Patent Analysis in External Technology Acquisition: A Case of Taiwan Semiconductor Manufacturing Company

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Abstract--**Prior research mentioned that external technology acquisition is a shortcut for companies that seek to develop breakthrough technologies or products. In this study, we examine the external technology acquisition in Taiwan Semiconductor Manufacturing Company (TSMC) based on the USPTO patent assignment data and analyze the complementary relationship between externally acquired technologies and self-owned technologies in TSMC. Based on our analysis, we argue that external technologies usage does not always create complementary synergetic effects from integration with self-owned technologies. The data shows that most of the externally acquired patents at TSMC were acquired from assignors of NCR/MAGNACHIP SEMI. and AMBERWAVE SYS in 2006-2010. External technology acquisitions in TSMC are concentrated on "Photovoltaic" and "Computer Hardware & Electrical Devices" technologies. According to the externally acquired patents cited by self-owned patents of TSMC, we conclude that although external technologies in "Photovoltaic" appear integrated with TSMC's self-owned technologies, other external technologies are not well- integrated with self-owned technologies, particularly for patents in the field of "Computer Hardware & Electrical Devices."**

I. INTRODUCTION

Patent assignment is the sale and transfer of ownership of a patent from the patentee to an assignee. The patentee may assign all or part of the rights associated with a patent. Assignments must be in writing and are irrevocable. While patents can be transferred directly to other parties for a variety of reasons, patents are most typically transferred to generate revenue for the transferring party[1]. Patent assignment as external technology acquisition has become an important resource for companies to innovation, especially when a rapidly changing technological landscape makes it harder for a single company to foresee and invest in all possible but uncertain areas of technology. In the past, a single company supervised all research and development (R&D) activities. However, the cost of R&D has risen tremendously with a shortening product life cycle. Hence, successful companies not only have to develop key technological knowledge themselves, but also have to acquire technological knowledge from outside sources[2].

Documenting an assignment of assignor's interest in patent applications and issued patents provides legal records to the public of the assignment.[1] The US Patent and Trademark Office also permits the listing of records of other documents relevant to the titles of applications or patents, including certificates issued by appropriate authorities showing a change of name or a merger of business as well as documents supporting security interests, licenses, liens, and mortgages. An assignment of assignor's interest (henceforth "assignment") is a transfer by an assignor of its right, title, and interest in a patent or patent application to an assignee.[2] A patent or application is assignable by an instrument of writing, and the assignment transfers to another a party's entire ownership interest or a percentage of that party's ownership interest in the patent or application. Valid assignments indicate ownership to establish standing to bring legal suit against infringers. Typically, a properly executed assignment is in writing. It identifies the assignor and assignee and the property interests conveyed, and is signed by an individual with proper authority to act for the assignor[3].

Patent citation information provides a useful approach to track a firm's usage of external technology because, like research papers, every registered patent is required to cite the prior technologies (both internal and external) on which the current patent is built. However, the patent citation relationship only reflects the passive technological relationship while patent assignment reflects the active relationships. Patent assignment data may provide a signal of the patent's value by showing when patents are used to secure financial obligations [4], licensed or litigated [5]. Moreover, assignments enable examination of the relationships between the parties to the transaction, complementary and spillovers from mergers [6]. Documented assignment data may provide further insights to econometric models on patents, R&D, and productivity [7]. It may also suggest strategic or competitive relationships relative to R&D spillovers [8], knowledge flows [9], patent quality [10]. Assignment data may supplement other widely-used patent value indicators such as forward citations [11]; patent renewal [12]; and patent families [13].

Chesbrough [14] supplied one of the initial studies using USPTO patent-assignment recordings data, showing a rising trend in reassignments to support his writings on "open innovation." Serrano [15] provided a largely descriptive treatment of these data for the 1980-2001 period, highlighting trends in the markets for technology by utilizing US patent renewals. Galasso, Schankerman, and Serrano [16] employed patent assignments with patent litigation data to test a model of gains from trade in patent enforcement and showed that patent litigation risk decreases after patent sales. Fischer and Henkel [17] utilized data on patent acquisitions to examine the role of non-practicing entities in the market for

[1] 37 CFR Part 3 (2015).

[2] 37 CFR 3.1 (2015).

technology.

This study will examine the patent assignment that Taiwan Semiconductor Manufacturing Company (TSMC) acquired. Moreover, it will explore the complementarity between externally acquired technologies and self-owned technologies in TSMC.

II. DATA COLLECTION

Patent data, which is structurally organized and substantially objective, is well recognized as a viable source of information for various technology management tasks such as policy making [18], tracing knowledge diffusion [1], strategic planning [19], technology analysis [20], technological forecasting [21], finding relationship among companies and industries [22], and providing assessment to targets of merger and acquisition [23].

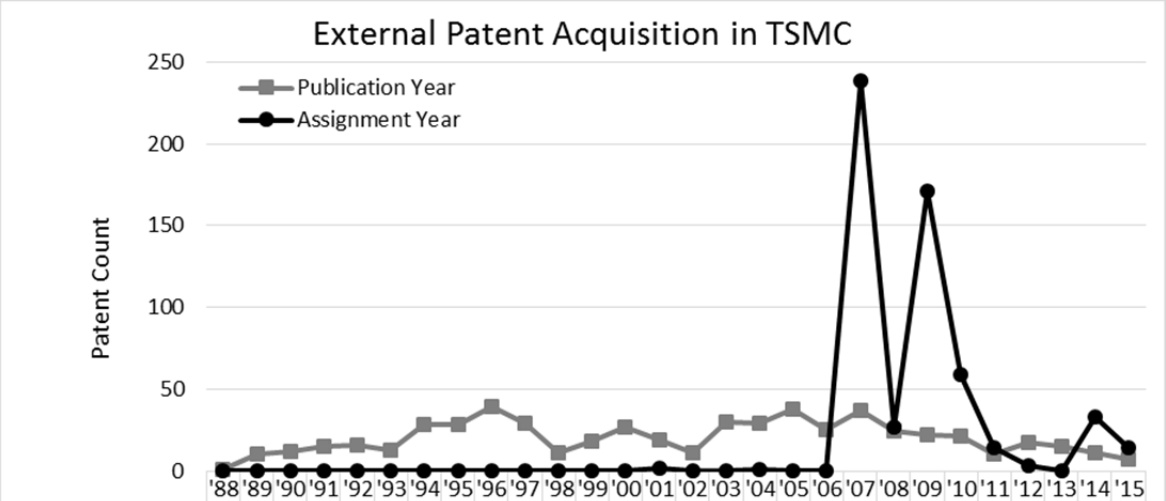
The empirical data utilized in this study were Patent Grant Bibliographic XML Text Data and Patent Assignment XML Text (the patent ownership assigned from assignee to assignor) download from the Bulk Data Storage System (BDSS, https://bulkdata.uspto.gov/) in United States Patent and Trademark Office (USPTO). These Patent Grant Bibliographic XML Texts were parsed into Microsoft SQL 2014 Database for this study and the Patent Grant Bibliographic Data was restricted to utility patents filed by TSMC granted between 2001 and 2015. The USPTO Patent databases do not have any authority control for assignees' names. Therefore, this study applies authority control to establish unified assignee names, which are collocated with all versions of an assignee patent, even if they were issued under alternative names. The Patent Assignment XML contains data for each transaction recorded, including the reel number, frame number, and recording date. The patent assignment records collected that the assignee were TSMC, and the assignor was a company and not person. It means that the TSMC acquired external technologies from other companies.

We analyzed the external patent acquisition in TSMC including the patent count according to grant year, which assignors transferred patent to TSMC and the citation networks. The relationship between external acquired technologies and self-owned technologies that the external acquired patent cited by the self-owned patent means that the complementary effects from external acquired patent.

III. FINDINGS

A. TSMC's most external patents were acquired in 2007-2010

Fig. 1 shows the trends of external patent acquisition in TSMC each year. In assignment year, the earliest patent acquired by TSMC was in 2001 and the acquisition activities peaked in 2007-2010. It means TSMC obtained external technologies to support its innovative technology development since 2001, but the acquisition activities significantly reduced after 2010. TSMC had acquired 563 external patents in total, but 247 of these were granted before 2001. Based on the data, the technologies TSMC planned to develop were not mature even though these technologies were already patented as early as 1988. Thus, acquisition of external patents presented a better way to obtain these technologies in compared to in-house technology R&D by TSMC.



	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15
Publication Year	1	10	12	15	16	13	28	28	39	29	11	18	27	19	11	30	29	38	25	37	24	22	21	10	17	15	11	7
Assignment Year	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	239	27	171	59	14	3	0	33	14

Fig. 1. The trends of external patent acquisition in TSMC

B. Most external technology acquisitions are from NCR / MAGNACHIP SEMI. and AMBERWAVE SYS.

Table 1 shows assignors and their patent counts that were assigned to TSMC. The table shows that NCR and MAGNACHIP SEMI. assigned 177 patents to TSMC - the highest among the assignors. AMBERWAVE SYS. also assigned 112 patents to TSMC. 51% of TSMC's externally acquired patents was from these two assignors. Besides these 25 assignors, TSMC also acquired 432 patents from Worldwide Semiconductor Manufacturing (merged into TSMC in 2000) and Vanguard International Semiconductor companies (invested by TSMC as the main shareholder). Because of the close relationship with TSMC, patents acquired from the two companies were not considered external technologies.

Fig. 2. Shows the completely externally acquired patents that are cited by self-owned patents within TSMC. It illustrates the relationship between externally acquired technologies and self-owned technologies in TSMC. The more externally acquired patents are cited by self-owned patents the higher technology complementarity there is. In the figure, we can see that there are segments of two completely isolated patent groups. In the left group, all the externally acquired patents in Photovoltaic Technology are from AMBERWAVE. The right group contains externally acquired patents in Computer Hardware & Electrical Devices from the other 24 assignors.

TABLE 1. COUNTS OF EXTERNAL PATENTS ACQUIRED BY TSMC

Assignor	Count	Assignor	Count
NCR / MAGNACHIP SEMI.	177	ITRI, TW	4
AMBERWAVE SYS.	112	MACGREGOR GROUP	4
NXP	62	AFA MICRO	3
HYMITE	35	PANASONIC	3
NCR	30	AUCTOR	2
HP	27	COMMIX SYSTEMS	2
MAGNACHIP SEMI.	24	SHIN-YI	2
AVAGO TECH.	22	BRITISH TELECOMM.	1
IBM	21	GLOBAL UNICHIP	1
INTELLECTUAL ASSET GROUP	8	IMEC KATHOLIEKE UNIVERSITEIT LEUVEN	1
SOFTWIRED	8	MOSAID TECH.	1
CONVERSANT IP MANAGEMENT	7	VINESTONE	1
FREESCALE SEMI.	5		

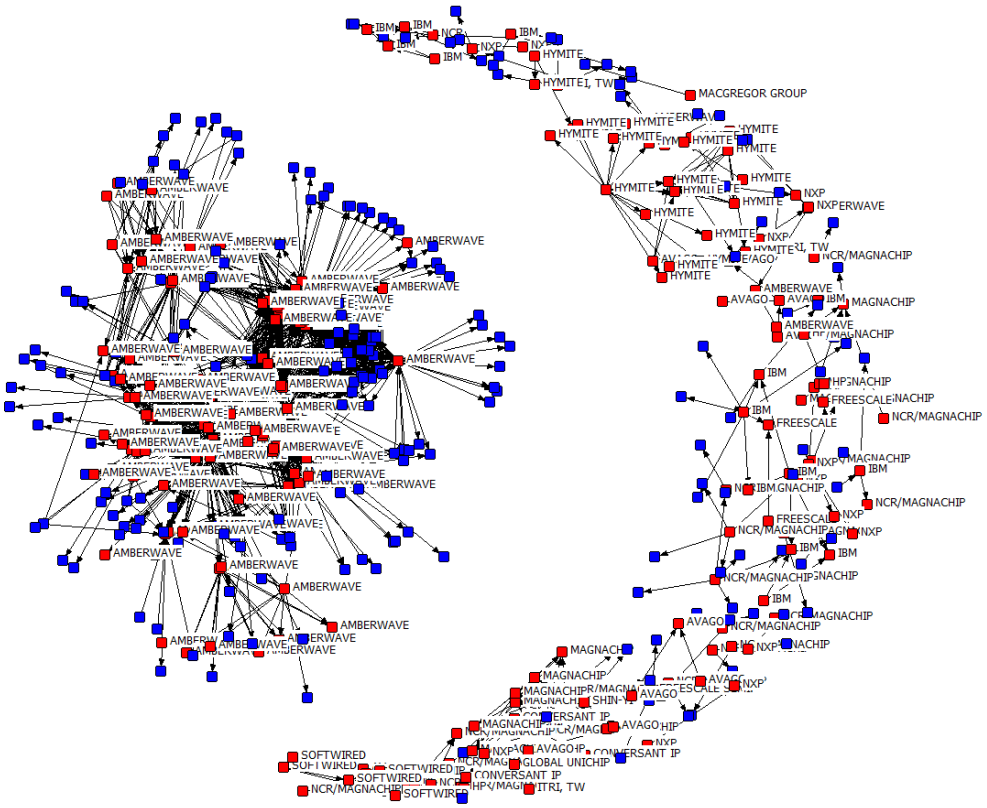
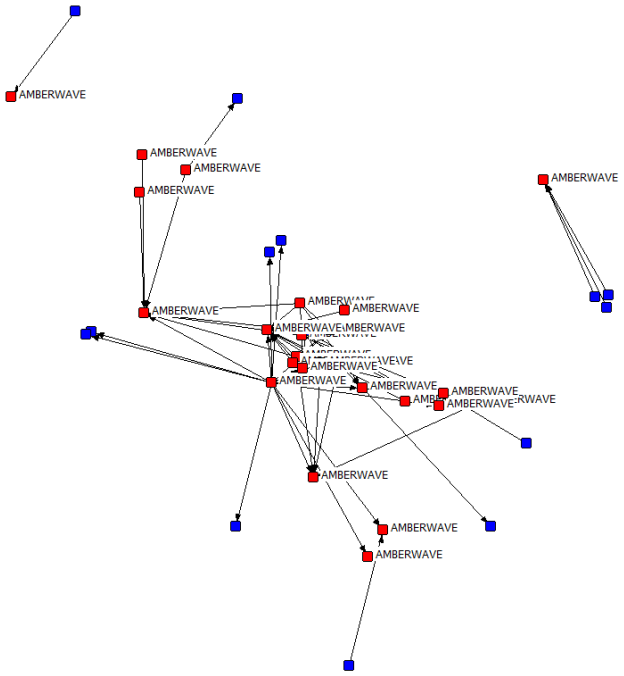


Fig. 2. External-acquired patents Cited by TSMC in 2001-2015

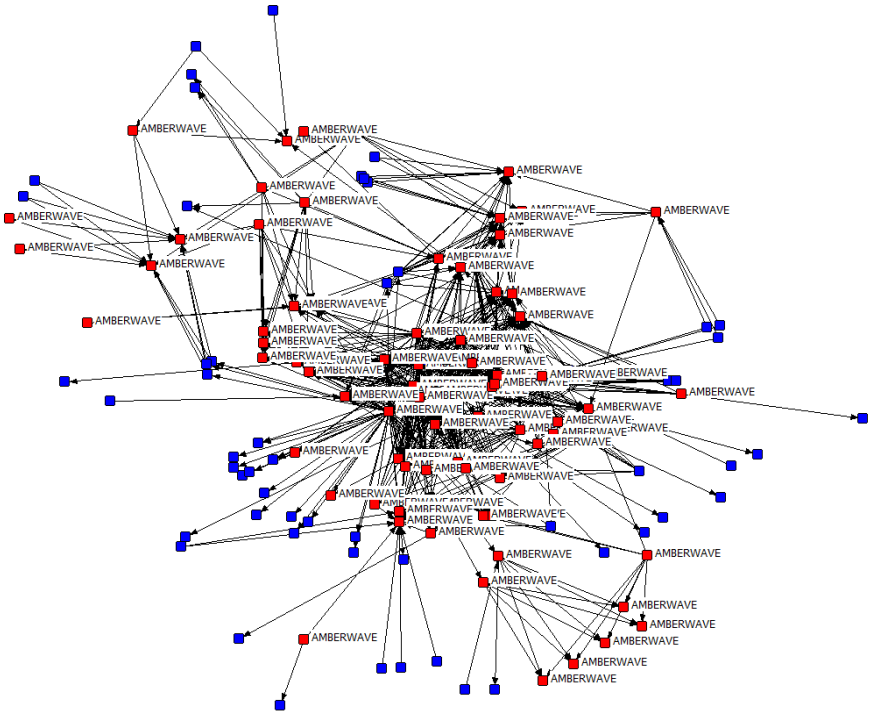
C. Externally acquired technologies in "Photovoltaic Technology" and "Computer Hardware & Electrical Devices" were less integrated into TSMC's self-owned existing technologies

Fig.3 to Fig. 8 are the breakdowns of the two patent citation networks in Fig. 2 in three different periods (2001-2005, 2006-2010 and 2011-2015) for a closer observation of the evolutions of technology complementarity in TSMC's external acquired patents and self-developed technologies. Fig. 3, 4 and 5 are the Photovoltaic technologies mostly acquired from AMBERWAVE that are cited by TSMC's self-owned technologies in three periods. As shown in these figures, these external patents were mostly acquired in the period of 2006-2010 and were granted from 1988 on. Thus, as shown in Fig. 3, these patents with earlier issue dates were scarcely cited by TSMC's self-owned patents before they were acquired. According to Fig.4 and 5, we can observe these external acquired patents in Photovoltaic technology were more cited by TSMC's self-owned patents from 2006 on. The trend reflects that the number of self-owned patents in Photovoltaic technology by TSMC started to increase in 2006. These patents were also highly related to those external patents acquired from AMBERWAVE. Based on this observation, we can see that the Photovoltaic technologies developed within TSMC highly benefit from externally acquired technologies, especially those patents from AMBERWAVE.



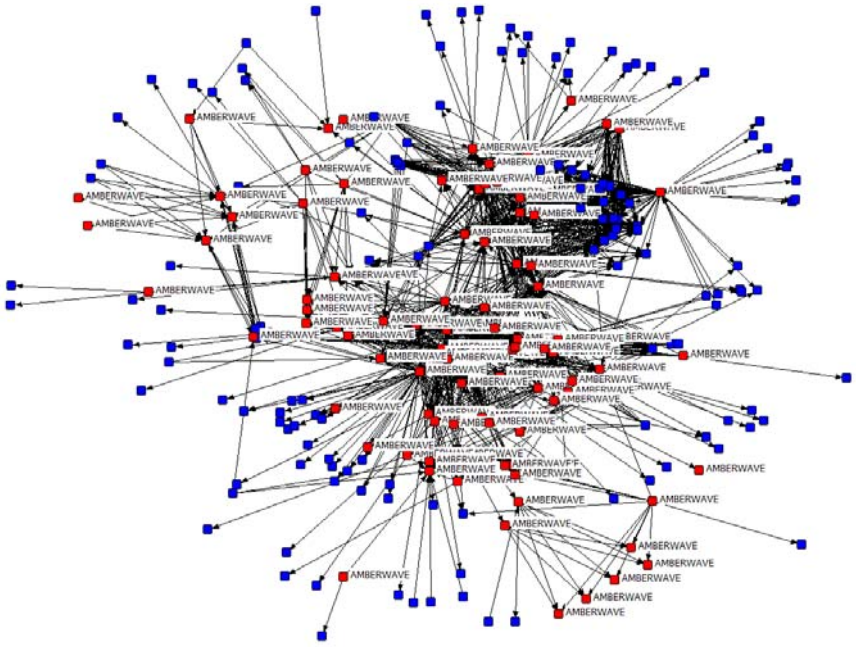
External patent acquired by TSMC; Self-owned patent in TSMC; → patent cited by

Fig. 3. External-acquired photovoltaic patents Cited by TSMC in 2001-2005



External patent acquired by TSMC; Self-owned patent in TSMC; →patent cited by

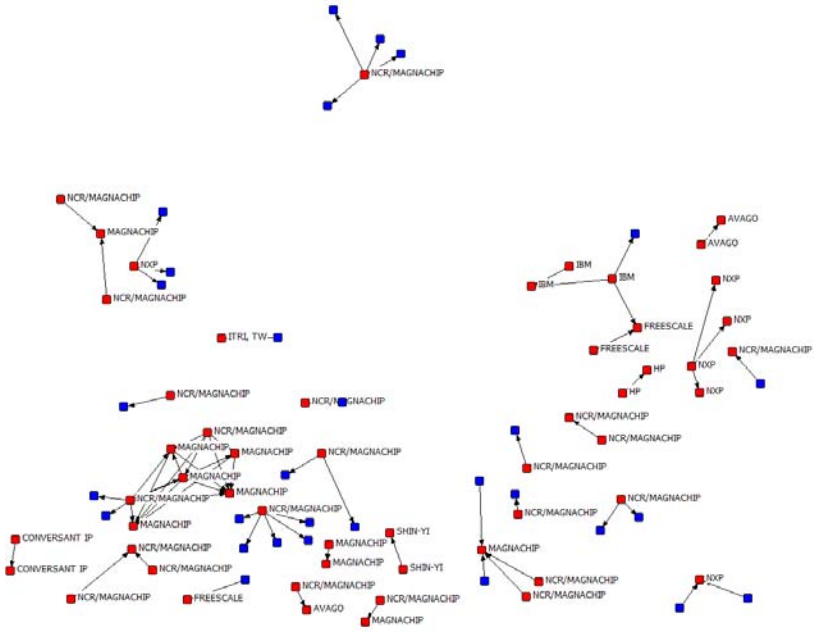
Fig. 4. External-acquired photovoltaic patents Cited by TSMC in 2006-2010



External patent acquired by TSMC; Self-owned patent in TSMC; →patent cited by

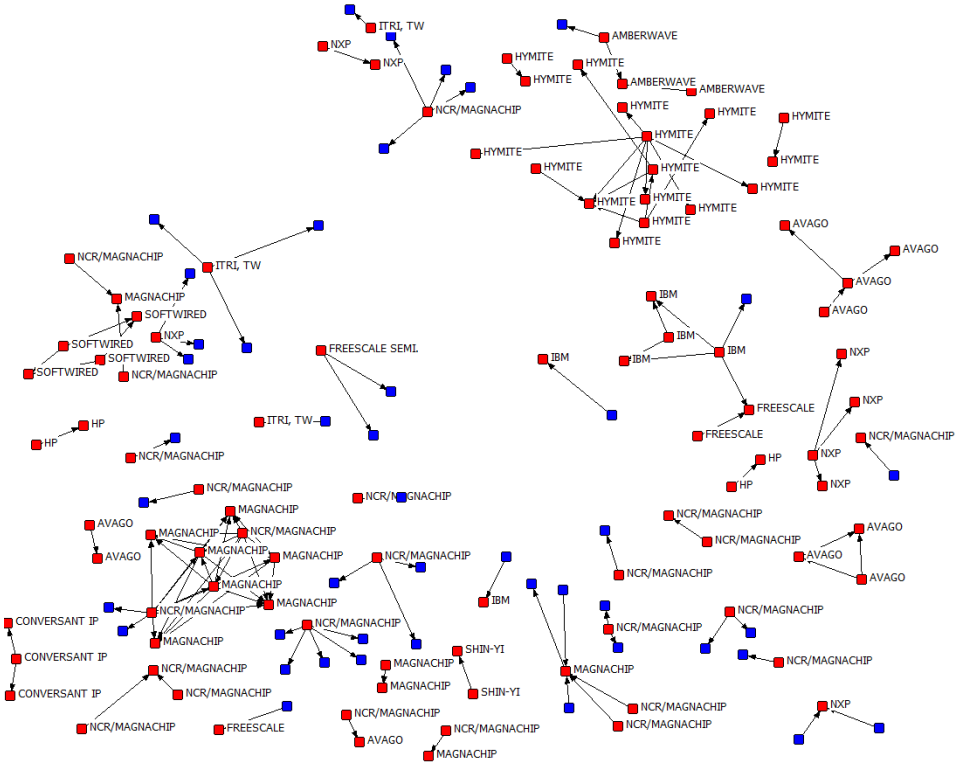
Fig. 5. External-acquired photovoltaic patents Cited by TSMC in 2011-2015

Fig. 6, 7 and 8 are the Computer Hardware & Electrical Devices technologies obtained from 24 assignors that are cited by TSMC's self-owned technologies in three different periods. TSMC is the leading manufacturer of wafer chips manufacture and Computer Hardware & Electrical Devices is a traditional application from wafer chips. These external patents were mostly acquired in the period of 2006-2010 and were granted from 1988 on. Thus, as shown in Fig. 3, these patents with earlier issue dates and mostly from NCR and MAGNACHIP, were already cited by TSMC's self-owned patents before they were acquired. This trend is different from external-acquired photovoltaic patents - the externally acquired Computer Hardware & Electrical Devices patents were more disperse and were already cited by TSMC's self-owned patents before they were acquired. This means that these technologies had already affected the development of TSMC's Computer Hardware & Electrical Devices technologies before the acquisition.



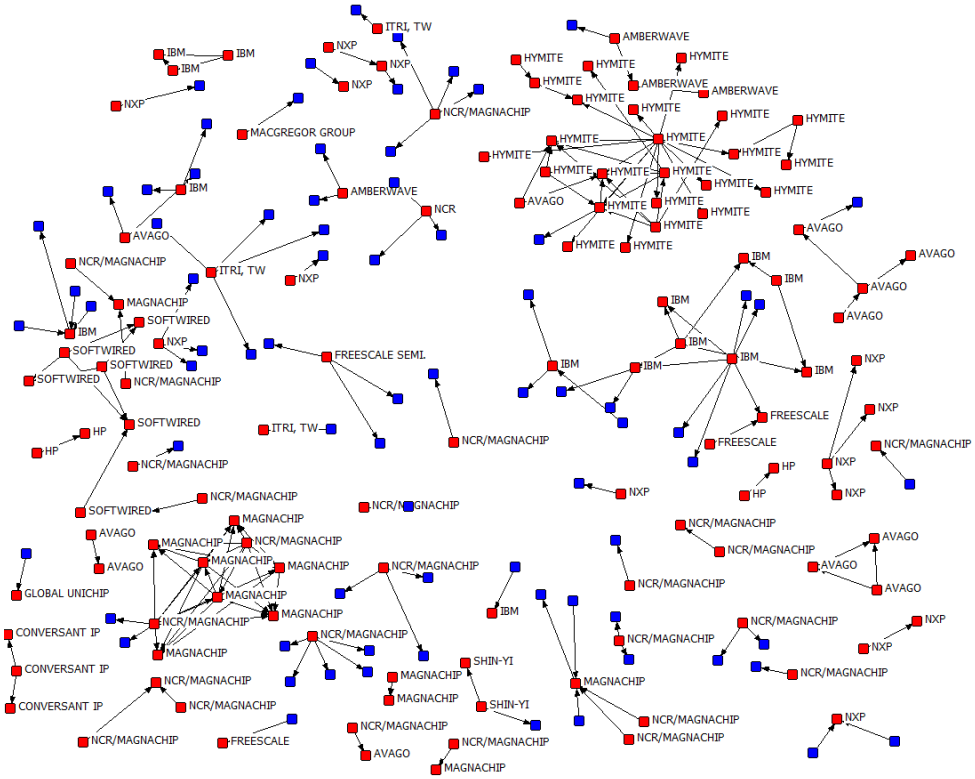
External patent acquired by TSMC; Self-owned patent in TSMC; →patent cited by

Fig. 6. External-acquired C.H. & E.D. Patents Cited by TSMC in 2001-2005



External patent acquired by TSMC; Self-owned patent in TSMC; →patent cited by

Fig. 7. External-acquired C.H. & E.D. Patents Cited by TSMC in 2006-2010



External patent acquired by TSMC; Self-owned patent in TSMC; →patent cited by

Fig. 8. External-acquired C.H. & E.D. Patents Cited by TSMC in 2011-2015

According to Fig.7 and 8, these externally acquired patents in Computer Hardware & Electrical Devices were not frequently cited by TSMC's self-owned patents as much as the patents in Photovoltaic. The data shows that although TSMC steadily obtained self-owned patents in Computer Hardware & Electrical Devices Technology from 2006, there was no significant increase in citations of these externally acquired patents. However, TSMC also continued to acquire external patents which included older and newer ones. These externally acquired patents have cited each other to form various technology clusters. With these trends, we can see some of the Computer Hardware & Electrical Devices Technologies developed by TSMC solely depended upon externally acquired technologies.

IV. CONCLUSION AND DISCUSSION

External technology acquisition is a useful path to enhance the completeness of a company's technological R&D portfolio. TSMC, the leading manufacturer of wafer chips, is the subject of this study for analysis into the company's externally acquired technologies to determine whether these external technologies can achieve full integration with self-owned technologies. The external technologies acquired by TSMC could be classified into two technology topics: Photovoltaic technology and Computer Hardware & Electrical Devices technology. In photovoltaic technology, most external technologies were transferred from AMBERWAVE. These technologies integrated well with TSMC's self-own technologies in the following periods. It means that TSMC's development of photovoltaic technology of TSMC is complementary and supportive to the acquired external resources. However, the other case is the Computer Hardware & Electrical Devices technology developed in TSMC. The external technologies acquired in this topic were mostly sub-technologies that almost fully depended on external resources without the support of concurrent self-owned technologies. Based on this study, we can expand to search for different R&D strategies for different technologies in TSMC. In addition, this methodology could be adaptable to analysis of other companies.

External technology acquisition has played an important role in the technology strategy field. External technology acquisition used to save labor cost and R&D time during R&D process. Tracking R&D technology trajectory after the external technology acquisition and measured the effectiveness will be important issues. This study presents a new methodology by measuring technical knowledge flow between external acquired technology and self-own technology based on patent citation data and showed the degree of technology complement relationship. External technology cited after acquisition by self-own technology, regarded as the degree that external technology integrated into the assignee company. This study will be an important reference about external acquired technology strategy.

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