International R&D Collaboration among Entrepreneurial Firms: Strategic and Policy Perspectives

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PhD thesis

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Summary

This study aims to identify the distinguishing characteristics of successful international R&D collaboration among Small and Medium-sized Enterprises (SMEs). For this purpose, I used survey and interview data on Korean SMEs. First, investigating the overall patterns of international technology collaboration involving SMEs, I found that the most observed and desired type of collaboration was R&D collaboration among SMEs, but it produced the lowest level of satisfaction and thus needed further investigation. Consequently, I focused only on one particular type of collaboration, that is, "international R&D collaboration among SMEs".

Then, I examined the main motivations behind such collaboration and motivation-specific features of the collaboration in terms of collective strength, partner selection criteria, and project management practices. An attention was paid on the diversity of motivation, where resource-based theory was adopted to develop a theoretical framework. I also analysed the benefits and costs of international R&D collaboration for SMEs compared to domestic R&D collaboration, where resource-based theory with transaction-cost theory were integrated. Finally, I suggested a framework to measure the performance of international R&D collaboration from the SME perspective. A logic model was adopted to identify feasible measures to assess the performance of R&D collaboration, from which the most significant measures for SMEs, considering that the collaboration is across firms in different nations, were investigated.

This study represents one of the few attempts to explain the mechanisms through which how international R&D collaborations in SMEs are initiated, managed and produce benefits, and to suggest the conditions that can offer SMEs a greater value from international collaboration than domestic collaboration. Practically, the research findings are expected to help establish an R&D strategy at the firm level and will also provide valuable knowledge to develop innovation policies for SMEs at the national level.

Keywords: SME, international collaboration, R&D collaboration, collaboration among SMEs, Korea

Statement of originality

I hereby declare that this thesis has not been and will not be submitted in whole or in part to another University for the award of any other degree.

Signature: 

Statement of contribution

This thesis contains material published or submitted for publication, based on the work presented in the thesis.

Conference paper

A part of Chapter 2 of this thesis was presented at the R&D Management Conference 2017 as "Lee, S., & Siepel, J. (2017), Do SMEs collaborate with international partners for their R&D and, if so, how? 2-5 July, Leuven, Belgium."

Journal article

Chapters 2, 3, 4 and 5 were submitted or will be submitted to international journals. For the three co-authored papers (Chapters 3-5), I designed the study in collaboration with my two supervisors, collected and analysed the data, and wrote the first draft of the manuscript. My supervisors gave comments over the whole research process, made critical revision of the first draft for important intellectual content, and gave a final approval of the version to be published.

Information source

Two types of data were mainly used in this study. The first type was qualitative data collected by the candidate from the interviews with top managers in 18 firms. The second type was quantitative data which the candidate had a permission to access.

Signature: 

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Sungjoo Lee

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1. Introduction

1.1. Background

1.1.1. Significance of topic

The breadth and depth of cross-border strategic partnerships have grown exponentially in the past three decades regardless of firm size (Narula and Hagedoorn, 1999). The issue of strategic partnership has been studied for a long time and, although recent studies have used the term, cross-border strategic partnership, less frequently than before, this issue has been addressed extensively in other related contexts such as open innovation, global value chain, global venturing, global offshoring, or global M&A. Indeed, with accelerated globalisation and technological advances that enable communication across borders, organisations tend to assume that potential partners can be located anywhere in the world. OECD (2000) also reported that a growing number of international technology collaborations is observed, in which firms involve partners from other countries in their innovation processes (OECD, 2000). Organisations have developed international strategic partnerships to optimise their innovation processes by finding the best resources available and/or responding to competitive pressures in today's globalised markets (Eng and Ozdemir, 2014). Consequently, international collaboration strategy has been the subject of much interest in both academic and real-world practices, and there has been extensive research on international collaboration (e.g., Alnuaimi et al., 2012; Chang et al., 2008; Colombo et al., 2009; Eng and Ozdemir, 2014; Gunasekaran, 1997; McArthur and Schill, 1995).

However, this topic has been studied by scholars from various research streams, for example, strategic management, international business, and innovation management, and thus the relevant studies are inevitably somewhat fragmented, as noted by Tarba et al. (2018)[1]: "Several recent studies have highlighted the fragmented nature of the literature on the technological innovation and social change initiated by the global strategic partnerships and the need to deepen its theoretical and test its empirical underpinnings; only rarely there are models that are pertinent across different national, organizational, technological and sectorial (high-tech vs. traditional) settings". Hence, defining clearly the boundaries of this research is essential if we are to make a meaningful contribution to the existing literature.

Therefore, this thesis restricts its focus to *small and medium-sized enterprises (SMEs)* and their *international technology collaboration*, and in particular, *to bilateral R&D collaboration among SMEs*. First, in terms of actors, it considers only SMEs. SMEs as well as large enterprises (LEs) are actively engaged in international strategic partnerships, being encouraged to be involved in such collaboration by governments (e.g., collaborative research through Horizon 2020, Eurostar, and Fast track to innovation programmes by European Commission). A Google keyword search using the term, "open innovation in SMEs", also indicated the increasing importance of SMEs collaboration; the ratio of hits from a Google

[1] https://www.journals.elsevier.com/technological-forecasting-and-social-change/call-for-papers/micro-foundations-of-innovation-in-global-strategic-partners

search for the topic “open innovation in SMEs” to that for the topic “open innovation” was 2.51% in 2013 but has increased to 4.06% in 2018 (retrieved on the 13th of August 2018). Second, as regards the type of collaboration, the focus of this thesis is on bilateral international R&D collaborations in which firms work together to co-develop a technology or product with co-financing. International R&D collaboration can take several forms, such as collaborations between headquarters and overseas branches, collaborations in the form of technology in-licensing or out-licensing, and collaborations between suppliers and overseas clients (Narula and Duysters, 2004). Yet, SMEs are more likely to be involved in bilateral R&D collaboration than multilateral R&D collaboration (Yoon et al., 2016) and a bilateral collaboration may have more direct benefits and risks for the firm than the other types. Hence, bilateral international R&D collaborations among SMEs were investigated in this thesis.

1.1.2. History of collaboration theory

Collaboration, which is defined by Gray (1989, p. 5) as “a process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible”, has long been discussed in organisational theory. However, its theorising has been rather fragmented, at least until the 1990s (Gray and Wood, 1991). By dividing the studies of collaboration theories into three generations, this section provides an overview of those theories.

- **First generation: before the early 1990s**[2]

In 1991, recognising the limitations of existing theory, Gray and Wood (1991) published a paper entitled “Collaborative Alliances: Moving from Practice to Theory”, which summarised the theoretical perspectives that might provide a foundation for collaboration theory. This period can be regarded as representing the first generation of collaboration theory. These theories had been developed much earlier but started to be applied to collaboration during this period. Gray and Wood listed six key theoretical perspectives with organisational- and domain-level research questions, which they divided into two types.

One research stream takes the individual organisation as the theoretical focus, i.e. it is *organisation-centred*. First, *resource dependence theory* assumes that the external resources of an organisation influence its behaviour at both the strategic and tactical management level (e.g., Pfeffer and Salancik, 1978). Second, *corporate social performance theory* (e.g., Carroll, 1979), *institutional economics theory* (e.g., Bromley, 1989) and *stakeholder theory* (e.g., Freeman, 1984) each puts the firm at the centre of a network of stakeholder relationships and focuses on firm-stakeholder relationships. When this concept is applied to collaboration, a collaboration network is formed and operates to meet the interests of participant organisations and the environment. Third, *strategic management theory* suggests that an organisation takes a particular action, here collaboration, to gain competitive advantage (Porter, 1980).

[2] For more information, see Gray and Wood (1991).

This theory has been criticised for failing to account for collective actions (Gray and Wood, 1991), and was later redirected to the interorganisational level by shifting to *social ecology* (Astley, 1984), an approach that highlights the benefits of collective strategy for problems faced collectively by organisations. Fourth, *microeconomics theory* has been used by economists to explain interorganisational behaviour as essentially a set of bilateral relationships (e.g., Williamson, 1975, 1985, 1991); here, collaboration is regarded as an effort to achieve efficiency within a firm's relationships with others.

The other main research stream sees collaboration concentrating more on relationships, i.e. it is *relationship-centred*. Two of the six perspectives suggested by Gray and Wood (1991) fall into this category. First, *institutional theory* is an approach to understand the behaviour of organisations adjusting themselves to institutional influences in order to achieve legitimacy from institutional actors (DiMaggio and Powell, 1983). Second, *political theory* has been used to explain private interests and conflict at various levels – intra-organisational relations (Benson, 1975), societal-level dynamics (Dahl, 1967) and international relations (Keohane, 1984). With its inherently relational nature, this theory can be applied to interorganisational-level analysis – for example, the dynamics of power and the distribution of benefits within a collaboration network (Gray and Wood, 1991).

- **Second generation: from the mid 1990s to the mid 2000s**

Later, organisational behaviour theories have been further elaborated and refined to provide a framework for collaboration, producing a number of relevant papers. The main collaboration theories have been established during this period, representing the second generation of collaboration studies. Within the organisation-centred theories, case studies, together with empirical studies, have been conducted to identify the motivations (e.g., Li and Yue, 2005; Miotti and Sachwald, 2003; Narula, 2004; Narula and Duysters, 2004), antecedents (e.g., Hagedoorn, 2002; Gassel and Pascha, 2000) and impacts of collaboration on performance (e.g., Brod and Shivakumar, 1997; Powell et al., 1996; Granovetter, 1973; Hitt et al., 2000; Lane et al., 2001). In addition, when the Community Innovation Survey (CIS)[3] data became available during this period, empirical analysis based on large data sets became feasible (e.g., Belderbos et al., 2004; Faems et al., 2005).

The relationship-centred theories have evolved on the basis of social network theory rather than institutional theory and political theory. Social network theory is a theoretical framework frequently used in social science (Wasserman and Faust, 1994). Based on this theory, various analyses have been performed on the network structure (e.g. Schilling and Phelps, 2007), the position of an organisation in the network and its effect on performance (e.g. Ahuja, 2000), and the evolution of networks (e.g. Barabási et al., 2002). Another popular theory focusing on relationships is game theory, which offers rich implications. Game theory, first proposed by von Neumann and Morgenstern (1944), has been widely used in such domains as economics, politics and management (Arsenyan et al., 2015). Within these,

[3] The CIS is a survey of the characteristics of innovation in different regions. It is executed in each of the European Union countries. The following data are available on the website (http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey)

collaboration has been a central topic in game theory (Goyal and Joshi, 2003), since it represents a situation where several parties interact with each other, very much a focus of game theory. Thus, the relevant topics encompass the various types of collaboration, including alliances, strategic partnerships and supply chains (Roh et al., 2014). According to this theory, when a decision is made, the potential choices of others are considered and vice versa (Erhun and Keskinocak, 2003)[4].

These theories are commonly combined with mathematical and computer modelling approaches. Axelrod (1997) is a leading scholar who has applied computer modelling to social science areas; one such application is an agent-based model, which is a relatively new approach to modelling a network, composed of the actions and interactions of autonomous decision-making entities, called agents. It enables simulation of the actions and interactions of the agents, analysing their effects on the network as a whole. Hence, it has been quite useful in depicting complex networks.

- **Third generation: mid 2000s to the present**

Recently, more diverse and extensive studies have emerged in the collaboration literature, which focus more on empirical or experimental analyses aiming to obtain meaningful implications applicable to strategic management or policy making rather than analyses for theory building. This period is designated as the third generation of collaboration studies. Within the organisation-centred theories, the different types of collaboration have been expanded. In particular, collaborations at the international level with respect to the behaviours of multinational enterprises (MNEs), R&D globalisation or global value chains have all been discussed. The effect of policy instruments regarding collaboration was assessed for the case of multinational R&D consortia (e.g. Bayona-Sáez and García-Marco, 2010; Mothe and Quélin, 2000). At the same time, these studies started to consider different types of collaboration and partners in order to generate more practical implications (e.g., Belderbos et al., 2004).

Within relationship-centred theories, social network theory has been combined with bibliometric analysis using patent or publication data; co-authorship and co-invention analyses have been frequently applied to investigate knowledge co-creation networks (e.g., Bidault and Hildebrand, 2014). Moreover, with the strong intellectual property (IP) regimes, an approach based on markets for technology, which assumes that the division of labour is limited by the extent of the market (Smith, 1776), has emerged as well. According to this approach, the degree of specialisation required in the overall market is one of the major determinants of firms' collaboration activities, and such collaborations are often in the form of IP licensing of technologies.

It should also be noted that the concept of open innovation has become increasingly popular during this period. The central premise of open innovation theory is that innovative ideas flow freely across firm boundaries (Chesbrough, 2006), and this concept has spawned numerous journal special issues on the

[4] Despite its value in analysing relations between and the behaviour of collaboration partners, this theory does not fully explain the characteristics of R&D collaboration, which consists of learning processes rather than a series of decision-making processes.

theme (e.g., *Industry and Innovation* 2008, *R&D Management* 2010, *Technovation* 2011, *International Small Business Journal* 2013, *Research Policy* 2014, *European Journal of Innovation* 2017, *Strategic Entrepreneurship Journal* 2018). Open innovation can be analysed at several levels, among which interorganisational-level analysis has often been the main focus, as it is here in this study.

1.1.3. Limitations of previous studies

When the existing studies on R&D collaboration in general and particularly those with overseas partners were reviewed, four limitations were identified. First, there is extensive literature on collaboration mostly in the context of large firms. It is not surprising that relatively little attention has been given to international R&D collaboration involving SMEs considering the existing findings that *size* and *R&D internal capacity*, which are factors directly and indirectly indicating the characteristics of large firms, have a substantial influence on the tendency to collaborate (Negassi, 2004). However, the literature also shows the potential contribution of international R&D collaboration to SMEs' innovation strategies as well as the potential challenges of losing technological knowledge to their foreign partners, pointing to the need for further work on matching organisational needs and institutional conditions with the benefits of global networks.

Second, most previous studies on international R&D collaboration have been conducted at the organisational-level. For example, by introducing a dummy variable of international R&D collaboration, which is given the value 1 if the firm has ever collaborated with overseas partners and 0 otherwise, the performance (or tendency) and the factors affecting the performance (or tendency) have been analysed (e.g., Mention, 2011; Lewandowska et al., 2016). As a result, few findings are available on the project level. The way to manage international partnerships is dependent on specific characteristics of the relevant R&D projects. Nevertheless, the operational and project investigation of international R&D collaboration is lacking, something which is essential if we are to understand the process of collaboration and evaluate the actual performance of collaboration.

Third, the existing literature could give only a limited answer as to how one defines the success of international R&D collaboration, for which it is intuitively easy to capture the meaning of success but difficult to operationalise and pin it down. Project-level success may be separated from organisational-level success. The success judged by one party may be different from the success judged by other parties. Further discussion and a clear definition are needed on this topic.

Finally, according to previous studies, collaborative linkages are conditioned by several opportunities and constraints, which can be classified largely into two groups on the basis of their roles, namely *facilitating factors* that increase the propensity of SMEs' international R&D collaboration, and *moderating factors* that have an influence on the collaboration results. These can also be grouped into four categories based on the level of analysis: *national*, *sectoral*, *organisational*, and *project*. A comprehensive review of these factors on the basis of the two criteria will be greatly helpful for understanding the key success factors with regard to international R&D collaboration in SMEs.

In the light of the above limitations/gaps, my study aims to focus on international R&D collaboration among SMEs, starting from the general trend of SMEs' technological collaboration with overseas partners, going through the detailed analysis on their collaboration with other SMEs for their R&D, and finally ending with the measures to define the success of such collaboration.

1.2. Purpose

1.2.1. Research questions

The above literature review showed that relatively little is known about international R&D collaboration involving SMEs in terms of motivations, costs and benefits, and performance, which are the main input, process and output factors in relation to such collaboration. Though R&D alliances are adopted more frequently in LEs than SMEs, it is apparent that a large number of SMEs are also involved in R&D alliances or at least interested in cooperating with foreign partners. Focusing on SMEs, therefore, this study aims to explore the process of international R&D collaboration. Thus, the main research question (RQ) to be addressed in this thesis is:

RQ: Why and how SMEs are involved in R&D collaboration with other SMEs in foreign countries, and what policy supports are needed to encourage them to be involved successfully in such collaboration?

In particular, four significant research gaps were identified and relevant sub-questions were formulated to address these. First, few studies have addressed SMEs' organisational needs with regard to collaborating with overseas partners for their technology development. The assumption of this study is that SMEs have been collaborating and want to collaborate in the future with foreign SMEs for their R&D, an assumption which needs to be empirically tested. Hence, the first RQ aims to address the patterns of international technology collaboration involving SMEs and was developed as follows.

RQ1. Do SMEs collaborate with international partners for their technology and, if so, how?

Second, though international R&D collaboration operates mainly at the project level, most existing studies have focused on the organisational-level characteristics of collaboration. The project-level investigation of international R&D collaboration is indispensable to study in-depth the mechanisms of such collaboration in SMEs. Moreover, the way to manage collaborative R&D projects with overseas partners is expected to differ from that involving collaboration with domestic partners. Indeed, understanding SMEs' motivation to engage in international R&D collaboration instead of domestic collaboration offers a starting point to identify and deploy the opportunities arising from such collaboration, as collaboration strategies and results are highly likely to be influenced by the motivation. Thus, different motivations could potentially drive behaviour in different ways and thereby yield distinctly different operational strategies. Thus, the second RQ can be stated as follows:

RQ2. What are the main motivations behind international R&D collaboration for SMEs? How are the strategies for international R&D collaboration affected by the motivation?

Third, decisions on types of collaboration partner depend on trade-offs between the expected costs and benefits. Consequently, the benefits and costs of international R&D alliances for SMEs need to be identified in explaining the motivation of such collaboration – that is, the situation where the benefits of international R&D collaborations are greater than those for domestic R&D collaborations. Thus the third RQ addressing these issues is:

RQ3. What are the benefits and costs of international R&D alliances for SMEs compared to domestic R&D collaboration?

Finally, the success of international R&D collaboration has rarely been defined in a clear and uniform manner. It can be evaluated at different levels (e.g. project level or organisational level) and by different measures (e.g. innovation performance, financial performance, degree of satisfaction, or behavioural intention). Without defining the success, it may be difficult to analyse the key success factors, which is essential if one is to help SMEs enter into global partnership. Furthermore, possibly due to the difficulties in defining the success of international R&D collaboration, existing studies have focused mostly on factors facilitating such collaboration while more studies are needed on factors leading to success. In particular, SMEs have limited capabilities to cope with failures. It is therefore essential to have a comprehensive review of those factors in order to develop a policy instrument for encouraging them to work with global partners and for helping them to achieve their goals in an effective way. The final research question stems from this challenge:

RQ4. How can we determine whether international R&D collaboration in SMEs is successful or not?

The overall thesis focuses on four topics and tries to answer these four questions. By answering these four RQs, we expect to identify the distinguishing characteristics of international R&D collaboration involving SMEs, and the organisational needs and institutional conditions that can influence the success of such collaboration. Each paper was prepared to address one of the above questions.

1.2.2. Conceptual framework

This section begins by describing collaboration theories and arguing that resource-based theory combined with transaction cost theory would be suited to explain international R&D collaboration involving SMEs. Resource-based theory has been criticised by some researchers in that it cannot be applied to smaller firms lacking resources (Connor, 2002). In order to overcome this criticism, this study focuses on knowledge as one of the main resources; SMEs as well as LEs can have valuable, rare, inimitable and non-substitutable knowledge – including both tacit and explicit knowledge – for sustainable competitive advantage, and international R&D collaboration can be a strategy to acquire such knowledge. This study also combined transaction cost theory with resource-based theory because SMEs may want to minimise their costs in acquiring the necessary resources, which is the focus of transaction cost theory (Kogut, 1988), as well as maximising their benefits via collaboration, which is the focus of resource-based theory (Das and Teng, 2000).

Then, a conceptual framework to answer the RQs was developed to assist in understanding the

mechanisms of international R&D collaboration involving SMEs, as shown in **Figure 1-1**. The SCP model was adopted as a base model for the framework but was modified to be suitable for explaining the nature of SMEs' collaborative R&D with cross-border partners. Consequently, the framework was designed to include: 1) three elements of "motivation", "operations" and "success", which represent the process of international R&D collaboration in SMEs; 2) two external factors of "national characteristics (policy support)" and "sector characteristics", which facilitate the use of such collaboration as part of SMEs' innovation strategy; and 3) two internal factors of "collaboration capacity" and "operational strategy", which make such collaborations successful by mediating the core three elements. Based on this framework, in-depth analysis of R&D projects conducted by SMEs with overseas partners was carried out.

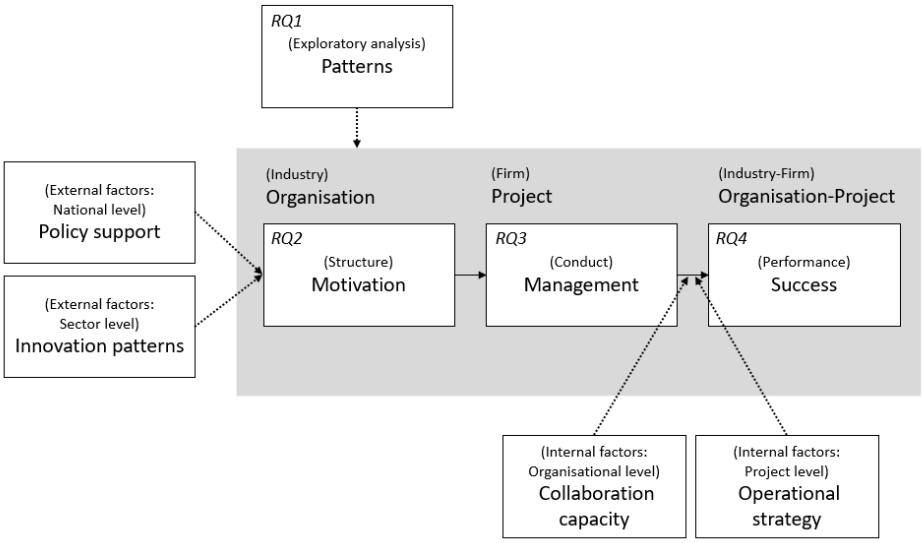

Figure 1-1. The overall conceptual framework of this study

1.2.3. Research methods

A mixed method approach (qualitative and quantitative) was adopted in this study, where both surveys and case studies were used to answer the four RQs. In order to understand SMEs' behaviour at the macro-level, a quantitative approach is needed, while investigating the mechanism of collaboration requires a micro-level investigation based on a qualitative approach. More specifically, for RQ1, the patterns of international technology collaboration involving SMEs were analysed in terms of collaboration modes and partners to test our assumption that R&D collaboration among SMEs is most preferred by SMEs. Then, for RQs 2 and 3, the characteristics of international R&D collaboration among SMEs were investigated with respect to motivations and operational strategies along with benefits and costs. The preference for overseas partners over domestic ones was highlighted in order to answer these questions. Finally, for RQ4, the success of international R&D collaboration was defined from a theoretical and practical point of view. A list of potential measures to evaluate the success needs to be developed and then reviewed by SMEs to ensure the validity of each measure. Across RQs, detailed analysis on the external and internal factors was conducted to identify the factor characteristics commonly observed in international R&D collaboration among SMEs.

South Korea (hereafter referred to simply as 'Korea') was selected as the target country for the following reasons. First, the share of SMEs to the total number of enterprises in Korea corresponds to 99.9%. As SMEs play a significant role in the Korean economy, they are worth investigating. Second, according to OECD (2014), Korea has a figure of 4.4% of GDP devoted to R&D expenditure, which is the highest among OECD countries, and the county also relies heavily on imports and exports. Nevertheless, it is ranked as one of the least active countries among OECD members with regard to international collaboration in the field of science and innovation (OECD, 2013). The country is in a position to derive benefits from international R&D collaboration. Thirdly, a relatively large number of studies on international R&D collaboration have been carried out in the context of the EU (e.g. Bayona-Sáez and García-Marco, 2010; Martin and Moodysson, 2011; ZeW, 2011), possibly due to active collaboration among European countries, while relatively little is known about the motivations, operations, and performance of collaborations in East Asia. With the accelerated globalisation of the world economy, R&D collaborations will occur in other contexts outside the EU so these need to be studied as well[5]. Given that the case country was set to be Korea, the target sector was set to be information and communications technology (ICT), which is the sector where Korea is in a leading position (Choung et al., 2014; Lee et al., 2009) and collaboration among hardware and software providers is required to provide successful products and services.

Two types of data were gathered. The first source was survey data, collected by a Korean consulting company (www.wipson.com) and funded by a Korean government agency (www.kiat.or.kr). In this survey, a series of questions were asked about the following: 1) the collaboration modes and partners (experiences and willingness); 2) the partner search strategy and the degree of its effectiveness; 3) the project management strategy; 4) the level of perceived costs and benefits; and 5) the degree of satisfaction with the collaboration. The survey was carried out between 20 March and 9 April 2014, the survey forms being sent to 19,006 Korean SMEs, out of which 1,096 firms responded. On the other hand, the other material was collected from interviews with 17 Korean SMEs, the aim being to test the conceptual framework for each of three RQs. The interviews were conducted from July 2016 to February 2017, either face-to-face or through a video conference. The target interviewees were top managers who have been involved in international R&D collaboration at some point in the last ten years.

1.3. Contribution

1.3.1. Summary of papers

The first paper (Chapter 2), addressing RQ1, investigated *the overall patterns of international technology collaboration involving SMEs* using survey data, and it found that SMEs have been working, and are

[5] According to a Google Trend search with the topic, open innovation, Korea was ranked first, followed by Japan, Austria, Denmark, and Switzerland, in terms of using the term for web searches, which shows some indication of the country's interest in collaboration (retrieved on the 13th of August 2018).

willing to work, with international partners to develop their technology. The most observed and desired type of collaboration was "R&D collaboration among SMEs", but somewhat puzzlingly it produced the lowest level of satisfaction and thus needed further investigation. After identifying this '*SME collaboration paradox'*, the rest of the thesis focused on one particular type of collaboration, that is, international R&D collaboration among SMEs.

The second paper (Chapter 3), addressing RQ2, examined *the main motivations behind such collaboration* and motivation-specific features of the collaboration in terms of collective strength, partner selection criteria, and project management practices. A particular focus was placed on the diversity of motivation, where resource-based theory was adopted to develop a theoretical framework. The framework was tested using interview data, with an Analytic Hierarchy Process (AHP) being employed as one of the approaches to analysing the data. There were four types of motivation – global scouting, capability-combining, stepping-stone, and capability-building; different collective strength, partner selection criteria, and project management practices were observed for each type of motivation.

The third paper (Chapter 4), focusing on RQ3, is about *the benefits and costs of international R&D collaboration for SMEs compared to domestic R&D collaboration*, where resource-based theory was integrated with transaction-cost theory. Unlike the first paper, which used the survey data to investigate the patterns of international "technology" collaboration "involving" SMEs, this paper used only a subset of the data, that is, the data from SMEs that have at some stage been involved in international technology collaboration with other SMEs. The main benefits were the reduction of production costs by accessing external resources, while main costs were the increase in transaction costs associated with partner search and monitoring and the management costs for the collaborative project; when the expected reduction in production costs is greater than the increase in transaction and management costs when collaborating with international partners, international R&D collaboration is likely to be preferred.

The final paper (Chapter 5), addressing RQ4, suggests *a framework to measure the performance of international R&D collaboration from an SME perspective*. A logic model was adopted to identify feasible measures to assess the performance of R&D collaboration, from which the most significant measures for SMEs engaged in collaboration across firms in different nations were investigated. SMEs defined success in four ways: capability-building based on synergy; new product development (NPD) and commercialisation; lesion learned for further innovation; and creating value for society. In addition, success could be measured at three levels – project, organisation, and network.

1.3.2. Theoretical and empirical contributions

This study investigated the phenomenon of international technology collaboration involving SMEs, for which, using resource-based theory, four hypotheses were developed regarding 1) SMEs' organisational characteristics, 2) collaboration purpose, 3) collaboration modes, and 4) collaboration partners. While international collaboration has been observed among firms of all sizes, relatively little is known about international technology collaboration involving SMEs, as most previous studies have focused on large multi-national enterprises (LEs). International technology collaboration in SMEs can be different from

that in LEs due to their differences in the amount and diversity of technological assets as well as their capabilities to manage such collaboration. Given today's increasing interest in SME collaboration, it is worth understanding why and how SMEs seek R&D collaboration with SMEs in other countries. A number of recent papers have also showed the emergence of firm globalisation including studies on the 'born global' firm (Cavusgil and Knight, 2015), the benefits of working globally (Nurmi and Hinds, 2016), the influence of cultural and national differences on international collaboration (Ertug et al., 2013; Joshi and Lahiri, 2015; Choi and Contractor, 2016; Lew et al., 2016), and different types of international technology collaboration such as licensing (Aulakh et al., 2013). In line with those papers, this study highlights the significance of SMEs' globalisation in their innovation process. Practically, this is one of very few attempts to investigate SME collaboration, and it thus provides a number of managerial and policy implications to support international technology collaboration for SMEs. Theoretically, this study applies resource-based theory to a specific type of collaboration, examining both the possibilities and limitations of the theory in analysing such collaboration.

This study also examined SMEs' motivation for becoming engaged in international R&D collaboration, drawing upon resource-based theory. To this end, a typology of motivations was developed based on the type of resources offered for collaboration and the way such resources are integrated, where four types of motivations – global-scouting, capability-combining, stepping-stone, and capability-building – are suggested, and the motivation-specific characteristics of collaboration are examined. This study is along the lines of a number of works published on collaboration (e.g., Katz and Martin, 1997; Tether, 2002, Miotti and Sachwald, 2003; Leung, 2013; Herstad et al., 2014), taking a resource-based view (Mowery et al., 1998; Walsh et al., 2016) and providing policy implications on the effect of public R&D support (David et al., 2000; Hagedoorn et al., 2000; Hall and Van Reenen, 2000; Bayona-Sáez and García-Marco, 2010; Huergo and Moreno, 2017). However, unlike the papers using CIS data to examine collaboration at the organizational level (e.g., Lhuillery and Pfister, 2009; Arora et al., 2016), this study has adopted a qualitative approach to analysing collaboration at the project level.

This study identified the costs and benefits of international R&D collaboration among SMEs and examined how these affect the success, measured by the degree of satisfaction, of such collaboration. The transaction-based view and resource-based view were combined to develop a suitable theoretical framework, which was tested by an empirical analysis based on interviews with 13 Korean SMEs and a survey of 118 Korean SMEs. Despite the potential benefits, international R&D collaboration should be undertaken with care since it requires considerable managerial effort. Nevertheless, few previous efforts have been made to investigate the potential costs and benefits of such SME collaboration in a systematic way. From a theoretical perspective, this study shows that a combination of transaction-cost theory and resource-based theory would seem to offer greater explanatory power in understanding international R&D collaboration among SMEs than either of them alone. Various attempts to integrate the two theories have been made in previous studies, for example, the work by Verbeke and Asmussen (2016) on regional strategy analysis, and the work by Mudambi and Tallman (2010) on knowledge governance decisions. This work is in line with these attempts, with its focus on international R&D collaboration. In practical terms, the research findings help us understand the characteristics of successful international R&D collaboration among SMEs, and are complementary to findings from other previous studies alliance

formation (e.g., Phene and Tallman, 2014), interfirm knowledge flows (e.g., Burg et al., 2013), alliance partners (e.g. Luo and Deng, 2009; Zheng and Yang, 2015), and the internationalisation of SMEs (e.g., Schwens et al., 2010).

Finally, this study analysed the nature and definition of successful international R&D collaboration along with an appropriate framework to evaluate it. For an effective collaboration, it is necessary for firms to evaluate their performance in order to find areas where they can improve. However, due to the inherent nature of R&D and collaboration, for which the expected and recognised benefits may vary by collaboration purposes and other factors, such benefits are not always visible, and the success of the collaboration may be regarded in a different light by the firms involved. This study differs from the previous studies in that it offered a systematic framework for evaluating the success of such collaboration, while most previous studies have focused on motivations and operational strategies. Thus, the research findings are expected to make a practical contribution to SME policy and management and provide a useful reference point in academia.

1.4. Thesis structure

This thesis consists of six chapters. The first chapter, Chapter I, has described the study's background, purpose and contribution along with the outline of this thesis. In particular, it explains how the four RQs were formulated to fill a research gap and introduces the main arguments of this study in relation to the RQs. Then, in the following four chapters (Chapters II, III, IV and V), four aspects of international R&D collaboration involving SMEs are examined by analysing survey data and/or interview data to answer each of four RQs developed in Chapter I. Chapter II discusses the patterns of international technology collaboration involving SMEs. Then, focusing only on international R&D collaboration among SMEs, further analyses were conducted and the results are summarised in Chapters III, IV and V: *motivation* from the input perspective (Chapter III); *costs and benefits* from the process perspective (Chapter VI); and *performance* from the output perspective (Chapter V). Since these four papers have to be self-standing in order to be considered for publication in a journal, each chapter will have its own introduction, examination of relevant studies, research framework, results and findings, discussion, and conclusion sections. Finally, Chapter VI summarises the findings to draw wider policy and managerial implications from them. In this chapter, the limitations of this study are explained in order to identify potential future research directions. **Figure 1-2** illustrates the overall structure of thesis.

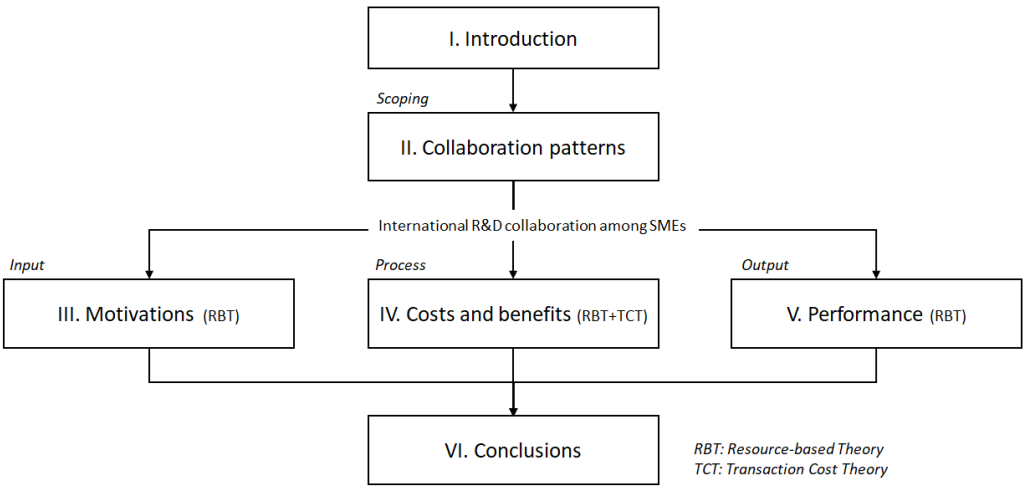

Figure 1-2. Overall structure of thesis

2. Patterns of international technology collaboration[6]

2.1. Introduction

Over recent years, firms have significantly changed the ways they carry out innovative activities; they have tended to increase the use of external networks to expand their technology capabilities (Hagedoorn, 2002; Motohashi, 2008), a phenomenon observed in firms of all sizes (Narula and Hagedoorn, 1999). Consequently, international technology collaboration strategy has been the subject of much interest among both academics and practitioners. Indeed, there has been extensive research on international technology collaboration (e.g., McArthur and Schill, 1995; Gunasekaran, 1997; Chang et al., 2008; Colombo et al., 2009; Alnuaimi et al., 2012; Eng and Ozdemir, 2014).

Despite their various contributions, however, most previous studies have focused on international technology collaboration involving large firms, with relatively few considering collaboration by small- and medium-sized enterprises (SMEs). Consequently, little is known about international technology collaboration involving SMEs. Though technology alliances are adopted more frequently in large firms than SMEs, large numbers of SMEs are also involved in technology alliances including R&D alliances (OECD, 2000) or at least are interested in cooperating with foreign partners. To cope with globalisation, more SMEs are extending their business to global markets than ever before (Lee et al., 2012), and even some start-ups may target a market outside their home region (Mahdjour et al., 2014; Cavusgil and Knight, 2015). This trend is shown in recent studies on SMEs' involvement in and management of global value chains (e.g., Brazinskas and Beinoravičius, 2014), on global hidden champions (e.g., Simon, 2009) and on global venturing (e.g., Mahdjour et al., 2014). SMEs are playing a more significant role in the global innovation system and their motivation to collaborate with global partners will surely increase. Furthermore, at an employment level, experience of working globally improves satisfaction, engagement and innovation (Nurmi and Hinds, 2016), which is also applicable to the SME context. Facing increasingly fierce technological competition and globalisation, not only large firms but also SMEs will seize the opportunity to engage in collaborative R&D in order to stay competitive; thus, studies on SME collaboration are urgently needed.

To fill the research gap, this study aims to identify and analyse the distinguishing characteristics of international technology collaboration involving SMEs. International collaboration can take several forms, such as collaborations between headquarters and overseas branches, collaborations in the form of technology in-sourcing or out-sourcing, and collaborations between suppliers and overseas clients (Narula and Duysters, 2004). Recent studies have emphasised more active modes of international R&D collaboration, especially those prompted by the EU Framework Programme and Eureka, which are multilateral international R&D collaboration programmes aiming to bring firms together to work towards

[6] Paper title: Why do SMEs seek R&D collaboration with other international SMEs even though they are often dissatisfied with the outcome? The SME collaboration paradox

the same goal (Bayona-Sáez and García-Marco, 2010). Among these various types of strategic alliances, a particular focus of this study is *technology collaboration* – a non-equity-based formal arrangement for technology development and commercialisation – as it may entail more direct benefits and risks for SMEs than others.

Collaboration can be explained in terms of various theories, among which this study has chosen to focus on resource-based theory. On the assumption that SMEs search for international collaboration partners possessing complementary resources, the theory is expected to help us understand the phenomenon of international technology collaboration involving SMEs. Four hypotheses were developed regarding the organisational characteristics, collaboration purpose, collaboration modes, and collaboration partners for SMEs. These hypotheses were then tested using survey data on the needs and experiences of SMEs collaborating with international partners, collected by WIPS (http://global.wipscorp.com) and funded by the Korea Institute for Advancement of Technology (KIAT). From a theoretical perspective, this is one of the first attempts to provide a basic understanding of SMEs' international technology collaboration drawing on resource-based theory. Unlike previous studies that applied the theory to general contexts (e.g. strategic alliances – see Das and Teng, 2000), this study restricted its focus to a specific context, and thus the research findings are expected to yield useful implications with regard to supporting SMEs' international technology collaborations. Furthermore, this study examined whether the theory can fully explain the phenomena of international technology collaboration involving SMEs. Hence, discussions regarding the explanatory power and limitations of resource-based theory are expected to be useful for further studies.

The remainder of this chapter is organised as follows. In Section 2.2, existing theories on collaboration are reviewed and the rationale for selecting resource-based theory for this study is set out. Based on the theoretical background, the characteristics of resources that SMEs possess are discussed and three hypotheses are developed in Section 2.3 The research methodology and research findings are described in Sections 2.4 and 2.5 respectively. Finally, Section 2.6 summarises the main findings along with the limitations of the study, possible future research directions, and the managerial and policy implications.

2.2. Collaboration theories to explain technology collaboration involving SMEs

Collaborations are formed in a great variety of settings, which makes it difficult to have a one-size-fits-all type of general theory. Hence, a number of theoretical perspectives have been investigated and the one providing the best foundation for explaining the characteristics of collaboration in this study was selected. This study focuses on "international" "technology" collaborations "involving SMEs", where the type of alliance is limited to "bilateral" links. In the light of these four collaboration parameters, the various network-centred perspectives were excluded. Gray and Wood (1991) criticised organisation-centred perspectives for failing to consider the overall efficiency of the social system, i.e. the collaboration network at the domain level. Nevertheless, this study takes the corporate view, seeking to identify the local optimum conditions to maximise the benefits to an *individual* firm, rather than a global optimum to

maximise the total benefits to all participants firms. Moreover, the organisation-centred perspective provides a better basis to deduce managerial and policy implications for international collaboration. Accordingly, four organisation-centred perspectives identified by Gray and Wood (1991) were adopted here, and their respective pros and cons for providing a framework of international technology collaboration involving SMEs were analysed (see **Table 2-1**).

First, *corporate social performance* is a theory of organisational behaviour in terms of business responsibilities. Transnational collaboration networks can be formed to solve a particular social problem but mostly in the form of multilateral relationships involving large firms. Hence, this theory may not be applicable to most international technology collaborations involving SMEs.

Second, *strategic management* theory, which involves the formation and pursuit of goals and strategies taking account of resources and internal/external conditions, can provide direct managerial implications. However, this theory is rather fragmented in its elements, which may hinder its application to practice. Moreover, the actual strategy-making by SMEs may be neither as systematic regarding the process nor as complete regarding the results as assumed in the theory. Gray and Wood (1991, p.9) have criticised the theory as follows: "Not only is the focal organization the center of theoretical attention but it is also viewed as the principal actor, the one whose interests are most important and whose decisions and actions carry the most weight. Such theories may perpetuate an illusion of control that organisations and their managers actually do not and cannot exercise. Furthermore, it may obscure real possibilities for progress toward meeting organisational and collective goals", which certainly may not be the case in most SMEs.

Third, *transaction cost theory* explains an alliance as a means to reduce the transaction costs of exchanging complementary capabilities between firms. Belderbos et al. (2004, p.1240) stated that "cooperation may reduce transaction costs through a better control and monitoring of technology transfer than on arm's length markets, while the inherent reciprocal relationship and "hostage" exchange between partners with complementary capabilities can minimize opportunism". Their arguments justified the use of alliances for technology transfer rather than market-based transaction in terms of transaction costs. Moreover, previous studies found that the propensity to engage in such an alliance is significantly higher for international alliances, where greater monitoring costs are expected, than domestic alliances (Narula and Hagedoorn, 1999). Therefore, it is well suited to explain the motivations of international alliances. Yet, this theory is subject to several limitations as well. First, some studies have suggested that previous findings on the increased monitoring costs for international R&D collaboration may not always be true (Reuer and Ariño, 2002). Second, the theory seems to be better suited to an equity-based alliance (e.g., a joint-venture) than a non-equity-based alliance (e.g., R&D networks). Strong relationships are more likely to reduce the transaction costs, whereas weak relationships still require a non-negligible level of such costs. Unlike in the past when most innovation alliances were in an equity-based form, recent alliances have been characterised by looser and more flexible forms of collaboration such as contract-based R&D collaborations (de Faria and Schmidt, 2012), and indeed the growth of alliances has been attributed to these kinds of collaboration (Narula and Hagedoorn, 1999).

Finally, *resource-based theory* has been regarded as a relatively powerful theory to explain

organisational behaviour, being rich in terms of the conceptualisation of interorganisational dynamics. It can describe corporate strategic behaviour in entering into alliances and can cover both equity and non-equity types of alliances. Indeed, a lack of resources is one of the biggest obstacles for innovation in SMEs and therefore it is expected to be one of the main reasons for collaboration. The characteristics of resources possessed by foreign firms may differ appreciably from those of domestic firms, providing a reason for SMEs' involvement in international rather than domestic collaboration. Moreover, differences in resources may be able to explain differences in collaboration types, ensuring the generalisability of the theory. This study suggests international technology collaboration offers one way to gain such resources.

Table 2-1. Pros and cons of alternative theories

Theoretical perspective	Pros	Cons
Corporate social performance	● It can explain corporate strategic decision-making related to non-financial performance, especially during the R&D process.	● SMEs' collaborations might have relatively few stakeholders compared with large enterprises. ● It is more suited to multilateral than bilateral collaboration
Strategic management	● It provides direct managerial implications which can support SMEs' strategic decision-making.	● The theory is relatively fragmented and SMEs' strategic-making process may not be as systematic as suggested in the theory. ● It assumes that the strategic decision-making results can be implemented, which may not be the case in practice, especially for SMEs.
Transaction cost	● It can explain the rationale of international alliances clearly because transaction costs are high with foreign partners compared to domestic partners. ● Cost is a significant factor for SMEs' decision-making.	● It may not be applicable to technology collaboration, where transaction costs are still needed and indeed are high to form a collaboration network. ● SMEs may decide to collaborate with foreign partners not only to reduce transaction costs but also to pursue strategies for greater profit and revenue.
Resource-based	● The motivations of international technology collaboration can be clearly explained as one of strategies to gain a sustained strategic advantage. ● It is generally applicable to various types of collaboration where diversity in collaboration types can be explained by diversity in resources and their combinations.	● It is limited in offering managerial implications and operational validity, failing to offer guidance on how to develop variable, rare, non-imitable, and non-substitutional resources that are indispensable for acquiring sustained competitive advantages. ● SMEs have limited resources and need to consider both costs and benefits in choosing collaboration modes.

2.3. International technology collaboration involving SMEs

2.3.1. Resource-based theory

Resource-based theory seems to be one of the most frequently used theories to explain the motivation for collaboration. However, in-depth discussions regarding how the theory can explain such collaboration are still lacking, although one exception is the work by Das and Teng (2000) who proposed a conceptual framework of strategic alliances based on the theory. Despite its valuable contribution to collaboration theory, the work has not specifically focused on international technology collaboration involving SMEs and thus is limited in terms of providing practical implications. On the other hand, existing studies regarding international technology collaboration seldom offer a comprehensive understanding of resource-based theory as a theoretical background to examining such collaboration. Most of these studies simply mention that firms try to collaborate with international partners to access complementary resources, but fail to give any details of whether international technology collaborations are motivated by SMEs and, if so, how.

When resource-based theory is applied to international technology collaboration involving SMEs, the characteristics of resources that SMEs are likely to possess and seek from overseas partners need to be carefully considered. Here, three distinguishing characteristics of resources in this particular context are worth noting: 1) technology collaboration; 2) collaboration involving SMEs; and 3) international collaboration.

First, the focus of this study is on *technology collaboration*. Technology collaboration is different from other types of strategic alliances in that the type of resources is related to technology. Das and Teng (2000) identified several types of resources based on resource characteristics (imperfect mobility, imperfect imitability, and imperfect substitutability) and resource types (property-based resources and knowledge-based resources[7]) in the context of general strategic alliances. If this is applied to technology, five types of approaches to resource alignment for technology collaboration can be identified, as shown in **Table 2-2**. A representative property-based resource that is not perfectly mobile is a human resource (Das and Teng, 2000); a common approach to access such a resource in the context of technology collaboration can be either by sending or hosting *human resources* (e.g. scientists and engineers). A property-based resource that is hard to imitate is intellectual property (Das and Teng, 2000); to access such a resource through technology collaboration may involve inwards- or outwards-transfer of technologies via *licensing*. As for a property-based resource characterised by imperfect substitutability, a physical resource was suggested as a typical example (Das and Teng, 2000); two possible approaches are feasible in the context of technology collaboration, namely *setting up a subsidiary* to collaborate with local partners for technology deployment, and *investing in foreign firms* to access their physical resources such as

[7] Miller and Shamsie (1996) classified all resources into two broad categories based on the degree of imitability: property-based resources (those protected by legal means such as human, financial and physical resources) and knowledge-based resources (those protected by knowledge and information barriers such as knowhow and management system). This classification scheme was later adopted by Das and Teng (2000).

distribution channels. On the other hand, knowledge-based resources in the context of technology collaboration include technology-related know-how, skills, and R&D systems, which can only be accessed through organisational learning; joint R&D is a common approach to accessing them.

Table 2-2. Types of technology collaboration (adopted and modified from Das and Teng, 2000)

Resource characteristics	Resource types	
	Property-based resources	Knowledge-based resources
Imperfect mobility	Human resources – in/out	Joint R&D
Imperfect imitability	Licensing – in/out	
Imperfect substitutability	Setting up a subsidiary Investing in foreign firms	

Second, this study restricts its focus to *collaboration involving SMEs* and consequently the perspective of SMEs is taken when resource-based theory is applied. A number of existing studies have taken the perspective of larger MNEs when analysing corporate strategies for international collaboration. However, collaboration from the SME's perspective can be quite different from the MNE's perspective for the following reasons. MNEs may have more viable options for collaboration due to their financial resources, while SMEs are more likely to have limited options. Nevertheless, this does not mean that SMEs do not want to engage in international technology collaboration. On the contrary, SMEs may be more eager to collaborate owing to their lack of resources. They tend to find a way to use their limited options more effectively, hoping to derive the most benefit from collaboration. Another key distinguishing feature of SME's collaboration is that MNEs are likely to have sufficient resources to attract partners and protect the appropriability of their own resources during collaboration, while SMEs tend to have little to attract partners and to be weak in protecting their own resources as well.

Finally, this study focuses on *international collaboration*. The resources can exhibit both location-specific and firm-specific characteristics. Such location-specific features provide a strong imperfect substitutability to the resources a firm possess, which gives a firm a strong motivation for collaborating with a local partner to enter a foreign market. On the other hand, technology collaboration can be divided into two types according to the purpose of collaboration; collaboration for technology exploration (i.e. to develop new areas of technological expertise) and collaboration for technology exploitation (i.e. to reinforce existing technological capabilities) (March, 1991). Firm-specific characteristics are more likely to be related to collaboration for technology exploration, while location-specific characteristics are likely to be concerned with collaboration for technology exploitation.

2.3.2. SMEs' tendency to engage in international technology collaboration

Previous studies suggest that the patterns of international technology collaboration are related to various factors, which can be largely classified into three categories – sectoral, national, and organisational factors (e.g., Choi and Contractor, 2016). Thus, the characteristics of resources in the sector, nation and organisation affect the patterns of international technology collaboration by SMEs.

First, firms are more likely to seek technology collaboration if knowledge creation in the sector is

characterised more by complex processes with high costs and risks, and by activities demanding complementary knowledge. In other word, SMEs in a sector where a successful innovation generally requires high levels of heterogeneous resources are more likely to engage in collaboration. This is supported by Miotti and Sachwal (2003, p.1483), who observe that "the resource-based perspective suggests that firms conducting expensive, risky or complex research projects will seek R&D co-operation." One of the most representative sectors is the pharmaceutical industry, which requires huge R&D investment and a long time to commercialise R&D results. In this sector, incumbents use external networks extensively in an attempt to expand their knowledge base by searching for new knowledge created by biotechnology firms (Powell and Brantley, 1992). In contrast, biotechnology start-ups tend to form vertical networks with pharmaceutical firms (or sometimes chemical firms) to enter a new market and to increase the operational efficiency of their value chain (Shan et al., 1994). In such cases, if the complementary resources are scattered across the world in a globalised market, the partner search may be extended to the global scale.

Second, a lower rate of collaboration failures is observed in sectors with a higher degree of appropriability for R&D results through a strong technology protection mechanism (Lhuillery and Pfister, 2009). That is, if knowledge-based resources can be transformed into property-based resources, enabling strong protection of those resources during collaboration, SMEs are more easily able to enter into technology collaboration. The importance of intellectual property (IP) rights protection to determine whether to engage in technology collaboration or not has been empirically demonstrated; Caloghirou et al. (2003) found that collaboration was more likely to be regarded as a success if it faced few difficulties regarding knowledge loss or appropriability. On the other hand, firms can send a signal to potential foreign partners regarding their innovation capability by using IP systems such as patents, utility models, and trademarks (Faria and Schmidt, 2012). These signals help SMEs to find appropriate collaboration partners and, conversely, can provide a channel for marketing their technologies to reach international markets.

Third, SMEs trying to initiate international technological collaboration need to possess strong competitive advantages over their competitors in order to attract potential overseas partners. Otherwise, even if such collaboration is formed with technologically advanced partners, it can prove difficult to sustain the collaboration due to gaps in the SMEs' technological capabilities. However, partners can also enter a collaboration network to approach other regional resources if a focal firm is located in a country with strong competitive advantages in the industry sector of interest. In contrast, technologically leading SMEs may seek partners abroad, in spite of the geographical distance and other obstacles, if technological advances by foreign firms are much greater than those by domestic firms. Hence, the more valuable, rare, inimitable, and non-substitutable resources a country has with respect to a particular sector, the more likely the country's SMEs in that sector are to be involved in international collaboration.

Finally, the motivation for overseas R&D is particularly strong in a small country where the pool of knowledge a firm can access within the country is limited (Griliches, 1995). Thus, firms in small countries are likely to engage in more alliances than those in large countries (Hagedoorn, 2002). Furthermore, the perceived trustworthiness of a collaboration partner is affected by the degree of trust in

the partner's home country (Ertug et al., 2013)

While understanding that the patterns of international technology collaboration can be affected by the above-mentioned sectoral and national characteristics, the main emphasis of this study is on organisational-level characteristics observed in SMEs (see **Figure 2-1**). OECD (2015) defines collaboration as "active participation in joint innovation projects with other organisations…" It also defines international collaboration on innovation as "active cross-border participation in innovation collaborations". Based on these definitions, two issues were focused on in this study. The first is the basic profiles of SMEs involved in international technology collaboration. The second is the collaboration patterns, which is associated with the phrase "joint innovation projects" in the definition. It also concerns the collaboration partner, which relates to the phrase "with other organisations" in the definition, and the collaboration mode, which is related to the phrase "active participation" in the definition.

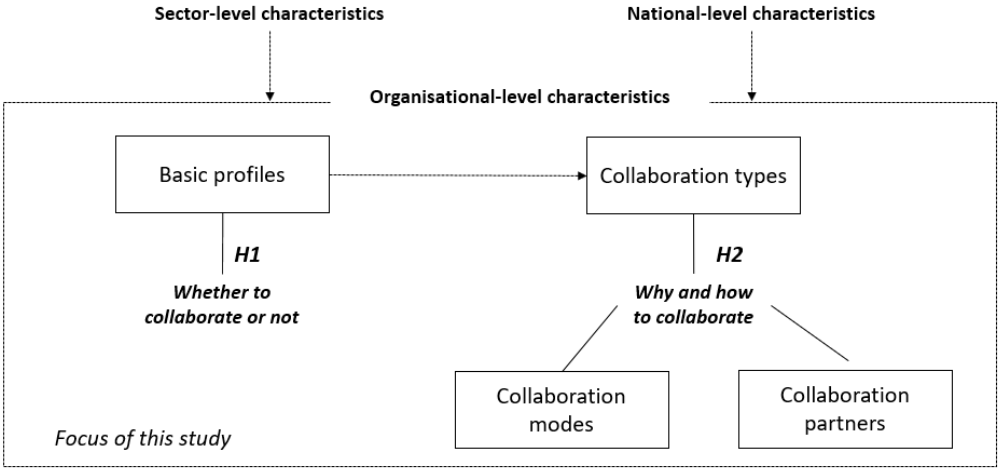

Figure 2-1. Core issues of international R&D collaboration (based on the definition by OECD, 2015)

2.3.3. Development of hypotheses

Of the two areas investigated, the first is related to the tendency towards international technology collaboration motivated by SMEs while the other two are concerned with SMEs' preferences with regard to collaboration modes and partners. Different SMEs may have different desires for collaboration, which need to be studied to understand such collaboration. Collaboration modes and partner types are two of the most significant factors when developing a collaboration strategy. Accordingly, the following hypotheses are developed.

2.3.3.1. Organisational characteristics

Resource-based theory explains that a collaboration is formed when there is potential for value creation by pooling resources across different firms (Day, 1995; Lambe et al., 2002; Varadarajan and Cunningham, 1995). From a single firm perspective, a firm tends to engage in collaboration with a partner when it is likely to gain benefits from accessing the resources the partner has (Das and Teng, 2000). The complexity

of technology is increasing and the market is rapidly becoming globalised. With increasing numbers of other firms in the global market, the resources that SMEs possess are likely to become less competitive – i.e. less valuable, rare, inimitable and non-substitutable. On the other hand, the resources required for technology innovation are diversifying and increasing in the global market. Access to external resources tends to become more critical for SMEs to sustain their competitiveness than for large MNEs.

In this study, the focus will be on R&D resources – the R&D staffs and R&D intensity. When SMEs have only a few R&D staffs, the desire and tendency towards international collaboration is expected to be greater due to their need to access external resources. If they are R&D-intensive firms, they might have less need to access external resources for technology exploration and exploitation due to their relatively abundant internal resources (Ceccagnoli et al., 2010). This study also considers the characteristics of organisational R&D resources affected by national and industrial factors; some industries have strong global technology leadership that encourages domestic SMEs to advance their technologies or attracts foreign SMEs to pursue technology opportunities through international collaboration. Likewise, national strength and industry structure in terms of global value chain and key technologies may affect the desire and tendency towards international technology collaboration. Hence the following hypotheses are developed.

H1. The desire and tendency towards international technology collaborated in SMEs is affected by their R&D resources.

H1-1. SMEs with fewer R&D staff tend to be more involved in international technology collaboration.

H1-2. SMEs with lower R&D intensity tend to be more involved in international technology collaboration.

H1-3. SMEs in some industries tend to be more involved in international technology collaboration than those in others.

2.3.3.2. Collaboration modes and partners

Approaches to using external foreign networks for the purpose of technology acquisition include human resource exchange (Bouty, 2000; Das and Teng, 2000), licensing (Parolini, 1990), R&D collaboration (Parolini, 1990; Aulakh et al., 2013), working with a foreign subsidiary (Veugelers and Cassiman, 2004) and foreign direct investment (Branstetter, 2000; Kohpaiboon, 2005), as summarised in **Table 2-2**. Among these, R&D collaboration is probably one of the most important forms of networking for technology acquisition. It can be defined as any voluntarily initiated collaborative exchange between organisations to find solutions to a known problem within a given technological context (Hagedoorn, 2002). Or, more simply, it is a formal non-equity arrangement in which companies pool their resources in order to undertake joint R&D activities (Nummela, 2003). SMEs are likely to have limited property-based resources and to tend to use their knowledge-based resources for international technology collaboration,

which makes R&D collaboration more attractive than other possible collaboration modes. In practice, R&D collaboration has been regarded as an effective way to acquire the necessary technology under the circumstances of increasing similarity of technologies across sectors and countries together with increasing costs and risks of innovation (Narula and Duysters, 2004). As SMEs have limited resources for innovation (ref), they are likely to actively seek a way to increase their R&D efficiency through R&D collaboration. Some may argue that, compared to property-based resources, knowledge-based resources are more vulnerable to unintended transfer and so SMEs are likely to be reluctant to engage in collaboration based on such resources for fear of losing their core competencies. However, if SMEs in a collaboration network are located in different regions or produce complementary products or services, the possibility of unwanted knowledge spillovers tends to decrease. Hence, it could be hypothesised that SMEs tend to prefer R&D collaboration to other collaboration modes for international technology collaboration.

On the other hand, firms have developed collaboration with various partners such as users and customers, suppliers, universities and research institutes, and even competitors, resulting in a new term, 'open innovation', to acknowledge the contributions of external partners to innovation (Chesbrough, 2003). The main types of partners for SMEs can include large enterprises (LEs), other SMEs, universities, and public research institutes. The resources of LEs and SMEs can be advantageous for both technology exploration and exploitation, while the resources that public research institutes and universities offer tend to be beneficial more for technology exploration than technology exploitation. Given that other enterprises are likely to be a customer or a supplier, collaboration with them can bring new opportunities for innovation. For example, according to Lee et al. (2010), 'customer and user', 'competitors in the industry', and 'affiliates' are the most significant external information sources (apart from public information) for innovations in SMEs. In particular, LEs can play a major role as a route to commercialise technologies belonging to SMEs (Rothwell and Dodgson, 1994; Etemad et al., 2001). In addition, working with international LEs can be a good starting-point for SMEs to develop further international networks, and thus may be preferred over collaborating with other SMEs. Universities and public research institutes can also be attractive collaboration partners in that most of them are not direct competitors for SMEs and possess advanced technologies. Nevertheless, the technologies developed in these organisations may need additional effort to commercialise them, which can devalue the collaboration with such partners. Indeed, the findings from Zeng et al. (2010) also indicate that collaboration with other firms has a more significant impact than collaboration with research institutions, universities or government agencies. Therefore, this study argues that SMEs desire to collaborate with LEs for their technology and that this desire is stronger than with other SMEs. In addition, such desire can increase the satisfaction with collaboration when the collaboration is set up. Accordingly, the second hypothesis can be stated as follows:

H2. SMEs prefer R&D collaboration with LEs to other types of collaboration for international technology collaboration.

H2-1. SMEs prefer R&D collaboration to other collaboration modes for international technology

collaboration.

H2-2. SMEs prefer LEs to other SMEs, universities and public research institutes as a partner for international technology collaboration.

H2-3. SMEs are more satisfied with the most preferred type of collaboration than the others.

2.4. Methodology

2.4.1. Data collection[8]

Survey data were used to test the hypotheses in the context of Korean SMEs. The data were collected by WIPS, a Korean consulting firm, and funded by KIAT, a government agency in charge of technology planning in Korea. The questionnaire was distributed to 19,006 Korean firms with fewer than 500 employees via e-mail, telephone, fax and website; several channels were used together to reduce nonresponse bias. In total, 1,096 firms responded, a response rate of 5.8% (plus or minus 2.9 % at the 95% significance level). The survey was targeted at leaders of, or participants in, international technology collaboration projects, where the main respondents were the equivalent of principal research associate or higher. However, if the main respondents were not able to answer some of the questions, information from others who had been involved in the same project was sought to ensure the overall quality of the data.

The survey questionnaire consists of four parts: 1) company profile; 2) experience of international technology collaboration; 3) plans for future international technology collaboration; and 4) policy recommendations (see Appendix **Table 8-1** for more details). The questionnaire contained questions relating to the motivation, management, and success of international technology collaborations involving Korean SMEs, the aim being to provide organisation-level characteristics. Specifically, the data relate to international technology collaboration, where most variables were measured on a five-point Likert scale. In addition, the data include Korean SMEs' plans for international R&D collaboration as well as their experiences, and thus the data analysis results are expected to provide valuable insights in terms of understanding the characteristics of international technology collaboration involving SMEs.

2.4.2. Analysis methods

The focus of the analysis regarding motivation is on the specific motivation of *smaller companies* compared to larger ones and for *technology* collaboration with *overseas partners* compared to other types of collaboration. The main purpose of the analysis is to test the two hypotheses.

[8] The data was used for another paper entitled "What makes for successful R&D collaboration among SMEs? An integrated perspective on the costs and benefits", but for different purpose of analysis.

2.4.2.1. Testing hypothesis H1

Firstly, for hypothesis H1, a logistic regression model was developed. The data records were divided into three groups – 1) SMEs with experience of international technology collaboration (the experienced group); 2) SMEs desiring for such collaboration (the desire group); and 3) SMEs with no intention for such collaboration (the no-desire group) – in order to examine the factors affecting this classification. Thus, these groups were referenced for testing further hypotheses aiming to investigate whether there are any notable organisational features in any of these groups. In the model, therefore, the dependent variable was experience of international technology collaboration – if a company has ever experienced or is in the preparation stage of such collaboration, the value 1 is given to the variable; if it has neither experience nor is in the preparation stage but is willing to be involved in such collaboration, the value 2 is given to the variable; otherwise, the value 3 was given to it. Initially, a multinomial logistic regression model was designed to distinguish Groups 1, 2 and 3 but this model was not valid. Consequently, two logistic regression models (Models 1-1 and 1-2) were developed to distinguish Groups 1 and 2, and Groups 1 and 3.

Three independent variables were considered: *R&D capacity*, measured by the number of R&D staff; *R&D intensity*, measured by the ratio of R&D investment to total revenues; and *industry*, measured by eight categories that include mechanics and materials, electrics and electronics, information and communications technologies (ICTs), chemicals, bio and medicals, energy and resources, knowledge intensive business services (KIBSs), and others.

This study controlled for the size effect whereby larger companies are more likely to have more R&D staff and mature R&D processes, where the control variable, *size* was measured by the volume of revenues. Company *age*, measured by the number of years since its establishment, was also controlled because companies at different maturity stages are likely to have different attitudes regarding the issues of international collaboration. In the data accessible, all the independent and control variables were in the form of ordinal or categorical values. The ordinal values were regarded as ratio values for analysis to reduce the complexity of models. The operational definitions of the three types of variables are given in **Table 2-3.**

Table 2-3. Operational definitions of variables for Model 1

Variables		Operational definitions	Categories
Dependent	Attitude	The tendency and desire towards international technology collaboration	1. With experience; 2. With desire but without experience; 3. Without experience and desire
Independent	R&D staffs	The number of R&D staffs	1. 1-3 people; 2. 4-5 people; 3. 6-9 people; 4. 10-19 people; 5. More than 20 people

	R&D intensity	The ratio of R&D investment to total revenues for the previous year	1. Less than 3%; 2. 3-6 % 3. 6-10% 4. 10-20%; 5. More than 20%
	Industry	The industry to which it belongs	1. Mechanics and materials; 2. Electrical and electronics; 3. ICTs; 4. Chemicals; 5. Bio and medicals; 6. Energy and resources; 7. KIBSs; 8. Others
Control	Revenue	The total annual incomes for the previous year	1. Less than 3 billion Won; 2. 3-8 billion Won; 3. 8-30 billion Won; 4. More than 30 billion Won
	Age	The number of years since its establishment	1. Less than 5 years; 2. 5-10 years; 3. 10-15 years; 4. 15-20 years; 5. More than 20 years

Rigorous assumptions were not required for multi-linear regression analysis. Nevertheless, the data showed no common-method bias (with the four independent and control variables except industry explaining only 29 % of variances, see Appendix **Table 8-2** for details) as well as no severe multi-collinearity issue (with all correlation coefficients values between the four variables being less than 0.4, see Appendix **Table 8-3** for more details). The basic statistics for the variables are presented in **Table 2-4.**

Table 2-4. Basic statistics of the variables for Model 1

Variables \ Values		1	2	3	4	5	6	7	8
Dependent	Attitude	335 (31%)	650 (59%)	111 (10%)	-	-	-	-	-
Independent	R&D staffs	407 (37%)	252 (23%)	213 (19%)	133 (12%)	91 (8%)	-	-	-
	R&D intensity	238 (22%)	301 (27%)	228 (21%)	140 (13%)	189 (17%)	-	-	-
	Industry	318 (29%)	195 (18%)	147 (13%)	140 (13%)	137 (13%)	51 (5%)	48 (4%)	60 (5%)
Control	Revenue	452 (41%)	141 (13%)	232 (21%)	271 (25%)	-	-	-	-
	Age	351 (32%)	272 (25%)	222 (20%)	85 (8%)	166 (15%)	-	-	-

2.4.2.2. Testing hypothesis H2

Secondly for hypothesis H2, descriptive statistics along with a logistic regression were used to understand the patterns of international technology collaborations and their effects on the level of satisfaction with such collaborations. For the patterns for the collaboration were analysed to test hypotheses H2-1 and H2-2. Limiting the focus to the SMEs that have ever involved in international technology collaborations, a cross tabulation analysis for the collaboration modes and partner types was carried out to test hypotheses H2-1 and H2-2 (see **Table 2-5** and Appendix **Table 8-4** for the types of collaboration desired by SMEs). The table indicates that most dominant types of collaboration involving SMEs include R&D collaboration with SMEs (13.4%), followed by licensing-in from SMEs (12.2%), licensing-out to SMEs (7.6%), and R&D collaboration with universities (7.6%).

Table 2-5. Collaboration modes and partner types

		Universities	Public research institutes	LEs	SMEs	Others
Human resources	Out	2(0.8%)	2(0.8%)	0(0.0%)	2(0.8%)	0(0.0%)
	In	0(0.0%)	0(0.0%)	7(2.7%)	10(3.8%)	4(1.5%)
Licensing (or buy)	Out	9(3.4%)	7(2.7%)	7(2.7%)	25(9.5%)	2(0.8%)
	In	7(2.7%)	6(2.3%)	12(4.6%)	32(12.2%)	5(1.9%)
R&D collaboration		20(7.6%)	16(6.1%)	13(5.0%)	35(13.4%)	7(2.7%)
Setting up a subsidiary		0(0.0%)	3(1.1%)	3(1.1%)	6(2.3%)	0(0.0%)
Investing in foreign firms		1(0.4%)	1(0.4%)	7(2.7%)	7(2.7%)	0(0.0%)
Others		0(0.0%)	3(1.1%)	0(0.0%)	1(0.4%)	0(0.0%)

Since these four types of collaborations (112 cases) explained 42.7% of all collaborations involving SMEs, another variable was introduced to investigate the impact of collaboration patterns on the degree of satisfaction with the collaboration. Accordingly, for hypothesis H2-3, the characteristics of *international technology collaboration among SMEs* were analysed with regard to the degree of satisfaction with the collaboration. A subset of the first group, the experienced group, was therefore used for this analysis, which includes 112 data records.

As in the first analysis, a logistic regression model (Model 2) was used as the main method for testing the hypothesis. In this model, the dependent variable was *the satisfaction* with the collaboration was adopted. This was measured by a five-point Likert scale but was transformed into a binary variable considering the small sample size; the value 1 (satisfied) was given to the original values of 4 and 5, while the value 0 (dissatisfied) was given to the other values of 1, 2 and 3. The same set of independent and control variables were used for this model except industry; instead of the industry variable, a variable indicating the four main types of collaboration were introduced in this model. Furthermore, whether the collaboration was funded by the government or not was added to a set of control variables because it enables to access other types of external resources but partners' resources and thus can affect the degree of satisfaction with the collaboration. Operational definitions of variables are summarised in **Tables 2-6**.

Table 2-6. Operational definitions of variables for Model 2

Variables		Operational definitions	Categories
Dependent	Satisfaction	Whether an SME was satisfaction with the collaboration or not	1. Satisfied; 2. Unsatisfied
Independent	R&D capacity	The number of R&D staffs	1. 1-3 people; 2. 4-5 people; 3. 6-9 people; 4. 10-19 people; 5. More than 20 people
	R&D intensity	The ratio of R&D investment to total revenues for the previous year	1. Less than 3%; 2. 3-6 % 3. 6-10% 4. 10-20%; 5. More than 20%
	Collaboration type	Collaboration modes and partner types	1. Collaborative R&D with universities; 2. Licensing(buy)-out to SMEs; 3. Licensing(buy)-in from SMEs; 4. Collaborative R&D with SMEs
Control	Revenue	The total annual incomes for the previous year	1. Less than 3 billion Won; 2. 3-8 billion Won; 3. 8-30 billion Won; 4. More than 30 billion Won
	Age	The number of years since its establishment	1. Less than 5 years; 2. 5-10 years; 3. 10-15 years; 4. 15-20 years; 5. More than 20 years
	Funding	Whether the collaboration was funded or not	1. Funded by the government 2. Not-funded by the government

Rigorous assumptions were not required for logistic regression analysis. Nevertheless, the data showed no common-method bias (with the four independent and control variables except industry explaining only 29 % of variances, see Appendix **Table 8-5** for details) as well as no severe multi-collinearity issue (with all correlation coefficients values between the four variables being less than 0.5, see Appendix **Table 8-6** for more details). The basic statistics for the variables are presented in **Table 2-7.**

Table 2-7. Basic statistics of the variables for Model 2

Variables \ Values		1	2	3	4	5
Dependent	Satisfaction	71 (63.4%)	41 (36.6%)	-	-	-
Independent	R&D staffs	27 (24.1%)	23 (20.5%)	29 (25.9%)	23 (20.5%)	10 (8.9%)
	R&D intensity	22 (19.6%)	28 (25.0%)	17 (15.2%)	18 (16.1%)	27 (24.1%)
	Collaboration types	20 (17.9%)	25 (22.3%)	32 (28.6%)	35 (31.3%)	-
Control	Revenue	53 (47.3%)	12 (10.7%)	22 (19.6%)	25 (22.3%)	-
	Age	38 (33.9%)	30 (26.8%)	20 (17.9%)	9 (8.0%)	15 (13.4%)
	Funding	42 (37.5%)	70 (62.5%)	-	-	-

2.5. Analysis results

The descriptive analysis results indicate that, among the 1,094 responding firms, 262 have had experience of international R&D collaboration in the past, 73 were implementing their plans for international R&D collaboration, and 650 had plans for international R&D collaboration. However, only 10.4% of respondents said that they had ever been supported by a government programme for their international technology collaboration, which means that there are many SMEs that have been involved in such collaboration without government funding. These figures show that SMEs have been collaborating and desire to collaborate with international partners for their technologies.

2.5.1. Organisational characteristics

Tables 2-8 summarise the regression analysis results only for valid models with Hosmer and Lemeshow test values greater than 0.05. The regression analysis results for Group 1 (the experienced group) and Group 2 (the desire group) show that both R&D staff numbers and R&D intensity have a significant impact on the tendency towards international technology collaboration; SMEs with larger R&D efforts are less likely to be involved in such collaboration. Similar results are presented for Group 1 (the experienced group) and Group 3 (the no-desire group) with respect to R&D efforts. Thus, H1-1 and H1-2 are supported.

On the other hand, three industries have a strong or a weak tendency for international technology collaboration involving SMEs. SMEs in electrics and electronics sectors are more likely to be involved in such collaboration, while SMEs in bio and medicals, and mechanics and materials sectors are less likely to be involved in such collaboration than the other industry sectors. The formal is the sector where Korea has a strong national competitive advantage thanks to some leading firms such as Samsung Electronics and LG Electronics. Furthermore, a global value chain is well established in this industry where products or services consist of a number of relatively independent components, which can facilitate international technology collaboration involving SMEs. On the contrary, Korea is a follower in the bio and medical sectors as well as in mechanics and materials; SMEs in these sectors are less successful in engaging in such collaboration. A finding worth to address is that in the mechanics and materials industry sector, less SMEs from those willing to collaborate with overseas partners are actually involved in such collaboration than other industry sectors, while no significant difference between this industry sector and the others is found in relation to the ratio of SMEs that experienced such collaboration to those with no intention to collaborate with overseas partners.

Table 2-8. Regression analysis to distinguish Group 1 and Group 2

Model 1-1		Model 1-1(a)			Model 1-1(b)			Model 1-1(c)		
		B	p-value	Exp(B)	B	p-value	Exp(B)	B	p-value	Exp(B)
	Constant	2.442	0.000	11.498	2.503	0.000	12.216	2.739	0.000	15.464
Control	Age	-.0061	0.337	0.941	-.0075	0.235	0.928	-0.032	0.632	0.969
	Revenue	0.071	0.297	1.074	0.098	0.149	1.103	0.060	0.405	1.062
Independent	R&D staff	-0.479	0.000	0.619	-0.442	0.000	0.643	-0.459	0.000	0.632
	R&D intensity	-0.170	0.004	0.844	-0.157	0.009	0.855	-0.210	0.001	0.811
	Electrical and Electronics	0.948	0.000	2.580						
	Bio and medicals				-0.512	0.018	0.599			
	Mechanics and materials							-0.462	0.016	0.630
Hosmer and Lemeshow test, Accuracy		0.435, 73.5%			0.869, 72.8%			0.887, 73.2%		
Cox and Snell R-square, Nagelkerke R-square		0.098, 0.141			0.087, 0.124			0.087, 0.125		

Table 2-9. Regression analysis to distinguish Group 1 and Group 3

Model 1-2		Model 1-2(a)			Model 1-2(b)		
		B	p-value	Exp(B)	B	p-value	Exp(B)
	Constant	2.693	0.000	14.780	2.765	0.000	15.881
Control	Age	-0.062	0.304	0.940	-0.075	0.215	0.927
	Revenue	0.054	0.412	1.055	0.082	0.210	1.086
Independent	R&D staffs	-0.451	0.000	0.637	-0.432	0.000	0.649
	R&D intensity	-0.177	0.002	0.838	-0.151	0.010	0.860
	Electrics and Electronics	0.896	0.000	2.451			
	Bio and medicals				-0.629	0.003	0.533
Hosmer and Lemeshow test, Accuracy		0.212, 76.1%			0.877, 77.1%		
Cox and Snell R-square, Nagelkerke R-square		0.086, 0.128			0.079, 0.118		

2.5.2. Collaboration types

The results show that *R&D collaboration* is the most commonly used and the most desired form of collaboration with regard to SMEs' international technology collaboration, followed by licensing(buy)-in from SMEs, licensing(buy)-out to SMEs, and collaborative R&D with universities, a result which is in line with H2-1 and H2-2.

The regression analysis results focusing on the four types of collaborations are presented in **Table 2-10**. Regardless of the type of collaboration, SMEs seem to be one of the most attractive and frequently used types of partner to other SMEs. Nevertheless, SMEs' technology collaboration with other SMEs resulted in a lower degree of satisfaction with the collaboration; the satisfaction with collaborative R&D with universities is much greater than the satisfaction with the other three types, for which collaboration partners are SMEs. Such dissatisfaction is observed more often in R&D collaboration among SMEs rather than in other types of collaboration with SMEs. SMEs were more likely to be satisfied with

licensing(buy)-out to other SMEs than R&D collaboration among SMEs by five times. In case of licensing(buy)-in from SMEs, though no statistically significant difference was found with R&D collaboration among SMEs, the average satisfaction measured by a five-point Likert scale for licensing(buy)-in from SMEs (3.74) was lower than R&D collaboration among SMEs (3.59). The satisfaction was not affected by the number of R&D staffs but was influenced positively by R&D intensity and weakly by government funding.

Table 2-10. Regression analysis to investigate the satisfaction with collaboration

Model 2		B	p-value	Exp(B)
	Constant	-2.965	0.030	0.052
Control	Age	-0.117	0.519	0.890
	Revenue	0.064	0.747	1.066
Independent	R&D staffs	0.009	0.965	1.009
	R&D intensity	0.438	0.025	1.549
	Collaboration types*		0.006	
	Type 1. Collaborative R&D with universities	3.305	0.003	27.259
	Type 2. Licensing(buy)-out to SMEs	1.623	0.013	5.066
	Type 3. Licensing(buy)-in from SMEs	0.762	0.200	2.144
	Funding	0.889	0.080	2.433
Hosmer and Lemeshow test, Accuracy		0.106, 73.2%		
Cox and Snell R-square, Nagelkerke R-square		0.262, 0.359		

* The reference collaboration type is Type 4 (Collaborative R&D with SMEs).

2.6. Discussion

This study reviewed existing theories that can be used to explain technology collaboration. Following the work by Gray and Wood (1991), the second and third generation of collaboration theories were examined to see how the theories have been evolved. After comparing several alternative theories, this study adopted resource-based theory as the main theoretical framework. Based on this theory and work by Das and Teng (2000), four modes of technology collaboration were then defined, including human resources in/out, licensing in/out, setting up a subsidiary or investing in foreign firms, and joint R&D. The technology-related resources SMEs are likely to have or to access from their collaboration partners were also discussed, which yielded several theoretical and managerial implications.

First, SMEs have been, and continue to desire to be, involved in international technology collaboration. In particular, those with lower R&D efforts (in terms of R&D staff and R&D intensity) are more likely to be involved in international technology collaboration, but the stage of growth of the firm does not have any significant impact on the tendency to engage in such collaboration. Such results indicate that international technology collaboration can be one viable option for innovation in SMEs. SMEs that are less capable of investing significant human and financial resources in R&D were found to have made an effort to access external resources; by introducing foreign resources to their own firms, SMEs could distinguish themselves from their competitors. Here, collaboration is a bi-directional process of managing and combining resources, and developing resources that can attract potential foreign partners

is therefore essential for SMEs to become involved in such collaboration, especially when they are lacking in R&D resources[9].

Second, SMEs prefer R&D collaboration to other collaboration modes for international technology collaboration. In addition, the propensity to engage in international R&D collaboration is greater in the electrical and electronics sector, which is characterised by strong protection mechanisms, the necessity of localisation, and national technological strength from the Korean perspective. Unlike other modes of technology collaboration, R&D collaboration is a process of combining knowledge-based resources, and consequently the risk of unwanted knowledge spillovers during the collaboration may be high. To deal with this, the target technologies for collaboration – that is, the partner's complementary resources to be accessed – need to be carefully determined; the complementary resources that can create significant value without too much interaction between the collaboration partners can represent such a case. A good example is a hardware (HW) company collaborating with a software (SW) company to develop a new HW product using new SW customised for the company targeting a global market. In this case, once the concept of the new market is well defined, based on which the HW and SW to be developed can be technologically specified, the collaboration does not require too much interaction but can nevertheless create value from the collaboration.

Third, SMEs seem to prefer other SMEs to LEs, universities and public research institutes as a partner for international technology collaboration, both for R&D and non-R&D types of collaboration. This is contrary to our expectations from resource-based theory and indicates a possible limitation of the theory in explaining SMEs' international technology collaboration. In choosing a collaboration partner, SMEs will take into account the "net benefits"; they consider the accessibility of the resources, the effort needed to acquire the resources, and the risks in using those resources in addition to the benefits of the resources. For example, working with LEs can impose bureaucratic processes, entailing high management costs. Jamieson et al. (2012) argued that "large businesses can also hamper SME growth through late payments, pressure to drive costs down, and the burdensome, administrative compliance with procurement and audit procedures, especially since these are different for each customer." That is, LEs may have more attractive resources than SMEs, but SMEs need to put much effort into accessing the resources. In addition, there is always a danger of unwanted spill-overs, which may benefit LEs significantly while eroding the core competencies of the SMEs. Although resource-based theory was chosen as the most appropriate of the existing theories, it still has limitations due to its underlying assumption that strategic alliances are formed to access external resources necessary for acquiring sustainable competitive advantage. By ignoring the costs, it fails to support the decision-making process for SMEs that are relatively sensitive to costs.

Finally, perhaps the most interesting finding is that, despite SMEs' clear preference, the degree of

[9] Lee et al. (2010) proposed a collaborative network among specialised SMEs as an open innovation model particularly suited to SMEs, which can be applied not only to domestic collaboration but also to international collaboration.

satisfaction for collaboration with other SMEs is actually lower than with other types of partners, a finding that is more noticeable in the case of R&D collaboration than the other types. This phenomenon – of SMEs being eager to work with other international SMEs for their R&D but being dissatisfied with it – is termed here the *SME collaboration paradox*, and it indicates there is a gap between expectation and reality with regard to international R&D collaboration among SMEs. This paradox can be summarised as follows:

> *SMEs want to work with international partners to overcome their size limitations and gain sustainable competitive advantages, though collaborative R&D, in the global market. However, if they choose LEs, transaction costs stemming from LEs' bureaucratic process and risks of unwanted knowledge spillovers can be high. If they choose universities or research institutes, they still need to invest a lot in technology commercialisation. As a result, they find other overseas SMEs as the most attractive partner for their R&D but, in reality, such collaboration produces less satisfaction than the others. Consequently, SMEs have to work either with less attractive partners or less satisfactory partners.*

This suggests that, although international R&D collaboration among SMEs may represent a promising model for open innovation in SMEs, managerial effort needs to be targeted at producing satisfactory outcomes. Resource alignment is essential to initiate R&D collaboration, whereas *how to manage and combine resources* is also a significant factor in order to generate the expected value from such collaboration. Uncertainty with regard to collaboration output may increase for R&D collaboration with international partners, which requires further strategies to be put in place to manage the uncertainty. At the same time, SMEs need to realise that collaborating with overseas SMEs may bring several hidden costs associated with appropriate partner selection and effective project management due to cultural (Lew et al., 2016) and language difference (Joshi and Lahiri, 2015). Bridging the gap between expectation and reality is essential to ensure "successful" international R&D collaboration among SMEs.

2.7. Conclusions

This study aims to explain why and how international technology collaboration involving SMEs takes place using resource-based theory, and then empirically tests this to see whether the arguments based on the theory are supported or not. The research findings indicate that: 1) SMEs as well as large MNEs tend to collaborate with international partners, with the main purpose being to facilitate exploitation of their technology, although the purpose is likely to change with firm growth; and 2) R&D collaboration among SMEs is regarded by SMEs as the most preferred but also the least satisfactory type of international technology collaboration.

Practically, this study is one of relatively few attempts to investigate SMEs collaboration and thus provide a number of managerial and policy implications to support international technology collaboration for SMEs. Theoretically, this study applied resource-based theory to a specific type of collaboration, that is, international technology collaboration in the context SMEs. To do this, three characteristics of

resources involved in such collaboration were considered: the resources that SMEs have, the resources required for technology collaboration, and the resources located in geographically different regions. Resource-based theory was expected to provide a rationale for such collaboration.

Although the study has yielded a number of theoretical contributions and practical implications, there are certain limitations to this study which point to possible future research directions. First, the data are confined to Korean SMEs and the empirical analysis results may therefore have limited generalisability. As discussed earlier, the tendency among SMEs to engage in international technology collaboration can be affected by sector and country characteristics. For example, Korea has a small domestic market, which encourages its SMEs to globalise their business and to collaborate with international partners to enter global markets. On the other hand, SMEs in Korea have relatively less experience of collaborating with international partners than European SMEs, which may discourage them from initiating such a new type of collaboration. Therefore, how the needs and the patterns of international technology collaboration involving SMEs can be influenced by national and sectoral characteristics needs to be further investigated.

Second, the hypotheses developed in this study are relatively simple, looking at patterns at the aggregate level and taking a static view. Though this study is exploratory in nature, more elaborate hypotheses can be developed on the basis of research findings from this study. For example, by taking account of the different purposes for which SMEs enter into international technology collaboration, purpose-specific operational and performance characteristics can be examined. Another research opportunity lies in historical analysis of the changing purposes for which SMEs collaborate with international partners as they grow or as their experiences of such collaboration increase.

Finally, resource-based theory, by taking a value maximisation approach, may result in overlooking the significance of costs to SMEs. In choosing whether to collaborate or not, as well as with whom to collaborate, SMEs are likely to consider both expected value and costs; SMEs pursuing cost reduction through collaboration are clearly observed in **Tables** from **2-4 to 2-7**, where quite a large proportion of respondents indicated their collaboration purposes as reducing time and costs for technology development. Unlike large MNEs, SMEs' strategic decisions are bounded by their very limited budgets. Moreover, they may have limited capabilities to manage collaboration with international partners, so the costs incurred by international technology collaboration are far from negligible. In a similar manner, the theory fails to explain the performance of such collaboration, in which both costs and benefits need to be factored in. The theoretical framework needs to be further developed to better describe the nature of international collaboration involving SMEs.

Nevertheless, the research findings provide valuable insights for policy making. First, international R&D collaboration with other SMEs is one of the most preferred and frequently used types of collaboration involving SMEs yet actually generates the least satisfaction. A policy programme to foster such collaboration needs to support not only the initiation of such collaboration but also help in managing it. International collaboration among SMEs may incur a number of unexpected costs, which need to be made more predictable and manageable by SMEs in order to encourage those SMEs likely to benefit most from collaboration to actually engage in it. Hence, the first step should be to identify the difficulties that

SMEs are likely to face during international R&D collaboration, that is, the negative aspects that could detract from the benefits of international R&D collaboration. The policy instruments need to be designed in a way to help SMEs overcome the difficulties.

Furthermore, SMEs are likely to collaborate on the basis of their knowledge-based resources. Since such resources are not easily protected by legal means, SMEs need to put great effort into preventing unwanted knowledge spillovers, while making the best use of access to their partners' resources, in order not to lose the competitive advantage derived from their resources. In this respect, international technology collaboration has both pros and cons. Because of the relatively high cost of learning (e.g. costs from collaborating over a long distance, and costs relating to language and cultural differences) and the limited absorptive capacity, less organisational learning is anticipated. Accordingly, insights and best practices need to be provided to SMEs to help them learn from overseas partners. A platform to support long-distance interactions may be useful to facilitate interactions, while designing a policy instrument to achieve effective knowledge exchange is also required. Here, a strong IP system that can effectively transform knowledge-based resources into property-based resources, protecting firms' own resources, is key to encouraging such collaboration; only when an SME's own resources are under strong protection, ensuring that unwanted knowledge spillovers are prevented, are they likely to be active in exchanging their resources. Innovation policies need to include SMEs, and a policy that enables SMEs to gain the greatest benefit from exchanging their resources globally would represent a significant step forward.

3. Motivation for international R&D collaboration[10]

3.1. Introduction

International alliances are on the rise (OECD, 2001), particularly for undertaking technology development activities (Narular and Hagedoorn, 1999). According to Narula and Duysters (2004), this growth is partly explained by the reduction in transaction costs that collaboration may bring. Yet collaboration entails additional costs in financial terms as well as costs related to time and increased administration (Katz and Martin, 1997). International R&D collaboration in particular involves the costs of long-distance collaboration, as well as the costs of overcoming language, cultural and institutional barriers (Sarasini, 2014). However, new technologies have cut cross-border communication and organisational costs. In particular, advances in information and communications technologies and the reduced costs of travel have boosted the flow of information between actors over long distances (Lang, 2001; Mirghani and Mohamed, 2007). Moreover, growing economic liberalisation has contributed to the development of harmonised regulatory systems across countries, lowering the barriers to entry. Accordingly, it is becoming feasible even for small or medium-sized enterprises (SMEs) to become involved in such collaboration, if they have good reasons for being engaged in it. Hence, international R&D collaboration has attracted great attention from both academics and practitioners.

The existing literature on international R&D collaboration is mainly concerned with the motivation for engaging in it, particularly with respect to the perspective of larger multi-national companies (MNCs). Based on the existing literature, there are two main types of factor—demand side and supply side—affecting whether a firm will prefer a foreign firm to a domestic firm as its R&D partner. First, the demand-side factors are associated with the need to adapt R&D to specific market conditions. Overseas R&D may be costly (Schmidt and Sofka, 2009), but collaboration with firms already active in the target market may promise certain gains, allowing direct access to knowledge of the market and thus enabling more cost-efficient R&D. By exploiting the resources of local partners, international R&D collaborations allow MNCs to focus on their core competence (Li, 2010) and to more easily respond to local market needs (Li and Yue, 2005), reducing the uncertainties associated with an unfamiliar foreign business environment (Lord and Ranft, 2000). In addition to these demand-side factors, the supply-side factors are also worth noting; firms may be seeking to utilise immovable assets via R&D collaboration. These assets, being either firm specific or location specific, can provide a motivation to conduct overseas R&D. For example, Li and Yue (2005) found that MNCs have continuously internationalised their R&D investments to access the host country's scientific and technological resources, which may be firm specific. Similarly Wu and Callahan (2005) found from their studies of MNCs that the motives behind R&D alliances with Chinese organisations were to establish vertical linkages and obtain human resources, which may be location specific.

[10] Paper title: International R&D collaboration among SMEs: Toward a typology of motivation

Therefore, international R&D collaboration is often initiated when firms are trying to expand their business internationally, to compete in several overseas markets simultaneously or to access assets specific to particular locations (Narula and Duysters, 2004). However, these findings from large MNCs may not be applicable to SMEs, due to differences in the resources that SMEs possess and the resources they are seeking. For example, SMEs are likely to look for different partners to globalise their innovation processes since they lack various resources; they may have more diverse needs for international R&D collaboration. Therefore, it is worth investigating the phenomenon of international R&D collaboration among SMEs to derive relevant managerial and policy implications. Yet little effort has previously been made to address this, despite the importance of SMEs as a key actor in national innovation systems.

To address this research gap, this study aims to examine the motivations underpinning international R&D collaboration among SMEs, drawing upon resource-based theory. The motivation of SMEs is focused on here since understanding motivation is essential in order to encourage (or discourage) such collaboration; the motivations of SMEs in collaborating with foreign partners are classified into four categories according to two criteria – (1) the types of resources that SMEs are attempting to acquire from their partners; and (2) the ways of using those resources in order to create new knowledge. In particular, this study analyses motivations at the project level. Though international R&D collaboration operates mainly at the project level, most previous studies have focused on organisational-level characteristics of collaboration using Community Innovation Survey (CIS) data (e.g. Mention, 2011; Arora et al., 2016; Lewandowska et al., 2016). The CIS data analysed at the organisational level have helped to investigate the tendency to engage in international R&D collaboration at the organisational level (and patterns of collaboration) but have generally failed to help us understand the real motivations underlying such collaboration. A project-level investigation is essential to study in-depth the mechanisms of international R&D collaboration in SMEs. Finally, this study restricts its analysis to international R&D collaboration *among SMEs*, since SMEs lacking resources are more likely to search for other SMEs possessing the complementary resources necessary for extending their markets. Collaboration among SMEs is seen as a promising open innovation mechanism for SMEs (Lee et al., 2010); it can avoid the bureaucracy associated with larger firms while maximising their flexibility for innovation.

In spite of the environmental changes that have resulted in much more favourable conditions for international R&D collaborations than in the past, there may be additional costs of collaborating with overseas partners compared to the costs of working with domestic partners or barriers to collaboration networks (Leung, 2013). Nevertheless, the costs can be reduced by appropriate management. As SMEs may be vulnerable to opportunistic behaviour on the part of collaboration partners (Osborn and Baughnnis, 1990), it is essential to reduce the risks of such behaviour by carefully controlling a project (Kloyer, 2011). In his study of vertical R&D collaboration, Kloyer (2011) found that SMEs, as R&D service providers, could avoid moral hazard issues by requiring their partners, as R&D service buyers, to share enforceable intellectual property rights with them – both as to ownership and regarding litigation. Therefore, how SMEs have managed international R&D collaboration projects to minimise the relevant costs and maximise the benefits, and how the management strategies differ with regard to motivations, will be further investigated in this study.

For the purpose of this analysis, a case study approach was adopted; 14 Korean SMEs that have been involved in international R&D collaboration in the past 10 years were interviewed, and in each case a representative project for such collaboration was analysed. Then, focusing only on four SMEs with a relatively long history of international R&D collaboration, the evolution of their motivations was investigated as well.

The remainder of this chapter is organised as follows. In Section 3.2, previous studies on international R&D collaboration are reviewed, revealing a significant research gap. A conceptual framework is suggested in Section 3.3, and a research design set out in Section 3.4. Then, in Section 3.5, the analysis results are presented, based on which several issues for discussion are addressed. Finally, the contribution of this research and possible future research directions are summarised in Section 3.6 along with some policy implications.

3.2. Literature review

3.2.1. Motivations of R&D collaboration

An inter-firm alliance is one of the major ways to build global networks and to gain access to the global resources necessary for innovation. The motivation for international collaboration is explored using resource-based theory in this study, according to which alliances are formed to maximise a firm's value by pooling and combining complementary resources (Kogut, 1988; Das and Teng, 2000; Hagedoorn et al., 2000).

In previous studies, the motivations of collaboration have been examined mostly on the basis of resource-based theory (Wernerfelt, 1984). Wernerfelt (1995, p.172) stated that "it is a truism that firms have different resource endowments and that it takes time and money to change these endowments." Later, the theory was extended to include the organisational learning and knowledge-based view, in which knowledge is seen as the most significant resource (Kogut and Zander, 1992), the competence-based theory, which is based on the notion that core competence is developed from corporate resources (Sanchez et al., 1996), and the dynamic capabilities approach, which relates to a firm's capabilities to adapt its resources to external environmental changes (Teece et al., 1997). Resource differences or similarities can explain why firms are willing to collaborate. Some skills, being tacit or immobile, cannot be transferred properly through market-based transactions; instead alliances are used. This theory has been applied to interpret R&D collaboration with foreign partners. International R&D collaboration is a way to access country-specific resources on the assumption that firms have acquired their competitive advantages based on resources indigenous to their home country.

According to the resource-based theory, different types of collaboration can be defined in terms of the types of resources firms seek from partners and the purpose of pooling their resources. Concerning the different types of resources, the choice of collaboration partners relies on a comparison of R&D resources with a focal firm and potential partner candidates. Access to a complementary technology is known to have the highest significance among the motivations for R&D collaboration (Narula, 2002). In a similar

vein, a complementary product increases the likelihood of R&D cooperation (Röller et al., 1997). On the other hand, market resources also can be a major driver of collaboration with foreign partners (Miotti and Sachwald, 2003). In this case, the focus of R&D collaboration may not be restricted to technology transfer or product development but may extend to market access.

As to the purpose of collaboration, most previous studies have emphasised access to complementary resources, or resource combination, as was found in the case of government sponsored research co-operation in Japan (Gassel and Pascha, 2000), R&D cooperation in European ICT firms (Narula, 2004), or collaboration at the invention stage in the US (Walsh et al., 2016). In contrast, few studies have paid attention to resource pooling aimed at achieving economies of scale or economies of scope in resource use. One exception is the work by Miotti and Sachwald (2003, p.1485), which linked the partner selection problem with NIS, arguing that "National innovation systems and technological specialisation are closer between European countries than between European countries and the US. As a result, intra-European R&D co-operation will typically not aim at pooling complementary resources. It may however be used to pool similar resources in order to reduce costs."

One of the most comprehensive frameworks to explain strategic alliances using the resource-based theory was developed by Das and Teng (2000). Arguing that "the resource-based view of the firm has not been systematically applied to strategic alliances", they addressed the issues regarding the rationale, formation, structural preferences, and performance of strategic alliances based on the theory. In their study, the resource types of partner firms – property-based resources (those protected by legal means) and knowledge-based resources (those protected by knowledge and information barriers) determines the alliance structures – equity joint ventures, minority equity alliances, bilateral contract-based alliances, and unilateral contract-based alliances. They also proposed a typology of inter-partner resource alignment – supplementary, surplus, complementary and wasteful – based on resource similarity concerning its type and resource utilisation.

Given that resources in each firm are heterogeneous, the motivation of international R&D collaboration is context-specific. Consequently, the findings from large enterprises may not be generalisable to SMEs. For example, one of the strategies SMEs can adopt to expand their business internationally is to collaborate with domestic partners that are already in global value chains, especially when they are B2B suppliers. Moreover, the motivations for domestic collaboration can be different from those for international collaboration. International R&D collaboration can be initiated through government-funded innovation programmes for SMEs (Gassel and Pascha, 2000). Hence, this study addresses the motivations for international R&D collaboration specific to SMEs, a topic which needs in-depth investigation.

3.2.2. Motivations for international R&D collaboration involving SMEs

SMEs are different from large enterprises with respect to business scope, R&D activities, and collaboration experiences and capabilities. However, in-depth discussion of international R&D collaboration among SMEs has been relatively limited in previous studies. The reasons for this are

various. First, R&D internationalisation has been mostly driven by large MNCs while SMEs have shown less of a tendency to collaborate with both international and domestic partners (Faria and Schmidt, 2012). Collaboration will be initiated only when the expected returns outweigh the perceived risks. As to the expected returns, SMEs are less likely to target global markets, focusing more on local markets than large firms, as domestic markets can be large enough for them to survive; thus the benefits of international R&D collaboration may not be as attractive to SMEs as to large firms. On the other hand, the risks of international partnerships perceived by SMEs may be greater than those for large firms. Indeed, international R&D collaboration can give rise to various difficulties, such as coordination costs linked to cultural differences, language barriers, and geographical distance (Lhuillery and Pfister, 2009). These costs may be perceived to be greater in SMEs than in large enterprises, given their limited managerial and other capabilities.

Second, large enterprises are likely to invest more in R&D than SMEs. Though some researchers argue that firm size is almost irrelevant to R&D intensity (e.g. Cohen et al., 1987), what is really important in decisions about international R&D collaboration is the absolute level of R&D investment, not the relative level. Large enterprises can manage an R&D portfolio consisting of various types of R&D projects, one of which may be an international R&D collaboration project. Conversely, the number of R&D projects SMEs can manage is likely to be limited within a given R&D budget, and thus a diversity of R&D projects could not be easily maintained in SMEs.

Third, according to resource-based theory, the choice of collaboration partner greatly affects complementary assets (Narula, 2002). In other words, SMEs trying to initiate international R&D collaboration need to possess strong competitive advantages over their competitors in order to attract potential overseas partners. However, SMEs are less likely to have much to exchange, and thus they may find it difficult to attract foreign partners. Even if such collaboration is formed with technologically advanced partners, it can be difficult to sustain due to gaps in their technological capabilities.

However, there are three factors that might provide a counterargument to the limited need for international R&D collaboration in SMEs. The first of these is that SMEs are likely to concentrate on their local markets, which, in turn, helps SMEs to collaborate with foreign partners focusing on their local markets. Referencing previous studies, Belderbos et al. (2004, p.1240) stated that “when firms are not direct competitors but market independent or complementary goods, cooperation is associated with higher R&D investment levels independent of any critical level of spillovers (De Bondt et al., 1992; Röller et al., 1997).” This claim was also supported by Lhuillery and Pfister (2009, p.47), who stated “in the case of horizontal cooperation, competition may be too intense between domestic companies for an efficient cooperation to be sustained, making collaborations with a foreign firm more performing”.

Regarding the second factor, international R&D collaboration can be an effective way for SMEs to diversify their R&D portfolios within a limited budget. In particular, by using external networks, SMEs may overcome barriers to growth due to their resource limits (van Dijk et al., 1997). Nooteboom (1994), furthermore, argued that the success of SMEs, especially vis-à-vis their larger competitors, may depend on how well they are able to use external networks. In the same vein, Mytelka (1991) suggested that what determines a firm’s competitiveness is its external network rather than its size. As R&D funding may be

limited in SMEs, it will often be helpful for them to use networks when seeking opportunities for growth.

Finally, with regard to the third factor, SMEs may lack competitive advantages in areas where economies of scale apply. Yet, they can have strong competitive advantages over their larger competitors in technology-based services or knowledge-based areas, where the assumption of economies of scale is unlikely to apply. In such areas, SMEs as well as large enterprises may be attractive to foreign partners. Conversely, technologically leading SMEs may seek partners abroad, in spite of geographical distance and other obstacles, if technological advances by foreign firms are much greater than those by domestic firms. In addition, other factors can affect the motivations of international R&D collaboration, including policy support (Abramovsky et al., 2009), sector characteristics (Tether, 2002), the activities of experts (Dachs et al., 2008), and company size and affiliates (Link and Bauer, 1987).

3.3. Conceptual framework

3.3.1. Typology of international R&D collaboration among SMEs

This study proposes a typology of SMEs' motivations for collaborating with overseas partners based on the two dimensions – 1) *resource type* in a partner firm; and 2) *resource alignment* in a partner firm. These two factors are critical for the formation of a collaboration network because the rationale for collaboration is the possibility of creating value by tapping into a partner's resources, where it was assumed assume that the value expected from collaboration is determined by the type of resources and the opportunity to align the resources in a focal firm together with the resources in a partner firm. A single perspective, that is, the perspective of a single firm, is adopted in this study because the emphasis of this study is on the motivations of SMEs, not the formation of a collaboration network. Here, the motivations of technology-based SMEs are considered because technology-based SMEs are more likely to be active in R&D collaboration.

First, the resource types were divided into two categories: *property-based resources* (e.g. distribution channels, manufacturing facilities, and intellectual property rights); and *knowledge-based resources* (e.g. know-how, skills, and R&D systems). This categorisation was developed originally by Miller and Shamsie (1996) and adopted by Das and Teng (2000) for establishing the rationales for strategic alliances. According to them, key differences between the two resources are that for the former one can legally protect knowledge almost perfectly while the latter is relatively vulnerable to unintended knowledge transfer. These differences are likely to affect not only how one designs a collaboration network but also how one operates the network. For example, the collaboration may continue over the long-term or only exist over the short-term, something which might be related to the type of resources. A firm can design a short-term collaboration to access property-based resources, since it is relatively easy to access those resources. In contrast, a firm may need to design a long-term collaboration to access knowledge-based resources as it tends to take longer to access knowledge-based resources due to the organisational learning necessary to access them. Such a target time-span influences the type of international technology collaboration (Trifilova et al., 2013), being an especially significant issue for SMEs needing to balance

their limited resources strategically over a particular period of time.

Second, resource alignment is concerned with the way to access resources in a partner firm, this being divided into two categories[11]: *complementing* (i.e. to obtain others' resources by combining them with one's own resources); and *pooling* (i.e. to develop one's own resources by integrating them with the others' resources). Kogut (1988) argued that a joint venture is established either to *acquire the other's organisational know-how* or to *maintain one's own organisational know-how while profiting from the other's resources*. Extending this concept to strategic alliances, Das and Teng (2000) redefined the motives of strategic alliances as follows: "(1) to obtain others' resources; and (2) to retain and develop one's own resources by combining them with others' resources". Drawing on these works, complementing and pooling can be defined as follows. Complementing is to obtain a partner's resources by using them (indirect reach); in this case, a firm does not necessarily need to access the others' resources. Resources are combined but do not actually need to be fully integrated to be used for retaining or developing the resources of a focal company. From the perspective of the focal firm, overcoming weaknesses can be a primary purpose of this alliance. For example, a company lacking manufacturing capabilities can work with a partner possessing manufacturing facilities. In this case, the purpose of collaboration may not be improving its own manufacturing capabilities but using the partner's manufacturing facilities and capabilities. On the other hand, pooling is to obtain a partner's resources by accessing them (direct reach); in this case, a firm directly accesses the resources, which will then be used to develop their own resources. This alignment type is linked with strengthening corporate competitive advantages through collaboration. For example, a company specialised in demand forecasting technology can work with other companies with similar technology. Their collaboration may aim to create new applications of their technologies and thus the scope of their technologies will be improved by learning from each other.

Figure 3-1 shows a typology of motivations based on the two dimensions identified from the existing studies (Miller and Shamsie, 1996; Das and Teng, 2000). It should be noted that technology-based SMEs, which are the target focal firms in this study, are highly likely to be characterised by knowledge-based resources. Moreover, the resource type and alignment strategy strongly influence the way in which SMEs tend to manage their international R&D collaboration, something which will be discussed in the following section.

[11] The empirical analysis results also showed a clear distinction between two groups – SMEs seeking to obtain others' resources and SMEs seeking to develop their own resources, which strongly supports the use of this criteria.

	Property-based (Market-oriented)	Knowledge-based (Technology-oriented)
Complementing (To overcome weaknesses)	**Exchange** (To access local resources)	**Supplement** (To acquire necessary technologies)
Pooling (To improve strengths)	**Exchanger** (To establish vertical linkages)	**Companion** (To strengthen core competencies)

Figure 3-1. Types of motivations for SMEs collaborating with global partners (developed in this study)

3.3.2. Characteristics of each type of motivation

3.3.2.1. Capability-combining type

The first type is Capability-combining defined as *complementing the knowledge-based resources* of the partner firm. SMEs may contact overseas partners to acquire technologies they are lacking but which are necessary for their business (Mowery et al. 1998). For example, SMEs may share a market but sell different products, and their collaboration might target a system-level innovation, which requires an innovation in several of the system components. Therefore, a focal firm will search for a partner firm having some complementary resource for that shared market; horizontal collaboration to meet current market demands might be expected. Although SMEs in a collaboration network have less-protected resources, a focal firm does not need to transfer in the partner's technology; technology protection is not a problem because codified knowledge can be protected by contracts (Pisano et al., 1988) while tacit knowledge can be protected by controlling its exposure to partners. Furthermore, the necessity to work together is relatively low since the resources in the two firms do not need to be integrated directly. This knowledge sharing feature is observed frequently in modular designs (Sanchez and Mahoney, 1996), while being applied to more general cases. However, too few interactions or difficulties in contacting a partner may, in turn, reduce the possible synergistic effects from collaboration and can cause inter-organisational conflict.

3.3.2.2. Capability-building type

The Capability-building type is characterised by *pooling the knowledge-based resources* of the partner firm. The collaboration with overseas partners in SMEs may be motivated by the need to strengthen their core competences. SMEs pool their resources to explore future possibilities together; they pursue novel technology and test it in an existing market regardless of the eventual target market; sustaining their resources is a key motivation to collaborate. In this case, there is a tendency to search for partners with strong technology competitiveness in the relevant fields, with the purpose of collaboration being to acquire innovative technologies. Thus, the collaboration may last for a long time. In short, a focal firm searches for a partner firm having a similar resource in terms of content with a view to some future market; a horizontal collaboration aimed at meeting future market demands is likely to be formed. Since

SMEs in a collaboration network have less-protected resources, both the probability and the impact of opportunistic behaviour by collaboration partners may be high, increasing the cost of monitoring partners (Oxley and Sampson, 2004); trust-building is important to protect the firm from opportunistic behaviour by the partner firm (Dodgson, 1993). Compared to the Capability-combining type, frequent face-to-face meetings are needed to share their technologies, which, in turn, may increase the risk of unwanted knowledge spill-overs (Kogut and Zander, 1992; Gulati and Singh, 1988) or even intellectual property infringement (Schmiele, 2013)[12].

3.3.2.3. Stepping-stone type

The third category is the Stepping-stone type, defined as the *pooling of property-based resources*. In this type of collaboration, SMEs directly access a partner's property-based resources (for example, market-testing infrastructure, distribution channels, or a partner's collaboration networks) during the collaborative R&D, which helps them to develop their own resources. This access is especially useful for the purposes of technology localisation. One of the most efficient ways to enter a local market is to collaborate with local partners, which improves the knowledge needed for such localisation (Narula and Duysters, 2004). This collaboration will bring business stability as well as considerable opportunities to exploit their core competences. In this case, SMEs are likely to search for a partner firm willing to introduce their technology into a local market through joint R&D aimed at technology localisation. Consequently, a vertical collaboration for the front-end innovation[13] process is likely to be formed with this type of motivation. To introduce its technology into a local market, a process of localisation is essential. This involves collecting information from a partner, where such information is created from the partner's property-based resources, in order to help develop its own knowledge-based resources. Frequent interaction is needed to fully understand the needs of local markets, although the degree of localisation will affect the degree of interaction. Possible inter-organisational conflicts may arise when participants have different objectives for the collaboration due to differences in their resources and position in value chains. For example, a focal firm may want to achieve the goal of market expansion while its partner may seek to maximise profits. Such a misalignment may create undesirable tension between collaboration partners, often leading to the failure of collaborative projects.

[12] Schmiele (2013) argued that "firms with international R&D activities are increasing their chances of losing technological knowledge to their local competitors abroad".

[13] In this study, front-end innovation is defined as innovation activities from the interaction with markets, such as "idea generation from markets" and "market testing and refining the ideas". On the other hand, rear-end innovation refers to innovation activities involving engineering, such as "concept development", "prototyping", and "production".

3.3.2.4. Global-scouting type

The final category is the Global-scouting type, which is characterised in terms of *complementing property-based resources*. SMEs may want to access property-based resources such as intellectual property, manufacturing facilities, and prototyping facilities to complement their own resources. Especially when a partner firm has a locational advantage or some competitive advantage regarding such resources, using them can increase R&D efficiency. However, accessing these resources directly is unlikely to contribute to the firm developing its own resources; the best strategy is instead to use those resources with the support of the partner firm. This collaboration is expected to be observed when a focal firm needs to increase its R&D efficiency; it searches for a partner firm having complementary resources for a current market; vertical collaboration for the rear-end innovation process is likely to be taking place. In this case, SMEs have completely different resources and core competences; even unexpected knowledge spill-overs are unlikely to cause serious problems because deficiencies in absorptive capacity are likely to restrict actual knowledge sharing (Mowery et al., 1996; Lane and Lubatkin, 1998). The focus of collaborative project management in this case should be on clear communication between the firms; they are likely to work independently but for a single product or service, which may result in a different understanding of the collaboration outputs between the collaboration partners. However, possible inter-organisational conflicts may arise when the communication is primarily unidirectional. That is, if one party exercises too tight a control over the other party in an attempt to align their understanding of the collaboration process as well as the outputs, their relationships can be damaged.

3.4. Research design

3.4.1. Research method

A multiple-case study, which is often considered more robust and compelling than a single-case study (Stake, 2013; Yin, 2013), was adopted here as the main research method. Though a multiple-case study requires extensive time and resources, given the heterogeneity of SMEs (Mangematin et al., 2003), it was necessary to acquire sufficient cases to ensure external validity. The case study was in the form of an embodied case, with the characteristics of projects being observed in the context of the firms. Data on the motivations for different international R&D projects in each firm were collected, along with data regarding organisational learning from those projects.

In this study, a firm was selected as a case but the unit of analysis was the project. This study focuses on project-level characteristics which will be affected by the organisational context. Thus, it started from the various motivations for SMEs collaborating with international partners for their R&D by analysing a set of projects conducted previously. Then, it focused on a single project and examined the detailed process and the results of the project. Therefore, a static analysis was designed to investigate how different SMEs exhibit different patterns of international R&D collaboration. At the same time, a dynamic analysis was conducted to examine how the organisational strategies for international R&D collaboration evolved to meet the internal organisational needs and changing external environmental conditions.

However, since not all firms have a long history of international R&D collaboration, only a few (four out of 12 firms) have been selected and used for this dynamic analysis.

The international R&D collaboration projects investigated in this study were selected to meet the following conditions. First, in terms of organisation type, this study addresses issues concerning collaboration among SMEs. Thus, SMEs' collaboration with large enterprises that are likely to be their customers was not included within the scope of this study. However, if at least two SMEs are involved in a multi-lateral network and have specific collaboration experiences with each other, this project was added to our target case project. Thus, the second condition is that a bi-lateral relationship between the SMEs should exist in the collaboration network. Finally, their partnership should be a "co-development" type of relationship. A collaboration can take various forms ranging from one-directional technology insourcing or outsourcing (e.g. technology consulting, technology licensing, training) to more interactive technology development (e.g. R&D insourcing, R&D outsourcing, and collaborative projects). Firms are likely to be involved more actively in a project for the latter case, which is the focus of this study. In addition, a number of R&D collaboration projects have been carried out between headquarters and subsidiaries. In this study, headquarters and subsidiaries were regarded as a single company and the links between them were excluded from the target case unless the subsidiary was co-founded as a joint venture by a firm in a host country. These strict conditions created difficulties in finding suitable case companies but should nevertheless provide more reliable results with regard to the case study findings.

3.4.2. Target country, sector and companies

On the basis of the three conditions, South Korea (hereafter referred to simply as 'Korea') was selected as the target country. The reasons for this choice are three-fold. First, SMEs represent 99.9% of the total number of enterprises in Korea. Since SMEs play a very significant role in the Korean economy, they are worth focusing on. Second, according to OECD (2014), Korea devotes 4.4% of GDP to R&D expenditure[14], the highest among OECD countries, and the county also depends heavily on imports and exports. Nevertheless, it is ranked as one of the least active countries among OECD members with regard to international collaboration in the field of science and innovation (OECD, 2013). The country is therefore in a position to derive benefits from international R&D collaboration. Thirdly, a relatively large number of studies on international R&D collaboration have been carried out in the context of the EU (e.g. Bayona-Sáez and García-Marco, 2010; Martin and Moodysson, 2011; ZeW, 2011), possibly due to the active collaboration among European countries, while relatively little is known about the motivations, operations, and performance of collaborations in East Asia. With the accelerated globalisation of the world economy, R&D collaborations will occur in other contexts outside the EU, so these need studying as well.

[14] According to the Korean Ministry of Science and ICT (www.msit.go.kr), the large enterprises in Korea spent 51.1364 trillion Korean Won (0.8 %increase) in 2015, while the SMEs (other than ventures) spent 6.3753 trillion Korean Won (7.2% increase) and the ventures spent 5.8308 Korean Won (10.2% increase) in the same year

On the assumption that the case country was set to be Korea, information and communications technology (ICT) was judged to be the most suitable sector for investigation; ICT is the sector where Korea occupies a leading position (Choung et al., 2014; Lee et al., 2009) and hence there are a relatively large number of SMEs with global competitiveness in this sector. Also, technology standards are significant in this sector, which may be an antecedent of international collaboration.

The pool of qualified companies capable of providing valuable inputs for this study was constructed from three sources. The first is based on the list of SMEs identified as high-growth global companies by the *World Class 300* project in Korea. This project was initiated in 2011 by Korea Institute of Advanced Technology (KIAT), the government agency responsible for R&D planning in Korea (in particular for industrial technologies), and which is sponsored by the Korean government. The project aims to identify Korean SMEs that have increased their competitiveness in global markets, and which are expected to have high potential in the future, by not only in terms of strengthening their capabilities and pursuing continuous innovation but also in terms of collaborating, competing and doing business with global partners. The second is from the list of SMEs that have received Korean government subsidies for international R&D collaboration between 2011 and 2015. The final source is SMEs identified from news or public reports as those which 1) are successfully integrated into global value chains; 2) have gained meaningful outputs from international R&D collaboration; 3) have demonstrated relatively strong performance in the global markets and received a *Global Hidden Champion award* by the Korean government; or 4) were acknowledged as a leading innovator, receiving a *JangYongSil award*, or have been recognised as a company driving industry convergence, nominated as a *Leader of Industry Convergence*. By combining the three sources and also using personal networks, this study is expected to cope with the heterogeneity of SMEs as well as covering all the factors conceptualised.

Thus, the following conditions are taken into account in selecting the target companies;

- Has been involved in both domestic and international R&D collaboration – either bi-lateral or multi-lateral international R&D collaboration including R&D outsourcing or R&D-based manufacturing outsourcing – in the last ten years;
- Has fewer than 300 employees (the criteria for an SME in Korea are “fewer than 300 employees” and “sales worth 30 billion won or less”);
- Is a born-global SME or a globalised SME rather than the affiliate of a large firm that tends to focus on domestic markets and whose innovation strategy is likely to be affected greatly by its partner.

3.4.3. Companies interviewed

Accordingly, 14 SMEs that responded to a request for an interview were investigated during the period from July to November 2016. **Table 3-1** lists the firms interviewed.

Table 3-1. A list of firms interviewed

Firm	ICT sector	Collaboration items	Interviewee	Interview date
F1	HW	Vision system	Project manager	26/07/16
F2	SW	IoT and data analytics	CEO	27/07/16
F3	Content	Game	Project manager	27/07/16
F4	SW	CAD/CAM	CTO	28/07/16
F5	SW	Data analytics	CEO	02/08/16, 09/02/17
F6	HW/SW	Voice recorder	CEO	02/08/16
F7	Content	K-pop	Top manager	02/08/16
F8	HW/SW	Healthcare device	CEO, Project manager	03/08/16
F9	HW	Transceiver	Top manager	08/08/16, 21/11/16
F10	Content	Education	Project manager	17/08/16
F11	SW	Environment	Top manager	28/09/16, 24/11/16
F12	SW	Vision system	CTO	29/09/16, 19/11/16
F13	Content	Game	Top manager	08/10/16
F14	SW	RFID	Project manager	12/10/16

In each company, a maximum of two managers – mostly top managers – were involved in the study, as R&D projects in SMEs were likely to be planned and managed by only a few managers and carrying out additional interviews was therefore unlikely to bring additional benefits. Out of the 14 SMEs, eight were drawn from the lists of companies awarded World Class 300 status, nominated as a leader of Industry Convergence, or funded by the government for their international R&D collaboration. Five others were derived from personal networks and one was introduced by interviewees. In this sector, most established firms were involved in international R&D collaboration using funds from government programmes that facilitate such collaboration, while start-ups were more likely to fund themselves.

3.4.4. Contents of interviews

A semi-structured interview was conducted using both a face-to-face meeting and a skype meeting. The interview content is divided into six categories: 1) General organisational-level motivations of international vs domestic R&D collaborations; 2) Basic information about a project selected for further investigation; 3) Motivation of the project in terms of “internal and external drivers of initiating the collaborations” and “expected and actual benefits and costs of the collaboration”; 4) Organisational learning process regarding activities, facilitators, and inhibitors; 5) Operational strategies in terms of target technology, partner selection and project management; 6) Government policies and their impact on the motivation of international R&D collaborations (see Appendix 8.3 for more details).

Using the data collected, the typology of motivations was tested by assigning the 14 firms to the four types of motivation, while the evolution of that motivation was also examined. Second, the operational strategies for international R&D collaboration, which are expected to be different from those for domestic R&D collaboration, were examined. Here, as different motivations could potentially influence behaviour in different ways and thus yield distinctly different costs, benefits, and operational strategies, the differences in motivation were considered in the second analysis.

3.4.5. Analytic framework

To investigate the factors affecting the success of cross-country R&D collaboration in SMEs, the Structure – Conduct – Performance (SCP) model, developed by Bain (1959) to explain firm performance through economic conduct in incomplete markets, was employed in this study. The model has been used to test the SCP hypothesis – that a firm's performance increases with increased industry concentration, which brings with it more possibilities to generate a profit – in several industries (e.g. Samad, 2008; Weiss and Choi, 2008). It has also been used as an analytic framework for various purposes such as for investigating market structure (Mesher and Zajac, 1997), strategic networks (Klint and Sjöberg, 2003), and the process employed by SMEs to identify technology opportunities (Cho et al., 2016). In this study, the SCP scheme is used as an analytic framework; the original model was defined at the industry level but was modified at the firm level to explain the performance of collaborative project in relation with project management, motivation for a collaborative project, and external factors affecting the motivation.

On the basis of this model, the organisational environment has a direct short-term impact on the motivation for international R&D collaboration. Then, the motivation, which may evolve over time, has a direct influence on how the firm operates the collaborative R&D project with respect to 'partner selection' and 'project management' strategies, which in turn affects the success of the project. Additionally, two external factors that are expected to affect the motivation are investigated, namely 'policy support' at the national level and 'technology characteristics' at the sector level. According to Gassel and Pascha (2000), Japanese firms are reluctant to provide others with access to their internal resources, but are inclined to engage in joint R&D if this is sponsored by the government. Cho et al. (2016) found that the main macro-level drivers of SMEs' efforts to identify technology opportunities include market and technology changes. In these cases, the motivation is extrinsic. Consequently, a conceptual framework consisting of four elements was developed as shown in **Figure 3-2**, but the focus of this study is limited to the factors directly related to the motivations: 1) types of motivation and its evolutionary characteristics (structure); 2) motivation-specific behaviour (conduct); and 3) national and sectoral factors affecting the motivation (external factors).

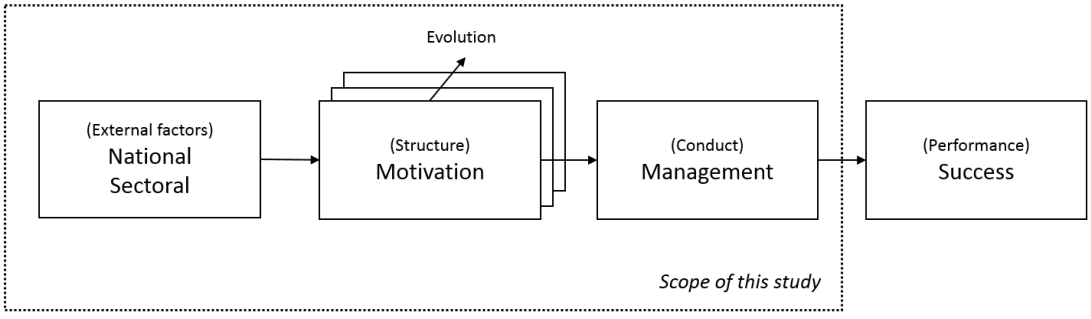

Figure 3-2. Analytic framework (adopted and modified from Bain, 1959)

3.5. Analysis results and findings

3.5.1. Types of motivations

The motivations of SMEs, focusing on their main international R&D collaboration projects of concern, were mapped onto a two-dimensional space according to the type of resources (*knowledge-based* or *property-based*) and the alignment of resources (*complementing resources* or *pooling resources*) by directly asking the two dimensions. Though it was rarely the case that a project was initiated only for one type of opportunity or that it aimed at only one type of purpose, there was a marked tendency among the SMEs to emphasise one motivation above the others. Four types of motivation in relation to international R&D collaboration projects were clearly observed in the 14 projects, and the approach adopted to organising and operating the project differed according to the type of motivation. In general, Korean SMEs occupied a position of leadership in a collaboration network involving property-based resources, while the opposite was true for knowledge-based resources. **Table 3-2** shows the results of assigning the 14 projects to the four types of motivation along with detailed information regarding the purpose of the collaboration. More detailed analysis results for each project is summarised in Appendix (see **Appendix 8.5**), and the international R&D collaboration models observed in the cases are summarised in **Figure 3-3**.

Table 3-2. Motivations of international R&D collaboration among SMEs

Type	Project	Detailed collaboration purpose	Partner
Capability-combining	F1	A HW firm working with a SW firm to develop a security system	Israel
	F2	A SW firm working with a HW firm to develop an evacuation system	Israel
	F4	A SW firm working with a HW firm to develop a manufacturing system	UK
	F6	A SW firm working with a HW firm to develop an audio recorder system	US
Capability-building	F5	Technology exploration by identifying early-stage technologies	Germany
	F9	Technology exploration by establishing global networks	Netherlands
	F14	Technology exploitation by working with a firm in global value chain	Czech
Stepping-stone	F3	Content localisation with the help from a local distributor	China
	F7	Content localisation with the help from a local distributor	China
	F11	Technology localisation for the EU market	Spain
	F12	Technology localisation for a potential client firm	Turkey
Global-scouting	F8	Outsourcing R&D-based prototyping	China
	F10	Outsourcing R&D-based manufacturing	China
	F13	Outsourcing ideas for further R&D	Israel

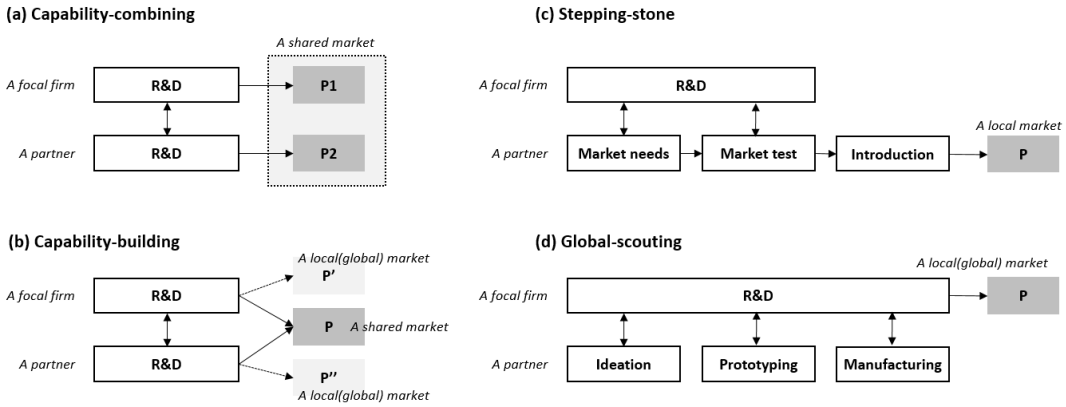

Figure 3-3. International R&D collaboration model among SMEs

3.5.1.1. Capability-combining type

SMEs in this type of collaboration network focused on different parts of the final product and pursued the development of a new technology (product) by combining their technologies. They have products and core technologies that are completely different from each other, while sharing the same target market. For example, F4 is a company that provides a software (SW) system to be embodied in manufacturing or medical equipment. It worked with a Chinese partner, a hardware (HW) firm selling electrical discharge machining equipment. The CTO of the company explained the motivation as follows:

> *"The two SMEs worked together to develop an integrated system for targeting a customer using particular HW embodying customised SW for the HW. We collaborate only when we expect a potential and clear market for combining the products produced by the two companies. Since each of the two SMEs develops and sells their own products, we have neither any intellectual property (IP) issues nor any profit-sharing issues (F4, CTO)."*

Similarly, F1 is a company selling the electronic device for a security system (HW), while its partner company in Israel specialises in the data analysis of images (SW). The final system, which includes both HW and SW modules, targeted clients needing a security system. F2 is a solution provider that has worked with a HW firm to develop an evacuation system embodying its solution.

In general, firms in this category are SMEs specialised in a particular module in a large ICT-based system such as a manufacturing system, a network-based security system, or an Internet of Things (IoT) platform. SMEs in a collaboration network are in charge of different modules of an end-product system; they work relatively independently, developing their own products (technologies) but targeting the shared market, usually in the form of *horizontal collaboration aimed at meeting current demands*. Hence, the purpose of the collaboration is to *acquire the technologies necessary to achieve a system-level innovation*. The Korean SMEs studied decided to work with an international partner because they had failed to find a suitable domestic partner for collaboration; they are technology leaders in their fields, wanting to find another technology leader with complementary capabilities.

3.5.1.2. Capability-building type

SMEs involved in this type of collaboration network are focused on emerging technology; they pursue novel technology (for a new product or service) by exploring new possibilities together. They have a similar interest in technologies (products) and hence try to develop a new market based on their interests. For example, F5 is a leading SW company in Korea, which provides solutions for real-time 'big data' analytics to forecast future trends based on next-generation cloud and artificial intelligence technologies. The CEO of F5 stated:

> *"We have been involved in this project to get a hint for new businesses targeting the future beyond the next five years. Therefore, the outcome of this project is not coming directly from this project, but rather from another project, which is called a "shadow project". When we are involved in this kind of collaborative project, we are also carrying out another internal project, which enables us to embody learning from the collaborative project in it. As companies in the network are targeting regionally different markets, we are not as competitive as you might*

think. (F5, CEO)"

Similarly, F9 has been collaborating for several years with partners in the Netherlands and Finland to develop an ICT network module (a next-generation transceiver[15]), though unfortunately the market is not as promising as it seemed when the collaboration was originally initiated. F14 worked with a company in Czech Republic because that country has good vendors in certain global automobile value chains. Working with the partner was expected to offer new opportunities to improve its technology; the Korean market was relatively underdeveloped, since global standards had not been adopted, and thus the firm decided to exploit their technology firstly in the European market and then come back to the Korean market, after developing their capabilities in the more mature market.

This type of collaboration can be defined as a *horizontal collaboration for future opportunity*, where companies that could be potential competitors tend to work together on a challenging project. As in the case of F14, a domestic market is sometimes not mature enough to test their leading-edge technologies and enabling technologies are not available in their domestic markets, which leads them to seek global partners to test the feasibility of their technologies. Unlike large multinational enterprises (MNEs) that are capable of supporting a large-scale project with a large budget, SMEs are likely to have only a limited budget to invest for their medium- and long-term future, which encourages SMEs to collaborate with the aim of improving their capabilities and strengthening their core competencies. Even when they fail to commercialise their collaborative R&D outputs, their capability-building efforts will generally be useful for developing further businesses. Korean SMEs decided to work with international *partners to keep up with leading technologies in a global market but also to avoid domestic competition*.

3.5.1.3. Stepping-stone type

Four of the companies interviewed correspond to this type of collaboration network. Korean companies pursue technology exploitation by introducing their products in foreign markets, usually Asian markets, while their foreign partners seek to distribute products from the Korean companies in their own countries. Of the four companies, two are content providers; one is a game developer, the other a company providing user experience (UX) design solutions that work in a digital environment. The other two are IT solution providers whose technology needs to be customised to the region and customer in order to be useful. SMEs in this category commonly offer technology-based content or solutions. There usually exists a prototype product developed by Korean companies or sometimes the product is already being sold in Korea. However, before introducing the product to a foreign market, the companies need a process of localisation to ensure effective market penetration. One of the game-developer companies explained the reason for collaboration as follows:

[15] This is a transceiver module whereby operators can migrate and integrate their SONET/SDH transport network into a single technology packet network in Carrie Ethernet networks.

"The preference for a particular game type may vary by gender and culture. When publishing our game, it is advantageous to find a "publisher" company in a target market. In our collaboration with a Chinese company, the partner company's role was to provide information about the target market, to collect feedback from customers, and to suggest ideas to localise our game. During the closed beta-test and the open beta-test, the partner publisher collected user feedback and then requested modifications of the game content, mostly related to user interfaces. (F3, PM)"

F7 initiated its collaboration with a Chinese partner to test the market feasibility of its products in the Chinese market. The partner provided a location to exhibit its music content in China while the Korean company established a digital signage content system[16] in the location and operated it for Chinese customers. On the other hand, F12, a Korean SME specialising in a particular camera system, initiated its collaboration with a Spanish SME, because the collaboration partner was a potential purchaser company. Its main motivation for becoming involved in this collaborative R&D project was to develop a new product that might be purchased by its collaboration partner, an upstream value-chain player.

Thus, the purpose of collaboration is to jointly introduce the product into a foreign market with foreign partners either as a buyer or a provider, which is a form of *vertical collaboration for front-end innovation processes*. Companies in this collaboration network work very closely together to localise the products in a new market, where a foreign company is involved in, or even in charge of, testing and operating the products. Korean SMEs decided to work with international collaboration partners *to effectively enter a foreign market*. MNEs tend to have their own subsidiaries in the main country for their businesses; a collaboration network is more likely to be formed between the subsidiaries and local firms in MNEs. On the other hand, the motivation to work with foreign partners to enter a foreign market is likely to be strong in SMEs, as their foreign partners are one of the few sources available for them to collect information about the local market and to keep the information up-to-date.

3.5.1.4. Global-scouting type

Finally, Korean SMEs are sometimes involved in pursuing a new business opportunity and the collaboration is formed to explore such an opportunity. The distinguishing feature of this type of collaboration compared to the *Stepping-stone* type is that foreign resources are needed to develop and commercialise their technology in an effective way. Such a collaboration was usually initiated by Korean start-ups; they worked with a partner to co-develop and subsequently to co-manufacture their new products. For example, F8, which is a start-up offering an ICT-based healthcare system, said that:

"We worked with a Chinese company to develop a prototype for our new product. There was no Korean company that was capable of making the prototype we requested in such a short time

[16] Digital signage is signage that displays digital content (e.g. images, video, streaming) using LCD, LED or Projection technologies, together with its management software that pushes information on the display via the Internet. It can be used for various purposes such as exhibitions, marketing, and outdoor advertisements.

and with a limited budget. China is a perfect place to find companies that can help us make a final prototype. Though we developed our prototype in China, we are targeting the domestic market at this moment (F8, CEO).”

F10 had a similar motivation. For these two SMEs, R&D collaboration took the form of outsourcing prototyping and acquiring manufacturing capabilities from other foreign SMEs that are likely to be downstream value-chain players. Content can be outsourced as well; F13 keeps searching for a game that might be attractive to the game players in the market. Once it comes across such a game, it contacts the game developer to request permission to localise the game or to co-develop another game with it.

Hence the purpose of this collaboration is to make the best use of global resources in the form of *vertical collaboration for the backend innovation process*. MNEs may have regionally distributed R&D operations, but SMEs recruit international collaboration partners to have similar effects to regionally distributed R&D operations. The Korean SMEs in this collaboration network are willing to work very closely with collaboration partners because developing a new product requires frequent interactions. They decided to work with international collaboration partners because the partner’s country is one of the best places to co-develop and manufacture their products in terms of time, cost and performance. That is, international R&D collaboration is a means for SMEs *to increase their R&D efficiency by accessing local resources*.

3.5.1.5. Evolution of motivation

The motivation at the project level can evolve as a firm grows. Further analysis was therefore conducted to understand the changes in motivation over time. Of the 14 firms investigated, four with a relatively rich experience of R&D collaboration with international partners (F5, F9, F11 and F12) were chosen for this analysis, and the history of their engagement in such collaboration has been investigated by gathering data from their homepages and conducting a second round of interviews. Interesting evolutionary patterns were observed in the four companies; the motivations of three companies have moved from *Capability-building* to *Stepping-stone* (F5, F9 and F11), whereas the motivation of the other company has remained unchanged as *Stepping-stone* (F12).

The international R&D collaboration projects in F5, F9 and F11 exhibited the characteristics of Capability-building early on but have shifted to the Stepping-stone category in later projects. F5 is a leading company in the domestic market for big data analytics and has a strong level of technological competitiveness[17]. There is a widespread belief that Korean SMEs prefer US, Japanese, or Chinese

[17] Its technology superiority is clearly demonstrated in the volume of its intellectual property: the company has 21 patents granted, 48 patents applied for, and 65 software packages registered. It was also awarded various prizes by the Korean government for its technologies and technology management practices. Furthermore, it is well known for its R&D globalisation strategies. In addition to these R&D globalisation efforts, the company has expanded its market from domestic to international.

partners because those countries offer significant advantages as collaboration partners; the US and Japan have leading technologies, while China has a large market and is geographically close to Korea as well. Nevertheless, the company first approached European companies, after which it started to expand its collaboration network to Japan and the US. Its first international R&D collaboration was in the form of participation in EU FP projects for Capability-building. Its technological superiority together with government support enabled it to become involved in various projects, improving its technological strengths. With these strengths, the company then collaborated with Japanese companies to enter Japanese markets - i.e. a Stepping-stone motivation.

F9 started its R&D collaboration with US companies; the CEO who is a founding member of the firm studied in the US, which opened up various possibilities for collaboration with US firms. In addition, the R&D collaboration in the early stages focused on technology in-transfer from leading companies in the US, representing a Capability-building motivation. However, once it had considerably developed its technological capabilities, it found a European partner to co-develop capabilities and competences, again representing a Capability-building motivation. In contrast, it is now interested in networking with Southeast Asian countries with a Stepping-stone motivation.

F11 started its collaboration with Germany and Slovenia for demand forecasting technology, aiming to advance the technology together, in other words, a Capability-building motivation. The next collaboration was on smart grid technologies in Spain with European partners; the aim of the collaborative project was to test its world-class technology in a real-world setting, i.e. closer to a Stepping-stone motivation. Though the economic benefits from the previous projects were not satisfactory, the capabilities acquired from those projects were useful for further business development in other countries.

The collaborative projects in the Capability-building category were exploratory and risky, but the companies continued with the projects as their learning from those projects was expected to form the basis for other projects, as the CTO of F11 explained:

> *"We wanted to test our technology in a real-world setting but the Korean market was so small and still at an early stage of development so it was difficult to implement such a pilot test with domestic partners. The purpose of our involvement in the project was to use the European market as a testbed for our technology. Though we did not manage to commercialise our new technology in the European market, the experience of European energy markets opened up a new possibility to start a new business in African countries; we have thus expanded our consulting business from domestic companies to African companies (F11, CTO)."*

In particular, the capabilities acquired through international R&D collaboration include not only technological capabilities but also management capabilities, the latter being essential to conduct business successfully in a foreign country.

3.5.2. Motivation-specific behaviours

This study assumes that the motivation for collaboration is determined by the types of resources required by a focal firm. Hence, the partner selection criteria may also be affected by the motivation, given that different partners are likely to have a different set of resources; the partner selection criteria may be seen as the resource selection criteria. In addition, the motivation for collaboration is defined on the basis of how resources in two different firms are aligned. Thus, the project management, which is interpreted here as a set of activities to explore, assimilate, and exploit resources, is again influenced by the motivation. So, motivation-specific behaviours are investigated in terms of *partner selection criteria* and *project management practices*.

3.5.2.1. Partner selection criteria

Despite the great diversity in partner search processes regardless of motivation, the criteria regarded as most significant during partner selection processes showed differences among SMEs relating to different motivations. In order to investigate the criteria recognised as important in each type of motivation, 10 potential criteria were identified from the literature (see **Table 8-9** in Appendix) and a follow-up survey questionnaire was sent to the interviewees. The criteria were designed from the perspective of expected costs and benefits on the premise that organisational decisions are generally made on the basis of such costs and benefits; costs are related to the level of resources required for the collaboration while benefits are concerned with the extent of the outcomes expected from the collaboration. An analytical hierarchy process (AHP) analysis was conducted to assess the recognised importance of each criterion in each company. **Table 3-3** presents the results of this analysis.

Table 3-3. The relative significance of partner selection criteria by motivations (%)

Category	Sub-category	Criteria	Capability-combining (F1, F4, F6)	Capability-building (F5, F12)	Stepping-stone (F9, F14)	Global-scouting (F10)
Costs	Direct	Human resources	7.0	14.5	12.9	6.0
		Financial resources	2.2	4.9	41.1	16.7
		Time	9.0	3.1	14.3	54.4
	Indirect	Organisational difference	8.1	1.7	4.7	4.3
		Opportunistic behaviours	2.6	5.8	10.7	4.3
Benefits	Direct	New products	40.9	32.6	11.6	6.4
		Intellectual properties	10.4	10.7	2.4	0.7
	Indirect	Capabilities increase	6.6	15.5	1.3	0.8
		Images	6.5	4.9	0.4	3.2
		Networks	6.6	6.3	0.6	3.2
Total			100.0	100.0	100.0	100.0

Note 1: Eight out of the 14 interviewees answered for the follow-up survey, which could cover all the four types.
Note 2: The dark grey cells indicate the criteria that are regarded as the most and second-most significant.

In general, companies pursuing *market opportunities* on the basis of *short-term relationships* with their international partners, that is, those with Stepping-stone and Global-scouting motivations, are more likely to be concerned with costs than benefits. For example, F10 was a start-up looking for a partner that could provide manufacturing technologies for its new product; quite naturally, the most significant sub-

criteria for partner selection was *time* with the emphasis on introducing its novel idea ahead of potential competitors, followed by *financial resources* required for the collaboration. Companies with a Global-scouting motivation tend to consider time and financial resources as key selection criteria for international partner selection. Like companies in the Stepping-stone category, the two criteria of *financial resources* and *time* are crucial in choosing an appropriate partner but in the opposite order. The goal of collaboration for companies with a Stepping-stone motivation is to enter a foreign market efficiently using less financial resources and in a timely manner.

In contrast, companies pursuing *technology opportunities* on the basis of *long-term relationships* with their international partners, that is, Capability-combining and Capability-building motivations are more likely to emphasise benefits rather than costs, or at least to regard both equally significant. In both types, they seek for the partners that can contribute to their new products. However, the direct benefits – *producing new products* and *intellectual properties* were key criteria for firms having Capability-combining motivation, while indirect benefits such as *images* and *network* were relatively more significant than the others. As a final product delivered to the customer is a set of combined modules produced by several companies, the product's performance is realised by customers as a whole, with the customer's purchase being influenced by the reputation of each of the companies involved in developing the product. Moreover, the customers in a partner's business network can offer a potential target market for the focal firm. Hence, the partner's image as well as its business network is expected to influence the collaboration outcome. On the other hand, the criterion of *increased capabilities,* along with *new products*, is identified as one of the most significant factors in companies with a Capability-building motivation. The possibilities of developing a new product through collaboration and of increasing the firm's capabilities through such collaboration are among the most important factors when selecting a collaboration partner.

3.5.2.2. Project management practices

Different forms of project management were observed for collaborations with different types of motivation. In the *Capability-combining* type of collaboration, each company was responsible for developing its own technologies to be used for a final product. SMEs in the collaboration network set a milestone for each project task to ensure that the task was completed as scheduled. Only a few face-to-face meetings for R&D were used to manage the collaboration project. A *restricted learning process* was observed during international R&D collaboration among SMEs in this category. Of the four types of learning processes suggested by Nonaka et al. (2000), *combination*, i.e. learning from transforming explicit knowledge into further explicit knowledge, was dominant, while tacit knowledge was rarely transferred; the collaboration was initially designed in a way to achieve the *combining of complementary capabilities* rather than *capability-transfer*[18]. Interestingly, F1 mentioned difficulties in contacting its

[18] Doz and Hamel (1997) argued that a firm's alliance strategy might focus on "combining complementary

partner; SMEs can work relatively independently but excessive independence may harm the collaboration outputs.

In the *Capability-building* type, each company was responsible for developing its own technologies; as with the previous type, milestones were used but this time together with relatively frequent face-to-face meetings. The meetings were to share new knowledge and also to manage the project. An interesting case was F5, which conducted a shadow project – an internal R&D project conducted simultaneously with its collaborative R&D project – in an attempt to develop its own knowledge-based resources. The shadow project aims to internalise and further advance the technologies obtained from the collaborative R&D, as well as to identify new applications for the technologies; it is a part of internalisation learning process among four types of knowledge transformation suggested by Nonaka, which is essential to maximise the opportunities to learn from others. The firm also insisted that its collaboration partners were willing to share their technologies as they were targeting a regionally different and future-oriented market; such different target markets and high risks embodied in the collaboration projects may remove the barriers in knowledge transfer between firms.

In the *Stepping-stone* type, Korean engineers stayed in the partner company for a relatively long time to introduce and customise their products effectively. However, this tendency was affected by the degree of localisation necessary to introduce their products to a foreign market. When only a small amount of localisation was needed (e.g. F3), few visits to the partner company were made. In contrast, when a great deal of localisation effort was required (e.g. F7), frequent visits to the local company were made. F12 mentioned that the collaboration partners did not want to provide details of their technologies and thus they could not learn anything from them; the openness of partners in the interaction process is significant in developing the resources in a focal firm.

Finally, in the *Global-scouting* type, Korean engineers were staying, or at least had the intention to stay, in the partner company over the course of the project to ensure clear communication. The motivation for SMEs in this category is to improve R&D efficiency as a short-term aim rather than to learn from others as a long-term goal. Physically staying in the same place enabled quick decision-making. Milestones were set to check the project's progress and a few face-to-face meetings were used for decision-making.

3.5.3. External factors affecting the motivation

Though this study emphasised the role of resources as a determinant of motivation, other factors can affect the motivation to engage in international R&D collaboration as follows.

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capabilities" or "transferring capabilities" and could also be "individual alliances" or a "network of alliances." Accordingly, they suggested four types of strategies.

3.5.3.1. Policy support

Government funding has facilitated international R&D collaboration especially of the *knowledge-based resources* type. Most SMEs in *Capability-combining* and *Capability-building* types of collaboration were funded by government; these are mainly companies with a leading technology in their particular area and, quite naturally, engaging in collaboration has opened up possibilities not only to improve their technology but also to expand their business to global markets, as was shown in the shift from *Capability-building* to *Stepping-stone* motivation. Particularly with European partners, Korean SMEs' collaborations were in the form of involvement in EU-funded projects, where Korean SMEs were funded by the Korean government and their European partners by EU programmes.

Some companies say that they started the collaboration to access the government funding (e.g. F12) but later found that the international R&D collaboration generated considerable benefits so they decided to continue to work with foreign partners. On the other hand, one company (F9) had had discussions regarding R&D collaboration with a foreign company, and the government funding enabled the initiation of actual collaboration. In addition to direct funding, the government provides a match-making service designed to promote collaboration between Korean and foreign SMEs, and sometimes contacts a candidate company for such collaboration in response to a request from a foreign government. Government funding is another type of resource that SMEs want to acquire from international collaboration with other SMEs.

3.5.3.2. Technology characteristics

The characteristics of technology in an industry can affect the tendency towards and patterns of international R&D collaboration among SMEs, as was addressed by Herstad et al. (2014) who emphasised industrial knowledge bases and technological regimes condition in investigating the degree of international innovation collaboration. R&D collaboration without the need for frequent interactions is feasible in the ICT sector, the target industry sector here. One recent ICT trend can be characterised in terms of the development of a product-service system (PSS), defined by van Halen et al. (2005) as "a marketable set of products and services capable of jointly fulfilling a user's needs". In a PSS, a number of products and services are integrated into a single system to offer value to customers. In such a system, SMEs providing different parts of the system can work together but relatively independently, once the specifications of each part making up the whole system have been clearly established when the collaboration is initiated.

Secondly, industries operating primarily on the basis of tacit knowledge tend to pursue collaboration on a more localised scale (Martin and Moodysson, 2011). In contrast, technology in the ICT sector is characterised more by explicit knowledge (Jung and Lee, 2010), which encourages collaboration on a much wider scale. Furthermore, SMEs have only a limited capability for learning. Yet, technologies that SMEs possess in the ICT sector are sometimes quite complex and specialised, so learning from partners during the collaboration may not be as straightforward as it first appears. When asked about the possibility of unwanted technology spillovers during R&D collaboration, most interviewees answered

that there are few such possibilities. The characteristics of their technologies might consequently have prevented their partners from learning from them, and vice versa.

3.5.4. Discussion

Although resource-based theory has been widely adopted by scholars, it has been criticised for certain weaknesses in its applicability in business practice[19]. The theory suggests that organisations have to develop strategic resources that are valuable, rare, non-imitable and non-substitutional to gain sustained competitive advantages without adequately explaining how to develop such resources (Priem and Butler, 2001). This study attempts to overcome the limitations of resource-based theory by extending it to provide more practical managerial implications.

Theoretically, this is one of relatively few attempts to apply resource-based theory to a specific type of strategic alliance – international R&D collaboration among SMEs. By focusing on a specific type, a number of practical implications could be derived. As shown in **Table 3-4** that are based on the discussions in Section 3.5.1 and supported by the findings in Section 3.5.2, various motivations could be identified and these were linked to the resource combination process through such concepts as "collective strength", "partner selection criteria", and "project management practices". As a consequence, the analysis results suggest a strategy to acquire necessary resources from overseas partners via R&D collaboration, which is based on the types of resources and resource alignment. Stepping-stone and Global-scouting have been frequently mentioned in previous studies of large enterprises, although the best way to manage collaborative projects may be different in SMEs, while Capability-building and Capability-combining may be relatively unique motivations; they reflect SMEs' collective efforts to overcome their limitations of small size while making the best use of their specialised knowledge and skills.

[19] Kraaijenbrink et al. (2010, p.351) in their critical review of the theory classified the criticisms into eight categories: "(a) the RBV [resource-based view] has no managerial implications; (b) the RBV implies infinite regress; (c) the RBV's applicability is too limited; (d) SCA [sustained competitive advantage] is not achievable; (e) the RBV is not a theory of the firm; (f) VRIN/O [valuable, rare, inimitable and non-substitutable organisation] is neither necessary nor sufficient for SCA, (g) the value of a resource is too indeterminate to provide for useful theory, and (h) the definition of resource is unworkable."

Table 3-4. Characteristics of international R&D collaboration by motivation

		Capability-combining	Capability-building	Stepping-stone	Global-scouting
Collective strength		System-level innovation	Future-oriented innovation	Innovation for a foreign market	Efficiency in innovation
Partner selection criteria	Target partner	Complementary technologies (horizontal)	Similar technology interests (horizontal)	Technology localisation (vertical: front-end)	Complementary properties (vertical: rear-end)
	Expected role	Co-designing and marketing products to build brand image and networks together	Co-developing innovative new products as well as co-learning	Reducing the financial resources needed to enter a foreign market	Reducing time needed to enter a market
Project management practices	Management focus	Clear goal-setting	Organisational learning for knowledge exchange	Frequent interaction for knowledge in-transfer	Clear communication
	Possible conflicts	Difficulties in interaction	Opportunistic behaviours	Different objectives of collaboration	Too much control

Methodologically, this study is distinguished from prior research in three respects: the target firm is SMEs; the unit of analysis is at project-level as well as organisational-level; and the primary focus of the analysis is on motivations – linked to the needs and conditions – which may lead to a particular set of results. The table above indicates that operational strategies for international R&D collaboration in SMEs differ by type of motivation. Thus, before starting such a collaboration, SMEs should clearly understand what kind of resources they are seeking from their partners and why. This starting requirement is also applied to intermediaries in charge of matchmaking. To achieve successful collaboration, intermediaries need to draw on partner selection criteria customised to each type of motivation.

As to external factors, it is evident that government funding has a positive influence in terms of increased motivation to engage in international R&D collaboration in line with the findings from Huergo and Moreno (2017), suggesting that direct R&D support stimulates R&D activities, and those from Hottenrott and Lopes-Bento (2014), showing that the public subsidies trigger R&D spending as well as R&D productivity especially in SMEs collaborating with international partners. However, if the international R&D collaboration was initiated by government funding, the possibility of success may decrease for two reasons. The first is at lack of desire to collaborate. One reason why SMEs decided to collaborate with at international partners was to access research funding, as mentioned by F12. As the funding for international R&D collaboration is relatively uncompetitive, it may be used to enable an SME that might otherwise have gone bankrupt to carry on, which then has a negative effect on both the collaboration partners and also the global innovation system. The second reason relates to the characteristics of the project. SMEs tended to carry out relatively challenging projects within government-funded programmes, as noted by F9. In this case, even when a project failed in terms of its performance targets, SMEs often believed that it generated a considerable amount of indirect benefits, especially networking effects, and they were more positive in assessing its success. Therefore, the effect of government spending in improving the innovation capabilities of SMEs may be debateable, in line with previous contradictory claims about the role of subsidies in private financing (David et al., 2000; Hall and

van Reenen, 2000).

3.6. Conclusions

This study aimed to investigate the motivations underpinning international R&D collaboration among SMEs. For this, four types of motivations – *Capability-combining*, *Capability-building*, *Stepping-stone* and *Global-scouting* – were defined drawing on resource-based theory, and the resulting typology was tested with case studies of 14 companies. The research findings indicate that SMEs' motivations for engaging in international R&D collaboration can be distinguished in terms of two dimensions – the types of resources in a potential partner, and the way to align its resources with the partner's. Furthermore, these resource characteristics have affected the project management processes – in particular, the partner selection criteria and project management practices – in SMEs. Unlike large MNCs, SMEs' motivation depends greatly on the resources they possess and those that they need, these being relatively diverse. It also has been influenced by government policy and industry characteristics; the case study results showed the significance of government policy in facilitating such collaboration, especially for collaborations focusing on knowledge-based resources.

Despite these meaningful contributions in terms of extending resource-based theory further into the realm of practice, this study is nevertheless subject to several limitations. First, our case study was carried out in the context of Korean firms in the ICT sector. Since national characteristics can affect SMEs' motivations to globalise their business and collaborate with international partners in their R&D, these findings from the Korean context need to be tested in other country contexts. Similarly, the findings from the ICT sector need to be tested in other sectors. Second, this study investigated only 14 SMEs. With more case companies, more types of motivations may be identified. Further study is required to establish the generalisability of the research findings. Third, despite the fact that collaboration involves an interactive process between participants, this study restricted its focus only just one of the participants in each collaboration. For a fuller understanding of how such collaborations are formed and managed, more in-depth case studies are needed involving all participants in each collaboration. Finally, a dichotomous approach was adopted to define the various types of the collaboration and in assigning collaboration projects to one of the motivation types. However, using a continuum to assign the projects could also be explored. Future research will address these issues.

A number of key policy implications can be derived from the research findings. First, various motivations for international R&D collaboration are observed, which points to the need for some diversification of government support for SMEs. Furthermore, the motivation evolves as experience of collaboration is accumulated. Nevertheless, government programmes to support SMEs' international R&D collaboration are likely to be limited to in-transfer of superior technologies or entering new foreign markets, at least in the case of Korea. More sophisticated programmes need to be developed to satisfy the varying needs of SMEs, and different systems for monitoring and evaluating project and programme performance need to be applied to collaborations with different motivations and different operational strategies.

Second, each of the motivations possesses distinguishing characteristics in terms of the establishment and management of the collaboration. To gain the most benefits from international R&D collaboration among SMEs, SMEs need to be fully aware of the characteristics of the collaboration in which they are planning to engage, thereby increasing the chances of success as well as their satisfaction with the collaboration. The government's role would be to support them in minimising the possible conflicts.

The final policy implication concerns the role of funding. Government funding has facilitated collaboration based on knowledge-based resources, playing an especially significant role in "initiating" such collaboration. International R&D collaboration among SMEs can be a powerful means to improve the innovation capabilities of SMEs. However, there may be two quite different types of SMEs; one seeks to access funding for internal R&D, while the other seeks to use the funds to accelerate international R&D collaboration. SMEs that can benefit more from the funding will tend to be of the second type. Distinguishing the second from the first type will be a significant issue when choosing the beneficiaries for such funding.

4. Costs and benefits and their impacts on satisfaction[20]

4.1. Introduction

An extensive literature on R&D collaboration has developed over past decades from various theoretical perspectives as well as several other contexts including open innovation (e.g., Enkel, 2009; Asakawa, 2010), strategic alliances (e.g., Lee et al., 2010), inter-organisational knowledge flow (e.g., Sammarra and Biggiero, 2008; Burg et al., 2013) and networking (e.g., Harryson, 1997). Regardless of their theoretical orientation or context, previous studies generally indicate that R&D collaboration enables a firm to minimise costs from a short-term perspective as well as to improve its technological assets from a long-term perspective. A strategic alliance can help a firm to enter new markets, reduce costs and risks, and establish new distribution channels efficiently (Desai et al., 2004; Chang et al., 2008; Qiu, 2010), and thus to support corporate entrepreneurship activities (Teng, 2006). Though the term 'strategic alliance' is a broader and more inclusive concept than inter-organisational collaboration, its benefits can also be applied to R&D collaborations; anticipating them, more and more firms are pursuing R&D collaboration in both domestic and international locations (Hagedoorn, 2002). Indeed, these collaborations with external partners have been recognised as a useful way for a firm to improve its internal innovation capabilities (Dodgson, 1993; Deeds and Rothaermel, 2003)

Despite the obvious advantages, however, many R&D collaborations fail to achieve their intended objectives (Nummela, 2003; Kloyer, 2011) and several studies have mentioned the unsatisfactory results of collaboration, including Lhuillery and Pfister (2009), who suggest that 40-70% of all alliances end up failing. Similarly, Bleeke and Ernst (1993) estimated that almost 60% of alliances fail, while Kogut (1989) found that roughly 50% of the alliances in his sample were judged to be a failure. Kale et al. (2002) showed a slightly more positive value of only 40% as the proportion of unsuccessful research partnerships. However, recent studies have reported a higher failure rate; Reuer and Zollo (2005) found that only 15% of the terminated R&D partnerships in their sample were successful while 34% failed, indicating a 69% failure rate. Yoon et al. (2016), focussing on collaboration involving SMEs, obtained a similarly high value of 66% for the failure rate with 16% of their sample having experienced successful collaborations and 31% having unsuccessful experiences.

These high failure rates observed in previous studies point to the difficulties in profiting from collaboration. The failures are attributed to various factors including limited learning capabilities (Larsson et al., 1998), lack of flexibility (Ring and van de Ven, 1994), different perspectives on outcomes (Larson, 1992), unintended technology transfer (Veugelers, 1998), and the inherently unstable nature of collaboration which may result in unilateral withdrawal from the collaboration (Reuer and Zollo, 2005). Apart from these reasons for failure, R&D collaboration was one of the least preferred collaborative activities by firms among several types of collaboration including marketing, manufacturing, and logistics

[20] Paper title: What makes for successful R&D collaboration among SMEs? An integrated perspective on the costs and benefits

(Hagedoorn et al., 2000).

These risks in R&D collaboration can be amplified or attenuated when an international collaboration is undertaken instead of a domestic one, something which will be investigated in this research. Careful choice by those planning a collaborative R&D project should be made with respect to partner types—domestic or international—after examination of the costs and benefits of collaborating with international partners compared to domestic ones. While international R&D collaboration can have a positive impact on innovation as observed in some previous studies, it should be undertaken with care, taking full account of the difficulties expected and risks embodied in such collaboration. Nevertheless, there is something of a research gap in terms of fully understanding the costs and benefits of international R&D collaboration. Extensive efforts have been devoted to analysing trends in international R&D collaboration (e.g. Chang et al., 2008; Lee et al., 2013) or identifying the benefits of collaborating with overseas partners (e.g. Glaister and Buckley, 1996; Hitt et al., 2000; Lane et al., 2001; Caloghirou et al., 2003; Li and Yue, 2005; Penner-Hahn and Shaver, 2005), but far less interest has been taken in the costs of international R&D collaboration with a view to obtaining a more balanced view of its overall impact (Leung, 2013). To fill this gap, this study aims to systematically investigate the benefits and costs of international R&D collaboration, and examine how these influence the success of such collaboration, measured by the degree of satisfaction felt by the participants. And as noted earlier, the particular focus here is on collaboration *among SMEs*, with their more limited resources and managerial capabilities.

For the purpose of analysis, a theoretical framework to describe the costs and benefits and to explain the rationale for international R&D collaboration is developed based on a combination of transaction-cost theory and resource-based theory. The two theories are among the most important perspectives with regard to strategic alliances, each having its own advantages and disadvantages. The distinctive difference between the two theories is that a strategic alliance is formed primarily to *minimise cost* according to transaction-cost theory (Kogut, 1988), whereas it is established to *create value* according to resource-based theory (Das and Teng, 2000). However, this study argues that neither theory can fully describe the phenomenon of international R&D collaboration among SMEs. With their limited resources and capabilities, SMEs are inclined to pursue *cost-minimisation for a given value* or *value-creation within a given cost*; hence, costs and benefits (value) both need to be considered during decision-making with regard to collaboration. Therefore, this study takes an integrated approach to the cost-benefit analysis of international R&D collaboration among SMEs, where the two theories are combined to 1) explain the reasons for SME's collaborating with international rather than domestic partners, and 2) to identify the factors affecting the success of international R&D collaboration. The theoretical framework was then tested by conducting case studies of 14 Korean SMEs and by analysing survey data of 118 Korean SMEs.

The research findings indicate that SMEs need to minimise the aggregate total of three types of costs – *production*, *transaction*, and *management* costs. Here, the reduction of production costs relates to the *direct benefits* of accessing a partner's resources (e.g. resources for technology development or commercialisation) or external resources (e.g. government funding). In addition, the collaboration decision includes *indirect benefits* that cannot be measured easily in terms of cost reduction (e.g. capability building or image building). Finally, the degree of satisfaction with international R&D collaboration among SMEs is affected by the unexpected benefits and costs, mostly concerning the

benefits of *technology development* and the reduction in *production costs and transaction costs*. From a theoretical perspective, this study shows that a combination of transaction-cost theory and resource-based theory would seem to have greater explanatory power in understanding international R&D collaboration among SMEs than either of them alone. In practical terms, the research findings help us understand the characteristics of successful international R&D collaboration among SMEs.

The rest of this paper is organised as follows. In Section 2, previous studies on the costs and benefits of international R&D collaboration are reviewed as well as the two basic theories adopted in this study. In Section 3, the theoretical framework and research hypotheses based on the framework are set out. Sections 4 and 5 then describe the research methodology and the analysis results respectively. The research findings and contributions are discussed in Section 6, while the main conclusions along with the research limitations and policy implications are set out in Section 7.

4.2. Literature review

4.2.1. Costs and benefits of international R&D collaboration

The motivation for and the performance of R&D collaboration are closely related to the issues regarding the costs and benefits; the motivation is linked to the *expected* costs and benefits, whereas the performance relates to the *actual* costs and benefits. On the one hand, collaborating or networking with others, whether they be international or domestic partners, is known to enhance organisational creativity (Powell et al., 1996) and information search capabilities (Granovetter, 1973). It enables firms to access the complementary assets needed to convert innovative R&D projects into commercially success products or processes (Teece, 1986; Hagedoorn, 1993). In particular, cross-border networks are expected to promote innovation by improving the quality and quantity of innovation outputs, thereby increasing the chances of technological and economic success of the innovation outputs. This argument has been supported by a number of previous studies, as described below, although not apparently in the context of SMEs and only with a limited number of empirical studies.

First, collaboration with an overseas partner tends to enhance a firm's technological innovation performance by improving and supplementing its capabilities (Hitt et al., 2000; Lane et al., 2001). Penner-Hahn and Shaver (2005) showed that the international R&D activities of Japanese pharmaceutical firms had a positive impact on innovation performance as measured by patents. This can be explained partly by the relatively high impact of technological learning from overseas partners (Kim and Inkpen, 2005), and partly in terms of the higher possibility of radical innovation from combining knowledge from very different sources (Lubatkin et al., 2001; Nummela, 2003).

Second, international R&D collaboration improves firms' economic performance by helping them to develop new markets (Glaister and Buckley, 1996; Li and Yue, 2005), to share the costs and risks of innovation activities (Caloghirou et al., 2003), and to increase labour productivity (Barajas et al., 2009). For instance, Cincera et al. (2002) found a positive influence of international R&D on growth of sales. Similarly, ZeW (the Centre for European Economic Research) (2011) analysed the business performance of German companies and concluded that those conducting both international and domestic R&D activities had higher profits than those focussing solely on domestic R&D. Barajas et al. (2009) argued

that the intangible assets (e.g. capitalised R&D expenditure, patents and software) acquired from collaboration have a positive influence on technological capabilities, and the improved capabilities then increase labour productivity, which in turn has a positive impact on the economic performance of firms.

Yet despite the potential benefits and reduced costs, previous studies have shown that collaborations with partners in different countries have experienced higher failure rates than those with domestic firms (Hitt et al., 2000). International collaborations bring challenges not generally encountered in domestic collaborations (Sirmon and Lane, 2004). Schmiele (2013) found that R&D activities in countries with weak intellectual property (IP) rights environments increase the risks of IP infringement (regardless of IP type), a problem which may not be encountered in domestic R&D activities. Hennart and Zeng (2002) suggested that national cultural differences can hinder collaboration and learning between partners, which might add to the costs of international R&D collaboration. However, Pothukuchi et al. (2002) argued that the significance of national cultural differences on international collaboration performance had been somewhat exaggerated because organisational cultural differences had not been adequately taken into account. Indeed, Sirmon and Lane (2004) found that organisational cultural differences tend to be more important than national cultural differences.

4.2.2. Costs and benefits of international versus domestic R&D collaboration

Both the costs and benefits of R&D collaboration can be greater with overseas partners than domestic ones (Lhuillery and Pfister, 2009). Several attempts have been made to compare the influence of national and international R&D collaboration on organisational performance. In an empirical study of Belgian manufacturing companies, Cincera et al. (2003) found somewhat surprisingly a negative impact of national collaboration and a positive impact of international collaboration on sales growth. They further showed that greater differences between these two types of collaboration were to be found in collaborations involving suppliers or clients as opposed to public research organisations. Similarly, after analysing the economic impact of participating EUREKA[21], the Danish Agency for Science Technology and Innovation (DASTI, 2011) reported that companies participating in EUREKA projects exhibited better performance in terms of exports, turnover, employment, and productivity than those that did not. EUREKA participants also experienced *relatively* faster growth in exports and employment compared to those who participated in domestic collaboration or EU Framework Programmes[22].

While these studies suggest that international R&D collaboration can create more value than domestic R&D collaboration, Brod and Shivakuma (1997) argued that this is not always true; international R&D collaboration will produce better results than domestic R&D collaboration only when international spillover effects are significantly greater than domestic ones. A more recent article by Frenz

[21] According to the official website (http://www.eurekanetwork.org/content/eureka-network-projects), EUREKA Network Projects are "transnational, market-driven innovative research and development projects, labelled by EUREKA and supported by the public administrations and public funding agencies that represent EUREKA in each of its 40+ member countries".

[22] According to the official website (https://ec.europa.eu/research/fp7/index_en.cfm), "EU FP7 was the European Union's Research and Innovation funding programme for 2007-2013".

and Ietto-Gillies (2009) also casts doubt on the benefits of international R&D collaboration. They argued that the international dimension of collaboration is irrelevant to innovation performance because of the relatively high failure rate and less frequent use of such collaboration; conversely, they argued that international R&D collaboration might be more effective within internal networks, where knowledge is exchanged across countries within a company, sharing the same organisational culture, a conclusion also supported by Sirmon and Lane (2004). In line with those findings, this study will compare international versus domestic R&D collaboration but is distinguished from prior research in that: 1) a theoretical framework is developed to conceptually investigate the preference for international rather than domestic R&D collaboration; and 2) the primary focus is on both the costs and benefits as factors affecting the success of international R&D collaboration.

4.2.3. Transaction-cost theory and resource-based theory

The two dominant theoretical perspectives for explaining alliances are transaction-cost theory and resource-based theory, which were also used to investigate the regional strategy being combined with international theory (Mudambi and Puck, 2016; Verbeke and Asmussen, 2016). Transaction-cost theory was put forward to explain the rationale for establishing a firm, and involves two types of costs – *transaction costs* and *production costs*. Coase (1937) claimed that market transactions incur a range of other costs, such as information search and evaluation costs, bargaining costs, and policing and enforcement costs, these being called transaction costs. Such costs are caused by the bounded rationality of actors and by opportunistic behaviour (Williamson, 1981). Actors are unlikely to act optimally given their complex environments (Simon, 1991), while being opportunistic due to information asymmetry and thus tending to make decisions in their own interest (Williamson, 1998). Williamson (1975) claimed that the characteristics of transaction depend on asset specificity, complexity and frequency of exchange. Due to such characteristics, some functions may not be tradable or may involve certain transaction costs in order to trade. For instance, the trading of knowledge may not be attractive because the nature of knowledge increases buyers' uncertainty during its transaction, increasing the transaction costs. In an attempt to avoid such costs, certain market functions are therefore internalised through the establishment of firms. However, internationalisation can result in an increase in production costs, since those functions need to be managed internally (Coase, 1937). Therefore, the total costs, as a result of adding together the production costs and transaction costs, tend to determine the choice between market transaction and internationalisation, with cost minimisation being the criterion for such a decision.

Transaction-cost theory has frequently been used to explain the logic of strategic alliances, mostly equity-based ones. According to Kogut (1988), shared internalisation (shared ownership) can offer another viable option to reducing costs when transaction costs are not large enough to justify internalisation. When a firm needs to acquire a particular asset belonging to another firm, and this involves large costs of reproduction but relatively small costs of additional use, it can choose the option of a strategic alliance with the firm possessing that asset. Mergers and acquisitions (M&A) can offer an alternative option but these can lead to an increase in coordination and management costs, requiring one to coordinate functions as well as to manage unfamiliar business areas in which the counterpart is engaged (Hennart, 1988). Shared ownership brought about through strategic alliances is thus motivated to

avoid both transaction and management costs (coordination costs) (Hennart, 1988). It is a hybrid form between market transactions and internalisation for minimising the total costs (Kogut, 1988; Yasuda, 2005). Although previous discussion has mostly focussed on equity-based alliances (Chen and Chen, 2003), the logic of cost minimisation could be extended to non-equity-based alliances, as the use of non-equity of alliances could also greatly reduce a firm's own production costs notwithstanding the transaction costs (Yasuda, 2005).

Another perspective frequently adopted to explain strategic alliances is resource-based theory (Yasuda, 2005). According to Penrose (1959), a firm is "a collection of productive resources"; the products and services it offers are provided by the resources, and its size can also be measured by the productive resources it possesses (Penrose, 1959). Those resources can be divided into three types (Barney, 1991): physical capital such as plants and equipment; human capital such as knowledge and experience; and organisational capital such as planning and coordination mechanisms. A firm can create a sustainable competitive advantage by acquiring and managing resources to make their products valuable, rare, inimitable, and non-substitutable (Wernerfelt, 1984). A strategic alliance may be employed to access the resources the firm lacks but needs to do business (Day, 1995; Varadarajan and Cunningham, 1995; Lambe et al., 2002) and can help the firm to drive a greater value from an alliance (Lioukas et al., 2016). Therefore, resource-based theory puts the emphasis on value creation, stressing the internal aspects of firms (Das and Teng, 2000). In this paper, transaction-cost theory is used as the base theory, given the restricted budget of SMEs, and resource-based theory is combined with it to explain how SMEs can reduce their costs through international R&D collaboration.

4.3. Research framework

4.3.1. An integrated perspective of transaction-cost theory and resource-based theory

An integrated perspective combining resource-based theory and transaction-cost theory can be used to shed light on the mechanisms of international R&D collaboration among SMEs in this study (see Figure 1). R&D collaboration is a typical non-asset-based alliance, where three types of costs – production, transaction, and management costs – need to be considered (Gulati and Singh, 1998).

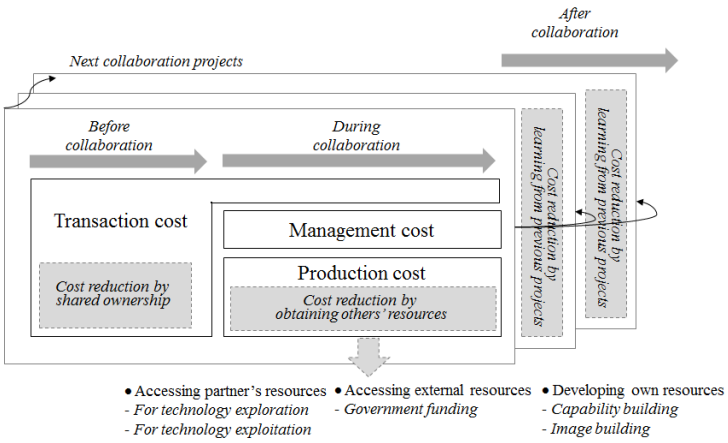

Figure 4-1. A theoretical framework (developed in this study)

First, the *production cost* is the internally-incurred cost to produce the desired outcomes (i.e. the cost of internal R&D). This cost can be reduced via R&D collaboration by accessing a partner's resources, where the purpose of the collaboration can be either *technology development* (e.g. reduced time for R&D, reduced cost for R&D, increased possibility of technology development success, increased quality of technology) or *technology commercialisation* (localisation of technology, reduced cost of imports, reduced time for technology commercialisation, reduced time to enter a global market). For the former, SMEs tend to access technology-related resources, such as leading technologies or complementary technologies, while they focus more on market-related resources for the latter, such as distribution channels or potential customers. Of course, a market transaction can be used to cut production costs. However, certain resources (e.g. knowledge, reputation, trust, and relationships), which are likely to be a target for R&D collaboration, are not tradable in a market (Peteraf, 1993) as they are intangible, firm-specific (Dierickx and Cool, 1989; Eisenhardt and Schoonhoven, 1996), and require learning to access (Das and Teng, 2000). Through collaboration, SMEs can create diverse value for increasing their competitiveness. For example, they can enjoy the benefits for economies of scale to compete against larger competitors. Sometimes, the reduction of production cost comes from not only accessing a partner's resources but also accessing other external resources; in particular, government funding may be available for such collaboration. Consequently, the amount of reduction in production costs is reflected in the total R&D costs actually used to achieve the R&D goal; the more reduction is associated with the less R&D costs and the R&D outputs more fairly shared.

Second, the *transaction cost* is the cost required for a market transaction of the desired resources (i.e. partner search, evaluation, and negotiation). Compared to market transaction, R&D collaboration enables a reduction in transaction costs by reducing the possibilities of opportunistic behaviour and overcoming the limitations of bounded rationality[23]. Opportunistic behaviour occurs when one party pursues its own interests at the expense of the other (Williamson, 1981; 1998); having a shared goal and establishing a longer-term relationship during collaboration helps to build trust and minimise such behaviour (Dyer, 1997). On the other hand, compared to internal R&D, the risk of opportunistic behaviour by the other party is generally perceived as a major challenge to collaboration (Human and Provan, 2000). However, SMEs tend to have quick and flexible decision-making processes due to their less bureaucratic organisational structure and greater flexibility (Chen and Hambrick, 1995), and to be less time-bounded as they continually update their decisions over the project's duration. Therefore, the transaction cost is mostly related to searching for and not being able to find an appropriate partner – a partner that can help create synergies through collaboration, can support the process of commercialisation, and has the required R&D capabilities.

Finally, the *management cost* is that of operating the joint R&D project. Such a cost was also mentioned with regard to internalisation of externally acquired resources, with Coase (1937) arguing that a process of coordinating functions internally is needed for internalisation. Gulati and Singh (1998)

[23] Transaction-cost theory argues that firms engage in equity-based collaboration when a high risk of opportunism is expected; otherwise less expensive non-equity modes such as R&D collaboration are used to economise on transaction costs (Hennart, 1988; Kogut, 1988; Williamson, 1991)

termed such costs the ‘coordination cost’ and stressed that cross-organisational cooperation would impose a substantial coordination cost. They also noted “the anticipated organizational complexity of decomposing tasks among partners along with ongoing coordination of activities to be completed jointly or individually across organizational boundaries and the related extent of communication and decisions that would be necessary.” Even though transaction costs and production costs can be reduced through R&D collaboration, management costs may still arise from the need to coordinate tasks across geographically dispersed organisations and to manage all those involved in conducting the various tasks. This cost directly affects the performance of the collaboration, as a wide-ranging set of purposes and poorly coordinated tasks may increase the level of uncertainty in the collaboration (Reuer and Zollo, 2005). Accordingly, it can influence a firm’ decision to collaborate or not (Kogut and Zander, 1992).

Along with the three types of costs, there is another type of cost reduction. Engaging in a collaboration or network brings benefits in terms of *improving one’s own resources* (e.g. capability-building and image-building) as well as *using a partner’s resources*. Studies of R&D have emphasised the role of organisational learning for R&D performance, and this may apply to R&D collaboration, too. R&D is a learning process, based on which new technological knowledge is created. These benefits, being long-term effects, may not be realised until after the project is completed. Specifically, both technology and networking capabilities will be improved through collaboration (Levitt and March, 1988; Laursen and Salter, 2006), benefiting the performance of subsequent collaborations. In addition, such collaboration experience, in particular, one’s reputation as a good partner, will often confer a benefit in terms of improved corporate image for the SME, reputation as partner (Powell et al., 1996).

4.3.2. International and domestic R&D collaboration

Based on the assumption that SMEs will incur the three types of costs during collaboration, the reason that SMEs may choose the mode of R&D collaboration can be explained in terms of the net balance of costs and benefits (i.e., the reduced costs against internal R&D). SMEs will prefer international R&D collaboration to domestic when they judge the balance of benefits compared with costs for the former is greater than for the latter.

First, regarding production costs, a significant reduction in production cost (benefit) is expected for SMEs collaborating with international partners when they want to access region-specific resources. Since some assets are region-specific as well as (or rather than) firm-specific, international collaboration may be regarded as a useful means to acquire such assets (Ghoshal, 1987; Dunning, 1999). Large MNEs may have branches in foreign countries and hence may find it relatively easy to reproduce the necessary resources through collaboration with domestic partners; in these, the difference in cost reduction between national and international collaboration may not be that significant. In contrast, the differences in cost reduction between the two types of collaboration can be much larger for SMEs. Thus, SMEs may tend to prefer international collaboration to domestic, encouraging them to find a suitable firm in the target region. Another reason for such a preference can be access to external resources. SMEs may be well-placed for government funding, particularly if the competition for funding is less fierce for international R&D collaboration than for other types of subsidy.

Second, transaction costs may increase when SMEs decide to work with international partners instead of domestic ones. Particularly with the development of information and communications technology (ICT) development, the tasks of searching, evaluating and monitoring partners have become less costly. Moreover, the transaction cost stemming from a partner's opportunistic behaviour may sometimes be lower for international collaboration than domestic. The level of risk of opportunistic behaviour is a combination of two factors – the probability of such behaviour and its impact (The Royal Society, 1992). The probability of opportunistic behaviour may be reduced when an intermediary is used to establish the collaboration. International R&D collaborations among SMEs are sometimes intermediated by their governments, which prevent them from being too opportunistic. Moreover, the impact of opportunistic behaviour may be less severe for international collaboration rather than domestic. Sometimes, a number of stakeholders may be involved in a collaboration with domestic partners (for example, a partner of a focal firm is likely to be collaborating with competitors of that focal firm), while this is less likely to be the case for collaboration with foreign partners. In addition, SMEs in different countries are likely to have geographically different markets, which reduces concerns about the effect of opportunistic behaviour. Therefore, if domestic market competition is intense, the transaction cost of domestic R&D collaboration might be as great as, or even greater than, for international R&D collaboration.

Third, management costs can also increase for international R&D collaboration compared to domestic, especially with communication and project operation costs. Particularly for international R&D collaboration among SMEs, this cost arises due to the communication difficulties caused by: 1) different geographic locations; 2) language and cultural barriers; and 3) different institutional environments. However, with advances in technologies and transportation systems, regional boundaries are often less pronounced nowadays (Wagner, 2006); firms are less constrained by time and space when it comes to communication and interaction, reducing management costs accordingly. Given all this, the gap between the management costs of international and domestic R&D collaboration has almost certainly narrowed significantly over the last decade. Moreover, there might be some technologies that require less complex coordination and less frequent interaction for R&D collaboration (e.g. modular products or services). If those technologies are chosen for international collaboration, the increase in management costs may not be significant compared to domestic collaboration.

Finally, further cost reduction can be expected from organisational learning, which helps the organisation develop its own resources. R&D collaboration with a foreign SME partner often requires bridging a gap between expectation and reality – a gap arising from cultural, organisational and institutional differences – as part of the learning process. This then enables SMEs to be better prepared for subsequent R&D collaboration projects, which could encourage them to work with overseas partners rather than domestic ones, particularly if they are planning to do business in foreign countries as a long-term strategy.

4.3.3. Hypothesis development to explain international R&D collaboration among SMEs

Using the framework in Figure 1, the analysis model was developed to identify the drivers of success[24] for international R&D collaboration among SMEs along the lines of expectation-confirmation theory, an approach developed in marketing in which consumer satisfaction is expressed as a function of expectation and expectancy (dis)confirmation (Oliver, 1977; 1980) (see Figure 2). According to the theory, the degree of satisfaction with an international R&D collaboration should depend on the level of its perceived performance, which can be viewed as a function of perceived benefits and costs (named as a *direct path* in this study). At the same time, the post-adoption satisfaction is determined by the (dis)confirmation of expectation and perceived performance (named as an *indirect path*[25] in this study). Our analysis models investigated the relationships between perceived performance and the degree of satisfaction, but the interpretation will be based on both direct and indirect paths for the relationships between the two elements.

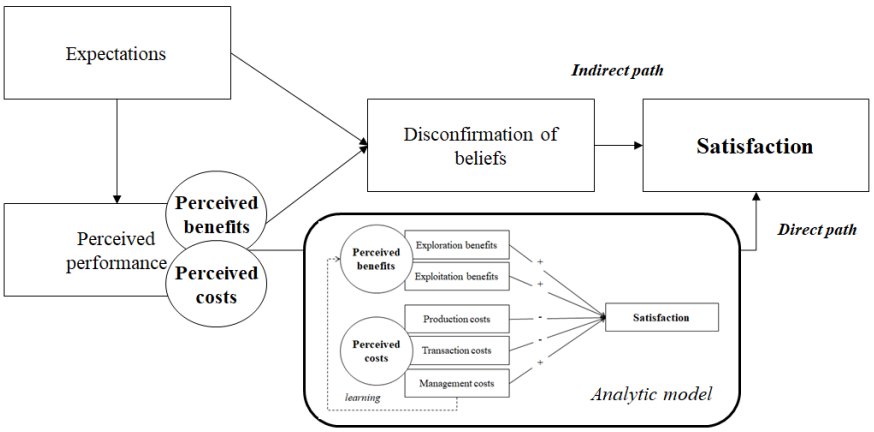

Figure 4-2. Analytical model to test the hypotheses (developed in this study)

Next, five hypotheses were developed to understand the benefits and difficulties as proxies for costs experienced during international R&D collaboration along with their impact on the satisfaction felt with such a collaboration. As shown in Figure 1, the main benefits perceived by SMEs can be divided into two types – benefits with regard to technology development and to technology commercialisation. Of the two, SMEs are likely to expect the latter, given their lack of resources for commercialising technology in the global market as argued by previous studies that SMEs' collaboration needs to emphasise more on the commercialisation stage than the other stages (van de Vrande et al., 2009; Hemert et al., 2013; Theyel, 2013). Therefore, the degree of their satisfaction is likely to increase with the level of benefits they perceived with regard to technology commercialisation. However, if the level of expectation is so high that the perceived performance is less than expected, this expectancy disconformation may decrease the

[24] Poppo and Zenger (2002) argued that the degree of satisfaction with collaboration indicates the perceived effectiveness of the collaboration and thus can be measured by the degree of satisfaction.

[25] To refer both to Figures 1 and 2 and the more indirect path involved

degree of satisfaction, an outcome which is quite likely for SMEs engaging in international R&D collaboration; international collaboration has been regarded as a useful means for business globalisation (Glaister and Buckley, 1996; Li and Yue, 2005), and collaboration with suppliers of similar knowledge base, which is likely the case of collaboration among SMEs, was found to be related with market performance (Tranekjer and Søndergaard, 2013), which may raise SMEs' expectations over much. Accordingly, these two effects will thus tend to cancel each other out.

On the other hand, SMEs pursuing international R&D collaboration are likely to have superior innovation performance to their competitors. Ebersberger and Herstad (2012) found that high performing SMEs in innovation are more inclined to engage broadly in global innovation collaboration, while low performing SMEs focus on internal R&D to strengthen their knowledge resources internally. Hemert et al. (2013) similarly argued that innovative SMEs are more likely to network with other SMEs. Restricting the type of collaboration to the collaboration among SMEs, the firms involved in such collaborations are likely to be innovative, quite naturally obtaining R&D related benefits through collaboration. Then, they are likely to be pleasantly surprised and therefore satisfied with a collaboration that brings technological opportunities such as advancing the SME's own technologies or introducing new technologies. Consequently, the following hypotheses are put forward:

H1a. The degree of satisfaction with an international R&D collaboration among SMEs increases with the degree of perceived benefits with regard to technology development.

H1b. The degree of satisfaction with an international R&D collaboration among SMEs is not affected by the degree *of perceived benefits with regard to technology commercialisation.*

In the same way, perceived costs, classified into three categories – production, transaction and management costs – are expected to affect the perceived performance and hence the level of satisfaction; if the costs turn out to be higher, then this, along with the level of perceived costs themselves, may bring dissatisfaction with the collaboration results. Among the three types of costs, the management costs are generally well understood and predictable, but the reduction in production costs and the increase in transaction costs may be more difficult to estimate. More specifically, a reduction in production costs is often a key reason to be involved in international R&D collaboration. Yet a gap between expectations and reality with regard to the size of the reduction is naturally to be expected in the case of collaboration among SMEs having little managerial control (Teece, 1986) and few resources (Alvarez and Barney, 2001), and this will inevitably affect the perceived performance.

Similarly, transaction cost is (initially, at least) a hidden cost. The results of any poor decision-making will not be apparent until the collaboration has been initiated, creating uncertainties caused by internal risks (Das and Teng, 2001; Nooteboom, 2002). The impact of opportunistic behaviour is also hard to recognise until it happens. Thus, the disparity between the expected and the actual transaction costs could be large, which will result in a disconfirmation of beliefs about performance.

On the other hand, the management costs are more predictable and sometimes can turn out to be less than expected, thanks to the advances in communications and transportation technologies. Furthermore, as shown in Figure 1, management costs may be related strongly with the future benefits. SMEs are likely

to learn management skills for further international R&D collaboration and thus may believe that the current costs may turn into future benefits, which may have a positive impact on the level of satisfaction and consequently offset the negative impact of the management costs incurred. The following hypotheses are therefore proposed:

H2a. The degree of satisfaction with international R&D collaboration among SMEs tends to decrease with the degree of perceived difficulties in managing the production costs.

H2b. The degree of satisfaction with international R&D collaboration among SMEs tends to decrease with the degree of perceived difficulties in managing the transaction costs.

H2c. The degree of satisfaction with international R&D collaboration among SMEs is not affected by the degree of perceived difficulties in managing the management costs.

4.4. Methodology

4.4.1. Data

For this study, the chosen country was Korea. The country has a small domestic market with a population of some 50 million and GDP per capita of nearly US$35,000, relying heavily on international trade with exports representing 46% of GDP (https://data.oecd.org/korea.htm). International R&D collaboration thus offers a useful way for SMEs to globalise their business. Two types of data were gathered. The first was collected from interviews with 14 Korean SMEs in the ICT sector, the aim being to test the conceptual framework by identifying the relevant cost and benefit factors. The interviews were conducted from July to October 2016, either face-to-face or through a video conference (see Appendix 1). The target interviewees were top managers who have been involved in international R&D collaboration at some point in the last five years. The interview lasted between one and two hours, asking about the benefits and costs the interviewees experienced during the collaboration.

The other source was survey data, collected by a Korean consulting company (www.wipson.com) and funded by a Korean government agency (www.kiat.or.kr). This was used to test the three hypotheses outlined above. In this survey, a series of questions were asked about the following: 1) the partner search strategy and the degree of its effectiveness; 2) the project management strategy; 3) the level of perceived costs and benefits; and 4) the degree of satisfaction with the collaboration. Here, the strategy-related variables were measured by a nominal value, while all other variables were measured on a 5-point Likert scale. The survey was carried out between 20 March and 9 April 2014, being sent to 19,006 Korean SMEs, out of which 1,096 firms responded. However, among the respondent firms, only 262 SMEs (23.9%) have had experience of international technology collaboration. Of these, 118 SMEs (10.8%) collaborated with other SMEs, and 35 (3.2%) were engaged specifically in collaborative R&D. In this survey, various channels (face-to-face, by phone, by mail, web-based) were used to reduce non-response bias.

4.4.2. Analysis methods

A mixed method approach was adopted to facilitate triangulation of key issues as well as to further explore the reasons why particular costs and benefits affected overall satisfaction, thereby enabling a deeper understanding on the issues regarding international R&D collaboration among SMEs. Thus, both quantitative and qualitative approaches were used to analyse the two types of data. First, from the interview data, the costs and benefits anticipated and experienced from international R&D collaboration among SMEs were identified; these were assigned to the proposed conceptual framework in order to test it empirically. Furthermore, the reasons for choosing international rather than domestic partners for their R&D collaboration were investigated based on the framework. Secondly, for testing hypotheses, logistic regression analysis was carried out, where the perceived benefits and difficulties were included as independent variables and the degree of satisfaction was used as the dependent variable. Three characteristics – age, R&D intensity, and government funding – were introduced as control variables.

It should be noted that H3 and H4 were tested with the data for all types of international *technology* collaboration among SMEs, because the data for international R&D collaboration among SMEs were limited to just 35 records; the assumption here is that the benefits and difficulties SMEs may face during collaboration with other SMEs in foreign countries will tend to be similar regardless of the collaboration type. This was supported by results of a t-test, in which no statistically significant differences (at a significance level of 0.05) were found to exist between the two groups for all types of benefits and difficulties apart from one; SMEs engaged in R&D collaboration suffered rather more from the disappointing R&D capabilities of partner firms (3.46 out of 5.00) than SMEs engaged in non-R&D forms of collaboration (3.04 out of 5.00). This difference was emphasised when the regression results were interpreted.

4.4.3. Variables

In this study, binary logistic regression was selected instead of ordinal logistic regression given the restricted numbers of data. The following provides a description of the three types of variables.

4.4.3.1. Dependent variables

The dependent variable, the level of satisfaction, was measured on 5-point Likert Scale (ranging from 5 for “completely satisfied” to 1 for “completely dissatisfied”) and was transformed into a binary variable by assigning 1 (satisfied) to the original values of 4 and 5 and 0 (unsatisfied) to the others. A total of 65 firms (55%) were satisfied with collaboration, whereas 53 firms (45%) were unsatisfied with collaboration.

4.4.3.2. Independent variables

The independent variables are based on survey answers regarding eight types of benefits from international technology collaboration along with the seven types of difficulties encountered during

collaboration. The respondents answered about the degree of benefits and difficulties using a 5-point Likert Scale (see **Table 4-1**), and exploratory factor analysis was carried out on the benefits and difficulties for the purposes of dimension reduction[26].

Table 4-1. Descriptions on the independent variables (%)

Please answer the degree of benefits you obtained by the collaboration when compare with internal R&D	1	2	3	4	5
B1. Reduced time for R&D	5.1	2.5	27.1	61.0	4.2
B2. Reduced cost for R&D	5.1	2.5	33.9	49.2	9.3
B3. Increased possibility of technology development success	0.0	5.1	19.5	55.9	19.5
B4. Increased quality of technology	0.0	5.1	15.3	72.0	7.6
B5. Localisation of technology	2.5	7.6	28.8	38.1	22.9
B6. Reduced cost on import	5.1	2.5	30.5	33.9	28.0
B7. Reduced time for technology commercialisation	0.0	10.2	14.4	58.5	16.9
B8. Reduced time for entering a global market	0.0	5.1	21.2	51.7	22.0
Please answer the degree of difficulties faced during the collaboration	1	2	3	4	5
D1. R&D costs	2.5	17.8	43.2	33.9	2.5
D2. Sharing collaboration outputs	2.5	12.7	50.8	33.9	0.0
D3. Creating synergies through collaboration	0.0	6.8	34.7	48.3	10.2
D4. Searching partners for commercialisation	0.0	15.3	28.0	47.5	9.3
D5. R&D capabilities of partner firms	4.2	12.7	31.4	44.1	7.6
D6. Networking with partners	2.5	7.6	35.6	54.2	0.0
D7. Language and cultural barriers	6.8	9.3	36.4	47.5	0.0

Table 4-2 shows that the eight types of benefits could be grouped into two main factors – one consisting of *technology exploration benefits* (*technology benefits*) (B1, B2, B3 and B4), and the other of *technology exploitation benefits* (*economic benefits*) (B5, B6, B7 and B8). These findings support the use of the two factors – technology development and commercialisation –to explore the benefits SMEs expected from international R&D collaboration as a means to reduce the cost.

Table 4-2. PCA results on the benefits

Benefits	Factor 1	Factor 2
B1. Reduced time for R&D	**0.846**	0.237
B2. Reduced cost for R&D	**0.865**	0.236
B3. Increased possibility of technology development success	**0.843**	0.257
B4. Increased quality of technology	**0.725**	0.433
B5. Localisation of technology	0.418	**0.766**
B6. Reduced cost on import	0.158	**0.882**
B7. Reduced time for technology commercialisation	0.517	**0.698**
B8. Reduced time for entering a global market	0.245	**0.865**
Total variance explained	*63.4%*	*77.4%*

When a similar analysis was conducted on the difficulties, three factors were identified, as shown in **Table 4-3.** The first was related to difficulties concerning *production costs* (D1, D2): R&D costs represent

[26] Principal Component Analysis (PCA) was conducted on those variables with Varimax rotation and Kaiser Normalization. For both cases, KMO values were greater than 0.5 while the Bartlett test of sphericity resulted in values of less than 0.05, indicating that the dimension reduction process is valid.

the cost that a focal firm had to pay for acquiring the expected outputs, while sharing collaboration outputs is linked to the cost that the firm could save through collaboration. The second was primarily connected with *transaction costs* (D3, D4 and D5), that is, the cost incurred by failing to create the expected synergistic effects of collaboration due to the partner not acting in the expected manner or not having the expected capabilities, and by failing to have a partner for commercialisation. The last was mainly associated with *management costs* (D6 and D7), including difficulties in networking and in overcoming language and cultural barriers.

Table 4-3. PCA results on the difficulties

Difficulties	Factor 1	Factor 2	Factor 3
D1. R&D costs	**0.855**	-0.042	0.181
D2. Sharing collaboration outputs	**0.789**	0.324	0.144
D3. Creating synergies through collaboration	-0.224	**0.739**	0.280
D4. Searching partners for commercialisation	0.410	**0.706**	-0.236
D5. R&D capabilities of partner firms	0.244	**0.722**	0.161
D6. Networking with partners	0.055	0.077	**0.874**
D7. Language and cultural barriers	0.474	0.174	**0.765**
Total variance explained	*39.7%*	*57.4%*	*73.3%*

4.4.3.3. Control variables

The rationales for three control variables are as follows. First, since established SMEs are likely to have more experience of collaboration as well as stronger management capabilities, *firm age* is a structural feature that needs to be controlled as in other studies (e.g. Powell, 1999; Aschhoff and Sofka, 2009). Second, SMEs with a higher *R&D intensity* are more likely to engage in different forms of R&D including collaborative R&D; R&D intensity has been shown to have a positive correlation with a tendency to collaborate (Colombo and Garrone, 1996) as well as with the intensity of collaboration (Keupp and Gassmann, 2009). Third, SMEs *funded by the government* for international technology collaboration tend to be more satisfied as a result of accessing government funding; previous studies commonly conclude that public funding stimulates private R&D funding, which is expected to contribute to better innovation outcomes (Aerts and Czarnitzki, 2006; Aerts and Schmidt, 2008; Czarnitzki and Lopes-Bento, 2013). These three factors therefore need to be controlled in order to analyse the relationship between the perceived benefits and difficulties, on the one hand, and the degree of satisfaction with the collaboration, on the other. These variables were operationalised by a categorical value and the distribution across answers is described in **Table 4-4**.

Table 4-4. Descriptions of the control variables (%)

C1. Firm age (years)	less than 5	5-10	10-15	10-20	more than 20
Respondents	25%	26%	20%	9%	20
C2. R&D intensity (%)	less than 3	3-6	6-10	10-20	more than 20
Respondents	21%	30%	10%	17%	22.0%
C3. Funding experiences		Yes		No	
Respondents		36%		64%	

4.5. Analysis results

4.5.1. Factors affecting the degree of satisfaction

The aim of this analysis is to identify the benefits and difficulties that affect the level of satisfaction most significantly, with a logistic regression model being designed to investigate these relationships. **Table 4-5** shows the analysis results, while the correlations between variables and endogeneity test results are summarised in Appendix (see **Figures 8-1** and **8-2**). The model was significant at a significance level of 0.05[27] and was free from a common method bias (see Appendix **Table 8-10**). The classification table also indicates a high performance of 87.3% in terms of accuracy of classification.

Table 4-5. Regression analysis results on the factors affecting the level of satisfaction

Variables	B	P-value	Exp(B)
Independent variables			
Technology exploration benefits	5.945	.000	381.858
Technology exploitation benefits	-1.272	.169	.280
Production costs	-2.039	.034	.130
Transaction costs	-.919	.216	.399
Management costs	2.735	.004	15.413
Control variables			
Funding (1) (not funded)	-3.929	.072	.020
R&D intensity (less than 3%)		.124	
R&D intensity (1) 3-6%	-5.838	.016	.003
R&D intensity (2) 6-10%	-2.399	.137	.091
R&D intensity (3) 10-20%	3.590	.263	36.216
R&D intensity (4) (more than 20%)	7.547	.040	1894.875
Age (less than 5 years)		.006	
Age(1) (5-10 years)	-.973	.480	.378
Age(2) (10-15 years)	-2.643	.108	.071
Age(3) (15-20 years)	-9.596	.001	.000
Age(4) (more than 25 years)	-.959	.586	.383
Constant	4.506	.027	90.555

The results show that three factors – technology exploration-related benefits, production costs-related difficulties, and management costs-related difficulties – had statistically significant effects on the level of satisfaction, indicating that SMEs are more likely to be satisfied with international technology collaboration with other SMEs when they had more technology exploration-oriented benefits, and when they struggled less with production costs-related issues. This result supports Hypotheses H1a, H1b and H2a. Contrary to our expectation, H2b and H2c are not supported; the transaction costs-related difficulties consisting of three elements – (1) creating synergies through collaboration, (2) searching for partners for commercialisation and (3) R&D capabilities of partner firms – do not have a statistically significant impact on the level of satisfaction. It seems that these difficulties are becoming more predictable (i.e. the indirect path) or ignorable compared to other costs (the direct path). Finally, an apparently counter-

[27] This model had the -2 Log likelihood value being 62.606, Cox and Snell's R-square value being 0.571, Nagelkerke R-square value being 0.763, and Hosmer and Lemeshow test p-value being 0.612 (greater than 0.05).

intuitive finding is that management costs-related difficulties seem to have a positive effect on the level of satisfaction, which means that firms that experienced more difficulties with (1) networking with partners and (2) language and cultural barriers tended to end up being more satisfied with the collaboration results. Such experiences are useful learning processes and can be expected to reduce the production or management costs for future collaborations, thus improving collaboration efficiency. Hence, firms may tend to view such difficulties in a positive light.

The analysis results also weakly suggest (with p-value of 0.072) that SMEs funded at some point by government support programmes were more likely to be satisfied with international technological collaboration with other SMEs. Government programmes encourage SMEs to become engaged in international technology collaboration, provide financial support for SMEs working with international partners, and supply legal and consulting services to promote successful collaboration. Hence, government programmes seem to have a positive impact on the collaboration results.

4.5.2. Costs and benefits of international R&D collaboration among SMEs

An in-depth analysis of survey findings is carried out based on the interview findings. First, technology exploration benefits were found to have the most significant impact on the level of satisfaction, followed by production costs and management costs. Thus, these are three key factors associated with the level of satisfaction for international R&D collaboration among SMEs.

First, the interviewees indicated various types of technology exploration benefits including reduced time and costs for R&D, increased possibility of technology development success, and increased quality of technology compared to internal R&D. In addition to these obvious outputs of collaborative R&D projects, SMEs seem to have obtained another type of indirect outcome, which supports the argument that R&D collaboration tends to reduce the production costs not only for the current project but also for later ones. Some of the interviewees (5 out of 14) mentioned that the collaboration had led to other possibilities for collaboration. After the collaboration projects had been successfully completed, SMEs in a collaboration network often became good business partners and tended to keep in touch to share market information or to help test their business ideas in the foreign markets where the partners are located; thus understanding global market trends and conducting a market test on foreign customers became easier than before the collaboration, as was noted by F2.

> *"Now we have become really good friends and can trust each other. Whenever a new business item comes up, I contact my ex- or current collaboration partners to discuss it. They give quite honest opinions on my idea. It is great that I have somebody in the same field to consult on my business items from a global perspective (F2, CEO)."*

Some interviewees emphasised the image-building effect; the history of international R&D collaboration improved the brand image of the SMEs, which benefited not only from the marketing and sales of their products but also from the support obtained from various government programmes for facilitating international R&D collaboration among SMEs. While different patterns of costs and benefits could be observed for different motivations, those indirect outcomes were more notable and visible for

collaboration among SMEs, regardless of the type of motivation.

> *"After we were funded by the government for a collaborative R&D project, we realised that other funding opportunities for international R&D collaboration exist both in Korea and Europe. Apart from R&D, there were other types of funding programmes available to commercialise our collaboration outcomes. Once, a government agency contacted us to ask if we were interested in a particular collaboration project. Without the first collaborative R&D projects, we could never have taken all these subsequent opportunities (F12, CTO)."*

Secondly, technology exploitation-related benefits, which include localisation of technology, reduced cost on import, reduced time for technology commercialisation, and reduced time for entering a global market, do not have a statistically significant impact on the level of satisfaction. Although the existing studies emphasised the importance of SMEs' collaboration at the commercialisation stage due to their lacking capabilities for that stage, (e.g., Lee et al., 2010), this argument does not seem to apply to the international collaboration among SMEs. The benefits from such collaboration is realised only in the limited number of SMEs targeting globalisation. Furthermore, collaboration for technology exploitation may require frequent interactions and intimate relationships between members, which may cause various difficulties. Thus, not all SMEs that had technology exploitation-related benefits were satisfied with the collaboration results. Another possible explanation is that SMEs involved in international R&D collaboration might have had a high expectation on the possibilities of technology exploitation in the global market, and thus this high expectation could have a negative effect on the level of satisfaction. According to the satisfaction discrepancy theory, the level of satisfaction is affected by the discrepancy between expectation and performance (Locke 1969); satisfaction with collaboration is considered a function of expectation and deviation from expectation.

Third, SMEs that experienced more difficulties related to the production costs (i.e., R&D costs and sharing collaboration outputs) showed the lower level of satisfaction. In particular, the project costs included not only those for financial resources but also for human resources. In our case studies, SMEs tended to be funded by their governments or the European Commission (EC), if they are European countries, in their collaborative R&D; without such funding, they tended to use their human resources for collaboration. By accessing human resources in a partner firm, they could reduce their production costs.

> *"We assigned two of our engineers to a collaborative R&D project for six months. An opportunity cost was incurred regarding the salaries we are paying to them (F4, CTO)."*

Therefore, even when no financial resources were invested in the collaborative R&D, without strong commitments from the partners, SMEs seemed to feel that the production costs could not be reduced to a satisfactory level. Indeed, most interviewees mentioned difficulties in ensuring commitment from the partners as follows.

> *"To test our pilot system, we needed data from our partners. However, it took longer than*

expected to get the data. And so we generated the data ourselves, which increased the burden of this project and decreased the benefits of international R&D collaboration (F12, CTO).”

“I was in charge of the project. It was quite hard to contact them. Whenever I needed some feedback from my collaboration partner, I wrote an e-mail to a liaison person. Without exception, it took ages to get a reply from him, which delayed the project on our side. On average, we had only two days per week that we could work together because of the differences in date systems, holiday systems, and time zones. If we missed the two days, we had to wait five more days to contact them (F1, PM).”

The costs incurred in dealing with changes and risks during the collaboration may cause certain difficulties in the reduction of production costs, although these were not frequently observed. However, compared to MNEs, SMEs have proportionately less stability in their business, which may adversely affect a partner SME. One interviewee commented on his experience of the bankruptcy of his partner company as follows:

“Three companies were carrying out the collaborative project and suddenly one of our partners went bankrupt. As we had already invested a large amount of effort in the project, we could not stop it, though we could manage to continue the project… (F1, CTO)”

Fourth, transaction costs, being mainly related to finding potential partners and coordinating collaboration activities to create synergies, were not found to be significant in determining the level of satisfaction. Various approaches to identifying potential partners have been adopted, with different criteria being applied to choose a final partner in different organisations and projects. If SMEs, having little information about potential partners, need to approach international partners directly, the search costs tend to increase. In contrast, if collaboration is initiated by a partner company or an intermediary, the search costs are generally less. In our case, government policy programmes have focussed on reducing these search costs by hosting a match-making event in Korea, taking Korean SMEs abroad to introduce them to potential partners, or hiring an intermediary to facilitate such match-making. Through such a channel, SMEs were able to find reliable partners and could be insensitive to the transaction costs.

Finally, management costs were found to have a positive impact on the level of satisfaction, which is different from what one might expect. Language and geographical differences were not regarded as particularly serious issues. Indeed, direct interactions between engineers were not observed frequently during international R&D collaboration among SMEs. Instead, each company had a person responsible for liaison, facilitating and managing the collaboration. They usually speak fluent English and are senior managers, capable of decision-making as well as detailed discussion regarding the target technology for the collaboration. Furthermore, the English required for an R&D collaboration mainly involves technical and professional terms that are relatively limited in number, greatly decreasing the complexity of communication. On the other hand, more difficulties may indicate more interactions, which are likely to increase the synergies of collaboration and ultimately the level of satisfaction. Furthermore, the more difficulties SMEs experience, the more learnings they earn; they expect the reduced costs for further projects because of those learnings, leading to the positive effects on the level of satisfaction.

4.5.3. Rationale for choosing an international rather than domestic partner

Generally, an investment decision in SMEs is based on a comparison of the costs and benefits of different options – in particular, minimising the cost of the expected benefits or maximising the benefits within a given budget. The decision on whether to work with foreign or domestic SMEs would seem to require a similar decision-making process. Among the five benefit and cost factors discussed above, management costs seemed to be less relevant when such decisions were made. Thus, their partner selection decisions depend on the other types of benefit and cost; when SMEs expected more direct benefits in terms of technology exploration and exploitation, lower project costs, and lower transaction costs for an international rather than a domestic R&D collaboration, they tended to choose international partners.

First, one core benefit of international R&D collaboration relates to technology exploration. A large proportion of interviewees (10 out of 14) stated that they had earlier failed to find an appropriate domestic partner to improve their technologies or technological capabilities. These companies were likely to have either globally competitive technologies or specialised technologies. On the other hand, some companies pursued the benefits of technology exploitation through international R&D collaboration. If an SME's business has only a small domestic market, the firm tended to exhibit a strong motivation to globalise its business. Particularly when an international partner could be a potential buyer (as in the case of F12), or a potential distribution channel (as with F3), or when collaboration with an international partner can help explore a new market in a cost-effective manner (as with F7), the tendency to collaborate increases. Thus, overseas partners with firm-specific or region-specific resources can reduce a focal firm's production costs significantly.

Second, international R&D collaboration is often more advantageous in terms of project funding than domestic R&D collaboration. Assuming a similar degree of benefit, SMEs will be inclined to choose the lower cost option. Compared to other countries, Korea has allocated relatively little R&D funding to international collaboration. Nevertheless, the ratio of SMEs interested in international R&D collaboration to internal R&D or domestic R&D collaboration is far smaller than the ratio of government R&D budget for international R&D collaboration to the total government R&D budget. Consequently, government funding for international R&D collaboration is often easier to access than other types of government funding, which attracted a number of Korean SMEs to international collaboration.

> *'It was relatively easy to be a beneficiary of an R&D support programme for international collaboration. The competition rate was less than 2:1, although it has been increasing these days as more companies are becoming interested in the programme (F11, PM).'*

Third, in relation to the transaction costs, search costs for a collaboration partner can be lower for international rather than domestic R&D collaboration. The Korean government has funded various programmes to link Korean SMEs to foreign firms; this decreases the cost of searching for partners and facilitates the collaboration. In addition, some SMEs were contacted by an intermediary company (e.g. F1) or a partner company (e.g. F3). In these cases, SMEs were more likely to be involved in international R&D collaboration, since they could reduce their search costs if other conditions were the same.

4.6. Discussion

4.6.1. Theoretical contribution

Recent studies have attempted to compare or even combine transaction-cost theory and resource-based theory in investigating various corporate decisions such as strategic alliances (e.g. Watjatrakul, 2005; Yosuda, 2005; Mclvor, 2009) and firm growth (Gancarczyk, 2016). Some have argued that one theory is superior to the other in terms of explanatory power (e.g. Brewer et al., 2014; Díez-Vial, 2007), while others have claimed the two are complementary (e.g. Bonet et al., 2010; Holcomb and Hitt, 2007; McIvor, 2009). There are some indications that the two theories are used interdependently to support different types of decisions. Resource-based theory, considering value and capabilities as the main issues involved in strategic choices, is more appropriate for long-term decision-making such as innovation and market creation (Gancarczyk, 2016; Pitelis and Teece, 2009), because it regards the firm as an entity that seeks to develop and protect its value. On the other hand, transaction-cost theory, founded as it is on transaction costs and associated uncertainty, is more for decision-making regarding existing alternatives in markets (Gancarczyk, 2016; Mahoney, 2001; Pitelis and Teece, 2009), because it reflects the nature of firm as an entity formed to minimise its cost based on accessible resources.

In the area of R&D collaboration research, there has been a strong emphasis on resource-based theory, examining drivers and motivations for strategic alliances, with less attention to studying the constraints in pursuing such alliances. The high failure rate of R&D collaboration indicates that firms inevitably face obstacles and impediments, which prevent them from implementing their collaboration strategy and profiting from it. SMEs may experience uncertainties that are proportionately greater than for larger firms, since previous studies have demonstrated that transaction costs can be moderated by firm size (Verwaal et al., 2010). Nevertheless, such difficulties and constraints, which are particularly significant in the context of “international R&D collaboration” and “collaboration among SMEs”, have previously been rather under-researched.

Hence, this study proposed an integrated framework for SMEs’ decision-making on international R&D collaboration with other SMEs, taking account of the difficulties as well as the benefits. Implementing such a collaboration strategy in SMEs involves understanding not only the motivations but also the constraints linked with transaction costs (Verwaal et al., 2010) and management costs (Chandler et al., 2009) as presented in previous studies showing that such cost affects entry mode choice (Schwens et al., 2010) or alliance formation (Phene and Tallman, 2014). The framework was employed to investigate the performance of international R&D collaboration among SMEs in a systematic way by considering both costs and benefits, and also the gap between expectation and reality with regard to the collaboration. The framework has been empirically tested and can be expected to form the basis for further work.

4.6.2. Practical contribution

The empirical analysis results provide valuable insights into the management of international R&D collaboration among SMEs. First, partner selection is one of the key procedures for R&D collaboration

and may determine the level of transaction costs a firm may incur. The partner selection issues may be more complex when the focal firm is an SME and the geographical areas of the partners are taken into account. Consequently, the development of an effective search strategy for potential R&D partners abroad may be a difficult task for SMEs. Choosing an appropriate partner and managing them may increase the search cost but ultimately reduce production costs and other transaction costs caused by not having a partner that can create synergy. In our findings, the level of satisfaction with a collaboration was not affected by transaction costs that include search costs, indicating that searching for partners was not regarded as difficult tasks by SMEs. Nevertheless, it doesn't mean that SMEs wanting international R&D collaboration can always easily find appropriate partners because the target respondents for this study were limited to those who were involved in such collaborations.

Second, collaborative R&D projects need to be well managed to actually reduce production costs. The research findings indicate that SMEs suffer more from limited commitment from their partners rather than geographical and language barriers or unwanted knowledge spillovers. To prevent this, the project tasks need to be coordinated carefully based on a mutual understanding of the project goal and their roles in achieving that goal. The findings also suggest that the level of satisfaction with R&D collaboration tends to be high when a collaborative R&D project is designed to obtain commitment from both parties. Mutual commitment to collaborative R&D projects is essential to the success of such collaboration among SMEs even though this may somewhat increase management costs.

Third, the main value of international R&D collaboration to SMEs comes in their efforts aimed at technology development and commercialisation. The benefits for both types were anticipated but rather more benefits than were expected have been created with regard to technology development. In other words, international R&D collaboration among SMEs can be particularly worthwhile for exploring innovative technological opportunities. Indeed, SMEs are likely to be more careful when it comes to selecting their technology for collaboration than large firms. In addition, the motivations for collaboration will be linked to the characteristics of the target technology for the collaboration. Yoon et al. (2016) analysed SMEs' collaboration projects and concluded that successful R&D collaboration projects involving SMEs are focussing *more on innovative technologies* than the others. This is in line with our findings that SMEs are more satisfied with their R&D collaboration results when they receive benefits regarding technology development rather than commercialisation.

4.7. Conclusion

This study sought to investigate the costs and benefits of international R&D collaboration among SMEs, and the criteria used by SMEs to make decisions regarding 1) whether to enter into an R&D collaboration or not (internal R&D versus collaborative R&D); and 2) which partners to choose for such a collaboration (domestic vs international). For this purpose, a theoretical framework was developed combining the perspectives of transaction-cost theory and resource-based theory. As R&D collaboration involves a long-term strategic decision, resource-based theory may be the more appropriate to use. However, since SMEs are limited in their management capabilities and budgets for pursuing their strategies, such constraints need to be considered, which point to the relevance of transaction-cost theory.

In the combined framework, SMEs make a decision to minimise the aggregate total of three types of costs – production costs, transaction costs and management costs – where accessing a partner's or other external resources will help them to decrease their production costs. However, during the decision-making process, SMEs will consider not only the current collaboration project but also the contribution of the current decision to subsequent projects, since future costs may be reduced by improving their resources. If the potential reduction in production costs is likely to be significant due to the firm- and region-specific resources that a firm hopes to access, and if the transaction costs and management costs for collaborating with foreign partners compared to regional partners are also moderate, the firm is likely to choose international R&D collaboration. Furthermore, the level of satisfaction with such collaboration tends to be affected by perceived costs and benefits. This framework was empirically tested with case studies of 14 Korean SMEs and a survey of 118 Korean SMEs, sufficient to ensure meaningful implications for practice.

Despite its contribution to theory and practice, this study is nevertheless subject to certain limitations. First, the empirical analysis was confined to Korea. A test of the framework when applied to other industries and countries is needed to generalise the research findings. Second, the theoretical framework was developed conceptually. Further research is needed to elaborate it to provide more practical implications. For example, mathematical modelling might be used to support actual decision-making regarding collaboration. If relationships between the three costs – production, transaction and management costs – can be formulated in an explicit way, an equation can be formulated to suggest the conditions where international R&D collaboration is preferred to domestic one and internal R&D. Finally, due to the small sample size, the regression analysis had to be conducted on all types of technology collaboration among SMEs. Though R&D and non-R&D collaborations apparently had no statistical differences in the degree of benefits and difficulties apart for one, more data collection focussing only on international R&D collaboration among SMEs is required. In addition, secondary data was used to investigate the relationships between the degree of satisfaction and the cost and benefit factors, which limited us to testing the types of costs and benefits identified during interviews. Also, a survey design needs to be elaborated considering non-response bias. Future research will address these issues.

The research findings also offer several policy implications. First, government funding programmes for international R&D collaboration need to consider not only the short-term but also the long-term effects of the policy. Government funding is useful to encourage SMEs to become engaged in international R&D collaboration. Once SMEs realise the value of such collaboration, they are likely to continue to be engaged in other collaborations. Collaborating with international partners will improve a firm's ability to search and manage partners, and thus help it to increase the value of further collaborations. Nevertheless, such outcomes can rarely be observed in the short term. A performance test adopting a long-term perspective is required.

Second, government policy needs to focus on the unexpected difficulties concerning production cost and transaction cost. Contrary to our expectation that SMEs will incur substantial management costs (to do with networking, language and cultural issues) and transaction cost (i.e. searching for a partner and creating synergies with that partner), they have actually experienced more difficulties relating to the production cost (i.e. sharing R&D costs and outputs). Of the three types of cost, management cost is

expected to continue to decrease with accelerated globalisation bridging language and cultural differences, and with advances in ICTs such as virtual reality and augmented reality facilitating the interaction with a partner. Furthermore, SMEs expect significant management costs and in general are well prepared for them; sometimes, management costs can be a basis for learning. In contrast, SMEs are less prepared for production costs as different firms will have different levels of such cost; the magnitude of this cost is not readily generalisable. Therefore, government policy should perhaps focus more on reducing both anticipated and unanticipated production costs.

The main forms of production cost identified in this study feature two in particular – search costs and commitment costs. To reduce the search costs, a match-making programme, enabling a firm to consider a wide range of candidates for collaboration, can be designed. However, SMEs' attempts to reduce search costs and to work with trustworthy but less capable partners may ultimately bring about the failure of the collaboration, because of not having the most appropriate partners. Offering more feasible candidates for collaboration will help SMEs to arrive at their decisions regarding partner selection. On the other hand, in order to reduce the commitment costs, which are related to uncertainty over the partners, the government arguably needs to play a larger role as an intermediary for collaborations among SMEs until they have acquired sufficient capability to design and manage such collaboration by themselves. As shown in the cases, a partner's opportunistic behaviour may occur if the collaboration is initiated by a private intermediary, as its focus is more on initiating the collaboration rather than successfully completing it. In order to be complementary to the efforts of private-sector intermediaries, a government programme needs to stress the monitoring and results of a collaboration as well as its initiation.

5. Success of international R&D collaboration[28]

5.1. Introduction

Whether small and medium-sized enterprises (SMEs) are more innovative than large enterprises has been long debated. Some researchers argue that more innovations tend to originate in new entrepreneurial firms characterised by creativity and flexibility (Schumpeter, 1934) and thus that SMEs contribute more in terms of new technology creation than their larger competitors (Taymaz and Üçdoğruk, 2009). On the other hand, despite their potential for innovation, SMEs are less likely to conduct R&D activities as a prerequisite for innovation. Their small size may prevent SMEs from not only investing in but also successfully exploiting R&D. However innovative, SMEs may face financial constraints in conducting R&D activities (Kang and Heshmati, 2008), since they are limited in both their internal funding and access to external finance. Moreover, SMEs generally exhibit a lack of absorptive capacity. They may not understand their competence needs (Czarnitzki, 2006) or have only a limited capacity to acquire the necessary competences (Dewaelheyns and van Hulle, 2008). Finally, SMEs are likely to lack risk-management capabilities. They may be unable to endure the uncertainties inherent in R&D or to spread the risks over several R&D projects. This uncertainty is higher in SMEs with a low level of the market power required to deal with risk and uncertainty (Comanor, 1967). Despite these disadvantages, however, studies have found that the effect of firm size on R&D intensity is negligible (Cohen et al., 1987) and that innovation activities among SMEs may be underestimated by the official R&D statistics (Kleinknecht and Reijnen, 1991). These statistics tend to ignore informal R&D, non-permanent R&D, and innovation activities that do not involve formal R&D expenditures, which are common among SMEs (Ortega-Argilés et al., 2009).

Irrespective of the degree to which SMEs contribute to innovation, the R&D activities of SMEs can be a significant factor in innovation, considering the role of SMEs in the global economy. Consequently, ways of increasing the efficiency of such activities in SMEs have received much attention in SME innovation research. Creating innovation alliances is one way to increase this efficiency (van Dijk et al., 1997); SMEs can increase their absorptive capacity (Cohen and Levinthal, 1990) or directly benefit from technological spillovers from external partners (Simonen and McCann, 2008). Particularly in the globalised economy, where R&D is also becoming globalised (Howells, 2008), R&D collaboration with overseas partners can benefit SMEs by localizing their technologies for regional markets and by enabling access to leading technologies in the global market.

However, most studies have focused on the motivations and antecedents of international R&D collaborations (e.g., Narula and Dunning, 1998; Nummela, 2003; Wu and Callahan, 2005), while few studies have measured the performance of such collaborations, possibly due to the difficulty of measuring R&D performance and collaboration performance. Lazzarotti et al. (2011) argued that measuring R&D

[28] Paper title: International R&D collaboration involving small entrepreneurial firms – what constitutes success?

performance is challenging because R&D includes unobservable inputs, uncertain outputs, and a time lag between inputs and outputs. These challenges may be even more severe when studying collaborative R&D with overseas partners since this R&D form implies even greater differences and uncertainties, factors that are virtually uncontrollable. Measuring collaboration performance is also challenging because of SMEs' heterogeneous collaboration goals, business models, and internal capabilities. Nevertheless, defining the success of international R&D collaboration is essential so that high-performing SMEs can be distinguished from low-performing ones.

To overcome the limitations of previous studies, this study focusses on the performance of international R&D collaboration to answer the following research question: How can we determine whether international R&D collaboration is successful from the perspective of entrepreneurial SMEs? To answer this query, we first identify the available performance measures for R&D collaboration and then revise them to fit the context of *international* R&D collaboration. Next, we empirically test a set of performance measures to propose a new set of measures customised to the context of international R&D collaboration involving SMEs. We conduct case studies on 17 Korean SMEs involved in R&D collaboration with foreign organisations, from which the four elements of success most strongly emphasised by SMEs are identified. The research findings provide a clear definition of success in international R&D collaboration and can thus serve as a basis for further analysis. The findings also assist R&D managers in charge of international R&D collaboration by identifying several key performance indicators that should be tracked during international R&D collaboration projects.

The rest of this paper is organised as follows. Section 2 reviews previous studies on the measures of R&D collaboration success. Based on that review, the study's framework is developed in Section 3. Sections 4 and 5 describe the study's research methodology and research findings. The theoretical and practical contributions of the study are then presented in Section 6, together with an outline of the possibilities for further research and this study's policy implications.

5.2. Literature review

This study draws upon the resource-based theory, which suggests that a firm engages in a strategic alliance to access external resources for the sake of competitive advantage (Das and Teng, 2000). Access to resources for innovation is likely to be one of the most significant criteria for strategic decision making in SMEs. Firms regard a collaboration as successful based on whether it gives them access to *the type of resources* they need (technological vs. complementary; Frattini et al., 2014) and *the purpose of the resources* they sought (using others' resources vs. improving their own resources; Das and Teng, 2000). In addition, success can be evaluated from either a single-organisation or multiple-organisation perspective, according to *the coverage of the resources* they sought (resources in a single firm vs. resources in a collaboration network) Therefore, three issues need to be discussed when defining R&D collaboration success.

First, in developing metrics to assess the success of international R&D collaboration, it is useful to

review existing approaches to assessments of "collaboration success" and "R&D success." *Collaboration success*, focussing more on relational than on technological resources, has been measured with various indicators, most of which concern firm performance metrics, such as profit (Brod and Shivakumar, 1997), profit margin on sales (Cao and Zhang, 2011), sales growth (Cincera et al., 2003), market share (Ramanathan et al., 2011), and return on investment (Cao and Zhang, 2011). It can also be measured in terms of the satisfaction level of collaboration participants or their behavioural intention—the intention to work with the same partner in the future—as success in the early stage of a collaboration may lead to further collaborations (Ramanathan et al., 2011). On the other hand, judging the *success of R&D*, which is linked more closely to technological than to relational resources, is commonly based on an evaluation of R&D performance. A substantial number of measures for evaluating R&D performance have been suggested over the past decades. After an extensive review, Ojanen and Vuola (2003) categorised these in terms of the measurement perspective, the measurement purpose, the measurement level, the R&D type, and the process phase—which means that different sets of measures may need to be applied to different contexts. Measuring R&D performance is made more complicated by the distinction between inputs (such as R&D funding) and the imperfect picture provided by a range of intermediate and direct outputs from the innovation process (Hopkins and Siepel, 2013).

The second issue concerns the unit of evaluation. The success of international R&D collaboration can be evaluated at both the project level, when relatively direct benefits are pursued using the partner's resources, and the organisational level, where relatively long-term benefits are pursued using the firm's own resources. If project-level analysis is not separated from organisation-level analysis, the effect of cooperation can be either exaggerated or significantly undervalued. For example, a project that generated a number of patents may be regarded as successful at the project-level but may offer only a limited contribution to the organisation if it fails to use those patents to create value. By contrast, a project that produced unsatisfactory results at the project level can nevertheless make a significant contribution to the organisation if the collaboration output is used in other teams to create value. This issue was raised by Negassi (2004, p. 366):

> *"A paramount problem in measuring the effects of co-operation resides in the diversity of both co-operation and innovation. Because of these measurement problems, most studies would simply elect discrete measuring of co-operation and innovation (for example, the number of co-operation agreements engaged in by the firm and the number of patents it has been granted), without accounting for the fact that co-operation differs in intensity, while innovation differs in the profits they yield."*

R&D collaboration success at the project level does not necessarily equate to that at the firm level if the latter is measured by firm performance while project-level success is concerned with only a particular project. Moreover, a time lag elapses between project success and organisational performance. Most studies have focused on the influence of international R&D collaboration on firm performance, largely due to data availability issues. Consequently, little attention has been given to the project-level success of international R&D collaboration.

The final issue is the perspective taken when defining success: The perspective that is useful for

collaborative R&D may differ from the perspective that is useful for general internal R&D. Collaborative R&D success has frequently been assessed by focussing on only one project participant, similarly to internal R&D, thus limiting the coverage of resources to the organisation that owns them. However, given the duality of collaboration, collaborative R&D success can be judged by considering both parties. Accordingly, Lhuillery and Pfister (2009) broke with the tradition of considering only one party and pointed out that "failures in an R&D partnership did not imply that the whole innovation project was delayed or abandoned, but merely that the firm had to resort to another partner or to internal knowledge sources to achieve its innovation" (p. 46). Consequently, failures are associated with a situation in which the performance of one partner is below the expectation of the other, and this underperformance is serious enough to affect the other's innovation project. Nummela (2003) also suggested that commitment inequality between partners is often the central problem in R&D collaboration. One partner may judge the collaboration as a failure, while the other might still believe it was successful. Mabey et al. (2014) support this view, finding that, in collaboration between researchers from China and Europe, Chinese scientists felt prevented from full participation in knowledge exchange with UK physicists. Hence, the question of whether to take a dual or single perspective needs to be carefully considered when defining the success of R&D collaboration. This issue is particularly important for international R&D collaboration, where large gaps between expectations and performance may appear due to a lack of information about overseas partners before the collaboration begins and cultural differences during the collaboration itself. Hagedoorn et al. (2005) argued that the uncertainty surrounding R&D may affect two types of ex ante information deficiency: the exact nature and extent of future knowledge generated through collaboration, and the value of the joint knowledge base formed with the partner. This information deficiency is expected to increase if a collaboration partner is in a foreign country.

Table 5-1 summarises the measures used in the literature to evaluate the success of R&D collaboration. To identify these measures, we used the term "R&D success measures" and "collaboration success measures" when searching for articles on http://scholar.google.co.kr/. However, we focus only on entrepreneurial SMEs, defined by Holgersson (2012) as "SMEs that base their businesses on new or improved technologies and/or that are newly established or with new or improved means for commercialization and growth" (p. 22), and international collaboration, defined as a collaboration with a foreign partner working together on a project. Thus, these measures need to be refined according to the inherent nature of *entrepreneurial SMEs* and *international collaboration*.

Table 5-1. Measures for evaluating R&D collaboration success

Type	Performance indices
R&D success at the project level	Patents and publications (Brown and Svenson, 1988) Return on investment (Cao and Zhang, 2011) Sales from new products (Brod and Shivakumar, 1997)
Collaboration success at the project level	R&D cost savings (Schill et al., 1994) R&D time savings (Bruce et al., 1995) New market creation (Pitelis et al., 2017) Degree of satisfaction (Cukor, 1992) Intention to collaborate again (Waruszynski, 2017)

R&D success at the organisational level	Increase in patents and publications (Brown and Svenson, 1988) Increase in market share (Ramanathan et al., 2011) Sales growth (Cincera et al., 2003) Increase in profit margin on sales (Cao and Zhang, 2011) Productivity improvement (Brown and Gobeli, 1992)
Collaboration success at the organisational level	Degree of satisfaction (Cukor, 1992) Intention to collaborate again (Waruszynski, 2017) Contribution to creating a new network (Laursen and Salter, 2006)

5.3. Research framework

The study's overall research process is presented in **Figure 5-1**. This study consists of two modules. The first focuses on the definition of success in international R&D collaboration specifically from the SME perspective (i.e., not the large enterprise perspective), while the second module addresses the characteristics of international R&D collaboration (i.e., not domestic R&D collaboration) that are relevant for identifying success measures.

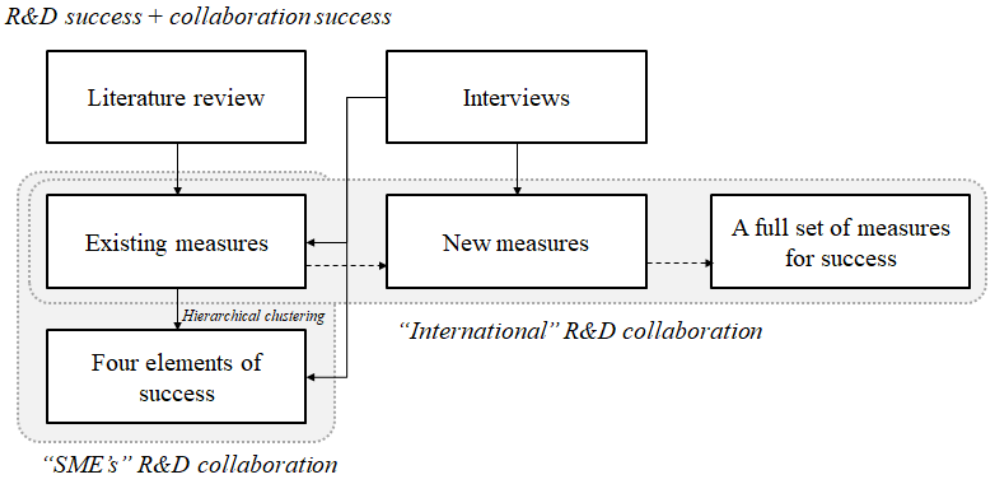

Figure 5-1. Overall research process

The measures commonly applied to R&D collaboration or R&D performance may not be directly applicable to international R&D collaboration success for SMEs. Unlike large enterprises, SMEs are likely to have only limited resources for innovation, and the emphasis placed on innovation through R&D collaboration may also vary across firms, which would cause success criteria to vary. Therefore, we investigate whether the perceived importance of the existing measures of R&D success and collaboration success differs across SMEs and, if they do not, how SMEs can be classified according to their importance and how the focus on success differs across firms. Furthermore, the purpose and nature of international R&D collaboration may differ from those of domestic R&D collaboration, given the time and cost expenditures required to work with foreign partners. Accordingly, existing measures for R&D success and collaboration success need to be combined and extended to reflect the specific contexts of international R&D collaboration and entrepreneurial SMEs.

This study divides the metrics that can be used to measure the success of international R&D collaboration into three levels: project, organisation, and network. Those metrics are developed based on a logic model that has previously been used to help assess R&D programmes (Millar et al., 2001). Here, the inputs are the resources used by SMEs for international R&D collaboration, while processes are the tasks SMEs undertake during the collaboration; these are analysed from the perspective of organisational learning (Lam, 2003). Outputs and outcomes are both related to collaboration results. Outputs are the results produced directly through collaboration activities, and are thus mostly concerned with measures of R&D performance at the project level. Outcomes are the benefits of the collaboration, and thus are closely related to measures of collaboration success at the organisation level. Here, the benefits can be measured in terms of direct project outputs (e.g., measurable outputs, including patents, publications, and new products or services; and unmeasurable outputs, including knowledge from foreign markets and international networks) and indirect outcomes (e.g., increased technology competency, improved market share, new market development, improved brand image). Similarly, the benefits can be investigated in terms of costs, such as reduced project inputs with respect to money and time. Although outputs, outcomes, and impacts are equated with the three levels of project, organisation, and network, strong relationships are expected to be found between outputs at the project level, outcomes at the organisation level, and impacts at the network level. Adopting the logic model enables us to analyse the components of international R&D collaboration at various levels systematically, as shown in **Figure 5-2**.

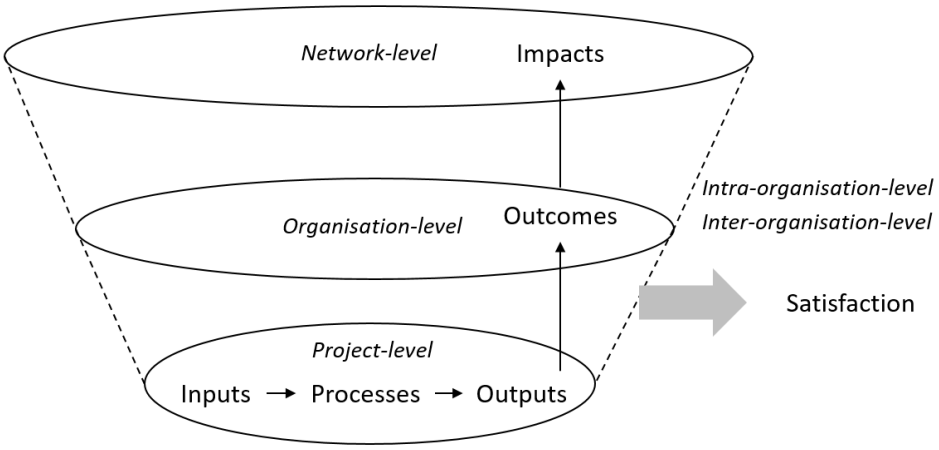

Figure 5-2. Logic model (adopted and modified from Millar et al. [2001])

5.4. Methodology

A multiple case study approach using semi-structured interviews was adopted for this study, for several reasons. First, this study is exploratory; thus, the more cases it examines, the more fruitful its results will be. Second, different firms may have different collaboration motivations, which may result in different perceptions about what constitutes successful collaboration; those differences can be considered in a multiple case study approach. Finally, gaining a balanced view of success requires that both successful and unsuccessful cases be investigated. Furthermore, a multiple case study allows a comparative analysis between successful and unsuccessful cases. Thus, the study conducted in-depth interviews with various

types of SMEs to conceptualise the success of international R&D collaboration and investigate the elements of success. The unit of analysis was a project, and the interview questionnaire included questions on both the project and the organisation.

The target country was South Korea. The target country needs to have strong national technological competitiveness to attract foreign partners. Relatively little is known about R&D collaboration involving Asian countries. It is thus worthwhile investigating South Korea: As it is one of the most technologically advanced nations in Asia (IMD, 2017),[29] it offers many opportunities for R&D collaboration with foreign partners. Moreover, as this country has a relatively small domestic market, its entrepreneurial firms are likely to focus on global markets, offering a strong motivation to work with foreign firms. Focusing on firms dealing with information and communication technologies (ICT) with distinct national competitive advantages, we held interviews with 17 Korean SMEs[30] who had engaged in international R&D collaboration. These firms are grouped in three categories, and their profiles are presented in **Table 5-2**. They include

- firms that have been involved in R&D collaboration with foreign firms (F1–F14)
- firms that have been involved in R&D collaboration with a foreign university (F15)
- born-global firms[31] that have been involved in R&D collaboration (light R&D[32]) with other firms abroad in their process of globalisation (F16–F17)

These target firms were extracted from two sources: 1) the list of firms nominated by the Korean government as globally competitive firms (World Class 300); and 2) the list of firms funded by the Korean government to pursue international R&D collaboration. Interview invitations were emailed; consequently, interviews were arranged with 15 firms. Later, two firms (F16, F17) were added to the list of interviewees after being suggested by other firms.

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[29] Korea was ranked 8th in scientific infrastructure and 17th in technological infrastructure in 2017.

[30] In Korea, the two criteria for SME status are 1) having under 500 billion Korean won in assets; and 2) having under 80 billion Korean won in sales for the information and communications sector and 100 billion Korean won for the electronic components and computer sector and the visual, sound, and communication equipment sector.

[31] A born-global firm is a "firm that is heavily involved in exporting at inception or shortly after establishment" (Knight and Cavusgil, 1996) and whose export income is the highest percentage of its total sales (Rennie, 1993).

[32] Here, "light R&D" indicates simple updates of technologies (e.g., changes of user interfaces).

Table 5-2. List of companies

Type	Firm	Sector	Collaboration items	Interviewee	Interview date
Type 1	F1	ICT-HW	Vision system	PM	26/07/16
	F2	ICT-SW	IoT and data analytics	CEO	27/07/16
	F3	ICT-Content	Game	PM	27/07/16
	F4	ICT-SW	CAD/CAM	CTO	28/07/16
	F5	ICT-SW	Data analytics	CEO	02/08/16, 09/02/17
	F6	ICT-HW/SW	Voice recorder	CEO	02/08/16
	F7	ICT-Content	K-pop	Top manager	02/08/16
	F8	ICT-HW/SW	Healthcare device	CEO, PM, Engineer	03/08/16
	F9	ICT-HW	Electronic device	Top manager	08/08/16, 21/11/16
	F10	ICT-Content	Education	PM	17/08/16
	F11	ICT-SW	Environment	Top manager	28/09/16, 24/11/16
	F12	ICT-SW	Vision system	CTO	29/09/16, 19/11/16
	F13	ICT-Content	Game	CEO	08/10/16
	F14	ICT-SW	RFID	PM	12/10/16
Type 2	F15	ICT-SW	Data security	CEO	08/11/16
Type 3	F16	ICT-Content	Game	CEO	16/10/16
	F17	ICT-Content	Game	CEO	24/10/16

A semi-structured interview was conducted to collect the data. All interviewees were at senior management levels, so that the expected performance of international R&D collaboration at the organisation level as well as the project level could be fully explained. Each interview lasted about one to two hours. In the interviews, the interviewee was asked to focus on one project. We collected data on the following: 1) the definition of success in international R&D collaboration; 2) the significance of different measures of success; and 3) the achievement level of each of the measures in their collaborative R&D projects. For 2) and 3), a seven-point Likert scale was used using measures taken from previous studies (see Table 2). Finally, the data were used to refine the framework for measuring the success of R&D collaboration initially proposed in this study (see **Table 5-1**). Additional measures were collected from the definitions of international R&D collaboration success and were combined with those that had already been identified from the literature review. For analysis, the interview data were transcribed manually (see Appendix **Tables 8-12** and **8-13**); the keywords were highlighted and grouped into semantically related categories.

5.5. Analysis results and findings

5.5.1. Four types of success perceived by entrepreneurial firms

We first investigated the perceived importance of the 13 measures identified from previous studies and gleaned from questions about the degree of achievement for each of the measures for a given case project. However, since data collection was not possible for some ongoing projects, perceived importance was analysed for only 11 firms, and performance was measured for only six firms (see Appendix **Table 8-13).** Here, a seven-point Likert scale was used; a value close to seven indicates greater importance or performance. **Figure 5-3** shows that the firms regarded “new market creation” and “sales from new product development (NPD)” as the most significant criteria for evaluating the success of their

collaboration project.[33] It also indicates that the gap between importance, or expected performance, and performance, or realised performance (i.e., gap = importance rating – performance rating), increases along with the importance level.

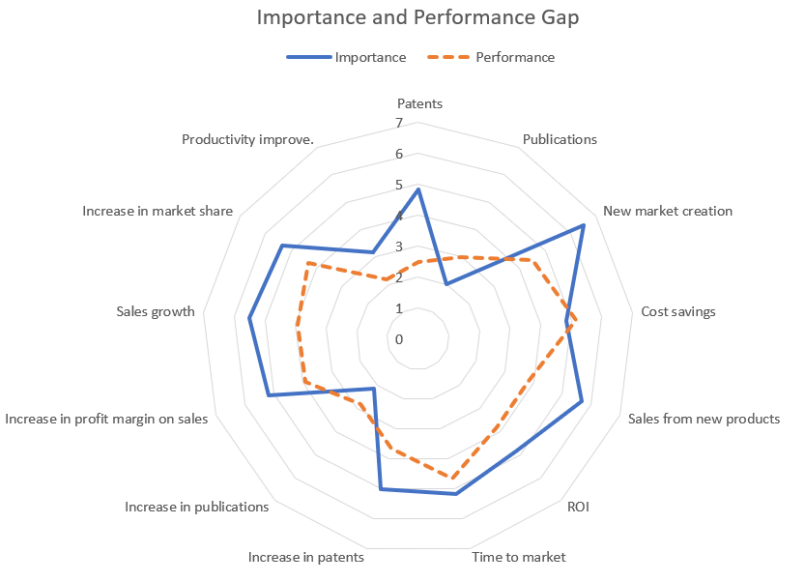

Figure 5-3. Importance and performance gap for success measures

What is more interesting was that the perceived importance of each measure varied significantly across firms. We clustered firms with similar patterns of perceived importance into four groups, for which a hierarchical clustering analysis was conducted on the perceived importance of 13 measures (see Appendix 4). Based on the analysis results, we set the number of categories to four, and found that the firms' definitions of international R&D collaboration along with their focus on measures drawn from the literature differed across categories (see **Table 5-3**).

Table 5-3. Four types of success perceived by firms

Type	Focus of success	Focus of measures (key measures)	Firms
1	Capability-building based on synergy	Knowledge acquisition (new market creation, cost savings, sales from new products, increase in patents, increase in profit margin on sales)	F1, F11, F12, F17
2	New product development (NPD) and commercialisation	Market opportunity (new market creation, sales from new products, ROI, increase in patents, sales growth, increase in market share)	F7, F10, F13, F14, F15
3	Lesson learned for further innovation	Agile development (new market creation, sales from new products, time to market, sales growth, increase in market share)	F8
4	Creating value for society	Exploitation opportunity (new market creation, cost savings)	F9

33 This analysis was based on six firms with available performance data (F1, F7, F8, F9, F11, and F12).

The four groups showed differences in terms of the weights on the 13 measures and definitions of success. The key measures in the table are those with average importance values greater than 6.0. The first group, consisting of three firms (F1, F11, F12 and F17), emphasised *building capabilities from the synergistic effects* of collaboration; the measures concerning collaborative opportunities—new market creation, cost savings, sales from new products, increase in patents, and increase in profit margin on sales—were weighted relatively highly by those firms. The second group includes five firms (F7, F10, F13, F14 and F15); they generally viewed success in terms of *developing a new product and bringing it to market*, assigning high weights to market-related opportunities measures such as new market creation, sales from new products, ROI, increase in patents, sales growth, and increase in market share. The third group comprised only one firm (F8), which defines success as *learning lessons for further innovation*, leading to high weights on measures related to agile development such as time-to-market along with other market-related opportunities measures, including new market creation, sales from new products, sales growth, and increase in market share. The final group, also consisting of one firm (F9), defined success as *collaboratively creating value for society*, giving relatively high weights to only two measures: new market creation and cost savings.

These differences flow from the characteristics of both R&D projects and R&D partners. First, all projects in Type 1, except (F17), were funded by government R&D programmes, which made the firms emphasise capability-building in addition to market benefits. According to Makadok (2001), capabilities are a "special type of resource, specifically an organizationally embedded non-transferable firm-specific resource whose purpose is to improve the productivity of the other resources possessed by the firm" (p. 388). All these firms are relatively small but have numerous collaboration experiences; they seem to use collaboration as a way to develop organisational capabilities and thus regard it as successful when it has improved the productivity of their own resources.

Contrariwise, all projects in Type 2, except (F14), were self-funded and initiated to develop new products and commercialize them, which made the firms emphasise direct business-related outputs. These firms are likely to consider their collaborations successful when they have produced visible and tangible outputs by sharing resources with their partner.

A unique feature was observed for a project in Type 3. This self-funded collaboration project was led by a start-up (F8), representing a high level of R&D intensity and operation in a rapidly growing technological field. The viewpoint of success is similar to that for Type 1; unlike Type 1, however, this type enters into collaboration to improve innovation capabilities, particularly by accessing the partner's resources. This firm regarded all its collaboration-related experiences as a learning process designed to achieve further innovation; thus, it is likely to regard its collaboration as successful when its innovation efficiency has increased.

Finally, one project in Type 4 was characterised by long-term private relationships with collaboration partners intended to identify a new collaborative value-creation opportunity. Despite the similarity with Type 2, the firm in this category has pursued a long-term collaboration with the same partner, rather than

a short-term collaboration with a one-time partner, by sharing resources to collaboratively seek for new opportunities (i.e., products or services valuable to society). Such a long-term relationship is feasible due to their relatively large size, which allows them to use financial resources to develop fundamental technologies.

5.5.2. Success of international R&D collaboration

The components constituting success in international R&D collaboration were identified based on the interviews and the literature. These were grouped into three main categories: project level, organisation level, and network level. Unlike previous studies' focus on one aspect (or a few aspects) of international R&D collaboration, we proposed an integrated framework with which to define collaboration success. First, at the project level, success was associated with the successful acquisition of technological/economic resources. The firms regarded their collaboration as successful when they achieved success in *technology acquisition* (new or improved technology/product/service from the collaboration) or success in *technology commercialisation* (new sales from the collaboration). In addition to the absolute gains generated from the collaboration, interaction with partners was also perceived as essential to successful collaboration, which was described in terms of *synergistic effects* (profits that would not have been gained without collaboration) and *revenue share* (a fair revenue share for both parties). Second, at the organisational level, success was perceived in terms of generating new opportunities. Some firms emphasised the value of *technology opportunities* (organisational learning for further technology development), *business opportunities* (spillover effects on other business areas), and *relational opportunities* (foundations for further collaborations). Finally, at the network level, success was related to *internal growth* (increase in size and R&D productivity of firms in the network), *external growth* (market and R&D internationalisation of firms in the network), and, ultimately, *network growth* (standard setting and infrastructure for R&D in the network, facilitating technology diffusion). All these experiences influenced satisfaction with the partner and the intention to collaborate again with that partner. Accordingly, we redefined the success of international R&D collaboration as follows:

> *Successful international R&D collaboration enables a firm to reduce R&D resources or realise technology development and commercialisation through synergistic effects and fair revenue share from collaboration. In addition, it should help the firm identify technological, relational, and business opportunities and, ultimately, achieve internal, external, and network growth.*

Table 5-4 summarises the measures for successful international R&D collaboration. Items marked with an asterisk are measures mentioned by the SMEs, while the others are adopted from previous studies. Concerning the measures emphasised by the entrepreneurial firms, three novel findings emerge: 1) the general tendency to maximize benefits from R&D rather than to achieve R&D efficiency through collaboration; 2) the strong emphasis on synergistic effects and fair revenue share in evaluating success; and 3) the importance of technology and relational opportunities relative to that of business opportunities.

Table 5-4. Components for successful international R&D collaboration

Project level	Organisation level	Network level
Single perspective (for one partner)		Dual perspective (for both partners)
Inputs: • Resource-savings - R&D cost savings - R&D time savings Processes: • Synergistic effects* - Synergies via collaboration* (F1, F4, F13, F16) - Profits via collaboration* (F4, F7) • Revenue share* - Having a fair share* (F2) - Balance between give and take* (F1) Outputs: • Technology acquisition* (F5) - (Co-)patents - (Co-)publications • Technology commercialisation (F6) - NPD* (F5, F6, F7, F8, F9, F10, F14, F16) - Profit generation* (F4, F17) (Sales from NPD* (F2, F3, F13, F14), technology transfer) - Return on investment - New market creation* (F7, F15)	Outcome: • Technology opportunities* (F11) - Increase in patents - Increase in publications • Relational opportunities* - Improvement in management skills* (F1, F8) - Image- and network-building in the foreign market* (F12) • Business opportunities - Increase in market share for existing products/services - Sales growth for existing products/services - Increase in profit margin on sales for existing products/services - Productivity improvement* (F1) (Increase in technology transfer for existing products/services, Applying the output to the existing business)	Impact: • Internal growth - Increase in size of both firms in the collaboration - Increase in R&D productivity of both firms in the collaboration • External growth - Market internationalisation of both firms in the collaboration - R&D internationalisation of both firms in the collaboration • Network growth* - Standard and infra* (F5) - Technology diffusion* (F5)
Satisfaction: • Satisfaction with the collaboration (F3, F4, F6, F13) • Intention to work together again		

First, at the project level, we found that entrepreneurial SMEs regarded their collaboration as successful when benefits were obtained rather than when costs were reduced; saving time and costs expended for technology development and commercialisation could be a significant motivation for collaboration, but SMEs wanted to have more explicit project outputs from collaboration. Of the 17 SMEs, 14 mentioned technology acquisition and commercialisation as an indicator of successful international R&D collaboration. Entrepreneurs tend to be innovative (Holgersson, 2012), and, being exposed to potential business scenarios, they tend to evaluate that opportunity of new technology acquisition and commercialisation more positively than others (Gustafsson, 2006). Thus, instead of pursuing cost and time savings, they tend to seek innovative outputs.

Second, four SMEs emphasised synergistic effects and fair revenue share as important factors in the

success of international R&D collaboration. Without creating synergies between collaboration partners, SMEs may evaluate the project as unsuccessful, even though they obtained satisfactory R&D results from it. This finding is in line with a recent view stressing the importance of the appropriability regime of the firm as an enabler of R&D collaboration (Henttonen et al., 2015). Moreover, because SMEs may have a process for international R&D collaboration that is less structured than that in larger firms, the way the firms manage the process to share knowledge while learning from each other seems to affect the perceived success of such collaboration.

Finally, at the organisation level, SMEs regard business opportunities as less important than relational and technology opportunities, since most are so small that they are likely to have only a few business units. They are unlikely to experience spillover effects from one project to other business units and have few expectations regarding these opportunities. This finding is contrary to prior findings based on relatively large multinational corporations, which emphasised the potential impacts of international R&D projects on the growth of their regional and international businesses.

5.6. Implications and discussion

Several implications emerge from this study. First, we find that SMEs involved in international R&D collaboration projects with different goals emphasised different elements of success (i.e., capability-building based on synergy, NPD and commercialisation, lessons learned for further innovation, and collectively creating value for society) by describing collaboration success in different ways at different levels. **Table 5-5** summarises the type, purpose and coverage of resources which entrepreneurial SMEs consider as successful international R&D collaboration.

Table 5-5. Resource-based theory to explain successful international R&D collaboration

		Capability-building based on synergy	NPD and commercialisation	Lessons learned for further innovation	Collectively creating value for society
Type	Technological resources	O	O	O	O
	Complementary resources	O	O	O	O
Purpose	Using others' resources		O		O
	Improving their own resources	O		O	
Coverage	A single-organisation	O	O	O	
	Multiple-organisation				O
Output characteristics		Intangible (organisational)	Tangible (short-term)	Intangible (innovation)	Tangible (long-term)

The table shows that the purpose and coverage of resources entrepreneurial SMEs sought play a major role in differentiating the focus of successful international R&D collaboration. It also indicates that notions of success differ according to the output characteristics of resources SMEs are aiming to acquire or improve by accessing external resources (*intangible* vs. *tangible* resources). However, these notions are

also related to the type of intangible resources (*organisational* vs *innovation* capabilities) involved, along with the time required to acquire tangible resources (*long-term* vs. *short-term* periods).

Hence, specific performance measures need to be developed to evaluate whether a particular collaboration purpose was achieved in a given target area. However, despite the diversity among definitions of success, most entrepreneurial firms seemed to focus on having a successful new product or service and reaching the commercialisation stage. Indeed, the most important criterion for international R&D collaboration success concerns whether the firms have experienced a satisfactory level of "technology commercialisation." Thus, the benefits of international collaboration may not be easily observable immediately after the collaboration project ends, as technology commercialisation takes time; thus, the longer-term benefits need to be analysed. Particularly for Type 4, only two measures of R&D collaboration success were found to be important (i.e., those with values greater than six). This indicates that the existing measures of R&D collaboration success cannot fully measure the performance of international R&D collaboration from the SMEs' perspective and that additional measures are needed with which to evaluate the effect of resource sharing from the long-term point of view.

Second, the number of patents or publications is not as important as they were thought to be by managers and policymakers in charge of supporting SMEs. Collaboration rarely results in co-patents or co-publications because SMEs collaborate mostly on the basis of different knowledge bases and modularize their work to remain as independent as possible, as is explained by the CTO of F4: "We were responsible for a SW module, while the partner was responsible for a HW module. Because these two modules should be combined to form a final product, a collaborative R&D project was needed considering their compatibility. Nevertheless, we hardly expected any co-patents or co-publications." Furthermore, SMEs are more likely to grant patents for licensing or to convince investors of the value of their innovation (Rassenfosse, 2012); thus, patents or publications are not a good measure for SME innovation performance. Similarly, the degree of continuous collaboration with the same partners, which has been commonly used to measure the performance of international R&D collaboration, may not be an appropriate measure because further collaboration possibilities can arise not only from the same partners but also from other partners, as entrepreneurial firms are likely to be aggressive in seeking opportunities. Consequently, ascertaining "success" would occur only in discussions with the firm's senior managers, considering this idiosyncratic feature of most SMEs.

Third, several neglected issues need to be considered in evaluating the performance of international R&D collaboration projects. Current evaluation systems often fail to assess the genuine value of international R&D collaboration involving entrepreneurial firms. **Table 5-6** presents the criteria commonly used to measure the performance of international R&D collaboration projects in Korea. More effort is required to add such neglected criteria to the list of existing performance measures (synergistic effects and revenue share). Moreover, a proxy measure for evaluating project performance from such criteria needs further consideration.

Table 5-6. Current performance measurement system

Criteria identified from this study		Criteria used by the government system*
Project level	Resource savings	Contribution to cost saving; Contribution to time-saving;
	Synergistic effects*	-
	Revenue share*	-
	Technology acquisition	Publications; Patents; Proceedings; Other intellectual properties; Loyalties-out
	Technology commercialisation	Use for commercialisation; Sales; Overseas expansion; Loyalties-in
Organisation level	Technology opportunities	Technology transfer; Sending researchers; Having foreign researchers
	Relational opportunities	Opportunities for further R&D projects; Foreign subsidiaries; Information on foreign markets; Awards and prizes; Broadcasting; MOU; Technology networking; Support of domestic firms to go abroad; Support of training HRs
	Business opportunities	Contribution to sales (domestic and foreign markets); Job creation
Network level	Internal growth*	-
	External growth*	-
	Network growth*	-

Source: National Science and Technology Information System in Korea
*measures not covered by the current performance evaluation system

5.7. Conclusions

This study evaluates the success of international R&D collaboration from the perspective of entrepreneurial firms. The criteria used to evaluate successful R&D collaboration with international partners were investigated, and measures for assessing success were identified by examining case studies of 17 Korean entrepreneurial firms. We applied the resource-based theory, wherein the measures differ based on the types, purposes, and coverage of the firms' resources in such collaboration, and we used a logic model to define the success of international R&D collaboration at three different levels. Studies on measuring international R&D collaboration have been fragmented. After reviewing the measures used to evaluate R&D and collaboration success, we conducted in-depth interviews with firms to propose a framework for measuring international R&D collaboration success from a practical point of view. We also employed a logic model to provide the basis for systematic analysis.

The research findings indicate that SMEs define success in four ways: (1) capability-building based on synergy (Type 1); (2) NPD and commercialisation (Type 2); (3) lessons learned for further innovation (Type 3); and (4) creating value for society (Type 4). Across all four definitions, technology commercialisation, and particularly new market creation, constitutes a significant success factor. For an Asian SME with a small technology and product market, the motivation to work with overseas partners can be strong, either to enter a new market or to acquire the latest knowledge from global sources. Naturally, the first success types (Types 1 and 2) can be important, bringing direct and visible short-term benefits, while the latter two (Types 3 and 4) can also be significant elements of success, in anticipation of long-term benefits. Accordingly, firms first need to be clear about the type of collaboration they are pursuing and then set relevant criteria as performance targets. Achieving those targets can enhance their

satisfaction with the collaboration. Furthermore, as an established range of capacities is required to deliver satisfactory performance, firms need to acquire those capacities. From a policy point of view, more customised and selective policy support for firms could be offered according to the types of collaboration they are pursuing and the capacity levels they possess.

Despite the important implications, this study also has several limitations. First, the case study was limited to Korean firms in the ICT sector. As R&D collaborations tend to be goal-oriented, their success measures are likely to be linked to motivations, which in turn are affected by the characteristics of the firm's industry and market. Korea has a small domestic market and features strong national competitiveness in the ICT sector, which may have affected the motivation for international R&D collaboration among the case firms. Moreover, definitions of SME vary across countries. For example, in Europe, SMEs are firms with less than or equal to 250 employees and 50 million euros in revenues. The US criterion is 500 to 1,500 employees depending on the sector (for manufacturing). Fortunately, most of the target firms in this study are small, rather than medium-sized, and applying different definitions would be unlikely to affect the analysis results. Accordingly, the findings may be generalisable to entrepreneurial firms in countries with a small domestic market and to sectors exhibiting strong national competitiveness. However, further research is needed on other sectors and countries.

Second, the scope of this study was limited in terms of the nature and definition of success and its measures. The perceived performance of international R&D collaboration may also be affected by various factors, including company profiles, business models, and collaboration purposes. Future studies could relate those factors to the research findings. Furthermore, although a new set of measures for evaluating success was proposed, these measures were proposed only conceptually; further analysis is needed to investigate each of the measures in terms of their relative importance and to provide specific operational definitions for them. A large-scale survey could be conducted to validate the research findings as well.

Finally, the study's research design could be extended to develop a clearer understanding of the relationships between the elements of collaboration success and to interview both parties in the collaboration. It is also worth investigating successes at different levels—for example, addressing whether project-level success is linked strongly to organisational- and network-level successes, or whether organisational-level success for one party is related to the organisational-level success for the other party in the collaboration network. Taking this dual perspective is necessary for investigating the nature of collaboration success at the network level.

This study identified four elements of success for international R&D collaboration among entrepreneurial SMEs (i.e., capability-building based on synergy, NPD and commercialisation, lessons learned for further innovation, and collectively creating value for society) and proposed a framework for assessing success at three levels: project, organisation, and network. Unlike most previous studies, which have focused on motivations and operational strategies, this study offered a systematic framework for evaluating the success of a collaboration. Thus, these research findings are expected to make a practical contribution to R&D management by helping R&D managers enhance the performance of collaborative R&D. They may also provide a useful reference point for future research, particularly for scholars working in the field of international R&D collaboration.

6. Conclusions

6.1. Summary of findings and contribution

The findings of this study can be summarised into four categories. First, SMEs were willing to collaborate with other SMEs in foreign countries for their R&D. They regarded such collaboration as an important means to enter into foreign markets as well as advance their own technologies. Most previous studies on SME collaboration have addressed the importance of SME collaboration at the commercialisation stage, considering the lack of capabilities for commercialisation in SMEs. This is in line with the findings of this study, indicating that a large share of SMEs have focused on technology exploitation. However, the findings show that technology-based SMEs with a high level of R&D intensity tend to collaborate with overseas partners for not only technology exploitation but also technology exploration. That is, such SMEs pursue such collaboration to maintain their global technology leadership in addition to disseminating their technologies, which are superior to others in general. Despite the potential uncertainties lying in overseas R&D partners, SMEs perceive that they have different target markets from their partners if their partners are located in foreign countries, which lowers the perceived risks caused by the uncertainties (i.e., the partners' opportunistic behaviours).

Second, according to the findings of this study, the level of satisfaction for global R&D collaboration is relatively low in SMEs compared with the relatively high level of need for such collaboration. This is attributable to the fact that the motivation for global R&D collaboration tends to be formed by expectations, while the satisfaction is determined by the actual benefits and costs compared to the expectations. During this process, various factors regarding costs and benefits are in trade-off relationships. Thus, an effort to reduce one type of cost may lead to an increase of another type of cost or a decrease in benefit. An optimal decision needs to take into account major cost and benefit elements as well as their trade-off relationships. Furthermore, satisfactory results are not always guaranteed by having the best collaboration partner. The more important part of collaboration is to motivate the chosen partner to be enthusiastically engaged in the collaboration project with enthusiasm.

Third, international R&D collaboration among SMEs is driven by various motivations, which are largely divided into four types: capability-combining, capability-building, stepping-stone, and global-scouting. Unlike SMEs, large MLEs can establish overseas branches to access external resources abroad. However, SMEs, lacking internal resources to establish such branches, seem to achieve the same goal by collaborating with other SMEs in foreign countries. Among the four types of motivation, capability-building is an interesting one observed only in the collaboration among SMEs. SMEs with such motivation possess similar technology competitiveness and conduct collaborative R&D to co-develop leading technologies in their industry sector. Through such collaboration, the SMEs aim to release the economies scale in R&D. On the other hand, the global-scouting motivation shows that SMEs have also actively introduced external resources necessary for their business. Due to those diverse motivations, the definition of success in international R&D collaboration seems to differ by SMEs.

Finally, this study found that the government funding may play both a positive and a negative role in

facilitating international R&D collaboration. Such collaboration is promoted by the government support, which enables SMEs to initiate such collaboration and experience its benefit for the first time. SMEs are likely to be equipped with the capabilities of international R&D collaboration and can effectively manage further collaborations based on their previous experiences. On the other hand, the government funding attracts SMEs that simply need R&D funding, as well as those desperate for international R&D collaboration, to be involved in such collaboration. If all participants in the collaboration belong to the former case (SMEs merely needing R&D funding), the collaboration is unlikely to yield synergistic effects. If only one party desires international R&D collaboration, with another party being involved in this collaboration only for R&D funding, the imbalance of commitment to the collaborative project may become large, bringing about dissatisfaction with the collaboration. Therefore, in addition to the direct support of offering R&D funding for international collaboration, more focus needs to be given to indirect support, for example, improving SMEs' collaboration capabilities or monitoring the collaboration process to accelerate actual collaboration. The performance of these support programmes and of beneficiaries need to be carefully designed as well because the behaviours of SMEs are strongly affected by the performance measures. The above findings are a synthesis of findings from four papers produced from this study, while the findings from individual papers to answer each of four research questions are summarised in **Table 6-1.**

Table 6-1. Main findings from each chapter

Chapter 2. Why do SMEs seek R&D collaboration with other international SMEs even though they are often dissatisfied with the outcome? The SME collaboration paradox
• RQ1: Do SMEs collaborate with international partners for their technology and, if so, how? • Theory: Resource-based theory was adopted. • Data and methods: Two techniques (logistic regression, cross-tabulation analysis) were conducted using the survey data on "SMEs' international technology collaboration." • Findings: SMEs with larger R&D efforts are less likely to be involved in international technology collaboration. SMEs in electrical and electronics industry sectors were more likely to be involved in such collaboration, while those in bio and medicals, and mechanics and materials were less likely to be involve in this collaboration. Among various types of collaboration involving SMEs, the most preferred type is R&D collaboration among SMEs, but the satisfaction with such collaboration is lower than the other types of collaboration.
Chapter 3. International R&D collaboration among SMEs: A typological approach to motivation
• RQ2: What are the main motivations behind international R&D collaboration for SMEs? How are the strategies for international R&D collaboration affected by the motivation? • Theory: Resource-based theory was adopted. • Data and methods: Case studies were undertaken using interview data on 14 Korean SMEs in the ICT sector. • Findings: Four types of motivations were identified that include capability-combining, capability-building, stepping-stone, and global-scouting, and different operational strategies in terms of partner selection criteria and project management practices were observed for each of them.
Chapter 4. What makes for successful R&D collaboration among SMEs? An integrated perspective on the costs and benefits
• RQ3: What are the benefits and costs of international R&D alliances for SMEs compared to domestic R&D collaboration? • Theory: Resource-based theory was integrated with transaction-cost theory. • Data and methods: Case studies were undertaken using interview data on 14 Korean SMEs in the ICT sector. • Findings: SMEs expect to experience technology exploration and exploitation benefits by accessing resources in foreign countries, whereas they may face difficulties in reducing the production costs through synergistic effects and have managerial and transaction costs to run collaborative R&D. If greater benefits are expected for given costs, or greater cost reductions are expected for given benefits

through R&D collaboration with overseas partners compared to that with domestic partners, international R&D collaborations among SMEs are formed. The research findings also indicated that technology exploration benefits affect the most impact on the satisfaction of this collaboration, along with the difficulties regarding the reduction of production costs. Interestingly, as SMEs had more managerial costs, their satisfaction increased possibility due to the learnings for further collaborations.
Chapter 5. International R&D collaboration involving SMEs – what constitutes success?
• RQ4: How can we determine whether international R&D collaboration in SMEs is successful or not? • Theory: Resource-based theory was adopted. • Data and methods: Case studies were undertaken using interview data on 17 Korean SMEs in the ICT sector. • Findings: SMEs define success in four ways: capability-building based on synergy; NPD and commercialisation; lessons learned for further innovation; and creating value for society. The success can be measured at three levels: project, organisation, and network considering both the success for R&D and the success for collaboration.

Here, it is worth discussing the generalisability of findings. This study was conducted within the context of Korean SMEs that have collaborated with foreign SMEs for their R&D. Consequently, several constraints are imposed in applying the findings to other contexts. First, in relation to the country context, Korea has several distinguishing features. This country has a small domestic market and is interested in globalisation. However, this country is located in East Asia and is characterised as a post-catch-up country, where global leading firms, catch-up firms, and firms lagging behind coexist. However, all these characteristics are applicable to most Asian countries; the findings can be generalised to the collaboration of other Asian SMEs.

Second, regarding the industry sector, this study focused only on the ICT sector. In this sector, the speed of technology development is striking and getting faster, and various technologies in different components in the form of platform, device, network, and software are combined to realise a product or service. Quite often, setting a technology standard can be the route to dominate a market in this winner-takes-all sector. Technologies are relatively easily protected by intellectual property rights. Accordingly, the findings from this study can be generalised to sectors similar to the ICT sector in terms of technological characteristics and industry value chain. Indeed, ICTs are converged with the technologies in other sectors, and more sectors have the characteristics of the ICT sector to some extent, so the findings can be applied to a wide range of sectors.

6.2. Policy implications

Several policy implications emerge from this study, which can be categorised into three subjects – motivation, management, and performance, which are the core elements of the conceptual framework of this study (see **Figure 1-1**). In addition to these elements, the role of a government support programme is discussed in this section because this study started with the following RQ: Should the government encourage SMEs to be involved in international R&D collaboration with other SMEs?

6.2.1. Motivation

Various motivations for SMEs' international R&D collaboration with other SMEs are observed in this study. Furthermore, the motivation evolves as collaboration experience is accumulated. Each of the motivations has distinguishing characteristics in terms of the establishment and management of the collaboration. More interestingly, SMEs with different motivations define successful international collaboration in different ways. For example, SMEs with the capability-combining motivation regard their collaboration as success when they gain a profit "from" a collaboration and emphasise the acquisition of exploitation opportunities or capability building based on synergies. On the other hand, to SMEs with stepping-stone or global-scouting motivations, the key success factors include new product development and commercialisation. All of these findings indicate the need for some diversification and sophistication of government support for SMEs, particularly in relation to international R&D collaboration, to increase the effectiveness of SME support programmes.

Nevertheless, existing programmes to support SMEs' international R&D collaboration in many countries are likely to be relatively simple, unable to support such heterogeneous motivations. Especially as a catch-up country, Korea has been running two major programmes to facilitate such collaboration: one is to help domestic firms to acquire superior technologies and knowledge from abroad, whereas the other is to help them to enter into new foreign markets. To gain the most benefits from international R&D collaboration among SMEs, more elaborate programmes need to put in place to satisfy the varying needs of SMEs, and different systems for monitoring and evaluating project and programme performance need to be applied to collaborations with different motivations and operational strategies. For example, SMEs pursuing capability building require different approaches to collaboration in terms of choosing target countries, searching for target partners, and protecting potential issues expected during collaboration than those pursuing capability combining. Hence, a different set of support is needed for each type of motivation. SMEs also need to be fully aware of the characteristics of the collaboration in which they are planning to engage, thereby increasing the chances of success as well as their satisfaction with the collaboration.

6.2.2. Costs and benefits

According to the transaction-cost theory, SMEs choose international partners instead of domestic partners to minimise the sum of three types of cost: production costs (i.e., sharing R&D costs and outputs), transaction costs (i.e., searching for a partner and creating synergies with that partner), and management costs (i.e., networking and costs incurred due to language and cultural issues). This study found that SMEs have actually experienced more difficulties relating to production and transaction costs than management costs. For example, SMEs have had difficulties allocating tasks in a way that creates synergy and sharing costs and benefits in a way that is fair rather than suffering from language issues or geographical distance. Indeed, of the three types of cost, management costs seem to continue to decrease with accelerated globalisation bridging language and cultural differences and with advances in ICTs enabling close interactions with a partner. Furthermore, SMEs expect significant management costs and in

general are well prepared for them. Government support has also focused on reducing management costs by supplying videoconference equipment for SMEs to share or offering programmes for SMEs to learn about other cultures. In contrast, SMEs are less prepared for transaction costs. Two main forms of transaction cost were identified in this study: search costs and commitment costs, which may arise due to uncertainty about the partners. Unlike management costs, the magnitude of both search and commitment costs is not generalisable because different firms will experience different levels of such costs. That is, it is not possible to predict how much a partner will contribute to the collaborative R&D until firms actually start to work together.

Therefore, government policy should focus more on reducing those costs. Firstly to reduce the search cost, a match-making programme, enabling an SME to consider a wide range of candidates for collaboration, can be designed. SMEs' attempts to reduce the search cost may lead to situations in which they decide to work with trustworthy but less capable partners. Such collaboration may generate less successful results due to having less appropriate partners. The analysis results also indicated that a firm regarded its partner search strategy as more effective when the partner was chosen from a formal network than from previous collaboration experiences. Thus, the government can help SMEs to expand their formal networks, giving them more options for collaboration partners.

Similarly, in order to reduce the commitment cost, the government can play a larger role as an intermediary for collaborations among SMEs until they have acquired sufficient capability to design and manage such collaborations by themselves. If collaboration is initiated by government agencies, SMEs' opportunistic behaviour may be limited as well because SMEs tend to be concerned about their reputation and its effect on further support from the government. Thus, government programmes should focus not only on the initiation of such collaboration but also on the monitoring and results of the collaboration, as a partial solution to reduce the commitment cost.

Finally, production costs need to be reduced through collaboration. To do so, how to share R&D costs and outputs between collaboration partners should be considered before the collaboration is formed. Accordingly, designing a collaboration project before the collaboration is initiated is quite important. Despite this importance, however, SMEs may have limitations in exploring potential collaboration partners for mutual understanding and in having enough discussions about possible issues that can occur during collaboration due to their lack of resources. To overcome such limitations, basic principles of sharing R&D costs and outputs are required for SMEs to have realistic expectations about the collaboration, which can either be provided by government or developed by participants.

6.2.3. Performance

This study showed the diversity regarding what constitutes success of SMEs' international R&D collaboration, possibly due to the diversity in motivations and the time lag between the collaboration and performance. SMEs' diversity in motivation makes it difficult to measure the performance of such collaboration. However, despite such diversity, the most important and common criterion is whether SMEs have experienced a satisfactory level of technology commercialisation or not. Quite naturally,

because technology commercialisation takes time, the benefits of international collaboration are neither easily observable nor objectively measurable. Therefore, an evaluation system to measure the performance should be designed, carefully considering the motivation of a programme to support SMEs.

Unfortunately, most of the existing evaluation systems fail to measure the performance of such collaboration. The metrics used in these systems (e.g., patents and publications) are not as important as they were thought to be by managers and policy-makers in charge of supporting SMEs. For example, one of the common metrics to measure innovation performance is the number of patents or publications. Yet, SMEs are more likely to grant patents for licensing or convincing investors about the value of their innovation, and thus, patents or publications cannot be a good measure for SMEs' innovation performance. Another metric to measure collaboration performance is the number of co-patents or co-citations. However, SMEs tend to collaborate on the basis of different knowledge bases and modularise their work to be as independent as possible, and thus, such a metric fails to assess the genuine value of international R&D collaboration involving SMEs. Sometimes, the degree of continuous collaboration with the same partner is used as a proxy to measure the collaboration performance. This also may not be an appropriate measure because SMEs may find better partners than previous ones, even if they were satisfied with the previous collaboration; with limited capabilities, SMEs are always faced with such a choice. On the contrary, there are certain previously neglected issues that need to be considered in evaluating the performance of international R&D collaboration projects. These issues include synergistic effects and revenue share. More effort is required to add such neglected criteria to the list of existing performance measures.

Another remarkable finding of this study is that international R&D collaboration with other SMEs is one of the most preferred types of collaboration among SMEs, and yet, this actually generates the least satisfaction among various types of technology collaboration with foreign partners. This low satisfaction may come from the discrepancy between expectation and reality, which can be reduced in two ways. A policy programme can be designed for SMEs to deal with a number of unexpected costs incurred by international collaboration with other SMEs. By making such costs more predictable and manageable by SMEs, such a discrepancy can be resolved to some extent. The first step will be to identify the difficulties that SMEs may face during such collaboration to control the level of expectations. The next step will be to design a policy instrument in a way that helps SMEs overcome those difficulties. For example, SME-matching algorithms can be developed to help SMEs search for and select the best candidates for their collaboration partners considering their needs and collaboration purposes; having the right collaboration partners can be one of the most effective approaches to lead to full commitment to collaboration, prevent opportunistic behaviours, and ultimately achieve the goal of collaboration. On the other hand, as an institutional strategy, a government funding programme may require SMEs to carry out their collaboration in two stages: one for planning and the other for R&D. SMEs that successfully undergo the planning stage are the final beneficiary of R&D funding. Finally, it is possible to reduce the management costs stemming from the differences in R&D support systems across countries by complying with the global standards for global R&D collaboration projects.

6.2.4. The role of government funding

There are two types of support – direct and indirect – from the government to facilitate international collaboration among SMEs. First, direct support is related to public funding, particularly for such collaboration, which actually plays a significant role in initiating the collaboration. However, there may be two quite different types of SMEs that apply for the funding: one aims to use the funding for internal R&D, while the other seeks to access the funds for accelerating international R&D collaboration. It is only for the second type that the funding is used to improve the innovation capabilities of SMEs. Distinguishing the second from the first type will be a significant issue when choosing the beneficiaries of such funding.

Second, the purpose of indirect support is to provide an environment in which SMEs can gain benefits from international R&D collaboration. For example, a platform to support long-distance interactions may be useful to reinforce interactions between collaboration partners, while designing a policy instrument to achieve effective knowledge exchange is also required. Here, a strong IP system that can protect firms' own resources while accessing those of partners is key to encouraging such collaboration; only when an SME's own resources are under strong protection, ensuring that unwanted knowledge spillovers are prevented, are they likely to be actively involved in collaboration.

Finally, when evaluating the effect of government policy programmes for international R&D collaboration, whether they are direct or indirect, both the short- and long-term effects of the policy need to be considered. Government funding is useful to encourage SMEs to start such collaboration. Once SMEs realise its value, they will continue to be engaged in other collaborations with overseas partners. Such collaboration experiences will improve SMEs' ability to search and manage overseas partners and thus increase the value of further collaborations. These outcomes can be observed only from a long-term perspective.

6.3. Limitations and future research directions

The limitations can be categorised under two headings – research framework and data collection and analysis – based on which future research directions are proposed.

6.3.1. Research framework

Using the SPC model, the conceptual framework of this study involved three main elements to investigate: the motivation, operation, and performance of international R&D collaboration among SMEs. The focus of this study was to analyse each of the elements and the relationships between them: for example, motivation affects operations, which was examined in Chapter III, and operations affects the performance, as argued in Chapter IV. Cross-sectional data were collected for static analysis, while those elements may evolve as firms grow. Though dynamic analysis was conducted in Chapter III to understand the evolution of motivation, further analysis is needed to analyse how other elements and their relationships change

over time. Similarly, this study was limited to analysis of the relationships between elements. However, the relationships of elements at different levels – project, organisation, and network levels – are worth addressing. For instance, the project-level motivation for collaboration may be different from the organisation-level motivation, but these two types of motivation may be interrelated. Investigating the relationships of elements at different levels will offer valuable insights into comprehending why and how SMEs are involved in R&D collaboration with other overseas SMEs.

Second, in addition to the three main elements, the framework proposed in this study includes four other elements: 1) national and sector characteristics as external factors and 2) operational strategies and organisational capabilities as internal factors. Yet, detailed analysis concerning those elements could not be carried out in this study, despite their significance in understanding the collaboration. For example, identifying SMEs' organisational capabilities that are required to produce successful results from international R&D collaboration among SMEs is essential to develop effective innovation policies for SMEs. This study needs to be extended to those issues.

Third, the conceptual framework of this study needs to be elaborated to provide more practical implications. More specifically, the relationships between the elements (e.g., definition of success and its measures according to motivation) or sub-elements (e.g., the relationships among production, transaction, and management costs) can be formulated in an explicit way to reveal the underlying mechanism of collaboration. Mathematical modelling can be used to present such relationships and further to support actual decision-making regarding collaboration based on the relationships. This also will enable to identify the conditions where international technology collaboration creates more values than domestic technology collaboration in the context of SMEs.

Finally, this study analysed characteristics of international R&D collaboration among SMEs as a whole, which are determined by characteristics of three types of collaboration – international collaboration, R&D collaboration, and collaboration among SMEs. Accordingly, the findings from all three different types of collaborations were mixed up when generating the findings of this study. Further effort is needed to separate effects from different types of collaboration on the findings of this study.

6.3.2. Data collection and analysis

First, the empirical analysis was confined to Korea and the ICT sector. National characteristics can affect SMEs' motivations to globalise their business and collaborate with international partners in their R&D. Korea is characterised by a small domestic market and has a strong national competitiveness in the ICT sector, which may have affected the motivation for international R&D collaboration of the case firms. Hence, the findings may be generalisable to SMEs in countries with a small domestic market and in sectors exhibiting strong national competitiveness. Therefore, the findings of this study need to be tested in other sectors and countries to ensure generalisability.

Second, through qualitative analysis, this study investigated only 18 SMEs. With more case companies, more reliable results may be obtained. A large-scale survey could be conducted to validate the

findings. In addition, this study took a single perspective, where only the perspective from a single side (Korean SMEs) in a bilateral relationship was considered when investigating the mechanism of international R&D collaboration among SMEs. Collaboration involves an interactive process between participants. For a full understanding of such collaboration, interviews with both sides of firms (Korean SMEs and their partners) are needed, taking a dual perspective. Therefore, further study is needed to expand the depth and breadth of case studies.

Third, regarding quantitative analysis, this study has room for improvement in both data collection and analysis. It used secondary data, which limited the researcher to testing the findings from interviews. Furthermore, the data were collected at the organisational level and included only a small set of data on international R&D collaboration among SMEs. More data collection focussing on this particular type of collaboration at the project level is required, for which the target survey respondents as well as survey questionnaires need to be carefully designed. The common method bias and non-response bias need to be controlled as well. In terms of the analysis method, a simple regression model was applied in this study, but advanced models can be considered in describing the complex relationships among the elements of conceptual framework proposed in this study. Future research will address these issues.

6.4. Concluding remarks

The purpose of this study was to investigate international R&D collaboration involving SMEs from various angles – in terms of collaboration patterns, motivations, operational strategies, and performance. While large efforts have been made to analyse R&D globalisation, most previous studies focused on large MLEs; little attention has been given to R&D globalisation in SMEs for innovation, while extensive literature has addressed the importance of SMEs in innovation. Recognising the importance of SMEs in innovation, this study restricted its focus to international R&D collaboration involving SMEs as a means to innovate their technologies or business models. The findings of this study also identified that SMEs have been and desire to be involved in R&D collaboration with overseas partners, in particular, other SMEs in foreign countries. Thus, this study proposed international R&D collaboration among SMEs as one of the mechanisms for achieving global competitiveness.

Theoretically, this study integrated the resource-based theory with the transaction-cost theory to analyse international R&D collaboration among SMEs, unlike most previous studies, which adopted on or the other of them. In SMEs' decision-making, minimising costs, which is the focus of the transaction-cost theory, as well as maximising benefits, which is the focus of the resource-based view, need to be considered, justifying the rationale for integrating the two theories. Accordingly, this study proposed an integrated approach incorporating both cost and benefit factors in explaining why SMEs choose other SMEs in foreign countries as their collaboration partners for R&D and thus is differentiated from the existing approaches.

Methodologically, this study was conducted in the context of Korean SMEs. International R&D collaboration of SMEs in Asian countries has gained little attention from researchers, with a few

exceptions focusing on China. Considering that the economies of Asia have been growing at a remarkable pace, the need for international R&D collaboration involving firms in this area is expected to increase and may present several challenges, which necessitated this study. Furthermore, this study adopted a mixed-method approach using both interview and survey data, enabling understanding of the general trends in international R&D collaboration involving SMEs as well as the detailed mechanisms underlying such collaboration.

From a practical perspective, this study provides meaningful policy implications to successfully initiate and operate international R&D collaboration among SMEs. Government policy programmes to support SMEs' R&D can be divided into two main categories: direct support and indirect support. First, direct support is related to offering funding for SMEs' R&D collaboration with other SMEs abroad. As to this support, the existing programmes need to be revised to reflect the diversity of SMEs' motivations for engaging in such collaboration. Furthermore, the distinguishing characteristics of each programme need to be taken into account in the selection criteria for beneficiaries and the evaluation criteria for measuring the programme performance. Second, indirect support is provided in the form of building collaboration capabilities or diminishing administrative costs, which may be more effective in the long term. According to the findings, this indirect support needs to focus on identifying potential collaboration partners as well as helping SMEs to manage their collaborations in a way that is fair to them.

7. References

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8. Appendix

8.1. Survey questionnaires

Table 8-1. Survey questionnaires

Section	Key questions
I. Company profiles	• Foundation year • Main sector (7 sector) • Size (Number of employees, Revenues in 2013) • R&D intensity in 2013
II. Experience of international technology collaboration	1. Collaboration experience 2. Main approach to partner search and its effectiveness 3. Main sector for collaboration (7 sector, 66 sub-sectors) 4. Purpose of collaboration - Collaboration type: HR-inward; HR-outward; technology licensing-inward; technology licensing-outward; collaborative R&D; foreign subsidiary; foreign investment; others - Technological purpose: leading technology acquisition; bottleneck technology acquisition; commercialisation technology acquisition; global standardisation; leading technology diffusion; others - Economic purpose: reduced time; reduced cost; market expansion or increase in exports; local resource use; others 5. Technology collaboration activities - Types of collaboration partner: university; public research centre; large firm; SME; others - Types of participation of partner: co-management; participant at the organisational level; outsourcing at the organisational level; participant at the individual level - Role sharing: equal responsibilities; core technology on my firm; R&D outsourced to a partner firm; R&D support from a partner firm; consulting and advice from a partner firm - Output sharing: exclusive right of my firm; proportionate to responsibilities (a key output is mine); equal right; proportionate to responsibilities (a key output is partner's); independent possess - The way to pay loyalty if collaboration output is commercialised in my firm - The way to receive loyalty if collaboration output is commercialised in a partner firm 6. Average collaboration periods and costs 7. Average number of partner countries 8. Main partner countries (max two) 9. Satisfaction of collaboration (5-point Likert scale) 10. Effectiveness of international collaboration compared to internal R&D in terms of (5-point of Likert-Scale): reduced time; reduced cost; increased possibility of technology development success; increased quality of technology; localisation of technology; reduced cost on import; reduced time for technology commercialisation; reduced time for entering a global market 11. Difficulties in international collaboration in terms of (5-point Likert scale): networking with partners; R&D costs; language and cultural barriers; creating synergies through collaboration; sharing collaboration outputs; searching partners for commercialisation; R&D capabilities of partner firms

III. Plans for international technology collaboration	• Plans for international technology collaboration If no, reasons of not collaborating with international partners • Capacities required to conduct the collaboration • Main sector for collaboration (7 sector, 66 sub-sectors) - same as II. 3 • Purpose of collaboration - same as II. 4 • Main partner countries (max two) - same as II. 8 • Planned collaboration periods and costs - same as II. 6
IV. Policy recommendation	• Government support - Experience - Types of support: R&D; HR; networking; technology commercialisation; other - Degree of satisfaction (5-point Likert scale) • Priority of support: networking to leading organisations and researchers; MOU; collaborative R&D project; socioeconomic and legal support for international researchers to settle down; investigating local business environments and business partners for entering international markets; providing information regarding market and technological environments for main countries; legal and accounting services for contracting international partners

8.2. Diagnosis for regression analysis – Chapter 2

8.2.1. Common method bias (Model 1)

Table 8-2. Common method bias test (Model 1)

Factor	Initial eigen value			Rotation Sums of Squared Loadings		
	Total	% variance	cumulated %	Total	% variance	cumulated %
1	1.662	41.547	41.547	1.150	28.753	28.753
2	1.041	26.023	67.571			
3	.799	19.984	87.555			
4	.498	12.445	100.000			

Method: Principal Axis Factoring

8.2.2. Correlation analysis (Model 2)

Table 8-3. Correlation analysis results (Model 1, N=1096)

		RnD intensity	Revenue	RnD staffs	Age
RnD intensity	Pearson correlation	1	-.098**	.027	-.304**
	Significance level		.001	.369	.000
Revenue	Pearson correlation	-.098**	1	.238**	.245**
	Significance level	.001		.000	.000
RnD staffs	Pearson correlation	.027	.238**	1	.383**
	Significance level	.369	.000		.000
Age	Pearson correlation	-.304**	.245**	.383**	1
	Significance level	.000	.000	.000	

8.2.3. A cross-tabulation analysis for the willing-to-collaborate SMEs

Table 8-4. A cross-tabulation analysis results (the willing-to-collaborate group)

	Universities	Public research institutes	LEs	SMEs	Others
Human resources-out	6	4	2	7	1
Human resources-in	0	7	1	7	0
Licensing(buy)-out	9	12	32	44	10
Licensing(buy)-in	16	24	11	46	1
Collaborative R&D	27	77	37	110	1
Setting up a subsidiary	4	8	8	28	0
Investment in foreign firms	5	26	28	42	3
Others	0	0	0	6	0

8.2.4. Common method bias (Model 2)

Table 8-5. Common method bias test (Model 2)

Factor	Initial eigen value			Rotation Sums of Squared Loadings		
	Total	% variance	cumulated %	Total	% variance	cumulated %
1	1.537	38.422	38.422	.859	21.466	21.466
2	1.233	30.836	69.259			
3	.764	19.111	88.369			
4	.465	11.631	100.000			

Method: Principal Axis Factoring

8.2.5. Correlation analysis (Model 2)

Table 8-6. Correlation analysis results (Model 2, N=112)

		Age	RnD staffs	Revenue	RnD intensity	Funding
Age	Pearson correlation	1	.105	.091	-.407**	-.082
	Significance level		.271	.339	.000	.388
RnD staffs	Pearson correlation	.105	1	.331**	.095	-.184
	Significance level	.271		.000	.320	.053
Revenue	Pearson correlation	.091	.331**	1	-.196*	-.162
	Significance level	.339	.000		.038	.088
RnD intensity	Pearson correlation	-.407**	.095	-.196*	1	.125
	Significance level	.000	.320	.038		.187
Funding	Pearson correlation	-.082	-.184	-.162	.125	1
	Significance level	.388	.053	.088	.187	

8.3. Interview materials

Interview with OOO

Date

Time

Location

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Purpose of this interview

- **Understand the motivation**
  - purpose, initiation (government support, sector characteristics)
  - expected costs and benefits, actual costs and benefits
  - choice of international (domestic) partners
- **Understand the management**
  - type of technology for collaboration
  - partner selection criteria
  - organisational learning process
- **Understand the notion and results of collaboration success**
  - project-level success, organisational-level success
  - one party success, both party success
  - collaboration satisfaction, behavioural intention
  - absorptive capabilities
  - project management strategies

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Collaboration history: domestic (recent 5 years)

	who (team), when (period), where (partner), what (technology), how (cost, funding), why (purpose)
Project D1	
Project D2	
Project D3	

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Collaboration history: international (recent 5 years)

	who (team), when (period), where (partner), what (technology), how (cost, funding), why (purpose)
Project I1	
Project I2	
Project I3	

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Motivation - domestic

		Project D1 ( )	Project D2 ( )	Project D3 ( )
Type of resources	Market			
	Technology			
Purpose of alliance	Weakness			
	Strength			
Target periods	Long-term			
	Short-term			

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Motivation - international

		Project I1 ( )	Project I2 ( )	Project I3 ( )
Type of resources	Market			
	Technology			
Purpose of alliance	Weakness			
	Strength			
Target periods	Long-term			
	Short-term			

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Basic information about a project

- **Project:**

- Types of project: ☐ international; ☐ domestic
  1) Project title:
  2) Project periods:
  3) Project costs :
  4) Funding sources:

- Partner type: ☐ industry; ☐ public; ☐ academic; ☐ others ( )
  1) Partner organisation:
  2) Partner location:

- Project organisation:

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Project:

Motivation – expected costs and benefits

		Direct output (patents, publications, new products…)	Indirect outcome (corporate images, networks, organisational capabilities…)	Gap between Expected-Actual
Benefit	Expected			
	Actual			
		Direct cost (human capital, money, time…)	**Indirect cost (language, cultural, institutional differences, collaboration risks…)**	**Gap between Expected-Actual**
Cost	Expected			
	Actual			
Partner selection rationale (domestic vs. international)				

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Respondents:

Project:

Management – operational strategy

		who (team), when (period), where (partner), what (technology), how (cost, funding), why (purpose)
Collaboration partner	Search strategies	
	Selection criteria	
Target technology	Basic vs. applied	
	Core vs. peripheral	
Project management	Schedule	
	Cost	
	Performance	

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Respondents:

Project:

Management – organisational learning

	Activities	Facilitators	Barriers
Socialisation (T ▸ T)	Joint meeting, joint brainstorming, training…		
Externalisation (T ▸ E)	Joint concept creation…		
Socialisation (E ▸ E)	Building prototypes, databases for collaboration…		
Socialisation (E ▸ T)	Learning by doing, applying the knowledge for organisational use…		

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Respondents:

Project:

Success – collaboration success

Success	Definition: Degree of satisfaction: Intention to work with the same collaboration partner:

		feasibility	Importance	Evaluation
Project-level	Patents			
	Publications			
	New market creation			
	Cost savings			
	Sales from new products			
Organisational level	Patents			
	Publications			
	Profit margin on sales			
	Sales growth			
	Market share			
	Return on investment			
	Productivity improvement			

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Respondents:

Project:

Success – absorptive capacity

R&D capability	R&D intensity	
	Number of patents	
Collaboration capability	Previous experiences of R&D collaboration (domestic, international)	
	Number of co-assigned patents	

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Respondents:

8.4. Interview results

8.4.1. A list of firms interviewed

Table 8-7. A list of firms interviewed

Firm	ICT sector	Interviewee's position	Interview date
F1	HW	Project manager	26/07/16
F2	SW	CEO	27/07/16
F3	Content	Project manager	27/07/16
F4	SW	CTO	28/07/16
F5	SW	CEO	02/08/16
F6	HW/SW	CEO	02/08/16
F7	Content	Top manager	02/08/16
F8	HW/SW	CEO, Project manager	03/08/16
F9	HW	Top manager	08/08/16, 21/11/16
F10	Content	Project manager	17/08/16
F11	SW	Top manager	28/09/16, 24/11/16
F12	SW	CTO	29/09/16, 19/11/16
F13	Content	Top manager	08/10/16
F14	SW	Project manager	12/10/16

8.4.2. Project characteristics

Table 8-8. Analysis of project characteristics

Firm	Company profile				Project profile			Partner profile			Technology profile	
	Size (employee)	Foundation	R&D intensity	Collaboration experience	Status	Start	End	Country	Funding	Selection	Status	Maturity
F1	85	2000	13%	Many	Complete	2011	2013	Israel	Korea-EU	Intermediary	Core	Applied
F2	17	2005	27%	Many	Ongoing	2016	-	Israel	Korea-Israel	Expo	Core	Applied
F3	150	1998	-	Many	Complete	2008	2009	China	Partner-self	Selected	Core	Applied
F4	71	1990	-	Many	Complete	2013	2014	UK	Self	Selected	Core	Applied
F5	100	1980	25%	Many	Ongoing	2015	-	Germany	Korea-EU	Selected	Core	Applied
F6	14	2005	20%	Many	Ongoing	2015	-	US	Self	Intermediary	Core	Applied
F7	120	2004	3%	Only a few	Complete	2012	2013	China	Self	Intermediary	Core	Applied
F8	20	2014	54%	Many	Complete	2015	2015	China	Self	Intermediary	Core	Applied
F9	250	2003	12%	Many	Ongoing	2014	-	Netherlands	Self+(Korea-EU)	CEO network	Core	Applied
F10	34	2011	-	Many	Ongoing	2016	-	China	Self	Search	Potential	Applied
F11	32	1997	9%	Many	Complete	2010	2012	Spain	Korea-EU	Intermediary	Core	Applied
F12	30	2005	-	Many	Ongoing	2014	-	Turkey	Korea-EU	Intermediary	Core	Applied
F13	50	2015	50%	Many	Complete	2015	2015	Israel	Self	Search	Potential	Applied
F14	11	2007	10%	Only a few	Complete	2012	2015	Czech	Korea-EU	Introduced	Core	Applied

8.4.3. Partner selection criteria

Table 8-9. Partner selection criteria for international R&D collaboration from a task-related perspective

Category	Sub-category	Criteria	Explanation	Reference
Costs	Direct costs	Human resources	The level and quality of human resources for collaboration	Geringer, 1991
		Financial resources	The level of financial resources for collaboration	Geringer, 1991
		Time	The amount of time expected to obtain the required results	Geringer, 1991
	Indirect costs	Organisational difference	The difficulties expected from differences in organisational culture	Emden et al., 2006; We et al., 2009
		Opportunistic behaviours	The difficulties expected from a partner's opportunistic behaviour	Li et al., 2008
Benefits	Direct benefits	New products	The quality of new products expected from collaboration	Emden et al., 2006;
		Intellectual property (IP)	The amount and quality of IP expected from collaboration	Geringer, 1991; We et al., 2009
	Indirect benefits	Capabilities increase	The degree of increase in capabilities expected from collaboration	Emden et al., 2006
		Image	The improvement in corporate image expected from collaboration	Geringer, 1991; We et al., 2009
		Networks	The new networks expected to be formed from collaboration	Geringer, 1991

8.4.4. Cost minimisation process

The decision-making processes regarding the three types of costs over time can be expressed in terms of the following optimisation problem Eq(1), where TC_k is the total cost to acquire the necessary resources by taking an option *k*, $\Delta TC_{k,t}$ indicates the total cost reduction in subsequent collaborations at time *t* by taking the option *k*, T is the maximum time for which the impact of choosing the option *k* lasts, PC is the production cost incurred to develop the necessary resources internally, ΔPC_k is the reduction in the production cost by taking the option *k*, TrC_k is the expected transaction cost by taking the option *k*, MC_k is the management cost by taking the option *k*, and B is the total budget available for acquiring the necessary resources. The firm will choose the best option that can minimise the total long-term cost (that is, maximising the total long-term benefit) within a total current budget B.

$$Option\ (k): \min_k (TC_k + \sum_{t=1}^{T} \Delta TC_{k,t})\ (t=1, \ldots, T) \quad \text{---------- Eq(1)}$$

$$where, TC_k = (PC - \Delta PC_k) + TrC_k + MC_k \qquad s.t. PC - \Delta PC_k \leq B$$

8.5. Diagnosis for regression analysis – Chapter 4

8.5.1. Endogeneity test

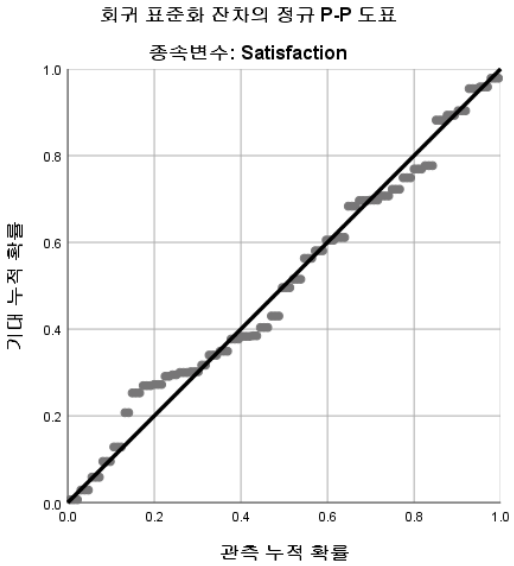

Figure 8-1. P-P chart

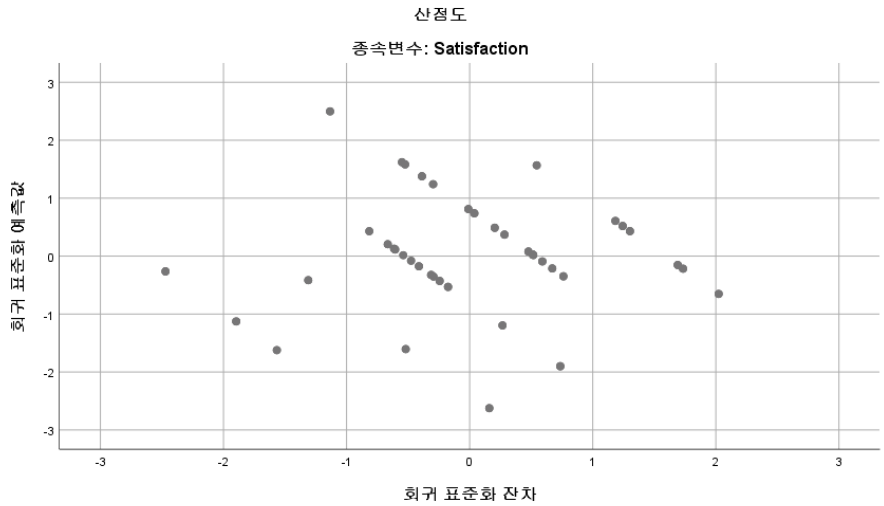

Figure 8-2. Scatter plot

8.5.2. Common method bias

Table 8-10. Common method bias test

Principal components	Initial eigen value		
	Total	% variance	Total %
1	1.464	24.403	24.403
2	1.440	24.006	48.409
3	1.123	18.717	67.126
4	.967	16.118	83.243
5	.620	10.329	93.572
6	.386	6.428	100.000
Method : Principal Axis Factoring			

8.5.3. Model summary for linear regression model

Table 8-11. Multicollinearity test

Model		Unstandardized Coefficients		Standardized coefficients	t	p	Multicollinearity	
		B	Standard error	Beta			Tolerance	VIF
1	(constant)	2.447	.455		5.383	.000		
	REGR factor score 1 for analysis 2	.551	.098	.498	5.608	.000	.788	1.268
	REGR factor score 2 for analysis 2	.078	.098	.070	.791	.431	.788	1.269
	REGR factor score 1 for analysis 1	-.274	.094	-.247	-2.897	.005	.855	1.170
	REGR factor score 2 for analysis 1	-.261	.099	-.235	-2.638	.010	.781	1.281
	REGR factor score 3 for analysis 1	.075	.089	.068	.845	.400	.972	1.029
	funding	.428	.184	.186	2.331	.022	.978	1.022
	Age	.015	.075	.020	.206	.837	.639	1.564
	RnD intensity	.106	.073	.143	1.466	.146	.657	1.523

Model summary [b]

Model	R	R square	adjusted R squrqe	Standard error of the estimate	Durbin-Watson
1	.568[a]	.323	.273	.944	1.804

a. independent variables: (constant), RnD intensity, REGR factor score 2 for analysis 1, REGR factor score 3 for analysis 1, funding, REGR factor score 1 for analysis 2, REGR factor score 1 for analysis 1, REGR factor score 2 for analysis 2, Age

b. dependent variable: Satisfaction

8.6. Definition of success and its measures

Table 8-12. Definition of success

Firm	Success
F1	Synergy via interaction, Balance of give-and-take, Exchange of human resources, Extension to other R&D (business areas), Organisational learning and project management
F2	New sales from a collaboration, having a fair revenue to both participants
F3	New sales from a collaboration, Poor results but satisfactory with the collaboration process
F4	Gaining profits that could not have been gained without collaboration. (Satisfaction from only one party can hardly happen)
F5	1) Acquiring original (novel) technology; 2) Technology diffusion; 3) Standard and infra; and 4) NPD
F6	1) Successful NPD; and 2) Successful Commercialisation; poor results of commercialisation are likely to come from poor collaboration
F7	Having a new or improved product that is satisfactory to both parties in a collaboration network; the degree of satisfaction with a focal firm from the partner; New sales from a collaboration; Enabling application of the collaboration results to new business areas
F8	PM: Successful NPD, CEO: Providing lessons for further innovation, CFO: Successful NPD
F9	Creating something valuable to society (successfully developing a product sold in a market)
F10	NPD
F11	Capability-building through collaboration
F12	Having a new opportunity to collaborate
F13	Meeting each other’s expectation + market success (profit), taking something that we don’t have
F14	Successful NPD + Successful commercialisation (New sales from a collaboration)
F15	Sharing resources, Entering a new market
F16	Creating something usable (new product used or sold)
F17	Profit generation

Table 8-13. Importance and performance of measures perceived by SMEs

	Project level (Importance, Performance)							Organisation level (Importance, Performance)					
	Pats.	Pubs.	New market creation	Cost savings	Sales from NP	ROI	Time to market	Increase in patents	Increase in publications	Increase in profit margin on sales	Sales growth	Increase in market share	Productivity improve.
F1	6(1)	1(1)	6(2)	5(7)	6(5)	6(5)	3(4)	6(7)	1(1)	5(4)	6(5)	4(4)	2(1)
F7	3(1)	2(1)	7(6)	5(6)	7(4)	7(4)	7(6)	3(1)	2(1)	6(4)	7(4)	7(4)	5(3)
F8	4(1)	4(5)	7(5)	1(4)	6(3)	4(3)	7(5)	4(1)	4(5)	3(3)	6(3)	7(5)	1(1)
F9	4(3)	1(2)	6(5)	6(6)	4(3)	1(4)	3(3)	5(5)	2(2)	4(4)	5(5)	5(5)	5(6)
F10	3(-)	3(-)	6(-)	1(-)	7(-)	7(-)	7(-)	3(-)	3(-)	6(-)	7(-)	7(-)	4(-)
F11	6(4)	3(6)	6(5)	5(2)	5(2)	5(1)	5(4)	6(3)	3(5)	6(1.5)	5(1.5)	5(4)	5(1)
F12	6(5)	1(3)	7(4)	7(6)	6(6)	6(6)	6(6)	6(5)	1(3)	7(7)	4(5)	4(4)	1(1)
F13	2(-)	1(-)	6(-)	4(-)	6(-)	5(-)	5(-)	1(-)	1(-)	6(-)	6(-)	5(-)	4(-)
F14	5(-)	3(-)	7(-)	5(-)	7(-)	5(-)	5(-)	3(-)	3(-)	6(-)	7(-)	6(-)	4(-)
F15	4(-)	1(-)	6(-)	6(-)	7(-)	7(-)	4(-)	2(-)	1(-)	7(-)	7(-)	7(-)	4(-)
F16	4(-)	1(-)	5(-)	3(-)	6(-)	6(-)	5(-)	1(-)	1(-)	4(-)	-	-	-
F17	5(-)	3(-)	7(-)	7(-)	7(-)	5(-)	7(-)	7(-)	2(-)	7(-)	7(-)	7(-)	7(-)
min	2	1	5	1	4	1	3	1	1	3	4	4	1
max	6	4	7	7	7	7	7	7	4	7	7	7	7
average	4.2	1.9	6.4	4.8	6.2	5.5	5.5	3.7	1.9	5.7	6.2	5.9	4.1
median	4	1	6	5	6	6	5	3	2	6	6.5	6.5	4
Type 1	**5.75**	2.00	**6.50**	**6.00**	**6.00**	5.50	5.25	**6.25**	1.75	**6.25**	5.50	5.00	3.75
Type 2	3.33	1.83	**6.50**	4.67	**6.83**	**6.33**	5.83	2.17	1.83	**6.33**	**6.83**	**6.50**	4.67
Type 3	4.00	4.00	**7.00**	1.00	**6.00**	4.00	**7.00**	4.00	4.00	3.00	**6.00**	**7.00**	1.00
Type 4	4.00	1.00	**6.00**	**6.00**	4.00	1.00	3.00	5.00	2.00	4.00	5.00	5.00	5.00

8.7. Further analysis

8.7.1. Collaboration purposes

Given the wide variety of expected benefits from strategic alliances, the purposes of collaboration in pursuit of those benefits may also vary (Huxham and Vangen, 2013). However, among the various purposes, SMEs are more likely to emphasise collaboration for technology exploitation than for technology exploration. SMEs tend to have superior technologies while lacking the capacity to commercialise them, with their limitations in terms of manufacturing facilities, marketing and distribution channels, and global contracts (Narula, 2004). SMEs tend to search for a partner that can provide the resources they are lacking, that is, resources at the commercialisation stage, unlike large MNEs which can establish their own subsidiaries to support market development and technology commercialisation. This issue was also addressed by Lee et al. (2010), who argued that open innovation efforts in SMEs focus more on commercialisation than R&D itself. Thus, the second hypothesis developed here addresses the significance of technology exploitation as the purpose of collaborating with international partners:

H1. SMEs tend to collaborate with overseas partners for technology exploitation rather than technology exploration.

In particular, SMEs in their early stages are more likely to stress technology exploitation, while mature SMEs will be more interested in seeking business opportunities to grow or sustain competitive through technology exploration. SMEs investing a lot on R&D are more likely to focus on technology exploration, considering their relatively diverse R&D portfolios. Accordingly, besides H2, the following hypothesis was also developed:

H1-1. The tendency of SMEs to collaborate with overseas partners for technology exploration increases with their own R&D efforts (in terms of R&D staff and R&D intensity).

H1-2. The tendency of SMEs to collaborate with overseas partners for technology exploration decreases with their age.

The following analysis aims to identify SMEs' reasons for being involved in international technology collaboration. As shown in **Table 8-14**, the main reasons are to acquire "commercialised technology" and to "expand the market and increase exports". Nevertheless, some SMEs still emphasise seeking new opportunities for technology exploration from international collaboration.

Table 8-14. Collaboration purpose

	Purpose of collaboration	Experienced		In-preparation group		Willing-to-collaborate group	
		%	Cases	%	Cases	%	Cases
Technological	Acquire superior technologies	34.0	89	32.9	24	38.2	248
	Develop bottleneck technologies	13.0	34	13.7	10	11.5	75
	Acquire commercialised technologies	**35.5**	93	47.9	35	**40.2**	261
	Internationally standardise technologies	1.9	5	0.0	0	4.2	27
	Outbound transfer of leading technologies	13.4	35	5.5	4	5.5	36
	Others	2.3	6	0.0	0	0.5	3
Total (Case)		262	100	73	100	650	100
Economic	Reduce time for technology development	29.0	76	20.5	15	14.0	91
	Reduce cost for technology development	11.5	30	27.4	20	12.9	84
	Market expansion and increase in exports	**49.2**	129	**52.1**	38	**68.8**	447
	Access to local resources	6.9	18	0.0	0	4.3	28
	Others	3.4	9	0.0	0	0.0	650
	Total (Case)	262	100	73	100	650	100

Note. The values in bold indicate the most frequent purpose in each group and each type.

This purpose of collaboration is expected to be affected by the characteristics of the SMEs. Accordingly, further analysis was conducted with a particular focus on the main purpose of such collaboration involving SMEs with different characteristics; 1) the number of R&D staff; 2) R&D intensity; and 3) firm age. The Chi-square test results indicated that the purposes differ with all three factors[34]. However, the analysis results only partially support H2-1. First, regarding the number of R&D staff, if the number of R&D staff is relatively small or relatively large, the SMEs' tendency to collaborate for technology exploitation, that is, for the purpose of "acquiring commercialised technologies" and "market expansion and increase in exports", increases (see **Table 8-15**). The former case seems to correspond to SMEs starting a business globally, while the latter case seems to involve technology-based SMEs attempting to globalise their business.

[34] A Chi-square test generated p-values of 0.038 (the number of R&D staff), 0.027 (R&D intensity), and 0.01 (firm age) for technological purposes, and 0.000 (the number of R&D staff), 0.003 (R&D intensity), and 0.000 (firm age) for economic purposes. Therefore, the differences are statistically significant at the 0.05 significance level.

Table 8-15. Collaboration purpose according to the number of R&D staff

	Purpose of collaboration	The number of R&D staff				
		1-3	4-5	6-9	10-19	20<
Technological	Acquire superior technologies	28.3	**41.8**	**41.4**	36.8	15.4
	Develop bottleneck technologies	11.3	20.0	6.9	10.5	17.9
	Acquire commercialised technologies	**43.4**	27.3	27.6	**42.1**	**38.5**
	Internationally standardise technologies	1.9	1.8	0.0	1.8	5.1
	Outbound transfer of leading technologies	15.1	9.1	19.0	8.8	15.4
	Others	0.0	0.0	5.2	0.0	7.7
Economic	Reduce time for technology development	34.0	**43.6**	24.1	14.0	30.8
	Reduce cost for technology development	0.0	16.4	15.5	21.1	0.0
	Market expansion and increase in exports	**49.1**	36.4	**46.6**	**64.9**	**48.7**
	Access to local resources	17.0	0.0	5.2	0.0	15.4
	Others	0.0	3.6	8.6	0.0	5.1
	Total (Case)	100(53)	100(55)	100(58)	100(57)	100(39)

Note. The values in bold indicate the most frequent purpose in each group and each type.

Second, SMEs with lower R&D intensity are more likely to collaborate with overseas partners for technology exploration. In contrast to our expectation, SMEs investing less effort in R&D are more likely to collaborate for technology exploration, showing a large percentage value for "acquire commercialised technologies" and "market expansion and increase exports" (see **Table 8-16**). It seems that SMEs lacking R&D resources explore superior technologies from abroad and then introduce them to their domestic market.

Table 8-16. Collaboration purpose according to R&D intensity

	Purpose of collaboration	R&D intensity (%)				
		0-3	3-6	6-10	10-20	20<
Technological	Acquire superior technologies	**54.5**	**41.9**	24.4	25.0	20.6
	Develop bottleneck technologies	12.7	6.5	9.8	19.4	17.6
	Acquire commercialisation technologies	21.8	37.1	**43.9**	**36.1**	**39.7**
	Internationally standardise technologies	20.0	0.0	0.0	5.6	2.9
	Outbound transfer of leading technologies	14.3	14.5	17.1	11.1	14.7
	Others	0.0	0.0	4.9	2.8	4.4
Economic	Reduce time for technology development	**49.1**	29.0	19.5	25.0	20.6
	Reduce cost for technology development	5.5	14.5	22.0	8.3	8.8
	Market expansion and increase in exports	30.9	**56.5**	**51.2**	**52.8**	**54.4**
	Access to local resources	10.9	0.0	7.3	8.3	8.8
	Others	3.6	0.0	0.0	5.6	7.4
	Total (Case)	100(55)	100(62)	100(41)	100(36)	100(68)

Note. The values in bold indicate the most frequent purpose in each group and each type.

Finally, the analysis indicated that the purpose of collaboration differs with the firm's age (see **Table 8-17**). With regard to technological purposes, SMEs in their early stages are more likely to be interested in the commercialisation of their technologies, while others tend to focus on acquiring superior technologies. On the other hand, with respect to economic purposes, the purposes of international technology collaboration in younger SMEs are more diverse than those in established SMEs, the latter pursuing mainly "market expansion and increase in exports" and "technology development time reduction". Young SMEs are likely to collaborate with international partners more for technology exploitation than for technology exploration.

Table 8-17. Collaboration purpose according to firm growth

	Purpose of collaboration	Age (years)				
		< 5	5-10	10-15	15-20	< 20
Technological	Acquire superior technologies	24.6	25.8	34.7	**41.7**	**52.9**
	Develop bottleneck technologies	16.4	9.1	11.1	16.7	15.7
	Acquire commercialisation technologies	**42.6**	**39.4**	**38.9**	**41.7**	15.7
	Internationally standardise technologies	6.6	0.0	1.4	0.0	0.0
	Outbound transfer of leading technologies	6.6	22.7	11.1	0.0	15.7
	Others	3.3	3.0	2.8	0.0	0.0
Economic	Reduce time for technology development	24.6	21.1	29.2	16.7	**47.1**
	Reduce cost for technology development	9.8	13.6	12.5	0.0	11.8
	Market expansion and increase in exports	**42.6**	**57.6**	**51.4**	**83.3**	35.3
	Access to local resources	19.7	4.5	0.0	0.0	5.9
	Others	3.3	3.0	6.9	0.0	0.0
	Total (Case)	100(61)	100(66)	100(72)	100(12)	100(51)

Note. The values in bold indicate the most frequent purpose in each group and each type.

8.7.2. Collaboration modes

Table 8-18 shows the share of the seven collaboration modes in three different groups: the experienced group; the in-preparation-group; and the willing-to-collaborate group. The results show that *R&D collaboration* is the most commonly used, the most expected to be used, and the most desired form of collaboration with regard to SMEs' international technology collaboration, followed by licensing-in and licensing-out.

Table 8-18. Needs and satisfaction by collaboration mode

Collaboration mode	Experienced group			In-preparation group		Willing-to group	
	%	Cases	Satisfaction*	%	Cases	%	Cases
Human resource – out	2.3	6	4.17	0.0	0	2.8	20
Human resource – in	8.0	21	3.57	0.0	0	2.1	15
Licensing – out	19.1	50	4.00	12.3	9	16.0	107
Licensing – in	23.7	62	3.74	17.8	13	15.4	98
R&D collaboration[35]	34.7	91	3.59	49.3	36	39.8	252
Setting up a subsidiary	4.6	12	3.58	0.0	0	6.6	48
Investment in foreign firms	6.1	16	3.75	20.5	15	16.5	104
Others	1.5	4	3.75	0.0	0	0.8	6
Total/means	100.0	262	3.73	100.0	73	100.0	650

Note. * Satisfaction was measured on a 5-point Likert scale.

However, one might expect the sector characteristics to affect the tendency towards a particular type of collaboration mode. For example, the tendency towards R&D technology collaboration in SMEs is stronger in the Bio and Medical (BM) and Information and Communications Technology (ICT) industries

[35] Despite its demand and potential, however, R&D collaboration has generated a relatively low degree of satisfaction, which requires further study.

than the others (see **Table 8-19**). When the collaboration modes were analysed by industries focusing only on the experienced group of firms, it was found that BM and ICT industries have engaged in R&D collaboration more than the other industries. Introducing new products and services in BM to a foreign market requires appreciable technology localisation and a very considerable amount of resources for R&D (Madhok and Osegowitsch, 2000) while ICT is an industry characterised by "strong national competitiveness" (Lee, 2003) and "strong technology appropriability" with more increase in patent applications for this sector than other sectors (OECD, 2007). These sectoral characteristics are expected to affect the tendency towards technology collaboration. That is, SME's tendency to engage in R&D technology collaboration is likely to be stronger in an industry characterised by "strong protection", "strong localisation" and "technological strength".

Table 8-19. Needs and satisfaction by collaboration mode

Collaboration modes	MM	EE	ICT	C	BM	ER	Others
Human resource – out	0.0%	0.0%	0.0%	0.0%	11.8%	0.0%	0.0%
Human resource – in	13.8%	11.1%	0.0%	7.3%	5.9%	0.0%	0.0%
Licensing – out	17.2%	11.1%	30.0%	22.0%	17.6%	25.0%	7.1%
Licensing – in	31.0%	44.4%	20.0%	34.1%	5.9%	0.0%	0.0%
R&D collaboration	31.0%	33.3%	**40.0%**	14.6%	**45.1%**	25.0%	78.6%
Setting up a subsidiary	0.0%	0.0%	10.0%	14.6%	0.0%	25.0%	0.0%
Investment in foreign firms	6.9%	0.0%	0.0%	7.3%	11.8%	0.0%	14.3%
Others	0.0%	0.0%	0.0%	0.0%	2.0%	25.0%	0.0%
Total cases	87	27	30	41	51	12	14

Note 1. M: Mechanical/Material, E: Electric/Electronics, ICT: Information and Communications Technologies, C: Chemical, BM: Bio/Medical, ER: Energy/Resources, KBS: Knowledge Based Services
Note 2. The values in bold indicate two sectors with the largest share of firms engaged in R&D collaboration.

8.7.3. Collaboration partners

Similarly, the share of partner types in the three groups was analysed, as shown in **Table 8-20**. The results reveal that both the most commonly used and the most desired type of partners for international technology collaboration are other SMEs; approximately 45% of SMEs have experienced or are seeking international collaboration with other SMEs.

Table 8-20. Needs and satisfaction by collaboration partner

Partner type	Experienced group			In-preparation group		Willing-to group	
	%	Cases	Satisfaction*	%	Cases	%	Cases
University	14.9	39	4.18	8.2	6	10.3	67
Public research institute	14.5	38	3.76	16.4	12	24.3	158
Large enterprise	18.7	49	3.80	30.1	22	18.3	119
SMEs	45.0	118	3.50	45.2	33	44.6	290
Others	6.9	18	4.00	0.0	0	2.5	16
Total	100.0	262	3.73	100.0	73	100.0	650

Note. * Satisfaction was measured on a 5-point Likert scale.

For further analysis, a Chi-square test on the differences in the distribution of collaboration partners between R&D collaboration and non-R&D collaboration was conducted for the experienced group. The

Pearson Chi-square value was 0.073, which means that there is no statistically significant evidence that this preference for collaborating with SMEs is stronger or weaker in R&D collaborations than in other types of collaboration at the 0.05 significance level; regardless of the type of collaboration, SMEs seem to be one of the most attractive types of partner to other SMEs. Nevertheless, SMEs' technology collaboration with other SMEs resulted in a lower degree of satisfaction with the collaboration, a finding statistically significant at the 0.01 level according to the ANOVA analysis results.

Such dissatisfaction is observed more often in R&D collaboration among SMEs rather than in other types of collaboration with SMEs. According to **Table 8-21**, which summarises the degree of satisfaction by type of collaboration partner for two different types of collaboration (R&D vs. non-R&D), it is evident that R&D collaboration with SMEs has the lowest satisfaction values. The ANOVA results also showed that there is a statistically significant difference in the degree of satisfaction with collaboration in R&D but not in other forms of collaboration. In R&D collaborations, SMEs are less likely to be satisfied with their collaboration with other SMEs than with universities, public research institutes, and large enterprises (at the significance level of 0.05). Interestingly, for other types of technology collaborations apart from R&D, the type of partner does not seem to affect the degree of satisfaction.

Table 8-21. Satisfaction by collaboration partners: R&D vs. non-R&D

Partner type	R&D collaboration		Non-R&D collaboration	
	Satisfaction*	Cases	Satisfaction*	Cases
University	4.25	20	4.11	19
Public research institute	3.69	16	3.82	22
Large enterprise	3.77	13	3.81	36
SMEs	3.06	35	3.69	83
Others	3.86	7	4.09	11
Total	3.59	91	3.80	171
ANOVA analysis results	p-value 0.001 (F-value 4.916)		p-value 0.324 (F-value 1.174)	

Note. * Satisfaction was measured on a 5-point Likert scale.

8.7.4. Partner selection

Although opportunistic behaviour may give rise to transaction costs in an inter-organisational collaboration, that risk can be reduced by building up trust (Beamish and Banks, 1987). According to Gulati (1995, p.91), trust is defined as "a type of expectation that alleviates the fear that one's exchange partner will act opportunistically", meaning that a collaboration will be less constrained by the risk of opportunistic behaviour while mutual commitment is facilitated, thereby increasing the chances of the collaboration being successful. Firms may be inclined to select partners from within their existing network to reduce uncertainty and risk (Baum et al., 2005), seeking trustworthy partners for R&D collaboration. This inclination may be particularly strong in SMEs, which are less well prepared for a partner's opportunistic behaviour, decreasing the likelihood of searching for overseas R&D partners outside of their networks. Within their networks, SMEs can identify their potential partners through the following channels in approximately ascending order of transaction cost; 1) past experience of working together; 2) member of their informal networks; and 3) member of their formal networks. On the other hand, SMEs may search for partners from outside their networks by; 1) meeting at international conferences or seminars; and 2) being introduced by intermediaries. Based on the above discussions, the transaction cost[36] is expected to be higher when searching partners outside an existing network than within. Moreover, the reduction in the transaction cost is expected to contribute to a decrease in the total cost, increasing the overall satisfaction with the collaboration. Thus, the following hypotheses can be put forward:

H2a. SMEs are likely to find their overseas partners from within their networks.

H2b. SMEs are more likely to be satisfied with their overseas partners and the collaboration results when their partners were chosen from within rather than outside their networks.

To investigate the partner search approaches and their effectiveness, an ANOVA analysis was conducted on the effectiveness of each approach. The results comparing the partner selection approach for R&D collaboration and non-R&D collaboration with SMEs are summarised in Table 1.

[36] The level of transaction cost was measured by a proxy of "effectiveness of partner search strategy" because the cost is related mainly to the costs for partner search, evaluation and negotiation along with the costs from partner's opportunistic behaviours. If all the partner-related costs were satisfactory, it is highly likely that the partner search strategy could be regarded as effective.

Table 8-22. Partner selection strategies

Partner search approaches			R&D collaboration			Non-R&D collaboration		
			%	Case	Eff.*	%	Case	Eff.*
Personal	Direct	Informal network	20.0	7	3.95	18.1	15	3.93
		Past experience of working together	28.6	10	3.12	37.3	31	3.16
	Indirect	Introduction by formal network	20.0	7	4.17	33.7	28	4.11
Public domain		International conferences/seminars	11.4	4	3.25	4.8	4	3.00
Intermediary		Introduction by intermediaries	20.0	7	3.50	6.0	5	3.60
Total cases			100	35	3.64	100	83	3.64
ANOVA results for Eff.			p-value 0.034			p-value 0.000		
Correlation analysis results between Eff. and satisfaction			p-value 0.921			p-value 0.000		

Note 1. * Eff.: Effectiveness was measured on a 5-point Likert scale.

The table shows that the largest number of SMEs search for partners based on their past experience of collaboration, a process which interestingly produced the lowest level of effectiveness among the five options for partner search. It is likely that, as SMEs have limited capabilities to adopt other approaches, they have few alternatives but to use their existing networks. On the other hand, the two approaches of using an "informal network" and being introduced by "formal networks" such as local subsidiaries or strategic alliance partners were regarded as more effective than the others, when SMEs are searching for other SME partners, with the difference being significant at the 0.05 level. While SMEs tend to rely on personal networks (the first three – introduction from an informal network, from past experience of working together, and from a formal network – are all regarded as personal networks), the degree of satisfaction with these three is not always greater than for other approaches. Hence, H1 is supported but H1a is only partially supported.

The difference in partner search approaches between R&D collaborations and non-R&D collaborations was not statistically significant at the 0.05 significance level, with a Pearson Chi-square value of 0.076. Though the general patterns of searching for partners are similar in both R&D and non-R&D collaborations, a distinguishing feature of R&D collaborations is the use of intermediaries; in an attempt to reduce transaction costs, more SMEs tend to rely on intermediaries such as government agencies or private consulting firms to identify or select qualified collaboration partners, although the degree of satisfaction with such an approach is not that high among SMEs (with an effectiveness value of 3.5).

An interesting finding emerges from the correlation analysis about the link between the effectiveness of partner search approaches and the level of satisfaction with the collaboration. A large and significant correlation is observed for non-R&D collaborations, with a correlation coefficient of 0.510 (and a significance value of 0.000). In contrast, the correlation was not significant (at the 0.05 significance level) for R&D collaborations (the significance value was 0.921). An effective approach to searching for collaboration partners can help in achieving satisfactory collaboration results for non-R&D collaboration, but a good partner does not automatically guarantee satisfactory results from an R&D collaboration; not only finding a good partner but also managing the project effectively is important for obtaining

satisfactory results.

Four main approaches to searching for international partners were observed from the interviews. The first was to use a *personal network*, which can be either a direct network (F9) or an indirect one, being introduced by other companies with which the focal company has links (F8, F10 and F14). Search costs could be reduced in these cases but the partners' capabilities could not be evaluated from an objective viewpoint, which sometimes led to unsatisfactory results from the collaboration. The second was to use an *intermediary*. Some intermediaries were from the private sector (F1 and F11) and some from the public sector (F12). By using an intermediary, it was easy for SMEs to identify potential partners with the necessary capabilities, although sometimes the partner recommended by the intermediary in the private sector proved not to be trustworthy when the project was initiated (F1). The third was from *public-domain information* such as online searches (F3 and F13), while the final way was *to be contacted by partners* (F4 and F6).

In our findings, the level of satisfaction with a collaboration was lowest when SMEs worked with a previous partner, which suggests several plausible explanations. One is that SMEs' attempts to decrease their transaction costs may in turn limit the reduction of their production cost though collaboration. Or diminishing-returns-to-learning from others may prevent them from receiving the same level of benefits from subsequent projects with the same partner, as was argued by previous studies (Gulati, 1995; Hoang and Rothaermel, 2005), although some of them suggest an inverted U-shaped relationship between innovation and partner familiarity, operationalized by alliance partner repeatedness (Zheng and Yang, 2015) or the number of similar partners in an alliance portfolio (Luo and Deng, 2009). Another possible explanation is that past experience of working together has increased their level of expectation with regard to their partners, which consequently decreased their degree of satisfaction. Relying too much on partners can be factor to decrease the degree of satisfaction (Hoecht, 2006).

8.7.5. Project ownership

Several options can be considered when designing a collaborative R&D project, ranging from individual participants to a broader organisational contribution according to the degree of organisational commitment to the project. If an international R&D collaboration is designed at the individual level, with consulting services from overseas professionals, a focal firm will take the position of project leader, coordinating the collaborative tasks and playing a central role in managing the project. In this case, the firm is likely to have a greater level of ownership of the project and accordingly the management cost can be reduced; the project needs less enforcement and control over the partners, and is likely to be less affected by cultural, organisational and institutional differences. In contrast, if SMEs cannot induce commitment on the part of their partners, the reduction in production costs may not be large enough to create synergistic effects between collaboration partners, potentially reducing the degree of satisfaction. Indeed, successful R&D collaboration needs the commitment of all the participants (Devlin and Bleakley, 1988; Anderson and Narus, 1990). Therefore, SMEs expect their partners to play a critical role in the collaboration to ensure access to the partners' resources and to improve their own resources through

learning. This tendency tends to be strong in R&D collaborations, where learning is essential to profit from that collaboration (Narula, 2004; Dodgson, 1992). For this reason, the following hypothesis is proposed:

H3. The degree of satisfaction with an international R&D collaboration among SMEs increases with the level of commitment from their partners.

Table 8-23 presents the project management strategy regarding the 'ownership' of the collaboration. Two variables in the survey questionnaire were concerned with this strategy. One is based on a question about the degree of control over the collaboration by the partner; with a higher value for this variable, it is more likely that the collaboration is manged by a focal firm with a partner's participation being at the individual level (informal) rather than the organisational level (formal). The other is derived from a question about the type of role that a partner firm is playing; with a higher value for this variable, it is more likely that a focal firm is playing a significant role in the collaboration where a partner's role is limited to providing consulting or other advice. The two variables measured by nominal values were transformed into interval values (on a five-point Likert scale), with the principle that the smaller the value, the greater the project ownership that SMEs have in their collaboration with international partners. Again, neither of the two variables showed a statistically significant difference between R&D collaborations and non-R&D collaborations at the 0.05 significance level.

The analysis results indicate that the level of satisfaction with international R&D collaboration among SMEs decreases with increased ownership of the project by the focal firm. If a project is designed to reduce the management costs by having more control over the project in the focal firm, that firm is less likely to reap the full benefits of collaboration, being unable to fully access the partner's resources.

Table 8-23. Project ownership strategies

Collaboration leaderships	R&D collaboration		Non-R&D collaboration	
	Degree	Corr**	Degree	Corr**
M1. Degree of control by a focal firm	2.65	-0.349*	3.13	-0.126
M2. Importance of the role played by a focal firm	2.77	-0.401*	3.18	-0.278*
Total cases (Cases used for analysis***)	35(34)		83(76)	

Note 1. * The values statistically significant at the significance level of 0.05.
Note 2. ** Corr: Correlationship between the degree of project ownership and the degree of satisfaction
Note 3. *** The size of data used for analysis has reduced by deleting the answers selecting "others".

Finally, there seems to be a particular type of technology suitable to, or preferred for, international R&D collaboration among SMEs. Regarding the innovativeness of technology, SMEs may collaborate with international partners on more innovative R&D projects. When the diversity from different cultures and organisations is combined with SMEs' flexibility and creativity, it is more likely that innovative outcomes will be obtained, reducing the production cost. As to the characteristics of the technology, SMEs may choose to collaborate on their core technologies in an attempt to enhance their competitive advantages by searching to collaborate with leading global organisations in their field. They may need to

collaborate on non-core technologies and focus on their core competency. These technology characteristics need to be considered in choosing a target technology for collaboration.