Master Thesis in Economics

Identifying ICT-Auto Manufacturing Convergence through Dynamic Network Analysis of Important Convergence Technology and R&D Actors

주요 융합 기술과 **R&D** 주체의 동적 네트워크 분석을 통한 **ICT-**자동차 제조업 융합에 관한 연구

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Identifying ICT-Auto Manufacturing Convergence through Dynamic Network Analysis of Important Convergence Technology and R&D Actors

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Abstract

Identifying ICT-Auto Manufacturing Convergence through Dynamic Network Analysis of Important Convergence Technology and R&D Actors

This paper aims to identify convergence between automobile manufacturing and ICT sectors in Korea's national R&D network. Although several studies have analyzed the technology convergence or cooperative alliances in R&D networks, network analysis specifically on Auto manufacturing-ICT convergence that contributes to identifying both important convergence technology and R&D actors over time is lacking. In an effort to bridge this gap, this study employs network analysis of patent information of the auto manufacturing and ICT sectors from 2008 to 2014. The dynamic changes of the two key subjects of interest, important convergence technology and R&D actors, are then examined together in groups of important technology identified as "hubs," "cores," and "bridges." The analysis results are expected to help identify priority areas and actors for R&D policies on auto manufacturing-ICT convergence as part of an effort to prepare for the ICT-driven manufacturing paradigm shift taking place today.

Keywords: ICT convergence, auto manufacturing, dynamic network analysis, IPC co-occurrence

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Chapter 1. Introduction

1.1 Background

Megatrends in the 21st century such as deepening interconnectedness, changing demographics and climate change pose great challenges for future growth across the globe. Against this backdrop, increasing attention has centered on the wider application of advanced technologies in traditional sectors as a new source of competitiveness for countries as well as firms (UN DESA, 2013; OECD Secretariat 2015). Indeed, this *convergence*, or innovation that occurs at the intersection of distinct industries (or products) is often associated with new opportunities (Hacklin et al., 2009).

Convergence of manufacturing and ICT, among others, is a core growth strategy initiated by leading countries today. Namely, the U.S. “National Strategic Plan for Advanced Manufacturing” (2012), Germany’s “Industry 4.0” (2012), China’s “Made in China 2025” (2013), and Korea’s “Manufacturing Innovation 3.0” (2014) are national policies that call upon advanced ICT innovations and digitalization in manufacturing in order to extend industrial value chains and increase productivity.[1]

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[1] GE Reports Korea. (2015). GE supports manufacturing innovation of Korea. http://www.gereports.kr/ge-supports-manufacturing-innovation-of-korea/

1.2 Research Objective

The objective of this study is to identify both important convergence technologies and R&D actors in Korea's auto manufacturing-ICT convergence network through dynamic network analysis of patent data.

1.3 Overview

The following chapter will provide a literature review on R&D networks, address limitations through the problem description and research questions of this paper. Chapter 3 introduces the analysis process step by step and Chapter 4 describes the data. Then, the analysis results are explored in detail in Chapter 5. Finally, Chapter 6 will conclude with a discussion of the key findings and implications, contributions, as well as the limitations and future study.

Chapter 2. Literature Review

2.1 Literature on R&D Networks

Existing literature on R&D networks have mostly focused on the interactive nature of actors in a R&D network; Broekel et al. (2015) and Biggiero and Angelini (2015) examine the network of R&D collaboration among firms through different methodologies while Dawid and Hellmann (2014) analyze the evolution of R&D networks by focusing on bilateral collaboration between firms. Meanwhile, Park et al. (2012) study the interdisciplinary characteristics between technology areas related to the Korean government's R&D by employing network analysis of patents.

2.2 Problem Description

Research on interdisciplinary traits of R&D networks particularly between the auto manufacturing and ICT sectors in a dynamic perspective is meager. More specifically, it lacks research which examines both important convergence technology and R&D actors over time.

2.3 Research Questions

This study aims to address two main research questions as follows.

i) What are the important technology areas in convergence between auto manufacturing and ICT in Korea’s R&D network, and do they differ over time?

ii) Who are the important R&D actors that lead convergence between auto manufacturing and ICT, and do they show trends over time?

Chapter 3.   Model

3.1 Analysis Process

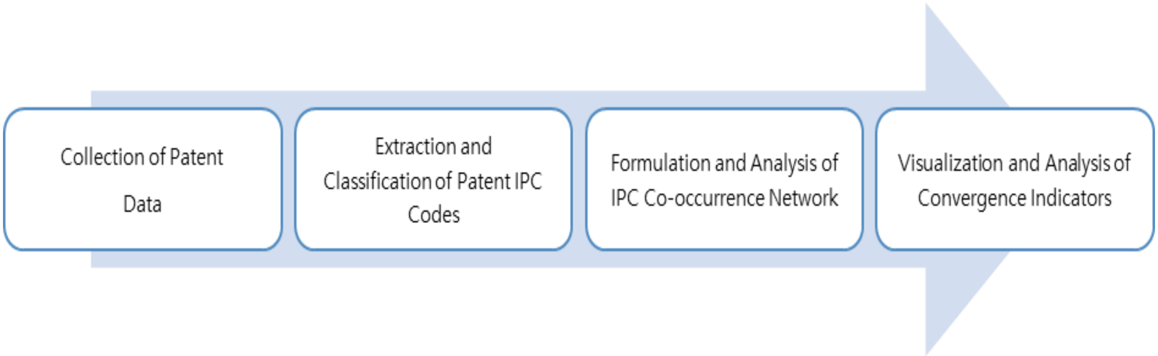

Figure 1. Analysis Process

3.2 Collection of Patent Data

This first step involves collecting bibliographic information of the auto manufacturing industry's national R&D patents in MS Excel form through the Korean government's R&D Intellectual Property Information System (RNDIP). Then, a process of eliminating redundant patent data based on patent application number is completed. Also, Eliminating applied patent data filed prior to 2008 in order to set the subject period of study to 2008-2014 since the Korean government initiated full-fledged ICT convergence policies starting from 2008.

3.3 Extraction and Classification of Patent IPC Codes

This step entails extracting patent International Patent Classification (IPC)[2] codes from Korea Institute of Science and Technology (KISTI)'s National Digital Science Library (NDSL) by utilizing the application number data collected from the previous step. Next, patent IPC codes for Korea's manufacture of motor vehicle industry are classified based on the Korea Standard Industry Code (KSIC) - IPC mapping classifications provided by Statistics Korea while IPC codes for the ICT Sector are classified based on classification provided by OECD as shown in the table below.

Table 1. Sector Classification of Auto Manufacturing and ICT[3]

Sector	IPC Codes
Auto Manufacturing	B60B, B60D, B60F, B60G, B60H, B60J, B60K, B60L (excluding B60L 13), B60N, B60P, B60R, B60S (excluding B60S 3), B60T, B60W, B62D, E05F, F02M, F02N, F02P, F16J, G05G
ICT	G10S, G08C, G09C, H01P, H01Q, H01S3/025, 3/043, 3/063, 3/067, 3/085, 3/0933, 3/0941, 3/103, 3/133, 3/18, 3/19, 3/25, 5, H03B, H03C, H03D, H03H, H03M, H04B, H04J, H04K, H04L, H04M, H04Q, G11B, H03F, H03G, H03J, H04H, H04N, H04R, H04D, B07C, B14J, B41K, G02F, G03G, G05F, G06, G07, G09G, G10L, G11C, H03K, H03L, G01B, G01C, G01D, G01F, G01G, G01H, G01J, G01K, G01L, G01M, G01N, G01P, G01R, G01V, G01W, G02B6, G05B, G08G, G09B, H01B1 1, H01J 11/, 13/, 15/, 17/, 19/, 21/, 23/, 25/, 2i7/, 29/, 31/, 33/, 40/, 41/, 43/, 45/, H01L

2 World Intellectual Property Organization, http://www.wipo.int/treaties/en/classification/strasbourg/
3 In reference to guidelines by Statistics Korea and OECD

3.4 Formulation and Analysis of the IPC Co-occurrence Network

For the purposes of this study, an undirected, weighted graph with each node representing a single IPC code is formed. And it is assumed that a link between a pair of nodes appears if the two nodes (IPCs) are a common feature of a single patent, and their weights show the number of common patents that the pair of IPCs are a composite of. This step by step stages of forming this network is illustrated in the example below.

	IPC Code 1	IPC Code 2	IPC Code 3
Patent A	IPC a	IPC b	IPC c
Patent B	IPC a	IPC b	-
Patent C	-	IPC b	-

	IPC Code 1	IPC Code 2	IPC Code 3
Patent A	IPC a	IPC b	IPC c
Patent B	IPC a	IPC b	-
Patent C	-	IPC b	-

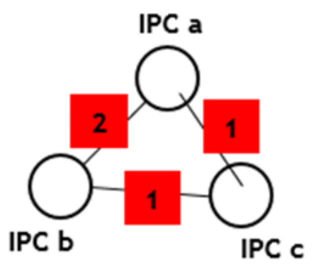

Figure 2. Example of IPC Co-occurrence Network Formation

Social network analysis helps describe various characteristics of a network. In this paper, the focus of study is identifying how a given node is related to the overall network. Centrality measures that capture this notion have been developed and can be categorized into 4 main groups as in the table below (Jackson, 2008).

Table 2. Four Main Groups of Centrality Measures[4]

Degree	How connected a node is.
Closeness	How easily a node can reach other nodes.
Betweenness	How important a node is in terms of connecting other nodes.
Neighbors' characteristics	How important, central, or influential a node's neighbors are.

In order to answer the two research questions focused on identifying important technology areas, actors and national R&D projects that lead Auto manufacturing-ICT convergence, degree centrality is used to determine how connected an IPC code is in the convergence network of the two industries. Yet, degree centrality does not measure how well located a node is in a network. For this purpose, betweenness centrality is utilized since it shows the importance of a node's position in interconnecting nodes. The combination of these two measures can help identify influential IPC codes that are both

[4] Jackson (2008)

highly connected and important to connecting other nodes.

In reference to the definitions of Opsahl et al. (2010) for degree centrality for weighted graphs, this paper utilizes the network measure degree centrality in the following equation:

$$\Sigma_{j \in G} w_{ij} \qquad (1)$$

, where w_{ij} is the weight of the link between nodes *i* and *j* of network G with size g. The weight is then 1 if nodes are connected and 0 if disconnected. Thus, a node's degree, *i*, refers to the sum of the weight of links of *i*.

Secondly, Opsahl et al (2010) is again referenced for the measure betweenness centrality of node ν for a weighted graph. Betweenness centrality is measured through the following equation:

$$\Sigma_{i,j,\, j \neq i}\, \sigma_{ij}^{w}(\nu) / \sigma_{ij}^{w} \qquad (2)$$

, where σ_{ij}^{w} is the number of shortest paths between the nodes *i* and *j* and $\sigma_{ij}^{w}(\nu)$ is the number of shortest paths between the nodes *i* and *j* which pass the node ν, both for a weighted graph G.

This paper interprets network positions as introduced Table 3 below.

Table 3. Network Positions based on Degree Centrality and Betweenness Centrality Measures[5]

	High Betweenness Centrality	Low Betweenness Centrality
High Degree Centrality	Hub	Core
Low Degree Centrality	Bridge	Periphery

The network positions categorized in table 3 are suggested by S. Baek et al. (2014). The interpretation of the network positions are as follows. A hub is highly connected and is important in connecting others. A core is highly connected but relatively not important in interconnecting while periphery is neither highly connecter nor vital to connecting others.

The definition of “high” is defined as the highest 25% of the total number of IPCs in the network at the time of the year. According to the distribution of the data, the remaining IPCs not included in the highest 25% is considered “low.” This way, the four different network positions are categorized in this paper.

[5] S. Baek et al. (2014)

Chapter 4. Data

4.1 Data

Since 2009, Korea's R&D Intellectual Property Information System (RIPIS) has been providing national R&D patent data registered from 2006 which are open to access on its management system (www.rndip.or.kr). This study utilizes the bibliographic information of Korea's national R&D patent documents in the Manufacturing and ICT Sectors.

This study utilizes 1589[6] R&D patent pending data of the "Manufacture of Motor Vehicle industry" (C30) during 2008-2014. Since the time gap between patent application and patent registration is approximately 1.5-2 years, it can be said that the R&D patents for a specific year is the output of R&D projects that date back 1.5-2 years and are thus fairly recent outcomes of R&D (Park et al, 2012).

The number of patents for each year is shown in Table 4 below for reference.

Table 4. Number of Applied Patents by Year (2008-2014)

Year	2008	2009	2010	2011	2012	2013	2014
Number of Patents	206	192	111	248	329	275	222

6 Thirteen applied patents by individuals and one applied patent with missing data has been excluded out of a total of 1598 applied patents.

Chapter 5. Analysis Results

5.1 Change in the Measures of the Entire Cumulative IPC Co-occurrence Network

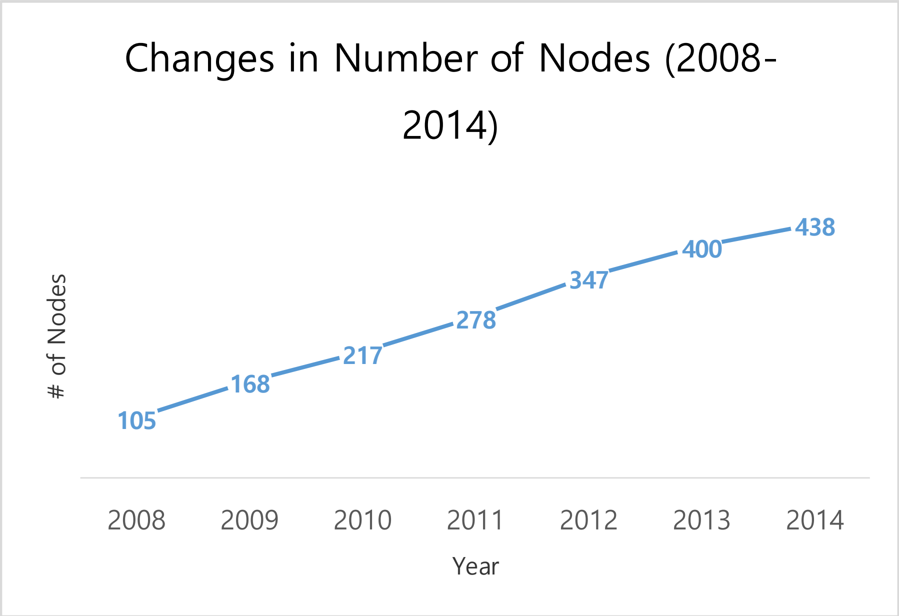

Figure 3. Changes in Number of Nodes (2008-2014)

This study defines a single node as an IPC code, which is a technology area of patents analyzed. Thus, the growing increase in the number of nodes throughout the study years 2008 to 2014 signifies growth in the variety of technology areas of patents in Korea's national R&D ICT convergence network of the auto manufacturing industry.

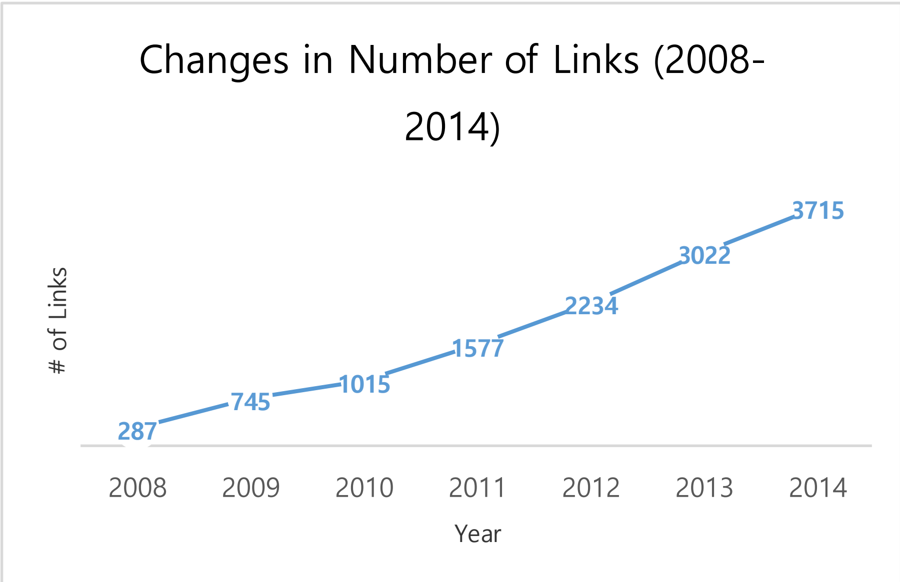

Figure 4 .Changes in Number of Links

A link between two nodes is defined in this study as that which appears if the two nodes are a common feature of a single patent. IPC codes being constituted together in the same patent means the use of more than one technology area in the creation of the patent, symbolizing convergence in this study. Thus, the growth in the number of links shows that convergence has continued to increase. In fact, a link itself signifies a patent connected to the IPC nodes that it converges.

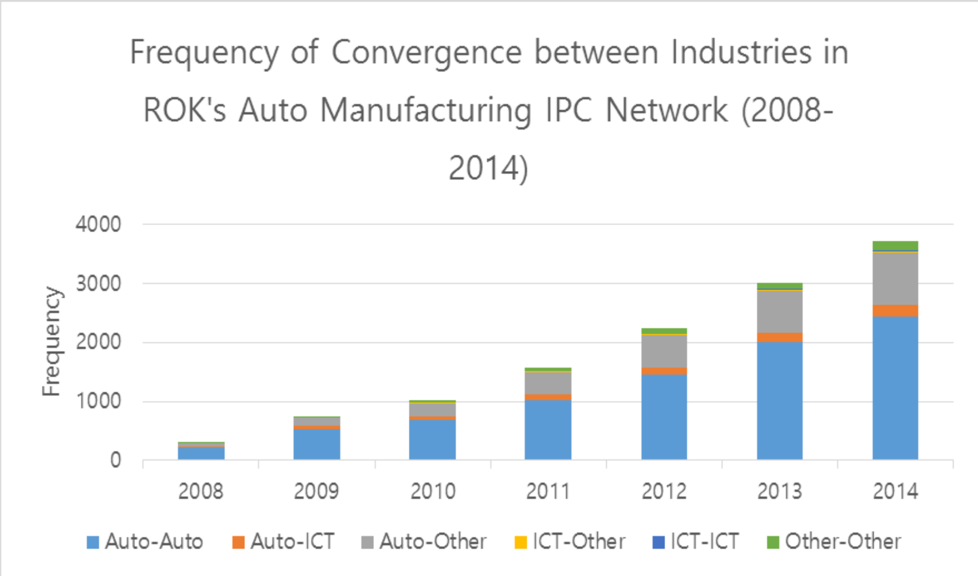

Figure 5. Frequency of Convergence between Industries

in Korea’s Auto Manufacturing IPC Network (2008-2014)

It can be seen in Figure 4 above that the frequency of convergence of ICT-related IPCs in the auto manufacturing industry has seen gradual increase especially in the case of Auto-ICT. The convergence between ICT-Other and ICT-ICT takes up a very small portion and shows little increase as well. Yet, this can be seen as a natural outcome since this study explores ICT convergence within the auto manufacturing industry, which is why auto-related convergence is most dominant. In this sense, the increase and portion of Auto-ICT can be understood as quite significant in this network.

5.2 Change of Important Technology and R&D Actors over Time

5.2.1. Important ICT-related Technology

Table 5. Number of IPCs by Network Positions (2008-2014)

Year	Industry	Hub	Core	Bridge	Periphery	Total # of IPC	25%
2008	All	16	9	9	71	105	26.25
2008	ICT	1	0	0	4	5	NA
2009	All	31	11	11	115	168	42
2009	ICT	1	1	0	10	12	NA
2010	All	43	12	12	150	218	54.5
2010	ICT	2	1	0	15	18	NA
2011	All	54	16	16	192	278	69.5
2011	ICT	3	1	1	22	27	NA
2012	All	67	20	20	240	347	86.75
2012	ICT	2	1	2	23	28	NA
2013	All	75	25	25	375	400	100
2013	ICT	1	1	2	27	31	NA
2014	All	79	31	31	297	438	111
2014	ICT	1	3	1	30	35	NA

Note: NA stands for Not Applicable

Table 5 shows the number of IPCs by network positions for the entire network and for the ICT-related IPCs. Similar to the small proportion of ICT convergence in the entire network, the number of hub ICTs are very minimal too. The core and bridge positions of

ICT-related IPCs are also minimal, yet the increase in the total number of the two positions are not as large as with the hub position. Most of the ICT-related IPCs were centered in the periphery position.

Table 6. Network Positions of ICT-related IPCs in Auto Manufacturing (2008-2014)

	2008	2009	2010	2011	2012	2013	2014
Hub	G08G/1	G08G/1	G08G/1, G01C/21	G08G/1, G01C/21, G01L/3	G08G/1, G01D/9,	G08G/1,	G08G/1
Core	None	G01C/21	G01D/9	G01D/9	G01C/21	G01C/21, G01D/9	G01D/9, G01C/21, H04N/7
Bridge	None	None	None	G01G/19	G01G/19, G01L/3	G01G/19, G01L/3	G01G/19

* Refer to Appendix 1 for the full version of the table with the column "Periphery."

More specifically, Table 6 lists the ICT-related IPCs that positioned as hubs, cores and bridges by year. The IPC represented by G08G/1 is an important hub from the first year of study 2008 through 2014. The World Intellectual Property Organization defines this IPC technology as the "traffic control systems for road vehicles (arrangement of road signs or traffic signals E01F 9/00)."[7] G01C/21 starts out as a core in 2009, moves toward the hub position in 2010 and 2011, then returns to the core position in 2013 and 2014. It is defined "navigation… (measuring distance traversed on the ground by a vehicle G01C 22/00; control of position, course, altitude or attitude of vehicles G05D 1/00; traffic

[7]World Intellectual Property Organization
http://web2.wipo.int/classifications/ipc/ipcpub/#refresh=page&notion=scheme&version=20160101

control systems for road vehicles involving transmission of navigation instructions to the vehicle G08G 1/0968)."[8] The ICT-related IPCs G01L/3 and G01D/9 also appear as hubs in 2011 and 2012, respectively. The former is defined as "measuring torque, work, mechanical power, or mechanical efficiency, in general" and the latter as "recording measured values."[9]

The IPC H04N/7 is only identified in the core position in 2014 and is defined as "Television systems (details H04N 3/00, H04N 5/00; methods or arrangements, for coding, decoding, compressing or decompressing digital video signals H04N 19/00; selective content distribution H04N 21/00)." Similarly, G01G/19 is only identified as a bridge from 2011 to 2014 and refers to "Weighing apparatus or methods adapted for special purposes not provided for in groups."

5.2.2. Important R&D Actors over Time

Table 7. Total Number of Applied Patents by Combination of R&D Actors (2008-2014)

Combination of R&D Actors	a	c	b	a-a	a-b	a-c	b-b	b-c	c-c
Total # of Applied Patents	684	485	240	79	45	25	17	6	2

[8] Ibid.
[9] Ibid.

Note: a - Firms; b - Universities; c - Government-funded Research Institutes

To provide a big picture at first, Table 7 shows the total number of applied patents by combination of R&D actors throughout the study period. In the case of a single R&D actor, the order of the most applied patents is firms, universities and government-funded research institutes. It is also evident that the combination of actors including firms represents the highest number of total applied patents relative to other combinations.

Further, examination into the change in R&D actors for the important ICT-related IPC hubs identified is required for a better understanding of the convergence taking place.

Table 8. Change in the Total Number of Applied Patents by Combination of R&D Actors for ICT-related hub IPC G08G/1

Year	a	b	c	a-a	a-b	a-c	b-b	b-c	c-c
2008			2						
2009	2	2	2			2			
2010	1								
2011		1	2	2					
2012		5	1						
2013		1	1						
2014	1	1	1						

Note: a - Firms; b - Universities; c - Government-funded Research Institutes. The blanks represent zero number of patents.

The above Table 8 reflects the changes in total number of applied patents in the R&D actors for the ICT-related hub G08G/1. The patents are mostly applied by a single actor. Surprisingly, it was not dominantly applied by firms but relatively applied more by universities and government-funded research institutes alike. The only combination of actors who interacted were firms-firms and firms-government-funded research institutes.

The remaining five ICT-related IPCs identified at least once as a hub, core or bridge are also shown in tables in Appendix 2. In words, G01D/9 also showed active participation mainly by single actors throughout the time period with no specific pattern. The only combinations were firms-universities and firms-government-funded research institutes. IPCs in the area of H04N/7 were only used in patents applied by single actors of firms and government-funded research institutes but no universities involved. G01C/21, G01L/3 and G01G/19 only showed a small number of single actors involved by either firms-government-funded research institutes or universities-government funded research institutes.

Chapter 6. Conclusion

6.1 Key Findings and Implications

The growing increase in the number of nodes throughout the study years 2008 to 2014 signifies growth in the variety of technology areas of patents in Korea's national R&D ICT convergence network of the auto manufacturing industry while the increase in the number of links shows that convergence has continued to increase. Most of the ICT-related IPCs were centered in the periphery position in the entire network.

ICT-related IPCs that were identified as hubs at least once were in the technology area of "traffic control systems for road vehicles," "navigation," "measuring torque, work, mechanical power, or mechanical efficiency, in general" and "recording measured values. These areas are thus the key type of technology that are highly connected and is important in connecting others.

The core, which is highly connected but not uninfluential in linking others, for ICT-related IPCs involved "television systems" "navigation" and "recording measured values." The opposite, bridge positions, were in "weighing apparatus or methods adapted for special purposes not provided for in groups" and "measuring torque, work, mechanical power, or mechanical efficiency, in general."

6.2 Contribution

This paper's analysis of national R&D network convergence trends, specifically between auto-manufacturing and ICT sectors, adds to the literature by examining the dynamic changes in important convergence technology and R&D actors. While many of the related literature examine convergence technology or R&D actors separately, it is necessary to study both aspects at the same time to derive meaningful and more detailed implications on convergence policies.

Moreover, since this study takes a closer look at convergence between auto manufacturing and ICT sectors through national R&D patents, it can give implications and strategies to setting priority areas for national convergence policy. Better public policies can serve as a stimulus in risky and new realms of technology and lead to improvement in ICT-auto manufacturing convergence led by other R&D actors.

6.3 Limitations and Future Study

The limitations of this study are as follow. Because this study only identifies the convergence trends between auto manufacturing and ICT in Korea, there is a need for extension of this analysis to global networks and identifying key technology areas and R&D actors over time at national levels and comparing them. Similarly, this paper's focus on national R&D network naturally restricts the scope of interpretation of ICT-auto manufacturing convergence that may be taking place in the entire R&D network. Further studies should analyze the entire R&D network mainly led by private firms in Korea or compare the national and private networks in order to identify convergence trends and provide policy implications for the respective sectors.

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Appendix 1: Full Version of Table 6 on Network Positions of ICT-related IPCs in Auto Manufacturing including the Column "Periphery" (2008-2014)

	2008	2009	2010	2011	2012	2013	2014
Hub	G08G/1	G08G/1	G08G/1, G01C/21	G08G/1, G01C/21, G01L/3	G08G/1, G01D/9,	G08G/1,	G08G/1
Core	None	G01C/21	G01D/9	G01D/9	G01C/21	G01C/21, G01D/9	G01D/9, G01C/21, H04N/7
Bridge	None	None	None	G01G/19	G01G/19, G01L/3	G01G/19, G01L/3	G01G/19
Periphery	G01D/9, G01F/23, G01L/3 H04N/7	G01B/11, G01B/21, G01D/1, G01D/9, G01F/23, G01L/3, H04M/1, H04N/5, H04N/7, H04Q/9,	G01B/11, G01B/21, G01B/7, G01D/1, G01D/21, G01D/5, G01F/23, G01G/19 G01L/3, G01P/15, H01L/21, H04M/1, H04N/5, H04N/7, H04Q/9	G01B/7, G01B/11, G01B/21, G01C/11, G01D/1, G01D/21, G01D/5, G01F/23, G01L/5, G01M/15, G01M/17, G01P/15, G01R/1, G01R/31, G08C/17,	G01B/11, G01B/21, G01B/7 G01C/11, G01D/1, G01D/21, G01D/5, G01F/23, G01J/1, G01L/5, G01M/15, G01M/17, G01P/15, G01R/1, G01R/31,	G01B/11, G01B/21, G01B/7, G01C/11, G01D/1, G01D/21, G01D/5, G01F/23, G01J/1, G01L/5, G01M/15, G01M/17, G01M/7, G01P/15, G01R/1,	G01B/11, G01B/21, G01B/7, G01C/11, G01D/1, G01D/21, G01D/5, G01F/1, G01F/23, G01J/1, G01L/3, G01L/5, G01M/15, G01M/17, G01M/7,

				H01L/21, H01L/35, H01L/41, H04M/1, H04N/5, H04N/7, H04Q/9,	G08C/17, H01L/21, H01L/35, H01L/41, H04M/1, H04N/5, H04N/7, H04Q/9,	G01R/19, G01R/31, G01R/33, G08C/17, H01L/21, H01L/35, H01L/41, H04B/1 H04M/1, H04N/5, H04N/7, H04Q/9,	G01P/15, G01R/1, G01R/19, G01R/31, G01R/33, G08C/17, G08C/19, H01L/21, H01L/35, H01L/41, H04B/1, H04B/7, H04L/12, H04L/29, H04M/1, H04N/5, H04Q/9

Appendix 2: Change in the Total Number of Applied Patents by Combination of R&D Actors for ICT-related hub IPCs

1. G01C/21

Year	a	b	c	a-a	a-b	a-c	b-b	b-c	c-c
2008									
2009		1	3						
2010			1						
2011									
2012									
2013		1							
2014									

2. G01L/3

Year	a	b	c	a-a	a-b	a-c	b-b	b-c	c-c
2008	1								
2009									
2010	1								
2011			2						
2012									
2013									
2014									

3. G01D/9

Year	a	b	c	a-a	a-b	a-c	b-b	b-c	c-c
2008		1							
2009	1		4			1			
2010		1							
2011									
2012	2	4							
2013	2	3	2						
2014	2		3		1				

4. H04N/7

Year	a	b	c	a-a	a-b	a-c	b-b	b-c	c-c
2008			1						
2009	1								
2010	2								
2011									
2012			1						
2013	1		1						
2014	1		1						

5. G01G/19

Year	a	b	c	a-a	a-b	a-c	b-b	b-c	c-c
2008									
2009									
2010		1							
2011			1						
2012									
2013									
2014									

Abstract (국문)

본 논문은 한국의 국가 연구개발 네트워크에서 자동차 제조업과 ICT 산업간의 융합을 분석한다. 기술 융합 또는 연구개발 네트워크 협력을 분석한 여러 문헌이 있으나 구체적으로 자동차 제조업과 ICT 산업간의 융합에 대한 분석을 실행한 연구는 적다. 나아가 본 논문은 기존의 연구가 시도하지 않은 주요 융합기술 및 연구개발 주체의 동적 변화라는 측면에서 특정 산업에서의 융합을 분석한다. 이를 위해 본 논문은 2008-2014년 한국의 자동차 제조업과 ICT 산업의 특허 정보를 활용한 동적 네트워크 분석을 시행한다. 이 분석을 통하여 주요 융합기술과 연구개발 주체의 동적 변화를 살펴보고 패턴을 알아본다. 주요 융합 기술을 도출하기 위해 "허브," "코어" 및 "브릿지"로 칭하는 주요 네트워크 포지션을 설정하여 분석한다. 결론적으로 본 논문의 연구 결과는 오늘날 일어나고 있는 ICT 주도의 제조업 변화에 대한 대비 차원에서 융합기술 우선순위 및 주요 연구개발 주체를 식별하고 정부 정책에 기여할 것으로 기대한다.

주요어 : ICT 융합, 자동차 제조업, 동적 네트워크 분석, IPC 동시출현
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