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Global Collaboration of R&D: A Case of Samsung Electro-Mechanics and UT Dallas

글로벌 R&D협력: Samsung Electro-Mechanics와 UT Dallas대학 사례연구

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목 차

국 문 요 약

공동기술개발은 작금의 글로벌 과학연구에 있어서 가장 의미있는 활동 중 하나이며, 이는 기회요인과 도전과제를 동시에 지닌다. 또한 국경을 넘는 활동은 참가자들의 특징, 조직유형, 협력목적 및 동기 등에 따라 성과가 매우 다르게 나타난다. 이러한 불확실성을 감소시키고 협력연구의 성과를 증진시키기 위해서는 포괄적인 차원의 연구와 구체적인 연구가 병행될 필요가 있다. 이에 본 연구는 한국과 미국 내의 기업, 대학 및 공공연구기관이 R&D를 둘러싼 협업의 성공사례를 분석했다. 본 연구의 목적은 성공적인 기술협력의 요인을 찾아내는 것이다. 사례분석 결과 성공요인으로서 연구팀의 강력한 의지, 파트너의 적정 선정 및 역할분담, 보완적 기술과 자산, 정부의 지원 등이 도출되었다.

핵심어 : 글로벌 R&D 협력, R&D협력 사례, R&D협력 성공요인, R&D협력 성과, 삼성과 UT Dallas 협력

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ABSTRACT

Collaborative technology development is now one of the most significant modes of activity in the global scientific community. However, the international cooperation of science and technology simultaneously provides opportunities and challenges, and the results of global R&D collaboration can be positive or negative as the cooperation conditions of the parties may be different according to the types or characteristics of the participants and the pattern, purpose, and motivation of cooperation.In order to minimize the risk and improve the performance of cooperation, more comprehensive as well as micro-level research is needed. This study investigates a case of successful collaborative R&D conducted by several firms, universities, and public research organizations in both Korea and the U.S.A. The aim of this study is to identify the factors of successful R&D collaboration.

Key Words : Global R&D Collaboration, Case study of R&D Collaboration, Key success of R&D Collaboration, Performance of R&D Collaboration, Samsung and UT Dallas Collaboration

I. Introduction

In recent years, with the ever accelerating advances in technology development and convergences among industries, the need to outsource R&D resources by various forms of cooperation is increasing more than ever. Hence, collaborative technological development is now one of the most significant modes of activity in the global scientific community.

In fact, the number of international R&D collaboration agreements has been increasing globally at an unprecedented rate. According to a government report, Korea has also seen a continuous rise in joint R&D activities (Kim, DaeIn, 2010).

While innovation capabilities for R&D improve by taking advantage of outside resources through cooperation and competition, a cross-border R&D collaboration, on the other hand, containsmuch more risks a collaboration at a national level., which makes any expectations of positive performance difficult.As Kim(2009) argues, the major obstacles to global research cooperation include language, different macro-environments such as culture of the countries, the divergence between the partners'interests, mismatches in the level of technology, etc. According to studies, the challenges of global R&D collaboration include searching for the right partners, the valuation of technology, the lack of appropriate expertise about the strategic alliances, reliability of potential partners, legal and administrative issues, communication problems, as well as cultural differences (Suh, 2011, re-quote).

Therefore, the performance of global R&D collaboration can be positive or negative depending upon the differences among the participants'characteristics and the pattern, purpose, and motivation of cooperation. In order to minimize the risk and to improve the performance of cooperation, more comprehensive and micro-level research is needed (Lee, 2011).

With that in mind, this study investigates a case of successful collaborative R&D conducted between several firms, universities, and public research organizations located in both Korea and the U.S.A. This study looks to explain the factors of successful R&D collaboration. This R&D case study is "6-axis light-harvesting sensor module project" led by Samsung Electronics and UT Dallas. The Korean government partly covered the cost of the R&D. Based on the results, this paper draws several conclusions that would help in ensuring successful R&D collaborations. After a review of the relevant literature, this paper outlines the cases, followed by analysis and then describing the real role of determinants in R&D collaboration. In the final section, we present out conclusions and reveal the real world implications.

II. Theoretical Background

1. Theories of R&D Collaboration

There have been several theories that aim to explain the motives of R&D collaboration. Three motivations have been identified; resource-based theory, learning perspective, and industrial organization theory (Sébastien Lechevalier et al, 2011). Theoretical literature derives several important advantages of R&D collaboration that may improve a firms'R&D productivity: overcoming the lack of internal resources and enhancing innovation, access to external resources, economies of scale and scope and synergy veffects for R&D, reducing the risk of wasteful duplication of R&D efforts, and increased incentive for R&D investment by increased relevant ability to capture profits generated by the innovation (Katz, 1986; d'Aspremont and Jacquemin, 1988; Suzumura, 1992; Combs, 1993; Hall et al., 2000).

Resource-based view of strategic management perspective-also known as capability theory-claims that each firm has different capabilities, and is costly to create and maintain capabilities. Following this argument, the cost of the transfer is not so much an issue (like in transaction cost theory), but the effectiveness of the transfer and the ability or experience of the firms in accessing and handling new knowledge may create the need for collaboration. Cooperation can be seen as a mean to combine effectively the capabilities of other R&D partners by utilizing the two complements each other. According to this argument, institutions will have an incentive to collaborate when possessing different and potentially complementary assets (Hagedoorn et al., 2000).

The learning perspective is more concerned about the interactive nature of cooperation and emphasizes the gain of technological capabilities or tacit knowledge rather than cost-saving or increase of short term profitability resulting from the collaborative project (Kogut, 1988; Teece, 1989). The main focus from this perspective is not placed on the resource but on the governance structure or the procedure of the inter-organizational relationship (Bonaccorsi and Piccaluga, 1994). Among other variables, consensus on performance measures, procedures, investment or contribution of participants, and information-sharing are the most important for successful collaboration (Bruce et al., 1995; Hakanson, 1993; Sakakibara, 1993; Souder and Nassar, 1990). In other words, the main factors for successful joint technological development derive from collaboration management practices and the relationships with partners.

Industrial organization theories focus on the potential of failure in the market of scientific and technological knowledge. The difficulty in forecasting the returns from knowledge is said to account for inadequate incentives to invest in it. Industrial organization literature has emphasized the existence of knowledge spillovers as an incentive, as well as a disincentive for engaging in collaborative research. Incoming spillovers are a major incentive for firms to engage in collaborative research. On the other hand, there are outgoing spillovers, which may increase free riding problems, decreasing the attractiveness of cooperation.

2. Key Factors for Successful R&D Collaboration

Collaborative R&D activities are well known to be not conducted in a successful way. The way in which R&D collaboration is performed effectively is a major question. Forrest & Martin (1992) identified the critical success factors into six major types: mutual agreements on strategic objectives and goals, communication, commitment, good interpersonal relations, compatibility, and mutual trust. In a study on collaborative ICT product development, Bruce, Leveric and Littler (1995) identified the following success factors: (1) choice of partner, (2) establishing the ground rules (3) factors related to the process of cooperation (e.g. communication, trust, flexibility), (4) balanced contribution, power and benefits, (5) people (e.g. commitment and personal relationships), and (6) environmental factors. Kim (2003) has summarized as follows: (1) project characteristics include market needs of the R&D outcomes, financial support from the government, the level of technological complexity, the strategic importance, (2) partner characteristics including mutual understanding and trust, prior collaborative experience, complementary resources/strength (3) collaboration management practices including procedures and rules, information-sharing, and communication frequency. Expanding the scope of interest to technology cooperation, Suh & Lee (2011) classify the determinants of successful cooperation into three types: environmental, planning, and implementation. The environmentally-related determinants include the culture of cooperation, confidence in the partner, and commitment. Planning determinants include communicating clear objectives and selecting the right partner. Finally, the implementing determinants include the determination of resource investment and the allocation of outcome, effective organizational structure.

3. Types of R&D Collaboration

In studying this type of R&D collaboration, Annique C. et al. (2010) builds upon the knowledge-based view, using the concepts of breadth and ease of access of new knowledge to analyze the likely impact of R&D collaborations on product innovation. First, product innovation requires a broad knowledge base because multiple disciplines contribute to the diverse dimensions of the product that can be innovated. Multiple disciplines provide specialized knowledge that others do not have. Second, product innovation can benefit from R&D collaborations in the cases where the new knowledge is easily accessible from the collaboration. Based on these two dimensions, each type of R&D collaboration can be positioned into a matrix (Table 2).

R&D collaborations with universities are likely to improve product innovation the most, because the knowledge is broader and the barriers to accessing it are reduced. Universities possess a broader knowledge base than other collaboration partners and are thus better at supporting product innovation. They are established to provide multiple fields of study to students within the same organization. The existence of multiple disciplines within the university provides a breadth of knowledge in fields that do not typically coexist in other organizations, thus presenting unique opportunities for access to and integration of knowledge. There is a general belief that collaboration with universities is more focused on basic, pre-competitive research (Arora & Gambardella, 1990) and that collaboration with universities is a driving force for basic research that might be less useful for immediate application in industry (Cohen, Nelson, and Walsh, 2002).Universities have systems and mechanisms in place that facilitate access to complex knowledge, making it easier for firms to obtain new knowledge and improve products.

R&D collaborations with competitors are likely to have the smallest impact on product innovation. There is a limited range of new knowledge that the firm can gain from its competitors, and even this will be difficult to access because the competitor will actively block its access. Firms and their competitors have a similar knowledge base, limiting the possibility of achieving product innovation. They are generating products designed to fulfill the needs of similar customers. Although the firm and its competitors are likely to have different knowledge bases because of differences in their resources and how they use these resources (Penrose, 1959), these knowledge bases are still relatively similar because they are designed to fulfill similar customer needs (Knudsen, 2007).

R&D collaborations with suppliers offer limited new knowledge, but is much more accessible, supporting innovation better than collaborations with customers and competitors, although not as well as collaborations with universities. This R&D collaboration with suppliers offers more limited new knowledge, but is still useful for product innovation because of its difference from the firm's existing knowledge. Any results obtained from

〈Table 1〉 Classification of Four Types of R&D Collaborations by Breadth of Knowledge and Ease of Access

		Ease of Accessing New Knowledge for Product Innovation by the Firm	
		Higher	Lower
Breadth of New Knowledge for Product Innovation	Higher	1. R&D collaboration with universities	3. R&D collaboration with customers
	Lower	2. R&D collaboration with suppliers	4. R&D collaboration with competitors

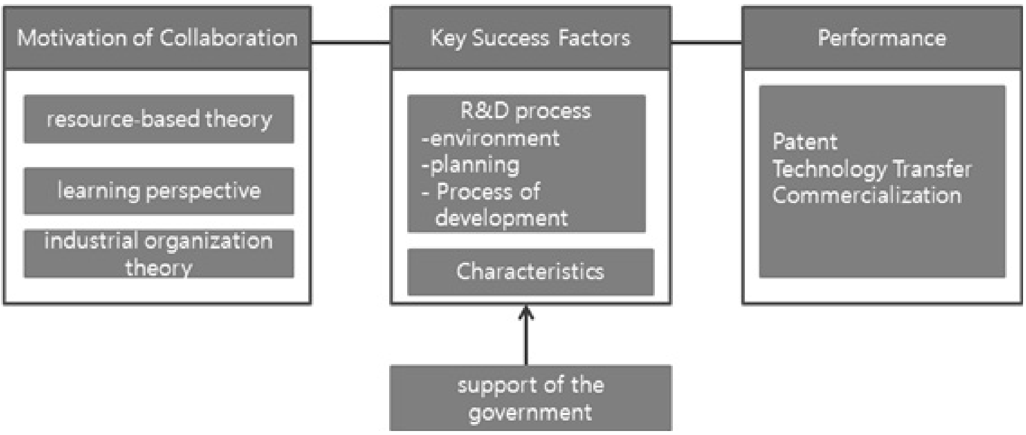
collaborating with suppliers are narrow because the partners are usually operating in the same or similar interests.

R&D collaboration with customers provides the firm with the broad knowledge that is helpful for product innovation but is difficult to access. As a result, R&D collaborations with customers will have less influence on product innovation than those with universities or suppliers, although more than those with competitors. Customers have knowledge about their unfulfilled preferences and needs, presenting opportunities to create innovations. Listening to customers helps firms better understand their needs (Flores, 1993). Interaction with customers can improve firms' understanding of their needs and can help avoid wasting time and making costly changes in orders later in the product development process (Koufteros, Vonderembse, and Jayaram, 2005).

III. Description of Case

1. Research Frame for the Case Study

The framework of analysis of this study is seen in (Figure 1). We applied the major concepts of the R&D collaboration theory described in Section II to analyze the



(Figure 1) Framework of Analysis

practices of global R&D collaboration of the case. Any single theory described above, however, is not able to account for the R&D setting and industry situation as a whole, especially in a global R&D collaboration. We composed our framework into motivations of collaboration, key success factors, and performance. Regarding the motivation of collaboration, we considered three theories described in Section II. As for the key success factors, we took the process and characteristics of R&D into account. Major concerns regarding performance include patent, technology transfer, and commercialization.

2. General Information of R&D Project

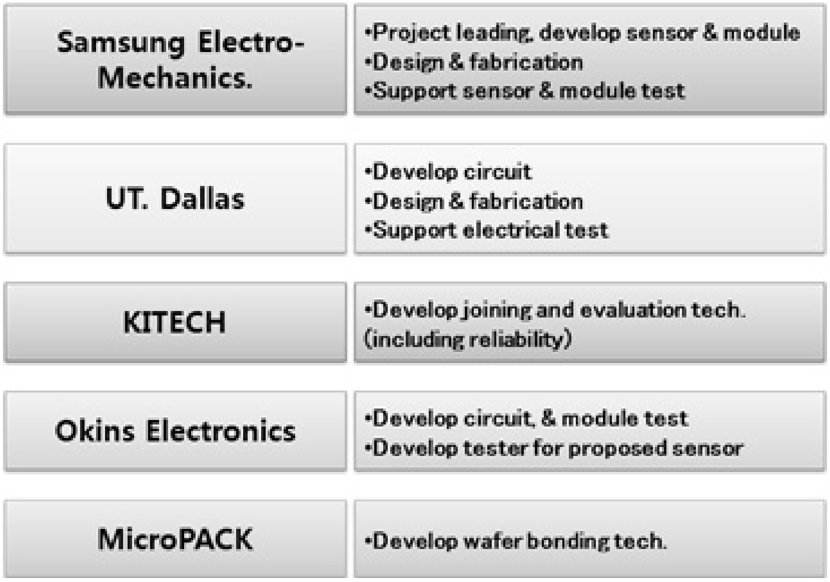
The R&D project started in 2008 and took three years to complete. The collaboratory research team was composed of Samsung Electro-mechanics, UT Dallas, KITECH, Okins Electronics, and MicroPACK. In addition, the Korean government supported R&D project's budget.

The primary objective of the R&D project was to develop an integrated single chip multi-functional sensor module (including 3-axes accelerometers and 3-axes gyroscopes) using piezoelectric technology.

The main objectives of the project were as follows:

- To develop the manufacturing technology for a sensor module which has a piezoelectric sensing and actuation method.
- To develop and commercialize an integrated single chip multi-functional sensor module.
- To integrate leading edge sensor design technology and circuit design technology with 3-D wafer level package (WLP) technology.
- To develop 6-axis single chip module for mass production.
- To acquire technologies from U.S.: sensor design, circuit design (ASIC).
- To become a leader in the field of piezoelectric technology, electrical interconnection technology, manufacturing technology for commercialization, sensor fabrication technology, and sensor & module test.

The role allocation of each party was as follows: Samsung Electro-mechanics was the leader of the R&D project, and also was in charge of developing and supporting the test of the sensor and module. The role of UT Dallas included developing the circuit, designing of fabrication and supporting of electrical test. As a government funded research institute, KITEC took charge of evaluating technology as well as joining of R&D. Okins Electronics and MicroPACK developed other part of R&D as seen in the (Figure 2).



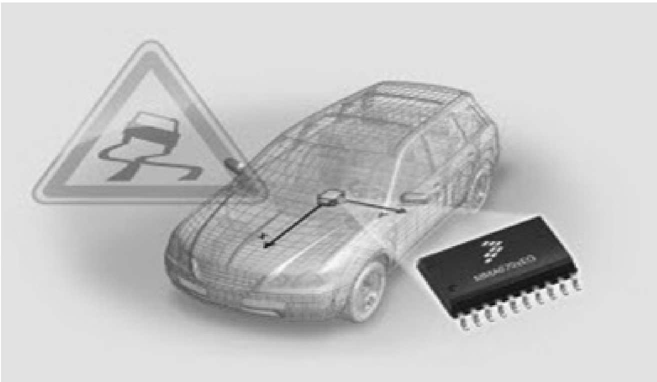
(Figure 2) Role Allocation of Each Party

The main expected effects from the industrial point of view were as follows:

- The motion sensor module has a big impact on the next generation automotive electronic systems, input interface functions of home appliances, and joint control of robotics.
- The industrial ripple domino effect is enormous since motion sensor module is used as core components and parts in the future mega market. The technology shows much promise for the next generation even though it is under development.
- Conventional bulky size inertial sensor module has integration limitations for multi DOF system. They do not have any possible integration for the future market. So, it is essential to develop the 6-axial motion sensor module as a piezoelectric method.

- Production technology of motion sensor module is based on WLP processes and is not limited only to the electronic components and parts. There is a huge potential in areas like semiconductors, intelligent automobile, next generation robotics, bio-medical industry, etc.

The development of an inertial module for the automobile was under active progress by many advanced countries. The accelerometer and gyroscopes were currently produced in large quantities in some advanced countries, and the development of sensor module was actively processed due to future marketability and the market opening possibility of the technical development. Advanced countries completed the development of expensive inertial sensor module, while a Micro Electro-Mechanical Systems (MEMS) based inexpensive inertial module was not developed at that time.



(Figure 3) Multi-Functional Sensor Module for the Car

IV. Process and Outcome of Collaboration

1. Early Recognition and Motivation at the Outset

The infrastructure of MEMS in Korea was relatively low in comparison to the R&D level. Moreover, the main components had to be imported from foreign countries because of weak market competitiveness. The most serious problem at that time was the lack of core source technologies. In this regards, to obtain the source technologies, Samsung Electro-Mechanics planned to conduct a joint development with R&D centers in the advanced countries such as U.S.A, Japan, and France. In 2008, Samsung Electro-Mechanics selected UT Dallas in the U.S.A.as a partner and began the collaborative R&D. To achieve more success in both the technology and commercialization aspects, Samsung Electro-Mechanics found out the fact that they had to cooperate with industries, research institutes, and universities. In the end, Samsung Electro-Mechanics organized a consortium with the Korea Institute of Industrial Technology, MicroPACK, Okins, and U.T. Dallas. Each participant had related technologies and played a key role in its own field.

The University of Texas at Dallas (UT Dallas) was one of the well-known colleges of Texas University System, with an excellent infrastructure and performance in the research in MEMS. Moreover, UT Dallas is a public research organization, meaning that they are not profit driven and so seemed to make less trouble with Samsung Electro-Mechanics, who set a joint research contract for developing an integrated single chip multi-functional sensor module.

This case is apparently an example of application of outside complementary assets to solve the technological difficulties and to shorten the period of technology development. This case is an example of R&D collaboration with the university, the main motivation of which is to facilitate the access to complex knowledge, making it easier for firms to obtain new knowledge and improve products and cut down the expenses or period of technology development.

2. Challenges

1) Initial Challenges

Developing advanced technology has an inherently high uncertainty. At the outset of the project, as is always the case, the research team in Samsung Electro-Mechanics had to take a great risk. In addition, they had to face worry and concern within the company. Nevertheless, the willingness and the support of top management to invest in the future made it possible to start.

Another difficulty in the early stages was due to the fact that the project was supported by the government. The financial aid from the government may be a good driving force, but as a leading company which is inevitably sensitive to the information security and strategy, executing the plan was not easy to carry the plan forward. However, this too was done smoothly without any major problems. In addition, the support from the government through KIAT(The Korea Institute for Advancement of Technology) was very helpful as an intermediary role to facilitate the bilateral cooperation between Korea and U.S.A.

2) Difficulty of the Partner Search

In this R&D collaboration project, the most difficult problem was finding the right partner. The major task of the research was development and learning of source technology. The outcome and even success and failure of the project depends upon partner selection. Thus, Samsung Electro-Mechanics had to determine the type of partners, what kind of comparative advantages should be obtained from them, if they have mutually complementary assets, etc. However, accurately identifying the technologies of the potential partners proved difficult. In the case of the source technology, it was particularly much more difficult to grasp the information due to its direct link to the core competence and income of the companies or organization who get hold of them.

In this circumstance, the main target of the cooperation was the universities and research institutions in the partner selection process. A long time passed before selecting UT Dallas among the several universities and research institutions, but not the first choice. With the continuous effort and help of the KIAT (The Korea Institute for Advancement of Technology), the partnership was established.

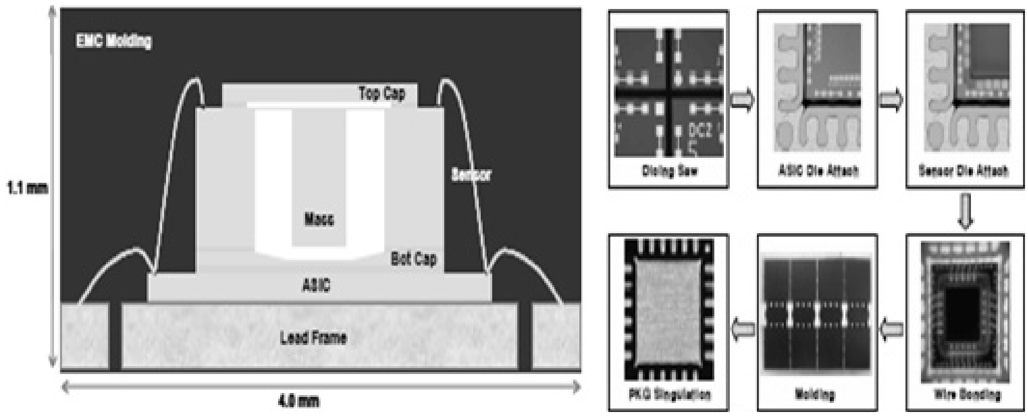
3) The Parties' Different Ways of Thinking

There are different ways of thought because of different cultures between East and West, a fact that can be taken for granted. At first Samsung Electro-Mechanics made contact with UC Berkeley. As a matter of fact, in the process of negotiations, there was a clear difference between the positions. What Samsung Electro-Mechanics needed most was the technological power, and they funded the joint research. However, UC Berkeley argued that the developed technologies had to belong to them as they developed them. Such situation could cause serious problems even related to the ownership of the patent.

Fortunately UT Dallas exhibited a different view from UC Berkeley. UT Dallas wanted to commercialize their technologies. In the process of agreement, the vice president of the university played a major role. We can see there could be a lot of different perspectives between the universities in the same country.

3. Outcome and Commercialization Outcome

The R&D collaboration started in December 2008 and finished in November 2011, taking three years to be completed. The primary objective of the project, which was to develop an integrated single chip multi-functional sensor module (including 3-axes accelerometers and 3-axes gyroscopes) using piezoelectric technology was completed. Through cooperation with UT Dallas and other partners, architecture. design of sensor, module design, the testing of sensor and design were all successfully carried out.



(Figure 4) Cross-Section of the Developed Inertial Sensor Module Developed

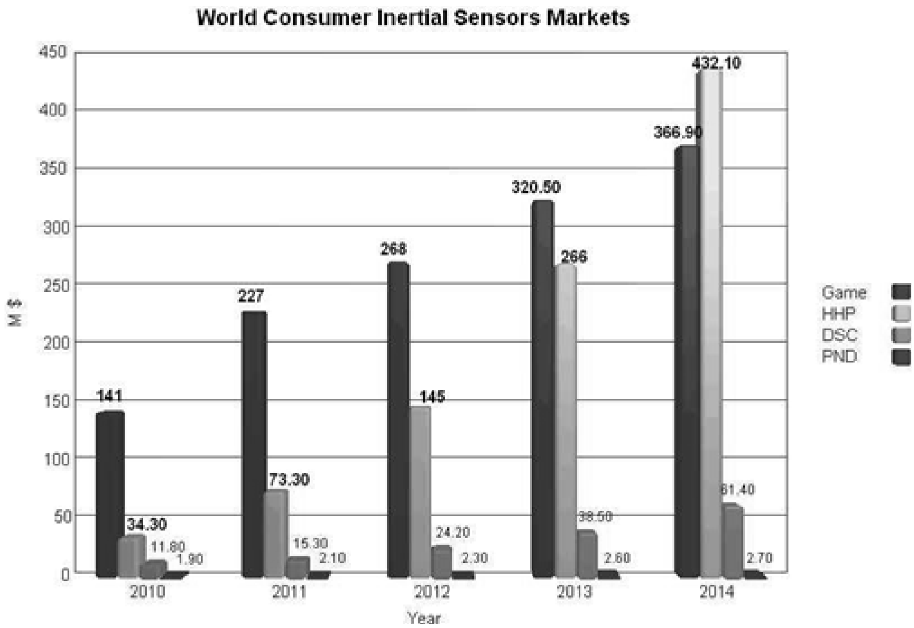
Samsung Electro-Mechanics has secured its worldwide position as an electronic parts manufacturer. Now the company is growing as a semi-conductor component manufacturer rather than an assembly focused manufacturer. In the process of development, Samsung Electro-Mechanics has accumulated a lot of process technologies and filed patents.

Such a wealth of technologies will bring a beneficial effect on the MEMS industry in Korea. In addition, the company set a solid foundation for the substitution of import which account for most in the sensor market.

4. Marketing and Commercialization Plans

In addition to automobile and CE, the sensor market will grow in the robot and bio application in near future. Safety and environmental issues in automobile field are getting important, resulting in various sensors are needed and required mandatory sensor installment. Furthermore, trends in the market need these sensor components to be in the form of module /system.

In the automobile market, the sensor market will grow 944 M$ to 1,028M$ in the period of 2012 and 2015 according to Report by 2007 Yole as shown in the Fig. 5. Main applications are ESC (electronic stability control) which is the primary target, air bag, lane keening system, active front lighting system, and ITS (intelligent transport system).



(Figure 5) SA, Navian

The Consumer Electronics (CE) market where the sensors were already well- adopted includethe Apple iPhone and the Nintendo Wii. The accelerometer and gyro sensors have been used in PS 3 controller (2006) and Wii motion plus (2009). The market will grow rapidly from 508 M$ to 904 M$ in the period between 2011 and 2015 (Refer to the Fig. 6). Main applications in the CE are, as expected, the game controller, HHP, DSC (digital still camera), and PND (personal navigation device), etc..

V. Success Factors

1. Strong Will of the Research Team

As stated earlier, there were a lot of difficulties in conducting the joint research across the border with other organizations composed of universities, government-funded research institutions, and private companies. Most of the difficulties resulted from the distance, the differences in culture, and the barrier of communications, etc. As a matter of fact, it seemed especially difficult at the beginning to expect a successful outcome. Moreover, the project of MEMS inertial sensor took lots of money and risks both in the technical and market dimensions. Despite these risks, the project was able to be pushed ahead by the strong will of Mr. WonGyu, Jung, team leader of the project and the researchers. No matter what challenges they faced, they did not give up. The strong backing of top management based on trust in the team was also a great help to that project. In the outset they had to do a feasibility study for several months in order to boost confidence in the project, which contributed to the start of the project. Any type of creation of new development is attended by not only big responsibility but also by need of the ability to cope with the challenges other than technological problems. The team's commitment and enthusiasm for the project were their motivations and also a major factor that led to a successful project.

2. Suitable Selection of Partners and Role Sharing

As the project was an R&D collaboration between companies and universities, it was very important to find the right partner for a fruitful performance both in the aspect of development and commercialization of technology. In this respect, UT Dallas was a suitable partner of Samsung Electro-Mechanics. Of course, there were a lot of difficulties in the early negotiation process until the contractual agreement was signed, but turned out that the cooperation with UT Dallas was an excellent strategy for Samsung Electro-Mechanics. The universityhad a high level of research as required, and Samsung Electro-Mechanics could easily negotiate on the conditions of profit and interest. In addition, especially in the case of international joint research, it was very important to duly share the responsibilities for the project among the parties. Numerous processes should progress and align according to the same rhythm. At the beginning of the process, partners elaborated a detailed plan for sharing the role and performing each role such as architecture and sensor design, module design, testing etc.. Each party achieved its own mission faithfully, which was another success factor.

3. Prepared Technologies and Complementary Property

As a leading conglomerate in Korea, one of the major advantages of Samsung Electro-Mechanics is the excellent ability to absorb technologies and superior technology infrastructure as well. Even if UT Dallas and other partners cooperate excellently, if Samsung Electro-Mechanics did not have the enough research application ability, new projects would never be easy to develop.

Samsung Electro-Mechanics had accumulated experience in producing various electronic and electrical components and various complementary property such as equipment and facilities, and has secured its worldwide position as an electronic parts manufacturer. With such proper complimentary asset of Samsung Electro-Mechanics, the project could be carried out smoothly without any problems. Furthermore, an early commercialization has been planned.

4. The Research and Development Supported by the Korean Government

The government intervention was especially helpful in the early stage in coping with the problem caused by the cross cultural situation. For example, the notion or interests of university and company for the patents were different and the contractual agreement could have been delayed long. The problem was who will get the ownership of the proprietary rights of patent. The Korean government (KIAT) analyzed the benefits for each partner of the project and then persuaded each partner persistently, so their project went well. At that time, the government emphasized each party's core areas to facilitate the process. Samsung Electro-Mechanics gained the technological know-how from the university and the university gained the chance to commercialize the technology. Without such a role of government intervention, the project would have been difficult to develop.

VI. Conclusions and Implications

As mentioned earlier, choosing the right partners is important, which should above all be aligned to the motivation of cooperation. However, even a leading company such as Samsung Electro-Mechanics also suffers from finding the suitable partners. In this regard, small- and medium- companies would suffer much more from looking for a good partner.

From the perspective of resource-based theory, it is very important to accumulate complimentary assets and absorption capability for the developed technology to achieve a fruitful performance from the cooperationas these capabilities enable to exchange the technologies between the partners. The companies should continuously select and focus on the core technology to get competitive advantages. To overcome the problem of selecting right partners, using the government support program would be very helpful. In view of the relatively small portion of global R&D cooperation in Korea, more systematic and sustained policy supports by the government are indispensable.

As shown in this case, the KIAT played a major role in aiding of partners selection as a mediator. This kind of program should be strengthened. For example, the government agencies need to systematically collect information on the overseas researchers, research organizations and on-going core technologies, in the foreign countries and build a database for facilitate R&D collaboration. and technology commercialization..

As an example of global R&D collaboration, this case could be regarded as having given good lessons to many companies and organizations which plan a joint research collaboration. More case studies related to this area are needed to attain sound conclusion.

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서상혁

프랑스 그래노블 대학에서 경영학 박사학위를 취득하고 현재 호서대학교 글로벌창업대학원 창업학과 교수로 재직 중이다. 관심분야는 하이테크마케팅, 정보마케팅, 성과분석, 기술경영 등이다.

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호서대학교에서 경영학 박사학위를 취득하였으며, 현재 구미대학교 마케팅학과에서 교수로 근무 중이다. 관심분야는 기술마케팅, 정보마케팅, 기술사업화, 대중소기업간 상생협력, 고객가치 등이다.