sets of entities, and relation connects the two sets, such as person-by-event matrix. The most classical example of a two-mode network is the "Deep South" data collected by Davis et al.[32].

Let the set of "actors" is denoted by $N = \{n_1, n_2, ..., n_g\}$ and the set of "events" is denoted by $M = \{m_1, m_2, ..., m_h\}$, then 2-mode matrix represented by $A = \{a_{ij}\}_{hxg}$, where a_{ij} records the affiliation of each actor *i* with each event *j*, and where

$$a_{ij} = \begin{cases} 1 & \text{if actor } i \text{ is affiliated with event } j \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

The value of a_{ij} is 1 if row actor *i* is affiliated with column event *j*, and a 0 is if no affiliation exists. The example of Faust [33] clearly illustrated a 2-mode network. The 2-mode network matrix for six actors and three events is presented in Table 1.

TABLE 1: ADJACENT MATRIX OF 2-MODE NETWORK

Actors\Events	m_1	m_2	m_3
n_1	1	0	1
n_2	0	1	0
n_3	0	1	1
n_4	0	0	1
n_5	1	1	1
n_6	1	1	0

Data source: data from Faust (1997)[33]

2. Bipartite graph

The structure of a 2-mode network can also be represented as a bipartite graph [34, 35]. In the bipartite graph, the lines indicate ties of affiliation between actors and events. Figure 1 depicts the bipartite graph of 2-mode network of Table 1. One is the set of actors, $N = \{n_1, n_2, ..., n_6\}$, and the other is the set of events, $M = \{m_1, m_2, m_3\}$. So there are 6+*3* nodes by the bipartite graph.

In this study, we are interesting in the intermediary position in the structure of alliance network. In this manner, the use of analysis of 2-mode network offers a different perspective on network relationships between focal firm and its technological alliance.

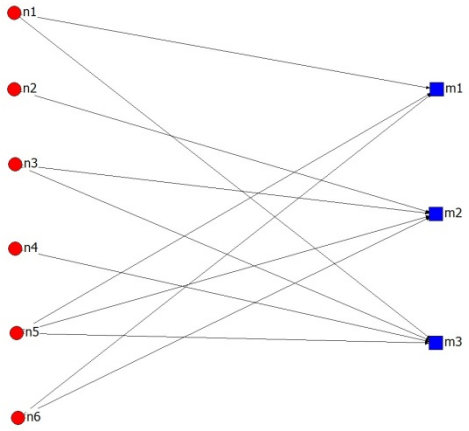

Figure 1: Bipartite graph of 2-mode network

3. Measurement of network

Because we are interested in exploring the affiliation of firms to technological alliance and identifying the relative position of firms located within the structure of the technological alliance network, the following centrality measures, which are degree, betweenness, closeness, and eigenvector, are discussed.

In general, centrality refers to a family of properties of node positions. Measures of centrality focus on the number of ties of network that actor has with other members of the network [36]. In a sense, the use of centrality measures gives us some indication of network effect on positions. Different aspects of centrality have been a lot discussed by Freeman [37], Knoke and Burt [38], and Faust and Wasserman [39]. Detail descriptions of 4 kinds of centrality please refer to Wasserman and Faust [35].

4. Identification of brokerage roles

Gould and Fernandez [15] identified five types of brokerage roles by examining differences in activities and interests of the actors in the network relationships. The five types of brokerage roles are called as follows: coordinator brokerage, itinerant brokerage (consultant), gatekeeper, representative brokerage and liaison brokerage, respectively. The five structurally distinct types of brokerage configurations are depicted in Figure 2.

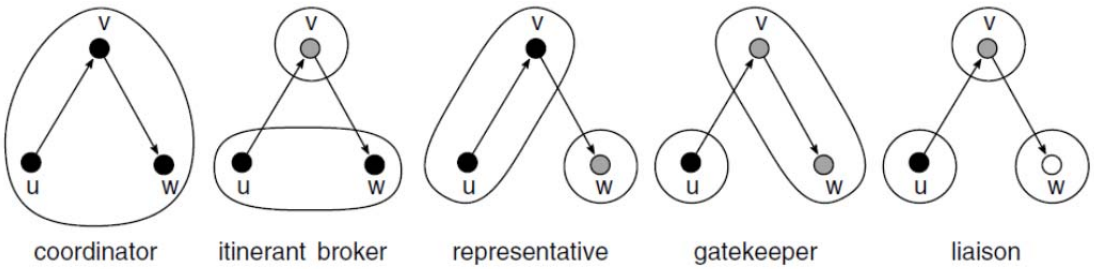

Figure 2: five brokerage roles by Gould and Fernandez [15]

For ego U, V and W[40]:

(1). Ego V as "coordinator": The ego who is "brokering" (node V), and both the source and destination nodes (U and W) are all members of the same group.

(2). Ego V as "consultant": The ego V is brokering a relation between two members of the same group, but is not itself a member of that group.

(3). Ego V as "representative": The ego V is in the same group as U, and acts as the contact point or representative of the black group to the grey.

(4). Ego V as "gatekeeper": The ego V is acting as a gatekeeper. V is a member of a group who is at its boundary, and controls access of outsiders (U) to the group.

(5). Ego V as "liaison": The ego V is brokering a relation between two groups and is not part of either.

The five brokerage types represent distinct social roles of an actor's structural position within a given network. Detail descriptions of 5 kinds of brokerage roles please refer to Gould and Fernandez [15]. Gould and Fernandez [15] also quantify the overall participation of individuals in brokerage roles via a brokerage score. In this paper, 2-mode networks and brokerage score of Gould and Fernandez [15] are performed by UCINET by Borgatti, Everett and Freeman [31].

IV. ANALYSIS AND RESULTS

We are interested in how firms act as brokerage role in alliance network with recombination potential for new knowledge creation or diverse technologies? We select the most representative firms out of 248 firms and calculate network measures for inspecting the details of network effect.

A. Data Selecting

The sample set contained 248 firms and 673 cooperative agreements, and the distribution of alliance of firms was as Table 2. Moody[41], suggested that abstracting the nodes into less than 100, usually less than 50 nodes, is proper way for analysis purpose. In order to explain the detail network structure effects, the large scale network needed to be abstracted.

A firm often entered into alliance with several different other firms with variety of cooperative agreements. 2-mode network is a good way to facilitate the knowledge and skills sharing within alliance events and to form a particular structure of alliance network. In order to utilize the 2-mode network analysis, this study refers to these firms as "focal firms" (abbreviation FF) to distinguish them from the "alliance partners" (abbreviation AF). Therefore, in network analysis, the focal firm is an "actor" and alliance partners can be treated as an "event" in the analysis, respectively.

B. 2-mode network structure

The bipartite graph allows us to clearly identify the structure of 2-mode network. Figure 3 represented the network structure of connections between focal firm and alliance partner. In the graph, focal firms were represented by round nodes and alliance partners by square nodes.

From Figure 1, it was obviously that FF6 located in the central of network with a greater number of alliance partners and played the key role within whole network. In contrast, AP6 was apparently the most popular and locates in the central of network. Figure 3 only gave us a rough sense of the position of firms. We need more precise measurement for further comparison. The following was the calculation of the centrality measurement.

C. Measures of centrality

4 kinds of properties of network structure were calculated as follows. Table 3 was the 2-mode centrality measures for each focal firm, and Table 4 was the 2-mode centrality measures for each alliance partner. Judged from Table 3, FF6 (Acer) with the highest centrality of all was obviously the most important focal firm among all. From Table 4, AP6 was with highest degree and AP12 was the next.

TABLE 2: THE DISTRIBUTION OF ALLIANCE OF FIRMS

Number of Agreement	1	2	3	4	5	6	7	8	9	Total
Firm	78	56	59	20	10	8	6	7	2	248
Total	78	112	177	80	50	60	42	56	18	673

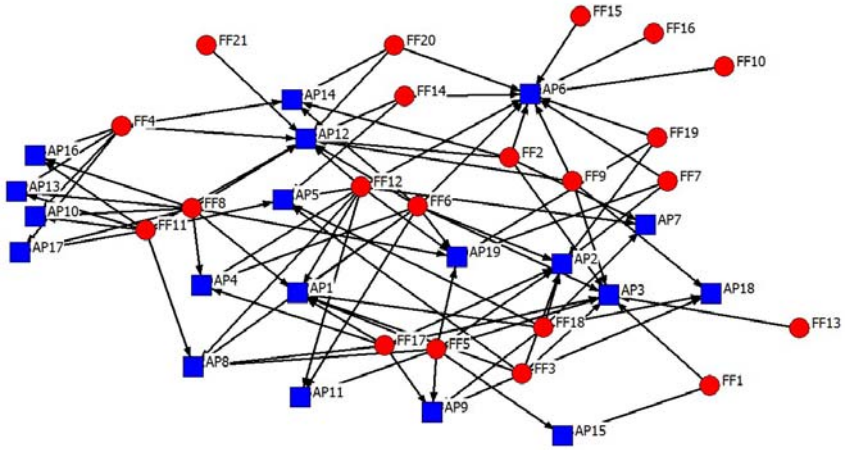

Figure 3: 2-mode network

TABLE 3: 2-MODE CENTRALITY MEASURES OF 21 FOCAL FIRMS

No.	Focal Firm	Degree	Closeness	Betweenne	Eigenvect
FF1	Powerchip	0.105	0.465	0.006	0.06
FF2	TATUNG CO.	0.263	0.678	0.058	0.217
FF3	CMC	0.316	0.608	0.043	0.238
FF4	Compal	0.316	0.532	0.039	0.16
FF5	AUO	0.421	0.621	0.094	0.325
FF6	ACER	0.526	0.766	0.161	0.469
FF7	GIGABYTE	0.158	0.584	0.011	0.154
FF8	BMC	0.421	0.648	0.113	0.28
FF9	VIA	0.211	0.663	0.052	0.184
FF10	LEO	0.053	0.465	0	0.056
FF11	ACCTON	0.368	0.608	0.073	0.212
FF12	ASUSTEK	0.474	0.711	0.112	0.399
FF13	ECS	0.053	0.457	0	0.049
FF14	SYSTEX CORP	0.158	0.584	0.016	0.151
FF15	TSMC	0.053	0.465	0	0.056
FF16	Far EasTone	0.053	0.465	0	0.056
FF17	QCI	0.316	0.596	0.033	0.272
FF18	RITEK	0.316	0.584	0.037	0.211
FF19	Synnex	0.158	0.584	0.011	0.154
FF20	UMC	0.158	0.551	0.012	0.145
FF21	HON HAI	0.053	0.488	0	0.062

TABLE 4: 2-MODE CENTRALITY MEASURES OF 19 ALLIANCE PARTNERS

No.	Alliance Partner	Degree	Closeness	Betweenne	Eigenvect
AP1	LITE-ON IT	0.333	0.671	0.073	0.362
AP2	ASUSTEK	0.333	0.613	0.056	0.301
AP3	TATUNG CO.	0.381	0.626	0.144	0.3
AP4	INVENTEC	0.19	0.6	0.018	0.235
AP5	RITEK	0.238	0.613	0.044	0.2
AP6	CHT	0.524	0.64	0.219	0.337
AP7	CMC	0.143	0.553	0.009	0.136
AP8	Compal	0.238	0.626	0.041	0.277
AP9	QSI	0.19	0.487	0.009	0.173
AP10	DELTA	0.143	0.479	0.004	0.108
AP11	CYU	0.143	0.553	0.007	0.197
AP12	HTC	0.476	0.687	0.19	0.376
AP13	BMC	0.143	0.479	0.004	0.108
AP14	TECO	0.19	0.576	0.024	0.164
AP15	ProMOS	0.095	0.435	0.005	0.064
AP16	YAGEO	0.143	0.479	0.004	0.108
AP17	WTC	0.143	0.479	0.004	0.108
AP18	Microsoft	0.143	0.504	0.007	0.105
AP19	QCI	0.286	0.64	0.061	0.294

D. Identification of brokerage roles

The notion of "brokerage" by Gould and Fernandez [15] is to examine ego's relations with its neighborhood from the perspective of ego acting as an agent in relations among groups. To examine the brokerage roles played by a given actor, we find every instance where that actor lies on the directed path between two others. Here, we examine which kinds of actors are involved. There are five possible combinations

The alliance partners and focal firms have been grouped together into 5 partitions according to the similarity of relationship in network. The partitions procedure was done by "Faction" function of UCINET after computing the Girvan-Newman clustering coefficient. Table 5 and Table 6 are the brokerage scores for alliance partners and focal firms in alliance network, respectively. Each row counts the raw number of times that each actor plays each of the five roles in the whole graph.

For Table 5, AP4 and AP19 are the main sources of inter-connection among the five areas. Alliance in the first, second and forth area (AP3, AP6, AP18, AP12) have overall low rates of brokerage. Alliance in the third area (AP8, AP7,…, AP15) seem to be more involved in coordinator than other roles. Alliance in fifth area (AP1, AP4,…, AP19) seem to be more important than other areas and play more diverse roles. By inspecting the network structure of alliance partners, the AP4 and AP19 located in the core positions with high centrality as well.

TABLE 5: BROKERAGE SCORES OF ALLIANCE PARTNERS

Partition	AP	Coordinator	Gatekeeper	Representative	Consultant	Liaison	Total
1	AP3	0	0	0	0	0	0
2	AP6	0	0	0	0	0	0
	AP18	0	0	0	0	0	0
3	AP8	2	0	0	0	0	2
	AP7	0	0	0	0	0	0
	AP2	0	0	0	0	0	0
	AP11	2	1	1	0	0	4
	AP9	0	1	1	0	0	2
	AP15	0	0	0	0	0	0
4	AP12	0	0	0	0	0	0
5	AP1	0	4	4	0	0	8
	AP4	0	8	8	0	0	16
	AP5	0	4	4	0	0	8
	AP10	2	0	0	0	0	2
	AP13	2	0	0	0	0	2
	AP16	2	0	0	0	0	2
	AP17	2	0	0	0	0	2
	AP14	0	4	4	0	0	8
	AP19	0	13	13	2	0	28

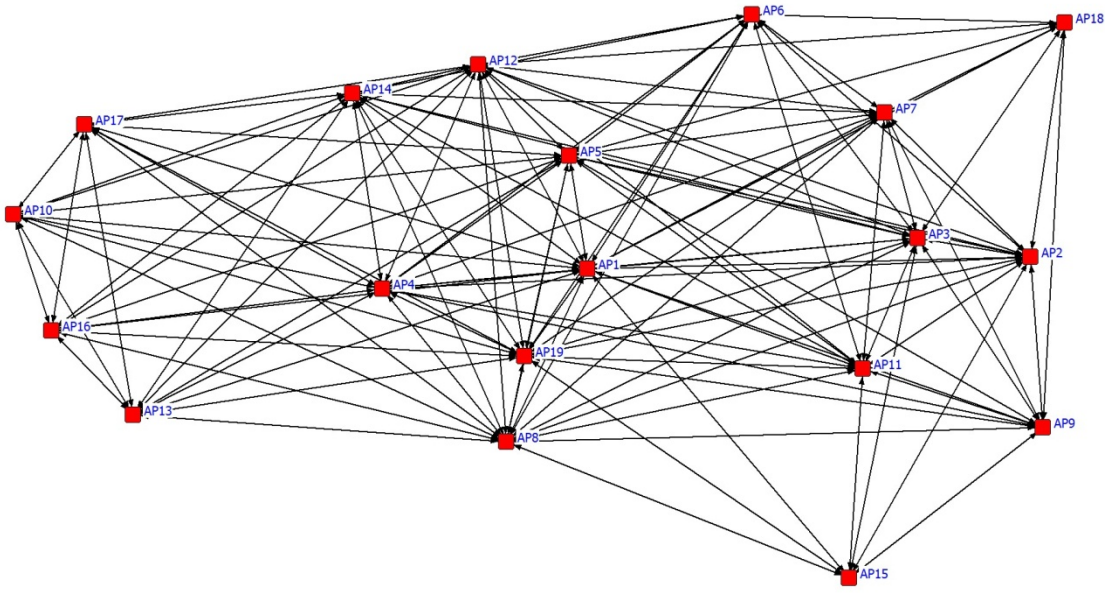

Figure 4: Network structure of alliance partners

The analysis of focal firms of Table 6 and Figure 5 are similar to the above. FF2, FF14, FF20 and FF9 are the main sources of inter-connection among the three areas. Besides, alliances in the first area have overall higher rates of brokerage, and are more involved in coordinator than other roles. Alliances in second area play more diverse roles. The network structure in Figure 5 is consistent with Table 6.

V. CONCLUSION

In this paper, we analyzed the brokerage role of technological alliances that are able to assemble and activate different resources from in variety of complementary firms. We combined social network analysis and brokerage roles on a Strategic Alliance Database established by the National Science Council (NSC) in Taiwan in order to highlight who, within the technological network of alliance in a Taiwan, can count on strategic positions and can activate different resources from the ones embedded within the Electronic and Information Technology industry. The results showed the fact that brokerage roles can be used to develop collaborations. Alliance offer access to complementary technologies or skills of others, which can be used to reduce uncertainty and risk in technological development and to create trust in the future cooperation. At the meantime, firms in crucial positions of brokerage in the alliance network may also spread or retain information strategically because they have control over the diffusion of information.

TABLE 6: BROKERAGE SCORES OF FOCAL FIRMS

Partition	FF	Coordinator	Gatekeeper	Representative	Consultant	Liaison	Total
1	FF11	0	2	2	0	0	4
	FF2	16	0	0	0	0	16
	FF8	2	1	1	0	0	4
	FF4	0	0	0	0	0	0
	FF15	0	0	0	0	0	0
	FF6	4	0	0	0	0	4
	FF7	4	0	0	0	0	4
	FF10	0	0	0	0	0	0
	FF14	16	4	4	0	0	24
	FF12	8	0	0	0	0	8
	FF21	0	0	0	0	0	0
	FF20	16	0	0	0	0	16
2	FF3	2	0	0	0	0	2
	FF9	2	9	9	0	0	20
	FF18	0	1	1	0	0	2
	FF1	0	0	0	0	0	0
	FF17	2	0	0	0	0	2
	FF5	0	0	0	0	0	0
	FF19	0	0	0	0	0	0
3	FF13	0	0	0	0	0	0
	FF16	0	0	0	0	0	0

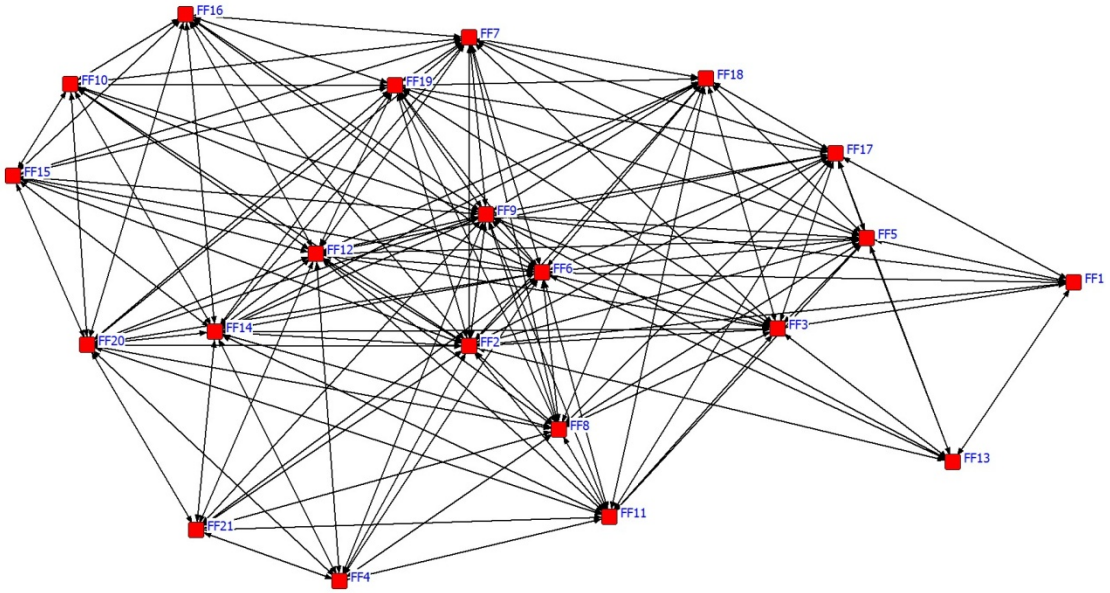

Figure 5: Network structure of focal firms

For the analysis, these brokerage roles may help us to understand how each firm in alliance may have opportunities and constraints in access to the resources of the technological knowledge of other firms, as well as individual. Moreover, the overall bipartite graph of 2-mode network informed us about the degree and form of connection within and between the focal firms and alliance partners. The measurement of centrality presented the position of firm located in the whole network. The brokerage scores indicated what role firm played in the alliance, and five brokerage roles were examined. These implicate that the outcomes of innovation intermediary may related to intangible assets such as learning and the facilitation of collaboration or social processes. Furthermore, the outcomes that are not the result of enabling processes but that are the outcome of coercive processes intended to balance the interests of firms with the interests of other stakeholders and the environment[42] .

Finally, of course, in this paper, we interpreted the function of innovation intermediary only from a methodological perspective. Brokerage roles are counted between firms which are formed according on relationships instead of attributes, thus the technique is based only on the analysis of structural and relational properties instead of inspecting individual properties or attributes. In other words, I do not know if firms play a brokerage roles are aware of their intermediary position and use their strategic resources intentionally. For further research, one may conduct a qualitative research to reveal the self perception of firms occupying different positions in the network, and to give an account to the perceived positions and the advantage or constrains they implies.

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