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SME's Appropriability Regime for Sustainable Development—the Role of Absorptive Capacity and Inventive Capacity

HanGyeol Seo ¹, Yanghon Chung ¹, Chungwon Woo ², Dongphil Chun ³ and Soojeen Sarah Jang ^{1,*}

¹ School of Business and Technology Management, College of Business, Korea Advanced Institute of Science and Technology, Daejeon 34141, Korea; hgseo@kaist.ac.kr (H.S.); coach@kaist.ac.kr (Y.C.)

² Science and Technology Policy Institute, Sejong National Research Complex 370, Sicheong-daero, Sejong-si 30147, Korea; woocw@stepi.re.kr

³ Graduate School of Management of Technology, Pukyong National University, 365, Sinseon-ro, Nam-gu, Busan 48547, Korea; performance@pknu.ac.kr

* Correspondence: sarahjang@kaist.ac.kr; Tel.: +82-42-350-6347; Fax: +82-42-350-6339

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Abstract: SMEs need to protect their innovation outcomes and increase profits from their innovations in order to make their growth sustainable. The appropriability regime enables SMEs to secure financial returns on their R&D investment so that SMEs can continuously invest in innovation and obtain financial gains. However, the appropriability regime can change the effects of protecting innovation outcomes depending on the capacity of knowledge exploration, especially for SMEs, and previous studies have not discussed these issues. Thus, the main objective of this paper is to explore how the knowledge exploration capacity affects the relationship between different types of appropriability regimes and innovation performance. Multivariate regression is used to analyze the manufacturing SMEs sampled from the Korea Innovation Survey 2007 (KIS 2007). Our results demonstrate that both formal and informal appropriability regimes can improve firm's innovation performance. Furthermore, although both inventive and absorptive capacity have positive moderating effects on the relationship between the informal appropriability regime and innovation performance, the inventive capacity moderates negatively the relationship between the formal appropriability regime and innovation performance. As a whole, the significance of this paper lies in providing further understanding of the different types of appropriability regimes and knowledge exploration capacity in SMEs.

Keywords: small and medium-sized enterprises (SMEs); appropriability; knowledge exploration capacity; inventive capacity; absorptive capacity; innovation performance

1. Introduction

Extracting new ideas and combining them with existing knowledge is one of the major processes in innovation activities, and it is absolutely imperative that SMEs protect their valuable knowledge and the outcomes of processes. They may disclose some of their knowledge in exchange for other assets due to a lack of resources, whereas they may hide their most valuable intellectual assets to keep them a secret from competitors in order to succeed commercially [1]. Knowledge sharing, however, has its own inherent risks of unanticipated knowledge spillover, which provides opportunities for competitors to capture innovation outputs [2]. Thus, one of the main goals of the firms is to secure the returns and rents from innovation activities (appropriability regime; see, e.g., [3,4]) after they develop new products and even during the processes of developing a new product or service. In particular,

small and medium-sized enterprises' appropriability regimes for innovative inventions are crucial for achieving long-term sustainable survival, due to the lack of complementary competencies, such as building infrastructure and high barriers to entry for potential competitors. Thus, the implementation of the appropriability regime for product innovation performance is inherently different from large firms [5–9].

Recently, the previous research works have investigated the effect of various appropriability regimes of SMEs in comparison between formal instruments (patent, license, trademarks, etc.) and informal instruments (secrecy, lead times, complex design, etc.) (i.e., [5,10,11]) However, the previous research works have left the research gap unfilled. Despite some attempts to approach them from external view conditions [7,12], only a few studies have provided an understanding of the different strengths of appropriability in terms of SME's individual organizational factors. It is difficult to reach general consensus on the impact of the appropriability regime because the effects of SMEs' appropriability regime and better practices are different depending on external factors, such as industries, legal system, intensity of cross border activities, etc. [13]. However, verification of the effect of the protection mechanisms depending on SMEs' organizational characteristics should not be overlooked to understand the appropriability regime from various perspectives [14].

Specifically, the previous research works have not yet paid adequate attention to describing the relationships between the appropriability regime and the firm's capacities of managing different knowledge processes. Enhancing the controllability of knowledge flows is an important part in carrying out innovation activities for SMEs, because knowledge sharing allows them to improve their innovation performance, but with a high risk of losing core knowledge assets to potential followers [14]. The appropriability regime provides a safeguard against the possible knowledge spillover in the process of active knowledge sharing or from specific firm's capacities, such as absorbing outside or inside knowledge that may be related to the effectiveness of the appropriability regime for innovation performance. These issues may provide further understanding of the different effects of appropriability from perspective of knowledge processes [15]. Lichtenthaler and Lichtenthaler (2009) [16] propose that the ability to acquire knowledge in firm's open innovation activities is the theoretical foundation for explaining interfirm heterogeneity in economic innovation performance, and they discuss the future research agenda that considers the relationship with potential contingency factors, such as the appropriability regime [15]. To address these gaps, the aim of our study is to analyze the moderate effects of knowledge exploration capacity between the appropriability regime and innovation performance. Specifically, we consider two modes of appropriability regime, which include the formal appropriability regime (patent, copyright and trademark; "FAR") and the informal appropriability regime (secrecy, lead time and complexity of design; "IAR"). Furthermore, two distinct knowledge exploration capacities (inventive capacity and absorptive capacity) are considered in resolving the aforementioned issues of our study.

The rest of the paper is structured as follows. Section 2 reviews the literature on the two modes of appropriability regime and knowledge exploration capacity as a moderating role between the appropriability regime and innovation performance. Section 3 describes the research design, and Section 4 presents the empirical results. Lastly, Section 5 provides some concluding remarks and discusses the implications for policy and research.

2. Literature Review and Hypothesis

2.1. Appropriability Regime of SMEs

Firms invest in R&D to enhance their technological capacities to cope with the fiercely competitive environment, and especially, SMEs that recognize the importance of innovation have been steadily expanding their R&D investment, which requires constant efforts to improve their innovation performance. Although they have successfully developed innovative products and are ready to become one of the top performers, competitors in the same industry are likely to imitate or produce

similar products and increase their market share. Therefore, SMEs contrive a way to protect and secure their innovative inventions. In this context, the appropriability regime provides a means to protect financial returns generated from innovative inventions. For example, SMEs obtain certain legal rights and use appropriability mechanisms to handle competitive pressures where the market place is full of the actions of rival firms. If SMEs establish a strong appropriability regime on their innovative inventions, it is relatively easy to protect and possess their innovative inventions, as well as the related knowledge [17]. SMEs, however, have the limitations of complementary competencies, such as resources and entry barriers for potential competitors, such that they are inherently different from large firms [13]. Therefore, SMEs' appropriability practices for innovative inventions remain a challenge for them and are crucial for achieving long-term sustainable survival.

The identical level of strength of the appropriability regime can be achieved in two different ways, which are formal and informal mechanisms. Even though each type of mechanism results in several different effects, both appropriability strategies are effective means of protecting innovations. While some SMEs rely on FAR, such as patent, utility model, industrial design, trademark and copyright, others depend on IAR, such as secrecy, complexity of design, lead time strategy and human regulation [11,18,19]. The previous studies have investigated the effect of these types of appropriability regimes on innovation performance in SMEs and many researchers argue that SMEs tend to apply IAR rather than FAR in terms of efficiency [4,10,11,20,21]. For instance, Kitching and Blackburn (1998) [22] discuss SMEs' practices of formal and informal protection in their study. They stress that SMEs place most emphasis on IAR because these informal methods are more familiar, less expensive and less time consuming under most circumstances. For example, secrecy allows SMEs to protect their innovative inventions as their innovation-related activities occur behind closed doors, and also, rival firms cannot easily duplicate technological products with complexity of design [7]. For these reasons, informal strategies make it unnecessary to use formal mechanisms, which require high costs and more time consuming. Another benefit of IAR is that the lead time advantage over competitors in introducing innovative products enables SMEs to stay ahead in a rapidly changing business environment. For example, SMEs have the advantage over larger firms, since they can respond promptly and effectively to market demand [11]. Therefore, IAR is generally considered important in SMEs such that managers have recognized these types of strategies as vital to profit generation from innovation outcomes as a key component of their survival. Although IAR has many obvious advantages, they are also weaknesses. Innovation performance and its related activities cannot be fully protected under IAR. There is a lack of safeguards for protecting from competitors when SMEs release products into the market. For instance, the tacitness of knowledge is one of the valuable protection mechanisms; however, they are not very useful due to a lack of the full protection of their intellectual assets. Furthermore, secrecy does not guarantee legal monopoly to the holder such that competitors cannot be penalized for copying products or innovation when they totally imitate or reverse engineer the product [23].

Although some of the studies view IAR as a more effective mechanism to protect SMEs' innovative inventions, others studies stress that the practice of FAR is also another effective way of protecting innovative inventions from rival firms [5,24,25]. For instance, SMEs gain the advantages of the patent strategy in situations where the SMEs perceive the potential benefits of their patent enrollments as any potential acquisition or enhancement of their market positions. In other words, these formal rights offer superior protection where SME business owners can gain greater benefit from their new innovative invention [11]. Furthermore, patents provide adequate protection for many innovative firms, especially those dealing with biotechnology and information communication technology such that the development of radical new technologies takes up a big part of their business [7]. Despite the critical drawback of information disclosure, SMEs rely on the patent strategy to build reputation, either to attract research alliances or receive financial support [26]. Even though FAR is important to all business firms, legal rights, such as patents, are often perceived by business owners as exorbitantly high due to the cost of preparing and prosecuting for a patent application [11,27]. Preparing a patent

application is not merely a problem for SMEs, but also requires being familiar with complex rules and regulations. For example, they are required to have a certain amount of money to monitor their own IPRs and also protect themselves from violation by rival firms, which may add heavy burden to SMEs [24,28]. As previously mentioned, there are pros and cons in the various approaches to the appropriability regime depending on the circumstances that firms are facing. Nevertheless, innovators are able to eventually gain greater economic benefits if their innovations are highly secured through a strong appropriability regime regardless of the ways for protecting their innovations [29].

Therefore:

Hypothesis 1a: There is a positive relationship between IAR and innovation performance.

Hypothesis 1b: There is a positive relationship between FAR and innovation performance.

2.2. The Knowledge Exploration Capacities

SMEs constantly seek to innovate to gain market share and competitive advantage, and their capacity for innovation stems from internal efforts of knowledge generation. Obviously, discovering problems and exploring and understanding new knowledge required for certain problems is a top priority for resolving various problems in innovation performance. When SMEs discover new knowledge within the organization, they integrate the new knowledge into their knowledge bases. This knowledge process is equated to the inventive capacity, which is a firm's ability to internally explore new knowledge [30]. While inventive capacity relates to generating new knowledge from the exploration of existing internal sources, absorptive capacity refers to the ability to explore external sources [30]. It acquires external knowledge and assimilates this knowledge into an existing knowledge base, which is a vital part of the process of knowledge acquisition [31]. SMEs should recognize the value of external knowledge and take the application of external knowledge into their innovation process for the benefit of innovation performance. In this sense, absorptive capacity contributes to the strength of innovation performance by recognizing and capturing relevant external knowledge. Absorptive capacity allows SMEs to efficiently utilize resources to solve the technological problems confronted during the innovation process and to improve the efficiency of existing products or processes [32]. As a result, SMEs are able to increase their knowledge assets and obtain new competitive benefits.

These knowledge exploration capacities are closely related to the effect of the appropriability regime on innovation performance. Firstly, innovative ideas may affect the appropriability for financial returns depending on the utilization of knowledge pools. In fact, the condition of knowledge spillover may affect firms' decision-making on whether their innovative inventions should be protected by formal or informal means. For example, utilizing external knowledge sources on innovation performance is beneficial for firms, but at the same time, competitors can capture the external knowledge and utilize it to improve the efficiency of their products or to solve the technological problems confronted in the innovation process. In this respect, knowledge exploration capacities may be related to returns from the innovation [33]. Particularly for SMEs, a short-term gain is a significant issue. Therefore, the impact of knowledge exploration on the effect of the appropriability regime in innovation returns remains important to SMEs. Secondly, both FAR and IAR influence the formation of the knowledge pool (i.e., a well-documented format that captures accumulated knowledge or the tacitness of the knowledge), and these impacts are associated with the knowledge exploration process [30,34,35]. The types of appropriability regimes affect the transferability of knowledge in the existing knowledge pool, and SMEs do not need to be concerned with uncontrolled knowledge leakage in various innovation activities (i.e., in-house R&D and R&D collaboration) when they build adequate appropriability regimes. Thus, they could have effective knowledge sharing within the firm or intra-firm, and SMEs may improve innovation performance depending on their knowledge exploration capacities.

2.2.1. The Moderating Role of Inventive Capacity

As mentioned above, inventive capacity refers to internal efforts of knowledge generation that enable SMEs to acquire new knowledge outputs. This could be strengthened when effective knowledge transfer is established within an organization. From FAR's point of view, a process of knowledge codification involves converting to explicit knowledge, which makes SMEs' knowledge become visible and accessible. The process of knowledge codification has the advantage of transferring information that allows flexible communication and knowledge sharing within an organization; however, this could be a disadvantage for SMEs that mainly pursue in-house R&D. The new knowledge generated from inventive capacity is not openly accessible such that only SMEs have the authority to utilize the knowledge, which is one of the indigenous resources. Additionally, there is a high possibility of outbound spillovers in the case of a high level of transferable and accessible knowledge. Considering SMEs' organizational characteristics, SMEs will face a major challenge in managing the controllability of knowledge if their knowledge is disclosed with FAR, since SMEs have the limitations of complementary competencies, including organizational legitimacy and financial capital to exercise their patent rights against competitors' threat [36]. Eventually, it will cause a considerable expense for SMEs to defend rival firms and monitor organizational knowledge for unwanted leakage. Therefore, SMEs are in a weak position for protecting their innovation performance, such as uncertain imitability from followers. For these reasons, the non-disclosure of knowledge would be the most effective way to secure and manage their processes of knowledge generation on innovation performance through inventive capacity. The use of informal protection methods among SMEs will have less risk opportunities, and the threat of competitors because of the internal creation of new knowledge cannot exist in others. Consequently, SMEs may take the first-mover advantage or technological competitiveness. In conclusion, FAR has many uncertainties to adequately protect SMEs' innovative inventions caused by outbound knowledge spillovers [36,37].

In contrast to FAR, IAR builds tacit knowledge in the knowledge process in such a way that the informal process of learning and experience-based knowhow are difficult to transfer to outsiders or competitors. Considering SMEs' organizational characteristics, tacit knowledge can be a more advantageous protection method for their new innovative inventions coming from inventive capacity. Articulating and transferring tacit knowledge takes much effort because tacit knowledge is difficult to transfer to another person and codify. Under these conditions, SMEs may have a higher innovation efficiency than large firms, because tacit knowledge has inherent imitability, and SMEs have a more efficient structure to control and manage their tacit knowledge, such as efficient communication networks. These benefits make SMEs take a lead time advantage to stay ahead of competitors compared to larger firms. Furthermore, this prevents knowledge spillovers unless SMEs are willing to disclose the informal process of learning and experience-based knowhow to competitors. Therefore, IAR builds an efficient barrier to replication and imitation cost, such as a time-consuming process [38,39]. Holgersson (2013) [34] points out that SMEs with sustainable inventive efforts attempt to maintain a market position over competitors by using IAR and establishing embedded values that competitors cannot easily imitate with respect to the quality level achieved by SMEs. As discussed above, internal creation of new knowledge with inventive capacity may not exist in others, such that it prevents knowledge spillovers, and this beneficial effect accelerates synergies with the effect of IAR on SMEs' innovation performance. In this sense, informal mechanisms provide better safeguards to SMEs' hidden internal innovative ideas and knowledge and explored knowledge with inventive capacity.

Therefore:

Hypothesis 2a: A firm's inventive capacity negatively moderates the impact of the formal appropriability strategy on innovation performance. Hypothesis 2b: A firm's inventive capacity positively moderates the impact of the informal appropriability strategy on innovation performance.

2.2.2. The Moderating Role of Absorptive Capacity

Cohen and Levinthal (1990) [40] argue that absorptive capacity determines a firm's ability to acquire and utilize knowledge from outside sources, which are already knowledge spillovers by nature. Utilizing external knowledge is related to the appropriability regime that involves risks of knowledge spillover, even though absorptive capacity enables SMEs to achieve innovation performance efficiently. In fact, firms may not successfully generate higher returns from innovation performance by acquiring external knowledge sources, since the same knowledge is accessible by their counterparts or competitors. The competitor confronts a similar set of problems in the same market places and strives to find valuable clues or external sources. Especially in SMEs, the availability of external sources of knowledge carries risk and uncertainty for SMEs due to their lack of complementary assets, such as abilities to commercialize products and enhancing financial returns of the innovative product. In other word, SMEs have a weak position for building a barrier when competitors invade their market and also have a lack of complementary assets, which are important for the commercialization stage, such as marketing capability, channel and market power [19].

In this case, FAR is a key factor for attaining successful returns from innovative inventions and protecting their knowledge before competitors become aware of innovation-related knowledge. SMEs need to have a lead position for property rights, to which FAR contributes greatly for SMEs to reduce uncertain risk in securing appropriate returns. Under certain legal protection, their innovative idea can make certain the full appropriability if knowledge sources are acquired from their absorptive capacity through external knowledge sharing, such as collaboration with other actors. Furthermore, FAR means that a firm may have higher incoming spillovers through voluntarily knowledge sharing, such as R&D cooperation [33]. Its voluntarily knowledge sharing allows improving the effects of absorptive capacity, such that synergy exists between FAR and innovation performance. Ritala and Hurmelinna-laukkanen (2012) [41] argue that IAR methods, such as tacitness or secrecy, hamper knowledge sharing in R&D cooperation, whereas patents enable firms to achieve a higher level of innovation performance through potential absorptive capacity. IAR mechanisms may cause inefficiency in knowledge sharing under certain circumstances, such as knowledge transfer, license-in and external collaboration. In contrast, FAR ensures that SMEs' knowledge is protected under law and prevents the threats of opportunity behaviors. SMEs may improve the effect of protection strength on innovation performance by utilizing FAR when SMEs frequently interact with external resources and assimilate them into the existing knowledge base in their innovation process. Thus, FAR enhances innovation performance by promoting the exploration of external knowledge.

In contrast, IAR causes critical problems with retaining the value created from exploring external knowledge [19]. Firms would not have an incentive to invest in the development of new knowledge if all of the benefits already have spillovers to their competitors. As discussed above, FAR allows outbound spillovers and protects valuable knowledge by certain legal rights at the same time. However, IAR is embedded with unavoidable risks and uncertainty after commercializing products due to the absence of the exclusive rights of innovative inventions [41]. The knowledge created from outside the firms is transferable and available to others, such that smart followers will be able to identify valuable technical information and easily imitate to develop outstanding innovative products [42]. Therefore, SMEs would not fully take the benefits of innovation performance using IAR, such as secrecy or the tacitness of knowledge. IAR, including lead time advantage, enables SMEs to stay ahead over competitors and brings out new products within a short cycle time [28]. However, SMEs often lack the ability to keep their innovation process concealed from their competitors for a long time. Thus, even if SMEs begin to succeed in generating high returns from R&D investment, they will not enjoy a lead time advantage for long periods of time. For these reasons, SMEs' innovation performance may not be completely secured through IAR. In short, innovative inventions, as well as the related knowledge generated from absorptive capacity may have many uncertainties to be adequately protected through IAR.

Therefore:

Hypothesis 3a: A firm's absorptive capacity positively moderates the impact of the formal appropriability strategy on innovation performance. Hypothesis 3b: A firm's absorptive capacity negatively moderates the impact of the informal appropriability strategy on innovation performance.

3. Research Design

3.1. Data and Sample

This study used the “Korean Innovation Survey (KIS) 2010: Manufacturing sector” collected by the Science & Technology Policy Institute (STEPI) of South Korea [43]. Survey methods and questionnaires used in KIS are based on the Organisation for Economic Cooperation and Development (OECD)'s Oslo Manual and Community Innovation Survey (CIS). KIS data are used extensively for research because this is a large set of data with a variety of issues that may be relevant for innovation activities in the manufacturing sector [19,44–46]. KIS 2010 covers the data for the years 2007–2009, including 3925 firms. Due to missing values, we excluded 3361 respondents. We use a sub-sample of the KIS data, including 564 firms, that contains all of the variables for the analysis. These firms represent 23 industries (at the two-digit level) of the manufacturing sector, according to the International Standard Industrial Classification (ISIC Rev. 4). The share for the entire sample varies between 0.4% for “manufacture of coke and refined petroleum products” and 9.9% for “manufacture of motor vehicles, trailers and semi-trailers”. Table 1 shows the sample distribution of firms by the two-digit industry.

Table 1. Sample distributions by industry sector.

Industry Sectors	Sample	Percentage (%)
Manufacture of basic metals	32	5.7
Manufacture of coke and refined petroleum products	2	0.4
Manufacture of machinery and equipment n.e.c.	49	8.7
Manufacture of motor vehicles, trailers and semi-trailers	56	9.9
Manufacture of other non-metallic mineral products	26	4.6
Manufacture of paper and paper products	15	2.7
Manufacture of pharmaceutical products and homeopathic pharmaceutical preparations	32	5.7
Printing and reproduction of recorded media	8	1.4
Manufacture and processing of leather and related products	4	0.7
Manufacture of beverages	10	1.8
Manufacture of chemicals and chemical products	50	8.9
Manufacture of computer, electronic and optical products	46	8.2
Manufacture of electrical equipment	30	5.3
Manufacture of fabricated metal products, except machinery and equipment	29	5.1
Manufacture of food products	32	5.7
Manufacture of furniture	11	2.0
Manufacture of other transport equipment	48	8.5
Manufacture of rubber and plastics products	28	5.0
Manufacture of textiles	20	3.5
Manufacture of wearing apparel	13	2.3
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	4	0.7
Other manufacturing	13	2.3
Repair and installation of machinery and equipment	6	1.1
Total	564	100

3.2. Measurement

3.2.1. Dependent Variable: Innovation Performance

The dependent variable in this study is innovation performance, which is operationalized as the sales of new innovative products per employee within the past three years [16,47,48]. In this context, new innovative products are defined as entirely new or improved products compared to existing

products in regard to the characteristics and purposes of use. The KIS collects data based on the proportion of product innovation sales introduced to the market within three years, and this outcome is our dependent variable (innovation performance, *Inn_per*). To measure the variable, we multiply the proportion of new products with total sales and divide this amount by the number of employees. By multiplying the share of new product sales with turnover and dividing this by the number of employees, it represents the innovation performance of one product and controls the firm size effect. We transform the variable by taking the natural log in order to improve its normality.

3.2.2. Independent Variable: Appropriability Regime

The independent variables in this research are the appropriability regime using the questions in the KIS; respondents were asked to evaluate the levels of importance for the protection mechanisms used during the three years, including patent, utility model rights, copyright, trademark, secrecy, complexity of design and lead time. The respondents evaluated mechanisms using a six-point Likert scale (0 = no utilization, from 1 = low importance to 5 = crucial importance). The first five of these constitute formal protection methods, which are patent, utility model, industrial design, trademark and copyright. They represent exclusive rights over intellectual property at a certain time. In this research, we construct the average score of five protection methods, which defines the variable as FAR. Others represent informal methods to protect against imitation. Secrecy prevents unanticipated knowledge spillover to rival firms, and the complexity of design can stop competitors from imitating innovative products by increasing the time and raising the cost required for imitation. Furthermore, the lead time advantage allows firms to gain benefits by rapidly implementing and introducing innovation projects. Thus, we construct the average score of three protection methods as the indicator variable for IAR.

3.2.3. Moderator: Inventive Capacity and Absorptive Capacity

Inventive capacity refers to a firm's ability to explore knowledge inside the firm and embed the new knowledge into the established knowledge bases [15,30]. There are a few ways of measuring inventive capacity, such as using patents as a proxy [49,50]. The patents represent the fundamental process of organizational knowledge creation, scientific capability and R&D management skill, which enable firms to capture valuable and intangible resources. However, patents could be inappropriate for this study as a proxy for the inventive capacity. According to the definition above, the greater a firm's inventive capacity, the greater its ability to explore and assimilate internal knowledge into an established knowledge basis and the greater the benefit to be obtained from the internal knowledge sources. However, the patents include not only a proxy for the contribution of internal, know-how capabilities, but also absorbing externally-acquired information. The patents are accumulated by various firm's activities, such as internal R&D, collaboration R&D, buying, etc. Therefore, we use the contributions of internal knowledge sources for innovation outputs, as the proxy for inventive capacity. We use a question in the KIS survey: "please, evaluate the contribution of your information sources in the last three years (6-point Likert scale: 0 = no utilization, from 1 = low importance to 5 = crucial importance)". This question examines the degree of contribution of various information sources. This question allows us to extract the data relevant to internal information sources, including: (1) internal knowledge in the firm; (2) within the enterprise group; and (3) the newly employed. This question is respectively measured on a six-point Likert scale (0 = no utilization, from 1 = low importance to 5 = crucial importance). We computed the average of three items' answers. Since the answers to this question involve judgment on the availability of these knowledge sources and absorption by the firm, these answers fit the definition of inventive capacity as explained above (*Inv_cap*).

For measuring absorptive capacity, many previous empirical studies have introduced various proxies for measuring the importance of training, R&D in-house, understanding external knowledge and the number of patents (e.g., [20,31,40,51–53]). The measurements vary by their circumstances

such that any type of proxy is not superior to others [54,55]. According to the aforementioned definition in the literature review, the operationalization of absorptive capacity in our research mainly is followed by potential absorptive capacity and exploratory learning [15,30]. We used data in KIS for the importance of external knowledge sources during the three years for the proxies. In the KIS questionnaire, firms rated the importance of external knowledge sources for innovation on a six-point scale from 0–5 during the period 2007–2009. We average the score of the importance of external knowledge sources, including: (1) supplier (raw materials, components and software); (2) demander and customer; (3) competitor; (4) association; (5) private advisory firm; (6) university; (7) government research institute; (8) conference; and (9) publication and journal. The proxy used in this study covers the firm-specific capacity of exploring external knowledge and utilizing it in their innovation activities (absorptive capacity, *Abs_cap*). The evaluations of the level of importance of external knowledge represents a proxy for potential absorptive capacity. For example, failing to identify external knowledge for solving problems can indicate a low level of knowledge exploration capacity. In this case, firms evaluate the importance level of external knowledge as low. Second, the evaluation of the importance level of external knowledge will be low if firms cannot acquire and assimilate the external knowledge, even though external knowledge exists that can be used by firms for solving problems. What this also means is that firms possess a low level of potential absorptive capacity. Following the argument, we expect that responses to the level of importance of different information sources for innovation performance will depend on: (1) the amount of external information accessible to firms in their environments; and (2) their ability to identify and assimilate it (i.e., potential absorptive capacity) [47,56].

3.2.4. Control Variables

In this study, we consider five control variables: collaboration, firm age, firm size, innovation obstacles and industry. Collaboration is included as one of the control variables. SMEs can achieve efficient resource allocations by using various collaborations. Many innovation-related studies discuss that the R&D cooperation with external organizations has considerable effects on innovation performance, as well as the appropriability regime. Effective collaboration for innovations enables firms to access strategic resources and to have knowledge sharing with other actors, and this collaborative innovation promotes innovation performance. However, also, it requires firms to have adequate the appropriability modes to protect their knowledge. Thus, we use collaboration to control the effects of the appropriability regime and innovation performance. The collaboration is constructed based on the question in the KIS as a dummy variable. Furthermore, we use firm age. New firms have different business structures compared to existing firms, as well as knowledge systems, where innovation occurs, as well as different appropriability modes [4,57]. Furthermore, new firms have different strategic approaches to innovation performance compared to existing firms, due to their relative inexperience with the market and the lack of complementary resources [58]. For example, firm age reflects the potential effect of firm's experience, the accumulated learning process and know-how on innovation performances. Thus, we include the firm age as the number of years (in natural logarithms) since establishment.

Firm size is used as a control variable. Small-sized firms are affected by institutional or environmental changes, such as financial and legal institutions in business activities. Moreover, they have different technological centrality and knowledge flows compared to large firms. For example, smaller firms are more likely to restrict themselves to a simple innovation strategy, whereas larger firms could utilize human resources for innovation performance. As a result, larger firms are more likely to gain market power, such that they easily enter their markets and prevent competitors from entering markets to continuously make large profits. Therefore, firm size is considered as one of the important variables in innovation performance-related studies, such that it is closely related to innovation performance [59–61]. By the KIS data, firm size is measured by the natural logarithm of the number of total employees in SMEs. We also control for the existence of factors that hinder innovation

performance (Inn_obs). SMEs face various obstacles to innovation due to their lack of various resources and capabilities. Financial constraints, firm capability factors, market factors, institutional factors and demand for innovations are major obstacles, such that they are very closely related to innovation performance. For example, intensive innovation activities can decrease when firms face financial constraints due to the reduction in R&D investments. Furthermore, firms with a lack of required capabilities have less intensive research activities, such that they are less likely to promote their innovations. They will be reluctant to invest in R&D due to higher levels of technical uncertainty and high costs. Thus, our study considers these main obstacles as one of the control variables. To measure obstacles, the KIS asks firms to assess and report the obstacle factors that may have hampered their product innovation within three years (from 2007–2010). We use the innovation obstacles data from the KIS 2010, which consist of 16 items based on a five-point Likert scale. 16 items include innovation obstacles in the KIS: (1) reluctant to invest in R&D due to higher levels of technical uncertainty; (2) reluctant to invest in R&D due to the high costs of R&D; (3) lack of funds in your firm or your affiliated group; (4) lack of funds due to not enough investments being received by outside groups, such as venture capital; (5) lack of funds due to not enough investments being received by the public sector; (6) shortage of skilled manpower for innovation; (7) lack of knowledge or information about technology; (8) lack of knowledge or information about the market; (9) absence of partners for innovation; (10) rigidity and resistance to have organizational changes within a firm; (11) uncertainty over the demand of innovation products in market; (12) dominate the market through monopoly power; (13) lack of infrastructure; (14) institutional restrictions, such as laws, regulations, standards; (15) other innovations are unnecessary due to having innovation performance during the previous three years; (16) other innovations are unnecessary due to the lack of demand for innovation (including OEM). We normalize the sum to vary between zero and one. Finally, we include industry dummies (at the level of the firm's two-digit SIC manufacture sector) to control for heterogeneity in the firm environment.

4. Results and Discussion

Table 2 below gives descriptive statistics, collinearity statistics and correlations between the variables (except for the industry dummies) in the analysis. The largest single correlation is between FAR and IAR. Practically, firms may not rely on only one type of appropriability regime. They simultaneously implement several types of appropriability regimes. For example, a firm could implement IAR to protect the leakage of information related to an invention at the development stage and subsequently use the formal methods when commercializing the invention [10]. In this study, the aim of our study is to identify different interactions between disparate types of appropriability and capacity. Therefore, this study is restricted to the combined appropriability instrument. None of the reported individual variance inflation factors (VIF) do not indicate serious concerns for multi-collinearity. After completing the regression diagnostics, we conducted multiple regression analysis to test the hypotheses.

Table 3 shows the regression results from estimating the direct effect of FAR on innovation performance (Inn_per), IAR on innovation performance (Inn_per) and the moderating effects of the knowledge exploration capacities on the relationship between appropriability regime (FAR, IAR) and innovation performance (Inn_per). Model 1, with only control variables, provides a benchmark against which to test the effects of independent variables on innovation performance (Inn_per). In Model 2, we tested the main effects, which are FAR and IAR, while Model 3 shows moderating effects of inventive capacity (Inv_cap) and absorptive capacity (Abs_cap). The F-value for each model is highly significant ($p < 0.02$) with the full model explaining approximately half of the variance in the dependent variable. As shown in Table 3, Models 2 and 3 indicate that FAR and IAR are significantly and positively associated with innovation performance (Inn_per) ($p < 0.02$, $p < 0.02$). Hence, Hypotheses 1a and 1b is supported. Regardless of the type of appropriability regime, the results suggest that the innovation performance is positively affected by both FAR and IAR. Our findings are consistent with previous studies. For example, Thoma and Bizer (2013) [27] prove that both FAR and IAR are effective

mechanisms to achieve company goals. This means that the appropriability regime can be considered as one of the important strategic tools.

Table 2. Means, standard deviations and Pearson correlations. VIF, variance inflation factors; Inn_per, innovation performance; FAR, formal appropriability regime; IAR, informal appropriability regime; Inv_cap, inventive capacity; Abs_cap, absorptive capacity.

Variable	VIF	1	2	3	4	5	6	7	8	9
1. Inn_per		1								
2. FAR	1.43	0.25 **	1							
3. IAR	1.37	0.21 **	0.43 **	1						
4. Inv_cap	1.19	0.08 *	0.17 **	0.25 **	1					
5. Abs_cap	1.46	0.16 **	0.27 **	0.21 **	0.16 **	1				
6. Collaboration	1.08	0.12 **	0.08 *	0.10 *	0.11 **	0.11 **	1			
7. Firm age	1.25	0.06	0.03	−0.02	−0.05	0.07	−0.03	1		
8. Firm Size	1.34	0.07	0.12 **	0.02	0.15 **	0.24 **	0.09 *	0.29 **	1	
9. Inn_obs	1.20	0.08 *	0.21 **	0.26 **	0.20 **	0.19 **	0.18 **	0.01	−0.03	1
Mean		3.27	1.90	2.23	2.03	−0.16	0.28	2.91	4.79	0.41
SD		4.12	1.48	1.35	0.78	0.97	0.45	0.60	0.75	0.30

* $p < 0.05$, ** $p < 0.01$. For presentational purposes, industry dummies are excluded from the table.

Table 3. Regression results for SME's innovation performance.

Variable	Model 1	Model 2	Model 3
	Inn_per	Inn_per	Inn_per
Control Variables			
Collaboration	0.100 **	0.087 **	0.085 **
Firm age	0.045	0.042	0.069
Firm Size	0.074	0.032	−0.003
Inn_obs	0.074 *	−0.001	−0.008
Main Effects			
FAR		0.140 ***	0.166 ***
IAR		0.129 ***	0.126 ***
Moderators			
Inv_cap		0.010	0.000
Abs_cap		0.084 *	0.099 **
Interaction Terms			
FAR × Inv_cap			−0.110 **
IAR × Inv_cap			0.162 ***
FAR × Abs_cap			−0.039
IAR × Abs_cap			0.098 **
Industry dummies			
	Included	Included	Included
R^2	0.077	0.133	0.162
<i>adj. R</i> ²	0.032	0.084	0.108
ΔR^2		0.056	0.029
F-value	1.727	8.572 ***	4.593 ***

Notes: $n = 564$; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.02$.

To demonstrate the moderation effect for a specific relationship, we multiplied FAR and IAR with inventive capacity (Inv_cap) and absorptive capacity (Abs_cap) separately and entered the multiplicative interaction items into the regression. We mean-centered the variables by transforming the data into the deviation score form with means equal to zero. In Model 3, the coefficient of the interactive relationship of FAR and inventive capacity (Inv_cap) was negative and significant ($p < 0.05$), indicating that the impact of FAR on innovation performance (Inn_per) is more weakly

positive dependent on a firm's inventive capacity (Ivn_cap). Hence, Hypothesis 2a is supported. The coefficient of the interaction of IAR and absorptive capacity (Abs_cap) was positive and significant ($p < 0.02$). Thus, Hypothesis 2b is supported. By considering moderating effects, Hypotheses 2a and 2b are supported, since adding the interaction effects of inventive capacity (Ivn_cap) significantly improve the impact on innovation performance regardless of the type of appropriability regime. These results show that FAR has many uncertainties to adequately protect innovation performance, which are derived from inventive capacity, especially for SMEs. Followers or competitors can advance their existing products or develop innovative products when knowledge is disclosed through formal mechanisms, such as patents. In this case, SMEs are less likely to achieve monopoly rents. In contrast, innovation performance that is generated from inventive capacity can be adequately protected through IAR, such as secrecy and lead time. Those strategies may accelerate synergies with SMEs' inherent characteristics of a lean and flexible structure for the fast response to market needs and decision making. Thus, we can conclude that IAR is a reasonable choice for SMEs when innovation performance is derived from inventive capacity.

Regarding Hypothesis 3a and 3b, the coefficient of the interaction of FAR and absorptive capacity (Abs_cap) is not statistically significant, and thus, Hypothesis 3a is not supported. Additionally, the coefficient of the interaction of IAR and absorptive capacity (Abs_cap) was significant ($p < 0.05$), indicating that the impact of IAR on innovation performance (Inn_per) is more strongly and positively dependent on a firm's absorptive capacity (Abs_cap). The anticipated moderating effects of absorptive capacity (Abs_cap) in the relationship between IAR and innovation performance (Inn_per) cannot be supported, since adding the interaction effects is positively significant. Thus, Hypothesis 3b is not supported. Absorptive capacity, which is the ability to access external know-how, allows firms to identify and capture relevant complementary knowledge for what they lack and to accumulate their knowledge by replacing less efficient knowledge, such as profitable techniques and routines [62–64]. There may be a large amount of tacit knowledge that remains unprotected by formal mechanisms. Tacit knowledge inherently cannot be seen, which eventually protects firm's know-how, and there is limited protection through FAR [65]. In this case, the use of informal protection might be the best alternative to protect innovation performance [6]. Thus, the inherent characteristics of SMEs, including the lack of resources, provide positive synergies for SMEs, pursuing IAR as the best way to secure SMEs' innovation performance.

5. Conclusions

Our study contributes to the existing knowledge by empirically examining the roles of knowledge exploration capacities when SMEs secure innovation performance through the appropriability regime. KIS data collected from 564 firms were utilized to perform multivariate regression analysis. We began our empirical investigation by looking at the relationship between the appropriability regime and innovation performance. The findings of this study indicate that both FAR and IAR have positive relationships with innovation performance. This paper also looked at the moderating roles played by knowledge exploration capacities. Our results suggest that SME's inventive capacity negatively moderates the impact of FAR on innovation performance, whereas inventive capacity positively moderates the impact of IAR on innovation performance. On the other hand, absorptive capacity as a moderator is not statistically significant. However, we found that absorptive capacity positively moderates the impact of IAR on innovation performance.

Our study has made several contributions to the academic field. According to previous research, SMEs tend to rely on IAR when they seek for the most effective way to protect innovation performance [11,66]. However, our findings shine a new light on the findings of previous studies that both FAR and IAR are essential to capture the returns from R&D investments. Furthermore, previous studies have drawn a distinction between IAR, such as secrecy and lead time, and FAR, such as patents, by exploring the effects of different types of protection mechanisms on innovation performance [13,14]. They mainly focused on these issues from an efficiency perspective, such as limited complementary

resources in SMEs. Our study contributes to a growing literature by investigating the moderating effect of knowledge exploration capacities in the relationship between the appropriability regime and innovation performance. As a result, SMEs are able to significantly do better on innovation performance and secure profits from innovation when internally-created knowledge is secure enough through IAR. They take advantage of tacitness or rapidly introducing new products into a market rather than making a disclosure of technological information. On the other hand, FAR has many uncertainties to adequately protect innovation performance that is derived from inventive capacity. Followers or competitors can advance their existing products or develop innovative products when knowledge is disclosed through formal mechanisms, which consequently leads to SMEs not achieving monopoly rents [37]. In the case of absorptive capacity, IAR is a relevant protection mechanism. Additionally, FAR is found to have a non-significant effect. This suggests that IAR enhances innovation performance, which is strongly dependent on an SME's absorptive capacity. When the knowledge exchange is secure enough by IAR, the value-creating effects of absorptive capacity can enhance innovation performance. The ability to extract knowledge from outside the firm is typically beneficial in innovation activity, whereas values created by the outside source inherently generate higher knowledge spillover risk [14]. Schmidt (2006) [58] discusses the effect of FAR on knowledge spillovers and suggests that the appropriability effect of FAR is greater than the disclosure effect of FAR. The implication is that even if external knowledge is disclosed, competitors have difficulties in recognizing and adapting this valuable external knowledge. SMEs, however, show different views due to their organizational characteristics, such as the limitations of complementary competencies (i.e., ability to explore and adapt the external knowledge). In this study, our results suggest that the effects of IAR enable SMEs to strengthen the protection of their innovation outcomes, whereas the effects of FAR may decrease the strength of protection according to SMEs' knowledge exploration capacities. Firm's specific capabilities are significant when determining the success of innovation, and it is concluded that an informal protection mechanism produces more favorable outcomes when there is adequate control available over a firm's created innovation output that is generated from absorptive capacity.

This research also offers some policy implications. Innovation is essential for SMEs to survive in a constantly changing environment. Requiring sustainable R&D investments, appropriability mechanisms are the most important factor for the implementation of a policy in order for SMEs to grow. Most policymakers design and implement policies based on financial measurements, such as patent effects. Patents are recognized as one of the important performance indicators for SMEs to prosper. However, these effects can vary according to the characteristics of SMEs. Therefore, the conclusions drawn by our studies, policymakers should also consider individual characteristics of SMEs for effective policy implementation. In addition, policymakers need to support policies that help SMEs to accumulate know-how, expert knowledge and tacit knowledge, rather than promoting the patent-oriented policy, since the effects of patents change depending upon the circumstances.

There are several limitations in this study. Firstly, the sample consists of Korean manufacturing firms to investigate the moderate effect of absorptive capacity and inventive capacity in the relationship between the appropriability regime and innovation performance. Future work should also explore the data collected from other countries or industries to determine that the findings can be also generalized to other countries or different industry sectors. Secondly, our study explains the moderating effect of knowledge exploration capacity in terms of knowledge spillover. However, there is a need for further explanation by introducing more diverse viewpoints. Specifically, our results may bring a different complexion depending on the amount of complementary resources firms have, especially for SMEs and large firms. Along these lines, the insights from new research on these issues could give additional help to understand the different effects of appropriability from the perspective of knowledge processes.

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Abbreviations

The following abbreviations are used in this manuscript:

MDPI	Multidisciplinary Digital Publishing Institute
DOAJ	Directory of Open Access Journals
TLA	Three letter acronym
LD	linear dichroism

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