Typology of R&D Service Firms and Customized Policy Suggestions in Korea[1]

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ABSTRACT

This paper originates from the questions concerning why Korea has had difficulties in boosting R&D service industries regardless of government efforts over a decade. We first review the intrinsic nature of the R&D services and set up four criteria such as establishment type, diversification of business models, coverage of client firms, and role of R&D service firms as innovation drivers and IP strategies, that will be used in interviewing and analyzing R&D service firms. Second, we carry out in-depth interviews of eighteen R&D service firms to understand business behaviors and relevant characteristics. Finally, we identify five groups of R&D service firms and conclude that differentiated polices have to be implemented according to the groups for promoting the industry effectively.

KEYWORDS: R&D service industry, knowledge intensive business services, R&D service clients, customized policies, Korea.

1. INTRODUCTION

Much research on the knowledge intensive business services (KIBS) has been performed since the 1990s (e. g. Nählinder, 2002; O'Farrell et al., 1993; MacPherson, 1997; den Hertog, 2000; Wong and He, 2002; Muller, 2001). KIBS firms have been considered as the co-producer of innovation with client firms as well as internal innovators (den Hertog, 2000). They had a positive influence on

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the innovation of manufacturing clients by intervening in the innovation process of their manufacturing clients (MacPherson 1997; Wong and He 2002). They created new knowledge through the active interaction with their client firms (Muller and Zenker 2001).

Less attention has been paid to R&D services as a sub category of KIBS in spite of a surge of interest in KIBS. It is mainly because R&D functions were evaluated as being more difficult to outsource (Howells 2006a: 63-65) than the other types of KIBS due to its intrinsic nature. This is also the case in Korea. The Korean government pursued diverse policy programs to develop knowledge intensive service sectors and succeeded in some sectors such as creative industries (e.g. Choi 2010; 2011), but did not acquire satisfactory results in R&D services, at least so far. The unique attributes of R&D service products lead to the difficulty in classifying R&D services as an industrial sector and figuring out their characteristics (Choi 2009). What R&D service providers sell is a function, not any type of final products with similar attributes such as financial services, education services, consulting services and the like. This means that each industrial sector may have its distinctive R&D service providers that are fully committed to itself. The characteristics of R&D service firms and their service products have been dealt with in the relationship with the characteristics of client sectors.

It is a starting point of this research that the dimension of client firms needs to be taken into account to analyze R&D services firms and accept the result of Choi (2009) where R&D service manufacturing clients are grouped into four types of sectors. Keeping this in mind, we first review the intrinsic nature of the R&D services and set up four criteria for the analysis of R&D service firms. Second, we carry out in-depth interviews of the eighteen R&D service firms based on the four categories of manufacturing client sectors according to Choi (2009) to understand business behaviors and relevant characteristics. Finally, we identify five groups of R&D service firms and conclude that differentiated polices have to be implemented according to the groups for promoting the industry effectively.

2. UNIQUENESS OF R&D SERVICE INDUSTRIES

When it comes to specific industries belonging to KIBS, each industry shows unique characteristics (O'Farrell et al. 1993; Pardos et al. 2007). R&D services are defined as the activity where external organizations provide a piece of R&D function for clients, usually client firms. They are a kind of strategy for obtaining external technologies (Granstrand and Sjöander 1990; Granstrand et al., 1992). The advantages of purchasing R&D services are diverse. For example, it helps client firms to acquire innovative capabilities, to solve the problems encountered unexpectedly, to temporarily use additional capacity, to mobilize the various fields of expertise for the best result of R&D activity, to bear the cost with some client firms sharing a common goal, and to get business/technical intelligence (Haour1992). In a more theoretical perspective, the motivation for utilizing R&D services is generally explained with the transaction cost theory of Williamson (1975) and the core competence theory of Prahalad and Hamel (1990). The former focuses on reducing cost by outsourcing standardized R&D activities, whereas the latter is related to upgrading firms' innovative capabilities (Howells 1999b).

R&D service is not a new phenomenon although much attention has been paid in recent years (Howells 2000: 276-277). Howells (2000) describes how the reliance on external R&D has been changed over time and emphasizes on the holistic balancing viewpoints between internal and external R&D.

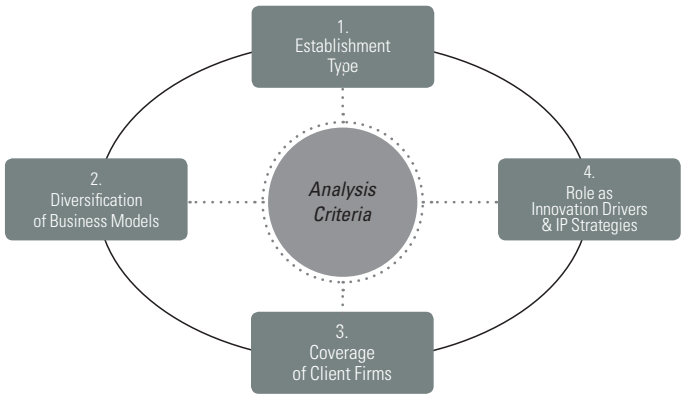
Meanwhile, as mentioned above, R&D services or outsourcing is differentiated from the other types of knowledge-intensive business services in some ways (Howells et al. 2008: 205; Howells 2006a: 63-64). For example, the unique attributes of R&D services are follows: the high levels of risk and uncertainty relevant to the outcome of research outsourcing; prior disclosure and information asymmetry; the poor speculation on the long-term value of research outcome; the intellectual property issues of the co-joint production; moral hazard problems in terms of both providers and clients; the influence on the survival of client firms in the case of R&D associated with core competence; the irreversible nature of R&D outsourcing decision at least over the short-term; the limitation of learning due to the uniqueness of each R&D outsourcing project; and the difficulty in the control of tacit knowledge, which is especially important in R&D projects. Of course, all the R&D services do not completely satisfy the above characteristics. However, they are clear enough to indicate the common basic characteristics of R&D services.

However, R&D services do not necessarily contribute to the positive effect on the performance of client firms. The use of R&D services is sometimes a double-edged sword. In terms of the transaction cost theory, the cost of R&D outsourcing is higher than other types of outsourcing. In addition, because R&D activities need frequent interaction with the other departments inside client firms during the whole innovation processes (Kline and Rosenberg 1986), internal R&D may be more effective than external R&D. Furthermore, as the absorptive capacity based on the internal R&D capabilities of clients directly affect the degree to which external R&D outcome is utilized (Cohen and Levinthal 1989), the purchase of R&D services itself does not guarantee the success of client firms. Howells (1999a: 21-22, 1999b: 118) and Howells et al. (2003a: 397) summarizes the previous empirical research dealing with the negative effect of R&D outsourcing services such as Byatt (1979), Mowery (1984), Häusler et al. (1994), and the like.

3. FOUR CRITERIA FOR ANALYZING R&D SERVICE FIRMS

This study begins from a research question of how differentiated R&D service firms are by industrial sectors. It reviews relevant articles and draws four criteria with which to investigate the characteristics of R&D service providers. The four criteria are shown in FIGURE 1.

FIGURE 1 Four Criteria for the Analysis of R&D Service Firms



First, R&D service firms have various historical backgrounds with regard to the establishment type. According to Howells (1999a: 24, 2000: 280), while some have been created as new firms, others have been spin-offs from firms or universities. In addition, existing organizations diversify into the market, and the government privatizes formerly government-owned laboratories.

Second, as R&D service businesses have grown, the business models of R&D service firms are diversified together with the expansion of the R&D functions that are served (Howells 2006b). Not only dedicated players but also partial players have come to the center of discussion (Howells 1999a). Partial players contribute to the increase in the dynamics of R&D service markets (Howells 1999a; Howells 2000). Moreover, they may grow enough to play a pivotal role in markets in the future (Howells et al. 2003). Meanwhile, the proliferation of partial players sometimes blurs the distinction between client and providers to some degree (Howells 2006a).

Third, as for the coverage of client firms, R&D service firms can be divided into three types (Sammons 2005b: 118-119). Some work for only one or a few number of specific companies, while others often serve a niche sector. Another type of R&D service firm has a broader range of clients covering various industrial sectors. Such a difference in the range of client firms can be described as the evolving stages of R&D services firms over time (Elfring and Baven 1994). They put forward the four stages of the evolutionary trajectory of R&D service firms. At the first stage, an R&D service function develops as one of the internal departments of large firms. As it grows, it starts to sell the services to third parties. The department becomes externalized as a spin-off along with the more coverage of clients beyond a specific niche sector. At the final stage, it develops new R&D service business models by leveraging existing relationships with various clients. One-to-one relationships are transformed into one-to-many relationships during the evolution (Howells 2006b). Meanwhile, some contrasting arguments have been made concerning the relationship between R&D service providers and their clients. On one side, García-Canal (1996) argues that it is based on the unilateral and vertical relationship where all the information/knowledge flows from client firms to R&D service providers. It is in line with Grimpe and Kaiser (2008: 1), which mentioned that the clients and the providers of R&D services did not have virtually any interaction with each other and did not cause any organizational cost. On the other side, however, it was insisted that some R&D services with a higher level of uncertainty in transaction and contract incompleteness (Howells et al.2008) needed constant interaction between R&D service clients and providers (Haour 1992). It is similar to the relationship between knowledge-intensive service firms and their clients as shown in Muller (2001).

Finally, the role of R&D service firms as the drivers in the innovation of client firms and intellectual property management strategies also needs to be taken into account. R&D service firms are sometimes regarded as, not only the innovation facilitators of client sectors, but also the innovation leaders for the whole innovation system (Howells 1999b). It is a contrasting view with a traditional recognition about service sectors, which were passive and dominated by the suppliers in their innovative behaviors, such as Pavitt (1984). In particular, as the contribution of R&D services to customers evolves from the provision of the sourcing input for problem-solving on a short-term basis to that of creating capabilities on a long-term basis (Howells 2006a), the leading role of R&D service firms in innovation processes is likely to be strengthened. R&D services are not just in a pure market form but also in more hybridized, quasi-market and relational transactional forms (Howells et al. 2003: 398). The issue of creating and managing the intellectual property between service providers and customers also deserves attention especially for the R&D service providers with a higher level of innovative capabilities. In this regard, Dhont-Peltrault and Pfister (2006) defines two types of R&D services including those that are purchased for cost reduction and those for innovative technological capa-

bilities. The paper hypothesizes that customers are likely to assign exclusive property rights to R&D service providers for the services relevant to the development of innovative and uncertain technologies. Ulset (1996) and Lerner and Merges (1998) also showed partially similar results with Dhont-Peltrault and Pfister (2006). However, it is also believed that the firms putting priority on intellectual property tend to be reluctant to outsource some of their R&D activities (Gooroochurn and Hanley 2007).

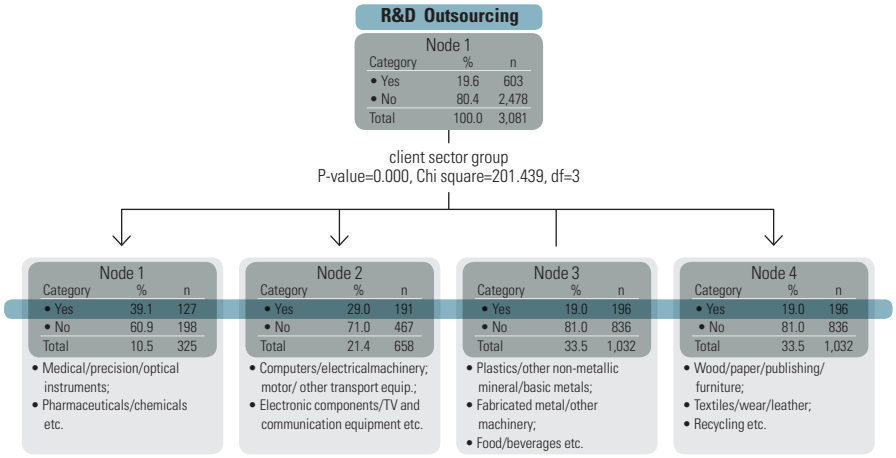
4. METHODOLOGY

This paper is based on the multiple case studies about private R&D service firms. The research method is similar to Howells (2006b). Howells interviewed the managers of twenty-two organizations and eight subsidiary organizations relevant to innovation intermediaries in the UK. He does not construct a complete population list during the case selection process, due to a lack of a converged definition or consensus, the complexity of the organizations, and no formal designation of the sector by government or statistical bodies (Howells 2006b: 720).

The situation is almost the same in the Korean R&D service industries, regardless of the government effort to clarify them. The cases for the analysis in this paper are first selected from the firms registered in the Korea R&D Service Association (http://www.rndservice.or.kr), considering client sectors and R&D service functions. The cases introduced in the media and recommended by experts are also added. Eighteen R&D services are finally selected excluding some firms rejected to participate in the research, a few of which were not defined as R&D service firms in their formal business categories, but worked as R&D service firms in reality.

Manufacturing client sector groups by the inclination toward R&D outsourcing are considered as an important factor that affects the behaviors of R&D service firms (Choi 2009). According to Choi (2009), the four sector groups are detected as shown in FIGURE 2. They are composed of new growth engine sectors (client group 1), high-technology based key industrial sectors (client group 2), traditional industrial sectors (client group 3), and consumer-goods sectors (client group 4) in descending order in regards to the intensity of utilizing R&D services.

FIGURE 2 Client Sector Grouping by the Experiences of R&D Outsourcing.



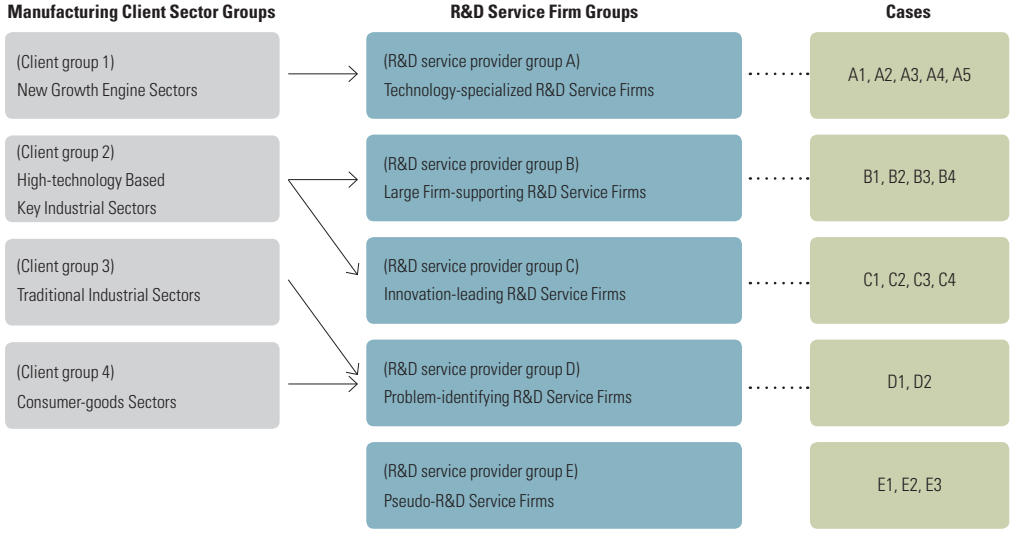
Notes: 1. The classification tree analysis with the growth method of CHAID, SPSS 16.0 software.
2. Raw data from the Korean Inno vation Survey 2008: Manufacturing Sector (see Kim et al. 2008).
Sources: Choi (2009; 180).

We suggest the customized policies for promoting R&D service firms based on the results of in-depth interviews and focused group interviews with experts. Focused group interviews with eight experts were helpful to do the job.

5. RESULTS

The in-depth interviews with the eighteen R&D service firms provide us useful information and knowledge about the status of Korean R&D service industries. The most significant finding from the case analysis is that the R&D service firms belonging to the four client sector groups are altered into different categories as shown in Figure 3. The R&D service firms in the client sector group 2 are divided into two sub-groups due to the differentiated characteristics of clients and represented as R&D service firm group B and C. The manufacturing client group 3 and 4 are grouped together because R&D service firms working for these sectors are not easily found due to the tendency of reluctancy to use R&D services (R&D service firm group D). Some are named as pseudo-R&D service firms, which are original design/development manufacturers (ODM) that have the capabilities of manufacturing products as well as providing R&D services.

FIGURE 3 Matching Between Manufacturing Client Groups and R&D Service Provider Groups



Notes: A1 - E3 are the symbolic expressions of the interviewed R&D service firms.

5.1 Similarities amongst the Interviewed Firms

Regardless of the diversity in the business and innovation behaviors of each R&D service firm, they had something in common in terms of the four criteria. First, as far as the establishment type is concerned, one thing in common was that the entrepreneurs from the eighteen R&D service firms had accumulated invaluable experience while working in the relevant industrial fields, as researchers or businessmen, for a considerably long period. Most of them branched off from relevant firms/universities/public research institutes. Some entrepreneurs still have kept relationships with their parent

companies as current main clients. However, most spin-offs were based on the individual decision of entrepreneurs, not on organizational support. Among the four types of market entrance by Howells (1999a), the market entrance based on the support of government-owned (research) institutes accounted for only a few examples; although efforts began to be made by public research institutes following government polices to encourage start-up companies. Rather, the R&D service provision from public research institutes was sometimes one of the reasons for the conflict between private R&D service firms and public research institutes in the market.

Second, as for business model diversification, most R&D service firms in the case analysis were not dedicated to what they were doing, but expanded (or prepared to expand) business areas into other areas, some of which were related to existent R&D services but others were less connected. The expansion into the manufacturing businesses was often related to give more reliability to R&D service clients by showing that the outcome of the R&D projects could become commercialized without any problem. When this collaboration with external manufacturing partners materialized, R&D service firms began influencing their manufacturing counterparts, which demonstrated that R&D service firms could become the innovation leaders of manufacturing industries. However, the income uncertainty that results from relying on irregular R&D projects became a prevailing reason for such diversification. Although royalty contracts subordinate to R&D project contracts may help to earn stable profits, they were not common in the moment of Korean R&D service industry, usually, because of the lower status of R&D service firms in the relationship with clients. Even the R&D service firms that were eager to develop R&D services and become dedicated players in future often considered carrying out different businesses for survival.

When it comes to the third criterion of client coverage of R&D service firms, the range of client firms of R&D service firms was diverse, depending on business strategies. Some focused on only one client firm, whereas others did business for many client firms in a specific manufacturing sector, and furthermore, with unspecified client firms across many pertinent industries. The array of client sector coverage was one of the criteria by which R&D service firms clearly reveal their differences. For example, the large firm-supporting R&D service firms in the field of IT/electronics/motors tended to be dependent on a few large client firms, whereas innovation-leading R&D service firms performed R&D services for more diverse client firms.

Fourth, as for the characteristics of the innovation-drivenness and intellectual property, some firms played pivotal roles as the innovation-leaders to client firms regardless of their small size. Such active roles were based on the innovative capabilities of R&D service firms usually combined with the possession of intellectual property. The new growth engine sectors relevant to medical/pharmaceutical sectors (R&D service firm group A) showed a distinctive feature in the internal innovative capabilities based on intellectual property rights. The innovation-leading R&D service firms mainly involved with small client firms belonging to IT/electronic/motor sectors (R&D service firm group C) also demonstrated a strong intention to lead the innovation of client firms. The R&D service firms that aim to problem-solve for traditional or consumer goods manufacturing sectors (R&D service firm group D) had at least some capability to initiate client innovation.

A summary table is given representing the characteristics of the R&D service firms belonging to the five categories, because it is not possible to describe in detail the characteristics of each R&D service firm in this paper.

5.2 Dissimilarities by amongst Groups

The firms in the R&D service group A (technology-specialized R&D service firms for client group

1)serve clients belonging to the recently spotlighted manufacturing sectors as a new growth engine in Korea such as pharmaceuticals/chemical, medical/precision instruments (TABLE 1). The client groups showed the highest level of the use of R&D services in recent years. The interviewed firms in this paper were all related to pharmaceutical sector and took part in the value chain for developing new drugs. As for the establishment type, the entrepreneurs of the five interviewed firms all shared over a decade's worth of managerial and technological knowledge involved with their present businesses. As for the business diversification, the five case firms were all pursuing other types of businesses in the relevant field of pharmaceutical industry, such as developing/manufacturing clinical diagnosis chips ([A4][2], [A5]), planning new drug release with their own brands by outsourcing production to manufacturers ([A1]), developing new pharmaceutical materials ([A2]), and serving pre-clinical tests with animal models ([A3]). The case companies regarded unspecified domestic pharmaceutical companies as potential clients, although concrete number of real customers differed by firm. Moreover, the main customers of the firm [A5] involved with sequencing services were not only pharmaceutical companies, but also an uncountable number of individual researchers around the world. The interviewed companies put a lot of stress on the knowledge assets on which their businesses were running. The legal protection of created knowledge (i.e. patent application) through their research projects was one of the key issues that R&D service firms are dealing with. Most interviewed R&D service firms expressed strong will to possess knowledge outcome by themselves, in spite of the differences of the type of businesses or projects. The focus on the knowledge expertise of R&D service firms contributes to the active role of R&D service firms in communicating with each other and providing R&D services to their clients, although their client firms were usually large and technology-intensive firms.

TABLE 1 Characteristics of Technology-Specialized R&D Service Firms

Client Sector Group	R&D Service Firm Group	Characteristics
New Growth Engine Sectors (Group 1)	Technology-specialized R&D Service Firms (R&D Service Group A)	1.Firm - Establishment type: personal/organizational spin-offs from pharmaceutical companies/ research institutes/universities - Firm size: polarized (but mainly about 20 employees) - Main R&D services: biotechnical research projects (drug delivery system), intermediation of pre-clinical test, technical service (bioequivalence tests, sequencing services) 2. Diversification of business: self-brand products (e.g. develop/produce clinical diagnosis chips, new drugs outsourced to manufacturers, discovery of new pharmaceutical materials) 3. Coverage of client firms: - Pharmaceuticals, medical instruments - Unspecified domestic firms 4. Innovation-drivenness/IPRs: Innovation initiators based on the complementary technological capabilities to client firms, strong intention to posses IPRs, the core assets for added values 5. Evaluation: a lack of labor with skills and experiences, a lack of research fund for entering into the global market, need for internationally qualified laboratories for experiments/tests

[2][A1]~ [E3] are the symbolic expressions of the interviewed R&D service firms.

The firms that belong to R&D service group B (large firm-supporting R&D service firms: for client group 2) are those for the client group 2, high-technology based manufacturing sectors such as computer/electrical machinery, electronic components, motors, and the like (TABLE 2). As revealed in the previous sections, the client group 2 is the second largest group that tends to utilize external R&D services. They provide R&D services to one or a few number of leading large manufacturers with high level of technological capabilities. The establishment type was not much differentiated from that of technology-specialized R&D service firms, in that the entrepreneurs had considerable experience in the relevant field they are working in. This type of R&D service firm usually provides R&D services to specific large manufacturing firms. They contract with their main clients on a long-term basis, even when R&D service projects initially take the form of single and one-off contracts. In this sense, they are not much different from the other types of the suppliers that produce components or semi-assembly products from the perspective of manufacturing clients. R&D service firms are just a type of suppliers that provide intangible software or relevant service products to them. The interviewed firms in this research were all related to the development of (embedded) software or engineering design. In spite of the differences in detail, the R&D service firms in this category generally pursue the stability in their businesses, rather than active innovation, with relatively higher level of sales and employees. It mainly comes from the fact that they have a large and reliable client from which they are guaranteed at least a stable amount of capacity, even though they often have to participate in the open biding procedures for some R&D projects. The tendency towards business stability causes the lack of the desire for innovation. The R&D service firms focused on maintaining the current relationship with clients rather than exploring new and adventurous business opportunities and technology development. It also led to an interesting situation where the major manufacturing client was the source from which novel ideas for innovation originated, and therefore, the innovation of R&D service firms was driven by their major manufacturing clients. For instance, [B4] recently introduced new software during the process of the embedded software for cellular phones, which was expected to improve the efficiency of development process by checking and solving programming errors instantly and efficiently. The interviewee mentioned that the software was recommended by its client firms and they were satisfied with the quality improvement. The customized R&D service firms with specific major clients did not seem to feel pressure on the proactive efforts of innovation. It was more interested in flexibly responding to the change of the R&D service demands over time. It also resulted in less enthusiasm for achieving the intellectual property rights, which were the core of the businesses in the previous type of R&D service firms, the technology-specialized R&D service firms. Manufacturing clients also exert a significant influence in the knowledge exchange between R&D service firms and manufacturing clients during R&D service projects. Additionally, [B1] is distinguished from the other three firms in this category as the foreign subsidiary of a global leading R&D service firms. Importantly, it shows an evolutionary path, to some extent, for the other domestic R&D service firms, in that it (more precisely, its parent firm) provides their R&D services to rival large manufacturing clients in automobile industry based on technological capabilities and confidentiality guarantee.

TABLE 2 Characteristics of Large Firm-Supporting R&D Service Firms

Client Sector Group	R&D Service Firm Group	Characteristics
High-technology Based Key Industrial Sectors (Group 2)	Large Firm-supporting R&D Service Firms (R&D Service Group B)	1. Firm - Establishment Type: spin-offs from the current main customer; branch offices from foreign R&D service providers, M&A type - Firm Size: polarized (but mainly over 100 employees) - Main R&D Services: engineering services, software development 2. Diversification of Business: existent, but not active, and limited 3. Coverage of Client Firms - Automotive, electronics (cellular-phones) - a few specific large client firms (indeed, a large client firm) 4. Innovation-drivenness/IPRs: (although the extent is differentiated) mainly reliant on the innovative capabilities of a specific large client firm; but the foreign subsidiary is relatively independent 5. Evaluation: - regardless of size and potential, the intention for internal innovation is relatively low (mainly due to the stable reliance on the large customers) - the foreign subsidiary has difficulty in attracting foreign investment due to a lack of institu tional support that does not reflect the specificity of R&D services businesses

The R&D service group C (innovation-leading R&D service firms for client group 2) also serves to the manufacturing client group 2, including computer/electrical machinery, electronic components, and motors (TABLE 3). The main difference between the large-firm supporting R&D service firms and innovation-leading R&D service firms comes from the characteristics of clients. In general, the innovation-leading R&D service firms provide R&D services to many small and medium sized firms, whereas the large-firm supporting R&D service firms serve one or a few number of major manufacturing clients. This study deals with four cases within this group of R&D service firms. The four case R&D service firms were all very small in its employment (under 10 employees) and turnover (under a million dollars). Some entrepreneurs had experiences working for relevant firms ([C3], [C4]) or university research centers ([C2]), and the other even had a doctoral degree in relevant field before running the business ([C1]). Those firms specialize in the R&D services such as mechanical/chemical reliability/malfunction analysis ([C1], [C2]), design engineering and consulting ([C3]), and technological foresight/consulting and technological business incubating ([C4]). The services are more useful for the small and medium sized firms that do not have the internal capabilities for those services than large ones. That is the main reason why the main clients for these R&D service firms are small and medium sized firms, even though some large firms use the services when they attempt to address the problems of their suppliers. The industrial areas their main clients belong are not just limited to a specific industry, but instead are relatively diverse, which is an important differentiated point. For example, the clients of [C1] and [C2] cover automobile, mechanics, electrics, home appliance, and electronics. The main clients of [C3] belong to electronics, electrics, and LED lighting, while those of [C4] work in the field of semi-conductors, display, energy/fuel cell, LED materials/equipment. The firms have special difficulties in earning steady profits because R&D service projects are intermittent and their clients are usually small and medium sized firms. Such a situation pushes R&D service firms to business diversification in order to survive. Unlike the general belief that business diversification is not desirable for the development of R&D service industry because the firms with business diversification are more likely to exit from the market than dedicated players, some interviewees highlighted that they attempted business diversification for the purpose of obtaining

resources to sustain their R&D services. Meanwhile, it deserves mention that the R&D service firms in this category are influential in setting up innovation paths and upgrading the innovative capabilities of their clients. All the interviewees in this category argued that they had the experience to affect the innovation processes of their clients, especially the small and medium sized firms which were often lacking internal innovative ideas and know-how, beyond just carrying out given R&D service projects. The experiences of these firms demonstrate the possibility that R&D services firms actively encourage the innovative capabilities for their small and medium sized clients. One of the serious challenges that were repeatedly told by the interviewees in this category is that their business rivals are not just the firms in the same businesses, but also the public research institutes that provide the same kinds of R&D services. In particular, central and local governments have actively have pursued promotion plans for domestic small and medium sized manufacturing firms in recent years, and the scope and scale of these public R&D services have been widened. Potential client firms welcome these services because they are provided at lower cost, higher efficiency, and the use of public R&D service itself is transformed into an incentive when they applying for public funds in future. It seems like a double-edged sword, though. The proliferation of the R&D services from public research institutes shrink the private R&D service firms even before they outgrow the infant stages.

TABLE 3 Characteristics of Innovation-leading R&D Service Firms

Client Sector Group	R&D Service Firm Group	Characteristics
High-technology Based Key Industrial Sectors (Group 2)	Innovation-leading R&D Service Firms (R&D Service Group C)	1. Firm - Establishment type: Spin-offs from universities/firms in relevant field - Firm Size: very small (about 10 employees) without exception - Main R&D Services: mechanical/chemical reliability/malfunction analyses, design engineering/consulting, technological foresight 2. Diversification of Business - In some cases, expansion to the relatively less relevant field (due to the difficulty in earning enough profit to run businesses) 3. Coverage of Client Firms - Expanded to relevant industries, (e.g. including automobile, mechanics, electrics, home appliance, and electronics (C1, C2); electronics, electrics, and LED lighting (C3), semiconductors, display, energy/fuel cell, LED materials/equipment (C4)) - Generally small and medium sized firms 4. Innovation-drivenness/IPRs: influential in the innovation path and upgrading the innovation capabilities of client firms; roles as innovation facilitators 5. Evaluation: problems caused by the conflict with public R&D service sectors due to the overlap of provided services; the co-evolution strategies are required

Notes: A1- E3 are the symbolic expression of interviewed R&D service firms.

The R&D service group D (Problem-identifying R&D service firms for client group 3 and 4) provides R&D services to traditional types of manufacturing industries (TABLE 4). The third manufacturing group includes plastics/other non-metallic mineral/basic materials, and fabricated metal/other machinery, while the fourth group includes wood/paper/publishing/furniture, textiles/wear/leather, and recycling. These client groups show the least use of external R&D services and the lowest level of industrial dynamics, in terms of technological change and industrial environments, even though the degree and the detailed characteristics are differentiated by each other. This paper deals with the R&D service firms working in the two client groups as one type. The number of the inter-

viewed firms is just two, which means the implication from the case analysis is limited and needs future research. [D1] is the interviewed R&D service firm that does business with the client group 3, belonging to steel industries. [D2] is the R&D service firm that is related to the manufacturing client group 4, natural dyeing industries[2] . The two cases are different in many ways, but one commonality is that they conceived of ideas to address problems even their clients did not even recognize. They had the process through which to educate their clients (traditional manufacturers) to understand the new ideas. An interviewee called the process "optimization of chimney manufacturing industries". In addition, attention needs to be paid to the fact that the two R&D service firms combined domain knowledge with information and communication technologies (ICTs). As already known well, ICTs were effectively used as a means to improve the competitiveness of their clients. It implies that the IT service firms may be important potential players that enter the R&D service markets and contribute to the upgrading of the innovative capabilities of traditional manufacturing industries.

TABLE 4 Characteristics of Problem-identifying R&D Service Firms

Client Sector Group	R&D Service Firm Group	Characteristics
Traditional Industrial Sectors (Group 3), Consumer-goods Sectors (Group 4)	Problem- identifying R&D Service Firms (R&D Service Group D)	1. Firm - Establishment Type: having worked as a researcher in the current main customer (D1), new business creation after master degree in relevant field (D2) - Firm Size: around 10 employees - Main R&D Services: software development and technological consulting for process innovation 2. Diversification of Business: relevant test equipment (D1), brand launching on the web (D2) 3. Coverage of Client Firms - A specific large client (D1), personally related client (D2) 4. Innovation-drivenness/IPRs: facilitating the innovation of client firms by suggesting the ideas, that are not considered by client firms 5. Evaluation: The need for the support from public R&D fund to improve internal innovative capabilities for searching for new ideas for potential client firms

Notes: A1- E3 are the symbolic expression of interviewed R&D service firms.

Firms within R&D service group E (Pseudo-R&D service firms) are the original development/design manufacturing (ODM) firms that need to be considered from the perspective of R&D services (TABLE 5). ODM firms carry out planning, designing, development, and manufacturing for client firms. They have recently shown evidence of the expansion of the boundary of outsourcing from a simple production function to complicated design or development functions. The main reason for the importance of ODM firms in terms of R&D services is that they conduct a type of R&D service function together with production function. Even as R&D service firms directly and indirectly pursue manufacturing capabilities, as shown in the case analysis (e.g. [A1], [A4], [A5], [C1], [C3], and [D1]), the distinction between pure R&D service firms and ODM firms becomes blurred. The

[3] Strictly speaking, [D2] is not a good example of R&D services, in that it's core business area is the user interface design of software and in terms of the services relevant to dyeing industry it does not formally provides R&D services to manufacturing clients, but just to its associated dyeing manufacturing firm.

example of ODM firms might be considered as an evolutionary path of R&D service firms. Three cases of ODM firms are analyzed in this paper. [E1] is a firm that introduced the concept of ODM in the Korean cosmetic industry for the first time in the 1990s, with the help of a Japanese partner firm. Much importance is placed on the internal capabilities of cosmetic firms to develop formulas for the production of new cosmetic products. Formulas are kept secret even to client firms and are the most important knowledge assets for the competitiveness of [E1]. This firm does not attempt to create self-brand products, although it ranks first in the market share of the ODM firms in the cosmetic industry. [E2] is a firm that develops and manufactures an engine part for large car makers. The company started from an original equipment manufacturer that focused on producing low-cost parts, by following the blueprints of client firms. Patents based on the technological capabilities are the source of the competitiveness of the firm. [E2] participates in the initial stage of the development of new cars and collaborates with the client firm over couple of years. [E1] and [E2] share innovation characteristics such as the introduction of new production process based on information technologies, new ways of human resource training, the achievement of ISO certificates, and even innovation awards from the government. [E3] plans, designs, and produces clothes for large firms. The proliferation of ODM firms in the clothing industry reflects the need for efficient reaction to the quickly changing desire of customers. However, [E3] is different from [E1] and [E2], in that it is small and has difficulty in maintaining the competitiveness due to easy imitation of design and an unbalanced relationship with large clients.

TABLE 5 Characteristics of Pseudo-R&D Service Firms

Client Sector Group	R&D Service Firm Group	Characteristics
All	Pseudo-R&D Service Firms	1. Firm - Establishment Type: having worked in relevant industries over a decade - Firm Size: polarized - Main R&D Services: ODM(original development/design manufacturing) 2. Diversification of Business: ODM includes R&D services plus manufacturing 3. Coverage of Client Firms - Mainly large firms, sometimes small and medium sized firms 4. Innovation-drivenness/IPRs: playing leading roles in product development based on internal technological/design capabilities 5. Evaluation: they are not categorized as the provider of R&D services, but manufacturers. The public support for R&D service capabilities is limited

6. CUSTOMIZED POLICY SUGGESTIONS BY R&D SERVICE FIRM GROUPS

This paper attempted to pick up the differentiating characteristics of the R&D service firms that did businesses under the different industry groups of manufacturing clients. This paper begins with the recognition that R&D services are differentiated from the stereotypical manufacturing or service industries. It is mainly because of their unique characteristics that R&D service firms are put together as a group with the criteria of their function, and not the products they produce. Indeed, the industrial grouping based on functional similarity such as R&D services implies that they serve various types of clients, which have different industrial structure, firm size, and/or business behaviors. Differ-

entiation of R&D service firms by their client grouping is of paramount importance in laying out the customized policy programs as well as clearly understanding what they are and how they work.

Confronted with the limitation of reliable data, this study mainly relied on the qualitative in-depth interviews with some R&D service firms that have carried out their businesses in each client group. Despite some fundamental limitations of the methodology in this study, it is supposed to be a starting point from which the detailed characteristics of R&D service firms are clearly revealed and we enrich the understanding of the R&D service industry.The section deals with the policy issues that are pressing for the development of each R&D service industry, by group, that we have described in the previous section (TABLE 6).

TABLE 6 Customized Policy Suggestion According to the Typology of R&D Service Firms

Client Sector Groups	R&D Service Firm Groups	Policy Suggestion
New Growth Engine Sectors (Group 1)	Technology-specialized R&D Service Firms (R&D Service Group A)	1. Systematic support for global intellectual property management 2. Selection of a few promising firms based on evaluation of knowledge assets and the public investments on a long-term basis 3. Investment on customized advanced infrastructure
High-technology Based Key Industrial Sectors (Group 2)	Large Firm-supporting R&D Service Firms (R&D Service Group B)	1. On/offline trading markets for R&D service transaction 2. Incentive schemes for technology development (e.g.: technology purchasing, escrow on technology trading) 3. Customized support for attracting foreign leading R&D service firms
Innovation-leading R&D Service Firms (Group 2)	Innovation-leading R&D Service Firms (R&D Service Group C)	1. Testing/inspection service: transfer of the functions from public institutes to private firms, Lending/provision of expensive testing devices in public institutes to private firms 2. Technology consulting services: expansion of public support for Sees through private R&D service firms 3. Both: incentive schemes for promoting the collocation of R&D services firms within the clusters, esp. those relevant to Sees
Traditional Industrial Sectors (Group 3), Consumer-goods Sectors (Group 4)	Problem-identifying R&D Service Firms (R&D Service Group D)	1. Financial R&D support for the projects to promote the competitiveness of traditional manufacturing firms 2. Incentive schemes for potential manufacturing clients with intention of buying private R&D services
All	Pseudo-R&D Service Firms (R&D Service Group E)	1. Broadening of the definition of R&D service providers 2. Public financial support for the R&D service firms that outsource to manufacturing allies
All	All	1. Internship programs for new graduates (masters/doctors) in private R&D service firms 2. Help for the job application of the PRI interns in private R&D service firms 3. Retraining the employees working for private R&D service firms at PRIs 4. Support for the spin-offs of R&D service firms from PRIs

With regard to the first category of R&D service firms named as technology-specialized R&D service firms, the systematic support for intellectual property management needs to be a top priority to help them to effectively protect and strategically utilize their intangible knowledge assets in global as well as domestic dimensions. As mentioned earlier, these R&D service firms do business for manu-

facturing industries that are deemed to be the 'new growth engines' and have the highest level of the use of external R&D services. The creation of knowledge assets is essential in many relevant business activities. The key to success for these firms is to acquire legal intellectual properties, such as patents, during research projects funded by client firms or by themselves. However, it seems that most R&D service firms in this group cannot afford a huge amount of money for IP processes. Well-organized public policy programs could encourage this group of R&D service firms to actively apply for intellectual property and earn money from diverse uses of them with the gradual progression toward open innovation. The evaluation of the future and present values of intangible assets has to precede it as a step for selecting those that deserve public support because a huge amount of financial, as well as institutional support is required on a long-term basis. Meanwhile, some interviewees argued that the internationally qualified laboratories for experimenting/testing specific processes during new drug development are required and, if needed, the collaboration of central/local governments with foreign investors needs to be seriously considered.

When it comes to the large firm-supporting R&D service firms, the role of the government for the promotion seems to be limited. The government helps segments of the industry to move toward establishing a horizontal relationship with its main manufacturing firms, instead of a vertical one, and extending the boundary of clients with the active effort to enhance internal innovative capabilities. As shown in the previous section, the R&D service firms in this category tend to maintain a relatively stable relationship with their specific leading manufacturing clients, which sometimes results in the passive attitude toward fostering internal innovative capabilities, as well as creating new products, regardless of their relatively large firm size and technological/non-technological potential. At the current situation, the government policy needs to gradually induce the group of R&D service firms to be interested in the enhancement of internal innovation capabilities and diversify their business partners on a long-term basis. Because it may be a strategic decision of individual firms, the effect of the government intervention might not be diminished. Then, indirect or institutional support with a farsighted view is more appropriate. For example, R&D service markets as places where R&D service clients, providers, and intermediating firms are freely gathered to search for suitable partners, as well as provide valuable information. It takes a lot of time to motivate such actors to show up in the physical/cyber R&D service markets voluntarily, although it seems easy to establish such physical/cyber spaces themselves. In addition, various incentive schemes are required to encourage the R&D service firms in this category to be involved with new product/process development. Besides, public support to attract global leading R&D service firms in the category is also likely to be helpful, as they tend to provide their R&D services to rival conglomerates while sustaining reliable but horizontal relationships with each client. The foreign subsidiaries provide a chance to develop domestic R&D service market and to train skilled labors in some ways. On the other hand, there is a concern about market dominance by capable foreign R&D service firms. Existing incentive schemes that are conceived for foreign manufacturers need to be changed to reflect the attributes of service firms. An interviewee noted that the provision of the location with low cost is not so attractive as that of the well-equipped buildings that matched the needs of R&D service firms.

In contrast with the large firm-supporting R&D service firms, the role of public policy initiatives seems of paramount importance in the innovation-leading R&D service firms because they serve different kind of firms, unspecified small and medium sized ones, regardless of the similarity in their industrial categories. The most important point is that the harmonization between private R&D service firms and public research institutes that have become competitive, but not complementary to each other. The main clients in the R&D service firms in this group have been major targets for public support, in order to promote the competitiveness of manufacturing sectors in Korea.

Public authorities were encouraged to put forward the measures with which to help those manufacturers. As a result, various measures were taken, some of which were associated with public research institutes. The R&D services of public research institutes were similar with those of private firms, but potential manufacturing clients favored public research institutes over private counterparts. This was mainly because of low cost, high quality, and other intangible advantages realized when clients apply for other public support in future. Although R&D services from public research institutes are favored by small and medium sized manufacturers, and they are strong competition for private R&D service providers, there seem to be advantages that private R&D service firms have over their public counterparts. For instance, some interviewees in this category mentioned that they could more promptly respond to client requests, even in the case of very small projects, in financial terms. However, private R&D service firms and public research institutes in this category are playing a zero-sum game. In this sense, the government needs to take a cautious approach to balance polices for promoting small and medium sized manufacturing firms with public R&D services and those for boosting private R&D service industry. The first step is to consider the way roles are assigned to ensure both sides are satisfied and jointly contribute to service and manufacturing industries. An interviewee suggested that those manufacturing firms could be supported by private R&D service firms with public funds and public research institutes could focus on the management process of relevant public policy programs.

A long-term approach is recommended for growing the R&D service firms in the category of D, the innovation-leading R&D services firms that provide R&D services for traditional types of manufacturing industries that represented the lowest level of using external R&D services. The expansion of national R&D programs in the area are likely to be helpful because they motivate small and medium sized R&D service firms to explore ways to improve the innovativeness of potential clients. In particular, the R&D service projects with important ICT components need to be supported, as illustrated by the two sample cases in this research. On the other hand, potential clients that are not aware of the benefits of external R&D services may be considered good target for the policies, such as incentive schemes for utilizing external R&D services.

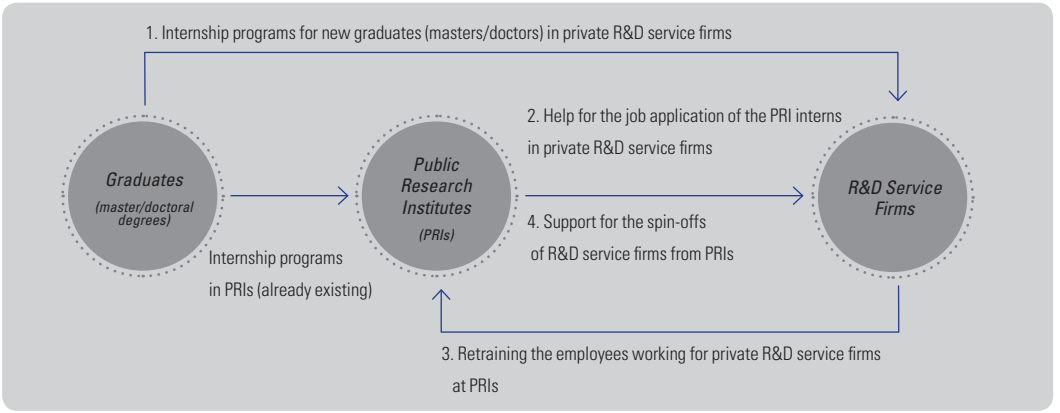
In regard to pseudo-R&D services firms, two policies are suggested in this paper. The first policy suggestion relates to whether ODM need to be promoted, in terms of R&D service industry development, because they have been considered as manufacturers. The product development capabilities of ODM are as important as manufacturing capabilities, from the perspective of client firms. ODM put much importance on the improvement of technological and design development capabilities. Expanding the definition of R&D service firms is needed in order to embrace ODM and allow them to be supported, in terms of R&D service industry promotion.

The second policy addresses the public financial and institutional support for the R&D service firms that outsource to manufacturers. R&D service firms lead the innovation of manufacturers when R&D service firms are clients and manufacturers are suppliers. The relationship may happen in the transition stage from pure R&D service firms to ODMs.

Most R&D service firms in this case study stressed the importance of recruiting and maintaining qualified skilled labor. But as mentioned, this is a main dilemma that many R&D service firms are confronted with. Ironically, they are still at their infant stage, but the required labor is highly skilled and hard to retain with non-monetary, as well as monetary incentive schemes. Even though the level of the professional/technological capabilities that are required for employees seems higher in the group of technology-specialized R&D service firms, most interviewees, regardless of their typology, expressed serious concerns over the issue, and asked for public policies that ease the burden they have in recruitment and retention of qualified skilled labor.

Based on suggestions from some interviewees and the experts in this area, we put forward a policy that positively connects highly educated new labor, public research institutes, and private R&D firms (FIGURE 4).

FIGURE 4 Policy Suggestion about Recruiting and Retraining Skilled Labors in R&D Service Firms



An important source for such skilled labors in the industry is new graduates who just obtained master or doctoral degrees and are looking for new jobs. So far, these new graduates preferred jobs in universities or public research institutes to firms in private sectors. Highly educated graduates have been reluctant to enter the labor market in relevant business sectors, which have been regarded as a serious economic and social issue for Korea. Moreover, R&D service sectors were considered not to provide enough monetary and non-monetary benefits and entrepreneurial expectation for future as well.

Four types of policy programs are considered in this paper. First, internship programs for new graduates (masters/doctors) in private R&D service firms are required. They provide the opportunity for fresh labor to learn about R&D service businesses and to allow for evaluation and recruitment of additional employees. Second, programs are needed to help interns from public research institutes to get jobs in private R&D service firms, according to the performance they showed during the internship program. Third, public research institutes are recommended to conceive of a new program that aims to retrain employees in private R&D service firms to acquire specific domain knowledge and learn the latest academic/business trends in the field. Fourth, the programs to promote R&D service spin-offs from public research institutes are needed. Experienced skilled labors in public research institutes are the best sources for entrepreneurs in R&D service industry.

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