



Article

Factors Affecting Outbound Open Innovation Performance in Bio-Pharmaceutical Industry-Focus on Out-Licensing Deals

Eungdo Kim ¹, InGyu Lee ¹, Hongbum Kim ^{2,*} and Kwangsoo Shin ^{1,*}

¹ Graduate School of Biomedical Convergence, College of Medicine, Chungbuk National University, 1 Chungdae-ro, Seowon-gu, Cheongju 28644, Chung-cheongbuk-do, Korea; edkim@chungbuk.ac.kr (E.K.); brsldld@gmail.com (I.L.)

² Korea National Industrial Convergence Center, Korea Institute of Industrial Technology, 143 Hangeul-ro, Sangnok-gu, Ansan-si 15588, Gyeonggi-do, Korea

* Correspondence: sirkim@snu.ac.kr (H.K.); sksidea@chungbuk.ac.kr (K.S.)

Abstract: Due to the high risk in development process, the bio-pharmaceutical industry has transformed itself into an open innovation framework in order to overcome economic risk. This study examines the relationship between outbound open innovation and financial performance in bio-pharmaceutical industry. Specifically, this study extends knowledge-based view to link the open innovation performance and licensor's sustainability. In order to provide empirical evidence, this study uses econometric methodology with several databases including bio-pharmaceutical firms. The analysis shows firm's desorptive capabilities have a significant effect on financial performance, confirming the application of knowledge capacity framework. The result of the study can suggest the way how the licensors can maintain the sustainability of competitiveness in bio-pharmaceutical industry.

Keywords: outbound open innovation; knowledge-based view (KBV); bio-pharmaceutical industry; out-licensing



Citation: Kim, E.; Lee, I.; Kim, H.; Shin, K. Factors Affecting Outbound Open Innovation Performance in Bio-Pharmaceutical Industry-Focus on Out-Licensing Deals. *Sustainability* **2021**, *13*, 4122. <https://doi.org/10.3390/su13084122>

Academic Editor: António Abreu

Received: 19 February 2021

Accepted: 2 April 2021

Published: 7 April 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The nature of the bio-pharmaceutical industry is innovation as the main driving force behind its growth. To overcome the challenges that the industry has been facing for several years and to inflect stagnating Research and development (R&D) productivity, bio-pharmaceutical companies started to disclose their R&D results to external innovation [1]. The bio-pharmaceutical industry has distinguished features that make it a fertile ground for adopting open innovation and for studying its managerial and organizational implications [2].

Because of the complexity of the bio-pharmaceutical R&D process, soaring technology intensity [3], the importance of technology transfer [4], the intensity of relationships between bio-pharmaceutical firms, universities and research institutes [5], and the birth of a venture capital market specialized in supporting biotech ventures [6], several scholars argue that the traditional business model in the bio-pharmaceutical industry needs to evolve to solve the problem of a declining R&D productivity [7,8]. Without R&D productivity increase, bio-pharmaceutical industry cannot maintain sufficient innovation incentives to replace the decrease of revenues because of patent expirations [8]. Recently, the innovation strategies have been designed in considering an openness, while the processes for producing products and services have been extended across the boundaries of firms and industries because of the necessity of external knowledge to complement internal knowledge bases [9,10].

"Open innovation" is one of the most frequently used keywords in management of technology field, and the management of intellectual property (IP) forms an inevitable component in this strategy for technology-based firms [11,12]. Open innovation is defined

as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation” [11]. Alternatively, it is “systematically relying on a firm’s capabilities of internally and externally carrying out the major technology management tasks along the innovation process” [13,14].

Bio-pharmaceutical firms need to explore improved commercialization opportunities and increasingly adopt a more proactive IP management strategy with additional values occurred in externally exploiting their IP [11]. Regarding the bio-pharmaceutical industry, increased complexity of new technologies and increased pressure on time and cost have accelerated the adoption of open innovation [1]. Today, multinational bio-pharmaceutical firms start to realize the potential of open innovation as they have begun to harness external sources of innovation by accessing ideas, technologies and the results of R&D projects. The bio-pharmaceutical industry has transformed itself into an open innovation ecosystem, and licensing strategy has become a core business model for biotechnology companies [15]. In the open innovation model, companies fill the gap of their internal product portfolio through licensing and acquisition of drug candidates [16]. In-licensing compound from a biotech company or a university allows the bio-pharmaceutical companies to avoid the full cost of development, decrease the early risk and selectively choose products that fit the firm’s business model. Companies can out-license abundant projects or technologies to cover high cost and to focus their efforts on a specific indication or technology [17].

The bio-pharmaceutical industry has a relatively high licensing propensity [18]. In the bio-pharmaceuticals industry, an IP is a means of appropriating rents from a technology, and thus the licensing propensity is quite higher. Research suggests that licensing out technologies is becoming more common [19]. Some firms have even made it a strategic priority to out-license technologies [20]. In the biotechnology industry, licensing is one of the most important strategies to overcome the economic crisis and is recognized as an exit strategy. This raises important question that is addressed in this paper: What are the factors that affect licensing that affect a company’s innovative performance?

This paper addresses this question by conceptually and analytically linking knowledge-based view (KBV) with firm performance. It is suggested that KBV is indirectly linked with firm performance to change a firm’s portfolio of resources, capacities, which in turn affect financial performance. Thus, this research used bio-pharmaceutical data to prove this empirically. We used a framework “KBV” to prove open innovation performance. The framework helps understand how firms may profit financial value from open innovation strategy. A firm’s resources and capacities determine its positional advantage, which, in turn, leads to firm performance. We notice that the relationship between KBV and firm performance is more complex rather than a simple and direct effect. We will present an integrative framework for managing KBV in the context of open innovation by considering firm capacities and resources. Drawing implications through quantitative analysis.

2. Research Background

2.1. Characteristics of Bio-Pharmaceutical Industry in Terms of Open Innovation

The main practices of open innovation in general are patent licensing, merge and acquisition (M&A), outsourcing, collaboration, and joint investment [21]. In particular, inbound open innovation based on absorptive capacity has been of interest to academia. However, the concept of knowledge flow with increased flexibility and the expectation to completely utilized technologies led outbound innovation to the academic attention. Knowledge such as the patent became the primary factor in innovation process, and knowledge transfer process including outside-in and inside-out innovation, beyond the organizational boundaries, is now emphasized in open innovation research [22,23].

The main practices of open innovation adopted in the bio-pharmaceutical industry are out-licensing in innovation and R&D process [24] and M&A [25]. Particularly, a product approved by authority can be competitive in the bio-pharmaceutical market by only charging a licensing fee to potential demand firms [21]. Currently, the open innovation framework and its methodologies are inevitable in bio-pharmaceutical industry [26], and

most of empirical studies in bio-pharmaceutical area are approached by open innovation theory and constructs [21,24,27].

The bio-pharmaceutical industry in general has been through a lot of changes over the decades with mergers and down-sizing of R&D functions within companies [28]. Because of significant changes in the competitive situation such as globalized markets, extreme dynamics in technology development process [2] and a growing mobility of highly skilled people [29], closed innovation strategies become less viable and restrict interactions with the firms' environment [30]. Many firms have recognized the potential of disclosing their innovation processes and therefore they increasingly explore and share ideas out of their organizational boundaries [31].

The fact that only one of the 10,000 substances found during the research and development phase in the bio-pharmaceutical industry can be marketed [32] shows the significant risks these companies face with regard to the results of technological innovation. Bio-pharmaceutical firms have organized over time to exchange technologies and knowledge with different classes of external organizations (e.g., universities or competitors) along the different stages of the R&D process (e.g., drug discovery and drug development) [2]. They have changed their business models by consolidating other firms (M&A), increasing partnerships, outsourcing information technology and R&D functions, or reorganizing their entire R&D.

Since Chesbrough presented an "open innovation" concept [33], research interests have been increasing in many scholars, especially in the areas of management and innovation. A number of bio-pharmaceutical firms have announced that they have been doing an open innovation strategy and 55% of the top 20 bio-pharmaceutical companies of 2016 "open innovation opportunity" on their web pages [16].

Bio-pharmaceutical firms need to seek knowledge from multiple areas both inside and outside of firm boundaries. In the last decade the number of externally sourced drug programs in big pharma's pipeline have increased significantly. Drug development process has transformed into an open innovation ecosystem where small biotech companies are the innovators and where the large bio-pharmaceutical companies act as their commercialization partner [15].

2.2. Outbound Open Innovation with Knowledge Based View

2.2.1. Licensing as Outbound Open Innovation Strategies

Open innovation encompasses various activities, e.g., inbound, outbound, and coupled activities [21,23] with emphasis mainly on the inbound strategy [34], whereas the outbound strategy has received little attention. Outbound open innovation can have monetary and strategic advantages for firms exploiting their technological knowledge outside their boundaries or co-developing it with another organization [35]. Inside-out (outbound) process refers to one of key approaches focusing on the externalization of the firm's internal knowledge for bringing new ideas to commercialize faster than it can be done only through internal R&D. The outbound open innovation refers to "earning profits by bringing ideas to market, selling IP, and multiplying technology by transferring ideas to the outside environment" [22]. Lichtenthaler et al. find a relationship between inside-out activities (e.g., external technology commercialization) and firm performance [36].

Licensing is one of the practices of the outbound open innovation strategy. Firms now can commercialize their IP externally, out-license and sell patented technologies [37,38]. The importance of technology licensing has been emphasized by the previous literature on management of technology [39]. Licensing agreements is a commonly observed type of inter-firm alliances, especially in technology-intensive industries [40]. Patent licensing is an important strategy for technology transfer [41]. By licensing external technology, licensees can use it to fill technological or strategical gaps, overcome blind spots, and complement their internal capabilities [42]. The patent licensing means the transfer of the right to use the patent from the licensor to the licensee. It refers that a patented technology owner can

authorize another firm to use the technology in a certain way for a certain period of time, and the licensee should pay for it to the licensor [41].

In bio-pharmaceutical industry, a firm with relatively full of drug candidates at one clinical phase is likely to license out some of drug candidates at the same stage [43]. Out-licensing of IP involves selling or offering licenses or royalty agreements to other organizations so as to profit from licensor IP [31,44–46]. More competitions and faster product and technology life cycles have led firms to make a thorough evaluation of their technology bundles, considering licensing as a commercialization strategy to generate more revenues without additional cost. By out-licensing, firms can more fully leverage their investments in R&D, partnering with actors adept at bringing inventions to the market-place [3]. Licensing-out requires firms to determine the value of IPs, contract with partners, and implement agreements that allow partners to use the patented knowledge [47].

Because drug development is expensive, time consuming, and risky, the importance of licensing deals between bio-pharmaceutical companies is highlighted. Because the licensor company lacks financial and physical resources to commercialize its technology, it seeks to create additional value through the out-licensing [48]. For small and medium-sized bio-pharmaceutical companies in partnership with Big Pharma, licensing is an essential element in business models. Therefore, in order to grow and succeed in industry, it is important for biotech companies to excel in licensing activities [15]. Licensing has been an essential part of bio-pharmaceutical industry [49].

The bio-pharmaceutical industry is a well-known as technology market has rapidly grown [50]. According to Cortellis, licensing accounted for 45% of all transactions in the bio-pharmaceutical industry in 2017 and 77% of companies participating in the 2018 Bio Convention were looking for licensing opportunities. Out-licensing allows firms to capture additional value from their technology [51,52].

2.2.2. Resource-Based View (RBV)

Resources are generally defined as “all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc., controlled by a firm.” [53] Resources are valuable when they help improve the firm’s efficiency and effectiveness [53]. Firm performance may be an aggregated result of the different effects of different resources [54]. Resources can form the basis of exclusive value-creating strategies and their activity systems leading to competitive advantage [55].

Resources are at the center of the resource-based view (RBV). The RBV is one of the most widely accepted theoretical perspectives in the strategic management field [56,57]. It is an influential theoretical framework for understanding how competitive advantage is realized and how that advantage is maintained over time [58,59]. A firm consists of “a collection of productive resources.” [60] According to RBV, each firm even in the identical industry performs differently because they differ in terms of the resources they control [19,61]. RBV notes that the ability to use resources relevantly is the point to firms’ innovation and financial success [57,62] and the extent of innovation is decided by the resources of the organization.

RBV assumes that firms can be conceptually developed as an array of resources, that those resources are heterogeneously distributed across firms, and that differences of resource continue over time [19,63]. The RBV expands the knowledge of individual firm performance and helps understand of strategic management [57,63]. The RBV has been expanded to use corporate resources in a strategic way for the firm’s innovation [57,64].

2.2.3. Dynamic Capabilities

Teece et al. proposed the dynamic capabilities approach as an extension of the RBV [62]. Dynamic capabilities are developed over time through complex interactions between the firm’s resources [19]. The dynamic capability perspective extends the RBV by addressing how valuable, rare, and difficult to imitate and imperfectly compatible resources can be created and how the current stock of valuable resources can be improved in changing envi-

ronments [24,65,66]. RBVs emphasize sustainable competitive advantage while dynamic capabilities focus on competitive survival issues that address today's rapidly changing business climate. The dynamic capabilities, which refer to "the firm's ability to integrate, build and reconfigure internal and external competencies to address rapidly changing environments" [62], has been used to explain the reason that firms in the same industry perform in a different way.

A dynamic capability is the capability of an organization to deliberately create, extend, or modify its resource base [67]. The emergence of dynamic capabilities has reinforced the RBV by suggesting the evolutionary nature of firm resources and capabilities in connection with environmental changes and enabling identification of firm-specific processes that are critical to firm innovation [68].

The effects of dynamic capabilities on firm performance are relatively complex. If a firm enhances its particular capabilities as directed by its strategic targets and if capability development and firm strategy are effectively coordinated, dynamic capabilities may lead the firm to have better performance. Dynamic capabilities are often steered by firm strategy [68]. This study extends the RBV to dynamic capabilities by combining it with open innovation theory.

2.2.4. Knowledge Based View (KBV)

The ratio of knowledge-based assets is increasing in terms of resource base of the organization [69,70]. Firms are repositories of knowledge. Knowledge is the most important firm resource which conceptualizes the firm as a unique bundle of distinguishable resources and capacities [60,71]. Knowledge creation fuels innovation. A dynamic and comprehensive view may strengthen "our understanding of knowledge strategies, their modification over time, and their effects on innovation performance" [72,73]. Evidences that firm performance is influenced by firms' abilities to integrate, build, and reconfigure their knowledge, resources, and capabilities are increasing.

It is generally accepted that the KBV of the firm is an extension of the RBV because it considers that organizations are heterogeneous entities loaded with knowledge [74,75]. The KBV is the logical evolution of the RBV considering the temporal evolution of its resources and the capabilities that maintain the competitive advantage [76]. In comparison with the RBV, the KBV takes a more fine-grained and profound understanding of knowledge as its basis.

KBV is indirectly linked with firm performance to change a firm's portfolio of capacities, resources, which in turn affect economic performance. Companies need to develop "knowledge capabilities" to benefit from open innovation [11,77]. The KBV focuses on how knowledge capacities and resources are utilized and coordinated [78]. The resources and capabilities generate economic returns to the firm [19]. Now that the concepts of the KBV place substantial emphasis on firm financial performance, the research model of this study is divided into firm resources and firm capacities based on KBV.

2.3. Research Framework and Hypothesis

2.3.1. Firm Capacity

This study focuses on the relationship between external connections for knowledge capacities within a licensor firm's innovation process. Lichtenthaler et al. identify "knowledge capacities", which represent a firm's capabilities of managing various knowledge processes reconfigures and realigns knowledge capacities of managing critical knowledge processes [79]. To capture external knowledge exploration, retention, and exploitation, we consider three interfirm main component factors of capacities, namely, absorptive capability, desorptive capability and connective capability. Table 1 describes how the three components together explain firms' mechanism of linking capacity advantage to competitive advantage, namely licensor financial performance.

Table 1. Classification of the Interfirm Knowledge Capacities.

	Knowledge Exploration	Knowledge Retention	Knowledge Exploitation
External (Interfirm)	Absorptive capacity	Connective capacity	Desorptive capacity

Considering existing studies in regards to KBV, knowledge retention is not frequently covered perspective. However, since connectivity among innovation actors is important in open innovation, knowledge retention by connective capacity should be considered [79]. Based on KBV, the linkage between knowledge capacities and financial performance should be more explained and enhanced in open innovation perspective, and thus the constructs used in this study will help understand of the relationship in order to enhance the knowledge capacities.

2.3.2. Absorptive Capacity

Absorptive capacity relates to exploring external knowledge inside the firm. It consists of the process stages of acquiring external knowledge and absorbing this knowledge by incorporating it into the firm's knowledge base [80,81]. Zahra and George [82] view absorptive capacity as a knowledge capacity that affects the nature and sustainability of a firm's competitive advantage.

For absorptive capacity, firms are required to have prior related knowledge to understand the knowledge being absorbed [80,83]. Firms with higher absorptive capacity demonstrate stronger ability of integrating external information and embedding it into firm's own knowledge. The examination of various knowledge processes complements prior absorptive capacity literature, and it improves our understanding of knowledge capacities [84]. Absorptive capacity is positively related to firm performance, making it an important construct from a managerial perspective [85,86]. An important characteristic of the licensee is its absorptive capacity, which concentrates on how the firm deals with external knowledge for developing innovative performance. In-licensing is considered as a process that a licensee absorbs and integrates a part of the licensor's knowledge into its own knowledge base.

Literature supporting the positive effect of absorptive capacity on in-licensing is growing [84,87]. A potential licensee is typically a large firm that can conduct substantial and complementary in-house R&D [80].

Based on the literature, in this study, the organizational dimension of licensee's absorptive capacity is considered by the number of in-licensing. In addition, we considered the number of patents as the technological dimension. Because patents can confirm the technological development and absorptive capacity, patent analysis can reveal how a company's technology can affect its absorptive capacity [27]. Thus, hypothesis is derived as follows.

Hypothesis 1 (H1). *In the licensing agreement, licensor's "Absorptive Capacity" will be positively correlated with licensor's financial performance.*

Hypothesis 1a (H1a). *The number of patents will be positively correlated with licensor's financial performance.*

Hypothesis 1b (H1b). *The number of in-licensing will be positively correlated with licensor's financial performance.*

2.3.3. Desorptive Capacity

Lichtenthaler et al. complemented absorptive capacity by introducing desorptive capacity, pointing at the relevance of external knowledge exploitation, comprehended as outward knowledge transfer [79]. As opposed to absorbing external knowledge, desorptive capacity refers to "a firm's ability to externalize internal knowledge assets in order to ap-

appropriate returns from innovation” [47]. One of streams of literature which are particularly rich in insights about outbound open innovation is theory work on desorptive capacity [67]. External knowledge exploitation refers to outbound knowledge transfer such as technology licensing [88] which has recently become a broader trend [20]. After identifying external knowledge exploitation opportunities based on the financial and strategic incentives for transferring knowledge, a firm may transfer its own knowledge to the recipient [38].

Absorptive capacity is associated with its desorptive capacity in bi-directional knowledge transfers [38]. External knowledge exploitation refers to the exploitation of knowledge outside the firm boundaries through selling of such as patents, out-licensing [89,90]. Since literature stated that desorptive capacity can contribute to enhancing a firm’s overall financial performance [91], in this study, we considered the number of forward patent citations at the technical dimension and the number of out-licensing at the organizational dimension in terms of the desorptive capacity of licensor. Hypothesis is derived as follows.

Hypothesis 2 (H2). *Licensor’s “Desorptive Capacity” will be positively correlated with licensor’s financial performance.*

Hypothesis 2a (H2a). *The number of forward patent citations will be positively correlated with licensor’s financial performance.*

Hypothesis 2b (H2b). *The number of out-licensing will be positively correlated with licensor’s financial performance.*

2.3.4. Connective Capacity

As connective capacity refers to a firm’s ability to maintain knowledge in relationships between firms, it consists of elements of alliance capacity [92] and relational capability [93]. Firms build strongly on interorganizational knowledge transactions to extend their internal knowledge bases [72,94]. Connective capacity also refers to the ability to establish links to other elements, and these links help access knowledge [24,95]. Following this logic, connective capacity is defined as a firm’s ability to maintain knowledge outside its organizational boundaries. Accordingly, connective capacity consists of the process stages of retaining knowledge in interfirms’ relationships and subsequently reactivating this knowledge [96,97].

External knowledge retention means knowledge maintained in the interorganizational relationship of an enterprise, e.g., alliances or collaborations [94]. The more knowledge a firm has in a specific field, the easier it is to manage interorganizational relationships and to profit from external knowledge possession. Bio-pharmaceutical firms with strong collaborations processes for accessing outside knowledge may achieve much better performance [98]. Many bio-pharmaceutical companies simultaneously collaborate R&D with multiple biotechnology firms [99].

Researchers recently started to relate each of absorptive, desorptive, and connective capacities to a firm’s KBV. We articulated the linkages between each component capacity with a viewpoint of KBV to explain the transformational mechanisms. The emerging KBV of the firm offers new insight into the causes and management of interfirm alliances [97].

In this study, we considered the number of same International Patent Classification (IPC) code at the technical dimension and the number of R&D collaboration at the organizational dimension in terms of the connective capacity of licensor and licensee. In contrast with R&D collaboration which is frequently used as a proxy, the degree of sharing IPC code is useful to examine the connectivity between firms since it is of interest in patent analysis [100]. Hypothesis is derived as follows.

Hypothesis 3 (H3). *Licensor and licensee’s “Connective Capacity” will be positively correlated with licensor’s financial performance.*

Hypothesis 3a (H3a). *The number of same IPC code will be positively correlated with licensor's financial performance.*

Hypothesis 3b (H3b). *The number of R&D collaboration will be positively correlated with licensor's financial performance.*

2.3.5. Firm Resource

Knowledge capacities refer to a firm's capacity to arrange resources, usually in combination, using organizational processes, to bring a desired end, whereas knowledge resources are "stocks of available factors that are owned or controlled by the firm" [19]. The resources explain the differences in performance between firms, as a consequence firms with specific competitive advantages obtain higher returns. Firm resources are the base of the organization's strategy and are major tools to implement it. The realization of the potential value of resources is dependent on the strategy of the firm and how the strategy is implemented and resources are utilized [58,101]. KBV is an important approach towards firm resources that forms the basis for establishing resources in the structural and routine activities of the firm. In terms of firm resources, this study considered R&D intensity and firm size—here, the number of employees, which are frequently used as the proximity of firm resources [24,79,102]. Hypothesis is derived as follows.

Hypothesis 4 (H4). *Licensor firm resources will be positively correlated with licensor's financial performance.*

Hypothesis 4 (H4a). *The degree of R&D intensity will be positively correlated with licensor's financial performance.*

Hypothesis 4 (H4b). *The number of employees will be positively correlated with licensor's financial performance.*

Figure 1 summarizes the research model and hypotheses used in this study.

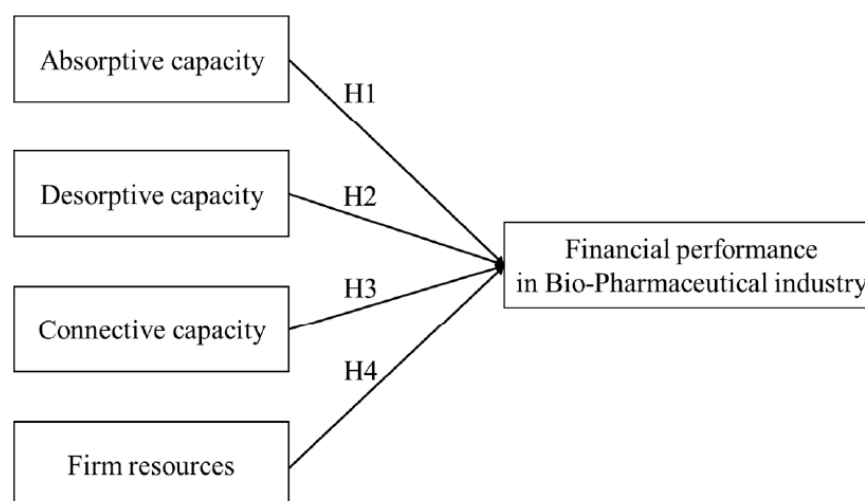


Figure 1. Research model and hypotheses.

3. Methodology

3.1. Data

Medtrack database from Informa is the most comprehensive, fully integrated, global bio-pharmaceutical database providing a one-stop-shop for information on companies, products, patents, pipelines, sales, deals, and venture financing. GPASS database from LexisNexis provides patent information of over 200 countries around the world. Com-

pustat database from Standard & Poor's is the award-winning research platform and business intelligence tool for over 40,000+ corporate, academic, government, and nonprofit clients at over 400+ institutions in 30+ countries. This study uses the above database to extract patents, licensing, R&D investment, manpower, and financial data from a total of 431 multinational bio-pharmaceutical companies from 2001 to 2015.

3.2. Econometric Method

The Ordinary Least Squares (OLS) is the most frequently used regression analysis method, which minimizes the square of the error term (e) of the regression equation. Regression tests the relationship between two or more independent variables and one dependent variable. The basic assumption of a regression model is that there is no correlation among independent variables that do not significantly affect dependent variables but since there are more than two independent variables, there is a possibility that a fairly high correlation between independent variables may be issued, which is called multi-collinearity. Multi-collinearity can be checked by using the Variance Inflation Factor (VIF). If the VIF exceeds 10, then there is usually a problem with multi-collinearity. The Durbin–Watson analysis is performed to determine the correlation of residuals. The reference value will be two representing the normal distribution curve, which is not correlated with the residuals. A positive correlation is closer to zero, a negative correlation is closer to four, and a regression model is inappropriate because of the correlation between residuals. If the tolerance is less than 0.1, it is interpreted that there is a problem with multi-collinearity. Endogeneity is a problem that occurs when the error term and the independent variable are not independent each other. This is a phenomenon that occurs when undiscovered cause (but not an independent variable) contained in an error term has a significant correlation.

3.3. Variables

Because of the difficulties inherent in measuring knowledge capacities and resources from KBV, many researchers have found ways to strictly operationalize their constructs with observable proxies [101,103].

3.3.1. Dependent Variable

The firm capacities and resources may affect the economic performance of the firms [104]. In order to focus on the significant results between variables through the financial performance of each licensor firm, this study uses licensor's average sales over three years after licensing as a dependent variable (FP).

3.3.2. Independent Variables

(1) The Number of Forward Patent Citation (CITN)

A cited patent can represent the extent of the technology level [105]. Patent citation analysis is used to examine the effectiveness or efficiency of technology transfer and innovation [106,107]. Patent citation is considered that technological progresses are characterized by technological paradigms, trajectories, and path dependencies [108]. If a firm cited a patent in the past, it may still require same types of technologies and attempt to access them. Then patent citation information can be an indicator for present or future technology transfer in terms of the path dependency of technology [109]. Forward patent citations, which are made by later patents to a patent previously issued, similarly indicates the traces of the importance of commercial innovations; although, the process by which they are generated is less deferential to status [110]. Harhoff et al. [111] found a noisy but positive correlation between forward patent citation and patent value. Reitzig [112] stated that both theoretically and empirically forward citations are an important determinant of patent value.

In bio-pharmaceutical industry, where patents are used to appropriate returns to innovation, citation rates are more likely than in other industries to contain information regarding the technological and economic value of a specific invention [113]. Narin et al. [114]

measure cited patents among registered patents of the US pharmaceutical industry. Cited patents are also being investigated for their effect on firm performance as valuable knowledge [115]. The positive relationship between the number of cited patents and the financial performance is examined [27]. Thus, forward citations are employed in this study to trace forward the source of newly created knowledge-capacity for licensor. CITN is calculated by the difference between the sum of forward citations of patents that the licensor has for each year and self-citations that the patent has.

(2) The Number of Patents (PAT)

Technology is mainly measured as the number of patents and the level of patent information [116] so that the patent analysis can evaluate a firm's technology development. Patents are important knowledge capacities for firm and can affect firm performance [117]. Previous studies have shown that patents are valuable not only as resources for achieving strategic goals like technology protection but also as sources of technical capacity that affect firm performance. Increasingly, firms use patents to grow and sustain competitive advantages in a KBV [118]. In the bio-pharmaceutical industry, compared with other industries, a patent is used as a means of appropriating incentive from a technological innovation [119]. Thus, this study focuses on the number of patents when we looked at KBV from a technological perspective. PAT is derived by the sum of patent applications that the licensee has for each year.

(3) The Number of Out-Licensing (OUT) and In-Licensing (IN)

In perspective of management of patent, opening up the innovation process needs a movement from the traditional patent protection to a wider approach considering patents as tradable assets [47]. Licensing out and in are much more common and are now the most important method for commercializing and diffusing new technologies outside the firm [120]. In recent years, technology out-licensing has drawn increasing attention as a method for outward technology transfer. Technology-based firms are focusing on maximizing revenues from their own technologies, and in this context, out-licensing can be referred as an important commercialization means that complements their traditional R&D processes [10]. Therefore, this study considers the number of out-licensing and in-licensing as firm capacities. OUT is derived by the number of licensees that the licensor has matched and IN is derived by the number of licensors that the licensee has matched.

(4) Number of Same IPC Code (IPC)

The International Patent Classification (IPC) is a general technological index designed by the World Intellectual Property Organization (WIPO) and operates like a keyword system estimating technological trajectories. A patent may be assigned only one or more than a dozen different eight-digit IPC code, depending largely upon the patent's breadth of coverage. The existence of IP is the core of collaborative relationships between firms [121]. Patents in many cases have multiple IPC code, so the patents characteristics can be precisely identified by using the IPC code. This study measures IPC as the number of identical IPC code between the licensor and the licensee to see the connective capacity.

(5) R&D Collaboration (COLA)

Bio-pharmaceutical companies gain access to external technologies through out-licensing and joint R&D, further expanding upon the internal knowledge base [1]. A recent paper further documents the critical role of collaborations between bio-pharmaceutical firms [2]. Many large pharmaceutical companies simultaneously collaborate R&D with multiple biotechnology firms [99]. COLA is derived by the number of R&D collaborations that the licensor has.

(6) R&D Intensity (RND)

R&D intensity is the most frequently used measure "to estimate the relative importance of R&D among firms in the industry." It has been defined as the ratio of R&D expenditures to the firm's total expenditures. In general, high-tech industries such as bio-pharmaceutical

are characterized by the highest R&D intensity. The resource accumulation process is considered as a reflection of firm's innovative R&D activities. Johnson [122] shows that the combination of a firm's past R&D activities and its current R&D investments contributes to innovative performance. R&D intensity is the key indicator in monitoring firm resources. RND is calculated by the ratio of R&D expenditures to the licensor's total expenditures.

(7) Firm Size (SIZE)

In an RBV, Hitt et al. [58] verified both the direct and moderating roles of human resources on firm performance and tested the independent effects of a firm's human resources and its leveraging capability on its performance. In a way, human resource directly contributes to improving the financial performance of firms by enhancing firms' overall capabilities to seek out and seize new technological and business opportunities [123]. This supports assumption that human resource affects firm performance within the open innovation paradigm in which a workforce performs knowledge transfers both inside and outside of firm boundaries [124]. SIZE is measured by the number of employees that is frequently used to examine firm size [125]. Table 2 summarizes variables used in this study and Equation (1) using these variables is used as a regression equation.

$$FP = B_0 + B_1CITN + B_2OUT + B_3PAT + B_4IN + B_5IPC + B_6COLA + B_7RND + B_8SIZE + \epsilon \quad (1)$$

Table 2. Explanation of Variables.

Variables	Explanation	Source	References
Dependent variable	Financial Performance (FP)	Average sales over three years after licensing	Compustat [126]
Independent Variable (Knowledge Capacities)	Descriptive capacity	Number of forward citation patents	GPASS [24]
	Absorptive capacity	Number of Out-licensing	Medtrack [2]
	Connective capacity	Number of patent applications	GPASS [24]
		Number of In-licensing	Medtrack [2]
		Number of same IPC code	GPASS [121]
Control variables	R&D intensity	Number of R&D Collaboration	Medtrack [2]
	Firm size	R&D Intensity	Compustat [127]
		Number of Employees	Compustat [24]

4. Estimation Results

Table 3 shows the descriptive statistics of independent variables, and the coefficient of correlation and VIF. According to VIF values for each variable, we can confirm that multi-collinearity problem does not exist in this model.

Table 3. Statistical Characteristic of Independent Variables.

	Mean	Std.Dev	VIF	CITN	OUT	PAT	IN	IPC	COLA	RND	SIZE
CITN	2.48600	0.99009	1.82277	1.000							
OUT	5.70998	3.59222	1.68487	0.50507	1.000						
PAT	0.30034	0.72335	1.24103	−0.0518	0.02905	1.000					
IN	2.41067	2.53914	1.03440	0.03716	0.03502	−0.05644	1.000				
IPC	0.01998	0.14772	1.24168	−0.0022	0.00836	0.42450	0.01391	1.000			
COLA	1.70998	2.61780	1.33455	0.38976	0.37361	−0.05222	0.13902	−0.03722	1.000		
RND	4.84061	0.28990	1.14128	−0.2668	−0.1826	−0.08521	−0.03782	−0.10952	−0.17654	1.000	
SIZE	63.91102	41.30372	1.86925	0.57277	0.54282	0.00439	−0.06320	−0.04018	0.14024	−0.27889	1.000

Table 4 shows the estimation results. The regression coefficient for the variable "IN" was found to be "−0.02522", the value of t was "−1.78" and the value of p was "<0.1". Therefore, it can be interpreted that the variable "IN" has a significant amount (−) effect on the dependent variable from a significant level of 10 percent. The regression coefficient for the variable "PAT" was found to be "−0.02209" but statistically insignificant. Thus, H1 including H1a and H1b is rejected. The regression coefficient for the variable "CITN" was

found to be “0.10909”, the value of t was “2.27” and the value of p was “<0.05”. Therefore, it can be interpreted that the variable “CITN” has a significant amount (+) effect on the dependent variable from a significant level of 5 percent. The regression coefficient for the variable “OUT” was found to be “0.05904”, the value of t was “4.63” and the value of p was “<0.01”. Therefore, it can be interpreted that the variable “OUT” has a significant amount (+) effect on the dependent variable from a significant level of 1 percent. Those lead to the acceptance of H2 including H2a and H2b. H3 including H3a and H3b is rejected because of the variables representing connective capacity were statistically insignificant. The regression coefficient for the variable “RND” was found to be “−1.13318”, the value of t was “−8.71” and the value of p was “<0.01”. Therefore, it can be interpreted that the variable “RND” has a significant amount (−) effect on the dependent variable from a significant level of 1 percent. The regression coefficient for the variable “SIZE” was found to be “0.01654”, the value of t was “14.15” and the value of p was “<0.01”. Therefore, it can be interpreted that the variable “SIZE” has a significant amount (+) effect on the dependent variable from a significant level of 1 percent. Thus, H4 is rejected because H4a is rejected in spite of the acceptance of H4b. The value of intercept, B_0 , is “7.82585” with the value of t “11.77”, and R square is 0.6701. The analysis of the F values shows a significant value, “107.15” with the significant level of 1 percent but the correction factor is high, which makes it a sufficient research model.

Table 4. Estimation Results.

Variables		Explanation	Performance Variables: Financial Performance (FP)
Knowledge capacity variables	Absorptive capacity	Number of patent applications (PAT)	−0.02209 (−0.41)
		Number of In-licensing (IN)	−0.02522 * (−1.78)
	Desorptive capacity	Number of forward citation patents (CITN)	0.10909 ** (2.27)
		Number of Out-licensing (OUT)	0.05904 *** (4.63)
	Connective capacity	Number of same IPC code (IPC)	0.22263 (0.84)
		Number of R&D collaboration (COLA)	−0.00307 (−0.20)
Control variables	R&D intensity	R&D Intensity (RND)	−1.13318 *** (−8.71)
	Firm size	Number of Employees (SIZE)	0.01654 *** (14.15)

Note: t -statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Discussion and Implications

According to the estimation, only H2 is fully supported. As a result, desorptive capacity has a positive correlation with licensor financial performance. This is consistent with previous studies suggesting that patent citations and out-licensing affect the financial performance of a firm [27,36]. Furthermore, in-licensing in the organizational aspect of absorptive capacity had a negative correlation with licensor financial performance. This does not have a positive impact on financial performance for the next three years just because of licensing, but because of additional spending, such as R&D investment.

In addition, H4 is statistically significant and H4-2 is supported. Those are consistent with previous research (e.g., [102]), meaning that the R&D intensity is not favored in terms of financial performance while the firm size shows positive effect on financial performance. However, R&D intensity itself is a critical factor in firms’ innovation performance in enhancing knowledge capabilities [80,102]. Thus, appropriate balancing strategy between financial performance and innovation performance should be followed for the licensors.

Based on the analysis, this paper can give several implications. First, theoretically, this article has implications for research into outbound open innovation with KBV. The research framework in this study integrates prior KBV research. This paper analyzes how the KBV complements outbound open innovation by incorporating KBV along these two dimensions: firm capacities and firm resources. With regard to open innovation, this study integrates knowledge from several research areas and advances toward the theory of open innovation. As such, it helps fill the theoretical gap of prior open innovation literature, which limited our understanding of outbound open innovation practices [13].

Second, practically, it is noteworthy that the relationship between desorptive capacity and financial performance emphasizes the importance of relevant partnership exploration. For the sustainability in bio-pharmaceutical industry, firms should maintain consistent collaboration and construct strategic alliance in order to retain partnership candidates, and continuously explore relevant partners to increase performance. Such strategic activities will surely provide advantage in maintaining sustainability.

Finally, in perspective of policy, despite the surprising progress in technology development driven by open innovation framework, associate regulations cannot keep pace with the technology, causing many products and services are not commercialized on time. Thus, regulatory reforms regarding bio-pharmaceutical products and services should be followed. Institutional supports such as regulatory sandbox can help demonstrate and verify creative products and services, deregulate and amend some outdated laws and rules, and therefore invigorate promising business in bio-pharmaceutical industry.

6. Conclusions

The fact that only one of the 10,000 substances found during the R&D phase in the Bio-pharmaceutical industry can be marketed shows the significant risks companies face with regard to the results of technological innovation. Thus bio-pharmaceutical industry has transformed itself into an open innovation ecosystem, and licensing has become a core business exit strategy to overcome economic risk. This study examines the relationship between outbound open innovation and financial performance with open innovation strategy. Specifically, this study extends knowledge-based view to link the open innovation performance and licensor's sustainability. The analysis shows firm's desorptive capabilities have a significant effect on financial performance, confirming the application of knowledge capacity framework.

Empirical research on firm resources and capacities has not yet reached maturity, in spite of significant growth in a decade. Our research proposed an integrated framework for identifying transformational mechanisms that link firms' capacities and resources to licensor firm performance. This study discovered a wide range of bio-pharmaceutical industry-specific capacities and resources relevant to KBV. By drawing on knowledge-based arguments, the framework considers the dynamic interaction of external knowledge in open innovation processes. This integrative view is complemented by three knowledge capacities—absorptive capacity, desorptive capacity, and connective capacity. While further study is required to elaborate the research framework, the integration of the KBV will help understanding of the interfirm heterogeneity in knowledge capacities and resources, organizational boundaries, and innovation performance.

One of limitations in this study is that the time-lag analysis was not taken into account in the process of affecting the firm performance of capacities and resources. As a further study, more sophisticated approach can be carried out through time-lag reflection models. In addition, this study proposes IPC code as a proxy of connective capacity. However, it does not show statistically significance. Thus, additional instruments capturing connective capabilities should be explored and this can be a further study.

Author Contributions: E.K., K.S., and I.L. worked together and significantly contributed to this paper; E.K., I.L., and H.K. designed this study and contributed to the literature review, study modelling and writing; and K.S. contributed to the literature review and data curation; and H.K. implemented and evaluated the analytical model as well as mainly contributed to revision of this paper. All authors have read and agreed to the published version of the manuscript.

Funding: This paper has been supported by Technology Innovation Program (No.20010644) funded By the Ministry of Trade, Industry & Energy (MOTIE, South Korea), by International Science & Business Belt support program, through the Korea Innovation Foundation funded by the Ministry of Science and ICT (No. 2019-DD-SB-0202-02), and by the Medical Research Information Center(MedRIC) through the National Research Foundation of Korea (NRF), funded by the Ministry of Science and ICT of Korean Government (NRF No. 2020R1A6A6018661).

Data Availability Statement: Restrictions apply to the availability of these data. Data was obtained from Medtrack, Computat, and GPASS database and are available with the permission of Informa, Standard & Poor's, and LexisNexis.

Acknowledgments: This paper is based on Master's thesis and extended to fit *Sustainability* journal.

Conflicts of Interest: The authors declare no conflict of interest.

References

- Schuhmacher, A.; Germann, P.-G.; Trill, H.; Gassmann, O. Models for open innovation in the pharmaceutical industry. *Drug Discov. Today* **2013**, *18*, 1133–1137. [\[CrossRef\]](#) [\[PubMed\]](#)
- Bianchi, M.; Cavaliere, A.; Chiaroni, D.; Frattini, F.; Chiesa, V. Organisational modes for Open Innovation in the bio-pharmaceutical industry: An exploratory analysis. *Technovation* **2011**, *31*, 22–33. [\[CrossRef\]](#)
- Dahlander, L.; Gann, D.M. How open is innovation? *Res. Policy* **2010**, *39*, 699–709. [\[CrossRef\]](#)
- Madhok, A.; Osegowitsch, T. The International Biotechnology Industry: A Dynamic Capabilities Perspective. *J. Int. Bus. Stud.* **2000**, *31*, 325–335. [\[CrossRef\]](#)
- Owen-Smith, J.; Riccaboni, M.; Pammolli, F.; Powell, W.W. A Comparison of U.S. and European University-Industry Relations in the Life Sciences. *Manag. Sci.* **2002**, *48*, 24–43. [\[CrossRef\]](#)
- Powell, W.W.; Koput, K.W.; Bowie, J.I.; Smith-Doerr, L. The spatial clustering of science and capital: Accounting for biotech firm-venture capital relationships. *Reg. Stud.* **2002**, *36*, 291–305. [\[CrossRef\]](#)
- Booth, B.; Zimmel, R. Opinion: Prospects for productivity. *Nat. Rev. Drug Discov.* **2004**, *3*, 451. [\[CrossRef\]](#)
- Paul, S.M.; Mytelka, D.S.; Dunwiddie, C.T.; Persinger, C.C.; Munos, B.H.; Lindborg, S.R.; Schacht, A.L. How to improve R&D productivity: The pharmaceutical industry's grand challenge. *Nat. Rev. Drug Discov.* **2010**, *9*, 203–214.
- Appleyard, M.M.; Chesbrough, H.W. The Dynamics of Open Strategy: From Adoption to Reversion. *Long Range Plan.* **2017**, *50*, 310–321. [\[CrossRef\]](#)
- Lichtenthaler, U. Implementation Steps for Successful Out-Licensing. *Res. Manag.* **2011**, *54*, 47–53. [\[CrossRef\]](#)
- Chesbrough, H. *Open Business Models: How to Thrive in the New Innovation Landscape*; Harvard Business Press: Boston, MA, USA, 2006.
- Rivera, K.G.; Kline, D. *Discovering New Value in Intellectual Property*; Harvard Business Review: Brighton, MA, USA, 2000; p. 55.
- Lichtenthaler, U. Open Innovation in Practice: An Analysis of Strategic Approaches to Technology Transactions. *IEEE Trans. Eng. Manag.* **2008**, *55*, 148–157. [\[CrossRef\]](#)
- Lichtenthaler, U. Open innovation: Past research, current debates, and future directions. *Acad. Manag. Perspect.* **2011**, *25*, 75–93.
- Hofman, J.; Niklasson, A. Success Factors in Product Licensing in the Pharmaceuticals Industry: Identification and Evaluation of Factors Influencing Likelihood and Financial Value of a Licensing Deal. Master's Thesis, Chalmers University of Technology, Gothenburg, Sweden, 2016.
- Hunter, J.; Stephens, S. Is open innovation the way forward for big pharma? *Nat. Rev. Drug Discov.* **2010**, *9*, 87–88. [\[CrossRef\]](#)
- Chesbrough, H. *Pharmaceutical Innovation Hits the Wall: How Open Innovation Can Help*; Forbes: Jersey City, NJ, USA, 2011.
- Anand, B.N.; Khanna, T. The Structure of Licensing Contracts. *J. Ind. Econ.* **2003**, *48*, 103–135. [\[CrossRef\]](#)
- Amit, R.; Schoemaker, P.J.H. Strategic assets and organizational rent. *Strateg. Manag. J.* **1993**, *14*, 33–46. [\[CrossRef\]](#)
- Fosfuri, A. The licensing dilemma: Understanding the determinants of the rate of technology licensing. *Strateg. Manag. J.* **2006**, *27*, 1141–1158. [\[CrossRef\]](#)
- Shin, K.; Lee, D.; Shin, K.; Kim, E. Measuring the Efficiency of U.S. Pharmaceutical Companies Based on Open Innovation Types. *J. Open Innov. Technol. Mark. Complex.* **2018**, *4*, 34. [\[CrossRef\]](#)
- Enkel, E.; Gassmann, O.; Chesbrough, H. Open R&D and open innovation: Exploring the phenomenon. *R D Manag.* **2009**, *39*, 311–316.
- Gassmann, O.; Enkel, E. Towards a Theory of Open Innovation: Three Core Process Archetypes. In Proceedings of the R&D Management Conference (RADMA), Lisbon, Portugal, 7–9 July 2004.
- Shin, K.; Kim, E.; Jeong, E. Structural Relationship and Influence between Open Innovation Capacities and Performances. *Sustainability* **2018**, *10*, 2787. [\[CrossRef\]](#)

25. Lee, Y.J.; Shin, K.; Kim, E. The Influence of a Firm's Capability and Dyadic Relationship of the Knowledge Base on Ambidextrous Innovation in Biopharmaceutical M&As. *Sustainability* **2019**, *11*, 4920.
26. Carroll, G.P.; Srivastava, S.; Volini, A.S.; Piñeiro-Núñez, M.M.; Vetman, T. Measuring the effectiveness and impact of an open innovation platform. *Drug Discov. Today* **2017**, *22*, 776–785. [[CrossRef](#)] [[PubMed](#)]
27. Kim, H.; Kim, E. How an Open Innovation Strategy for Commercialization Affects the Firm Performance of Korean Healthcare IT SMEs. *Sustainability* **2018**, *10*, 2476. [[CrossRef](#)]
28. Gautam, A.; Pan, X. The changing model of big pharma: Impact of key trends. *Drug Discov. Today* **2016**, *21*, 379–384. [[CrossRef](#)] [[PubMed](#)]
29. Florida, R. *The Rise of the Creative Class*; Basic Books: New York, NY, USA, 2002.
30. Teece, D.J. Capturing Value from Knowledge Assets: The New Economy, Markets for Know-How, and Intangible Assets. *Calif. Manag. Rev.* **1998**, *40*, 55–79. [[CrossRef](#)]
31. Gassmann, O. Opening up the innovation process: Towards an agenda. *R D Manag.* **2006**, *36*, 223–228. [[CrossRef](#)]
32. Gassmann, O.; Reepmeyer, G. Organizing Pharmaceutical Innovation: From Science-based Knowledge Creators to Drug-oriented Knowledge Brokers. *Creat. Innov. Manag.* **2005**, *14*, 233–245. [[CrossRef](#)]
33. Chesbrough, H. The Logic of Open Innovation: Managing Intellectual Property. *Calif. Manag. Rev.* **2003**, *45*, 33–58. [[CrossRef](#)]
34. Lee, S.; Park, G.; Yoon, B.; Park, J. Open innovation in SMEs—An intermediated network model. *Res. Policy* **2010**, *39*, 290–300. [[CrossRef](#)]
35. Hung, K.-P.; Chou, C. The impact of open innovation on firm performance: The moderating effects of internal R&D and environmental turbulence. *Technovation* **2013**, *33*, 368–380.
36. Lichtenthaler, U.; Ernst, H.; Hoegl, M. Not-Sold-Here: How Attitudes Influence External Knowledge Exploitation. *Organ. Sci.* **2010**, *21*, 1054–1071. [[CrossRef](#)]
37. Davis, L. Intellectual property rights, strategy and policy. *Econ. Innov. New Technol.* **2004**, *13*, 399–415. [[CrossRef](#)]
38. Rivette, K.G.; Kline, D. *Rembrandts in the Attic: Unlocking the Hidden Value of Patents*; Harvard Business Press: Boston, MA, USA, 2000.
39. Gambardella, A.; Giuri, P.; Luzzi, A. The market for patents in Europe. *Res. Policy* **2007**, *36*, 1163–1183. [[CrossRef](#)]
40. Kim, Y.; Vonortas, N.S.; Kim, Y.; Vonortas, N.S. Determinants of technology licensing: The case of licensors. *Manag. Decis. Econ.* **2006**, *27*, 235–249. [[CrossRef](#)]
41. Cai, Y. The Evolution of Distribution of Technology Transfer in China: Evidence from Patent Licensing. *Am. J. Ind. Bus. Manag.* **2018**, *8*, 1239–1252. [[CrossRef](#)]
42. Tsai, K.-H.; Wang, J.-C. External technology sourcing and innovation performance in LMT sectors: An analysis based on the Taiwanese Technological Innovation Survey. *Res. Policy* **2009**, *38*, 518–526. [[CrossRef](#)]
43. Nishimura, J.; Okada, Y. R&D portfolios and pharmaceutical licensing. *Res. Policy* **2014**, *43*, 1250–1263.
44. Lee, J.H.; Sung, T.-E.; Kim, E.; Shin, K. Evaluating Determinant Priority of License Fee in Biotech Industry. *J. Open Innov. Technol. Mark. Complex.* **2018**, *4*, 30. [[CrossRef](#)]
45. Lee, J.H.; Kim, E.; Sung, T.-E.; Shin, K. Factors Affecting Pricing in Patent Licensing Contracts in the Biopharmaceutical Industry. *Sustainability* **2018**, *10*, 3143. [[CrossRef](#)]
46. Van de Vrande, V.; de Jong, J.P.; Vanhaverbeke, W.; De Rochemont, M. Open innovation in SMEs: Trends, motives and management challenges. *Technovation* **2009**, *29*, 423–437. [[CrossRef](#)]
47. Ziegler, N.; Ruether, F.; Bader, M.A.; Gassmann, O. Creating value through external intellectual property commercialization: A desorptive capacity view. *J. Technol. Transf.* **2013**, *38*, 930–949. [[CrossRef](#)]
48. Ruckman, K.; McCarthy, I. Why do some patents get licensed while others do not? *Ind. Corp. Chang.* **2016**, *26*, 667–688. [[CrossRef](#)]
49. Arnold, K.; Coia, A.; Saywell, S.; Smith, T.; Minick, S.; Loffler, A. Value drivers in licensing deals. *Nat. Biotechnol.* **2002**, *20*, 1085–1089. [[CrossRef](#)] [[PubMed](#)]
50. Arora, A.; Gambardella, A. Ideas for rent: An overview of markets for technology. *Ind. Corp. Chang.* **2010**, *19*, 775–803. [[CrossRef](#)]
51. Di Minin, A.; Frattini, F.; Piccaluga, A. Fiat: Open innovation in a downturn (1993–2003). *Calif. Manag. Rev.* **2010**, *52*, 132–159. [[CrossRef](#)]
52. Kim, Y. Choosing between international technology licensing partners: An empirical analysis of U.S. biotechnology firms. *J. Eng. Technol. Manag.* **2009**, *26*, 57–72. [[CrossRef](#)]
53. Barney, J. Firm Resources and Sustained Competitive Advantage. *J. Manag.* **1991**, *17*, 99–120. [[CrossRef](#)]
54. Ray, G.; Barney, J.B.; Muhanna, W.A. Capabilities, business processes, and competitive advantage: Choosing the dependent variable in empirical tests of the resource-based view. *Strateg. Manag. J.* **2003**, *25*, 23–37. [[CrossRef](#)]
55. Eisenhardt, K.M.; Martin, J.A. Dynamic capabilities: What are they? *Strateg. Manag. J.* **2000**, *21*, 1105–1121. [[CrossRef](#)]
56. Powell, T.C. Competitive advantage: Logical and philosophical considerations. *Strateg. Manag. J.* **2001**, *22*, 875–888. [[CrossRef](#)]
57. Priem, R.L.; Butler, J.E. Is the Resource-Based “View” a Useful Perspective for Strategic Management Research? *Acad. Manag. Rev.* **2001**, *26*, 22.
58. Hitt, M.A.; Bierman, L.; Shimizu, K.; Kochhar, R. Direct and moderating effects of human capital on strategy and performance in professional service firms: A resource-based perspective. *Acad. Manag. J.* **2001**, *44*, 13–28.
59. Nelson, R.R. Why do firms differ, and how does it matter? *Strateg. Manag. J.* **1991**, *12*, 61–74. [[CrossRef](#)]
60. Penrose, E.T. *The Theory of the Growth of the Firm*; Oxford University Press: New York, NY, USA, 1959.
61. Barney, J.B. Strategic Factor Markets: Expectations, Luck, and Business Strategy. *Manag. Sci.* **1986**, *32*, 1231–1241. [[CrossRef](#)]

62. Teece, D.; Pisano, G.; Shuen, A. Dynamic Capabilities and Strategic Management. *Strateg. Manag. J.* **1997**, *18*, 509–533. [\[CrossRef\]](#)
63. Mahoney, J.T.; Pandian, J.R. The resource-based view within the conversation of strategic management. *Strateg. Manag. J.* **1992**, *13*, 363–380. [\[CrossRef\]](#)
64. Dierickx, I.; Cool, K. Asset Stock Accumulation and Sustainability of Competitive Advantage. *Manag. Sci.* **1989**, *35*, 1504–1511. [\[CrossRef\]](#)
65. Ambrosini, V.; Bowman, C. What are dynamic capabilities and are they a useful construct in strategic management? *Int. J. Manag. Rev.* **2009**, *11*, 29–49. [\[CrossRef\]](#)
66. Yun, J.J.; Won, D.; Park, K. Dynamics from open innovation to evolutionary change. *J. Open Innov. Technol. Mark. Complex.* **2016**, *2*, 1–22. [\[CrossRef\]](#)
67. Helfat, C.E.; Finkelstein, S.; Mitchell, W.; Peteraf, M.; Singh, H.; Teece, D.; Winter, S.G. *Dynamic Capabilities: Understanding Strategic Change in Organizations*; John Wiley & Sons: Hoboken, NJ, USA, 2009.
68. Wang, C.L.; Ahmed, P.K. Dynamic capabilities: A review and research agenda. *Int. J. Manag. Rev.* **2007**, *9*, 31–51. [\[CrossRef\]](#)
69. Roos, J.; Edvinsson, L.; Dragonetti, N.C. *Intellectual Capital: Navigating the New Business Landscape*; Springer: Berlin/Heidelberg, Germany, 1997.
70. Stewart, T.; Ruckdeschel, C. Intellectual capital: The new wealth of organizations. *Perform. Improv.* **1998**, *37*, 56–59. [\[CrossRef\]](#)
71. Wernerfelt, B. A resource-based view of the firm. *Strateg. Manag. J.* **1984**, *5*, 171–180. [\[CrossRef\]](#)
72. Argote, L.; McEvily, B.; Reagans, R. Managing Knowledge in Organizations: An Integrative Framework and Review of Emerging Themes. *Manag. Sci.* **2003**, *49*, 571–582. [\[CrossRef\]](#)
73. Zahra, S.A.; Sapienza, H.J.; Davidsson, P. Entrepreneurship and Dynamic Capabilities: A Review, Model and Research Agenda*. *J. Manag. Stud.* **2006**, *43*, 917–955. [\[CrossRef\]](#)
74. Grant, R.M. Toward a knowledge-based theory of the firm. *Strateg. Manag. J.* **1996**, *17*, 109–122. [\[CrossRef\]](#)
75. Hoskisson, R.E.; Wan, W.P.; Yiu, D.; Hitt, M.A. Theory and research in strategic management: Swings of a pendulum. *J. Manag.* **1999**, *25*, 417–456. [\[CrossRef\]](#)
76. Helfat, C.E.; Peteraf, M.A. The dynamic resource-based view: Capability lifecycles. *Strateg. Manag. J.* **2003**, *24*, 997–1010. [\[CrossRef\]](#)
77. Teece, D.J. Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strateg. Manag. J.* **2007**, *28*, 1319–1350. [\[CrossRef\]](#)
78. Spender, J.-C. Making knowledge the basis of a dynamic theory of the firm. *Strateg. Manag. J.* **1996**, *17*, 45–62. [\[CrossRef\]](#)
79. Lichtenthaler, U.; Lichtenthaler, E. A Capability-Based Framework for Open Innovation: Complementing Absorptive Capacity. *J. Manag. Stud.* **2009**, *46*, 1315–1338. [\[CrossRef\]](#)
80. Cohen, W.M.; Levinthal, D.A. Absorptive Capacity: A New Perspective on Learning and Innovation. *Adm. Sci. Q.* **1990**, *35*, 128. [\[CrossRef\]](#)
81. Lane, P.J.; Koka, B.R.; Pathak, S. The reification of absorptive capacity: A critical review and rejuvenation of the construct. *Acad. Manag. Rev.* **2006**, *31*, 833–863. [\[CrossRef\]](#)
82. Zahra, S.A.; George, G. Absorptive capacity: A review, reconceptualization, and extension. *Acad. Manag. Rev.* **2002**, *27*, 185–203. [\[CrossRef\]](#)
83. Jansen, J.J.P.; van den Bosch, F.A.J.; Volberda, H.W. Managing potential and realized absorptive capacity: How do organizational antecedents matter? *Acad. Manag. J.* **2005**, *48*, 999–1015. [\[CrossRef\]](#)
84. Laursen, K.; Leone, M.I.; Torrisi, S. Technological exploration through licensing: New insights from the licensee's point of view. *Ind. Corp. Chang.* **2010**, *19*, 871–897. [\[CrossRef\]](#)
85. McAdam, R.; McAdam, M.; Brown, V. Proof of concept processes in UK university technology transfer: An absorptive capacity perspective. *R D Manag.* **2009**, *39*, 192–210. [\[CrossRef\]](#)
86. Riccaboni, M.; Moliterni, R. Managing technological transitions through R&D alliances. *R D Manag.* **2009**, *39*, 124–135.
87. Eom, B.-Y.; Lee, K. Determinants of industry-academy linkages and, their impact on firm performance: The case of Korea as a latecomer in knowledge industrialization. *Res. Policy* **2010**, *39*, 625–639. [\[CrossRef\]](#)
88. Lichtenthaler, U. The Drivers of Technology Licensing: An Industry Comparison. *Calif. Manag. Rev.* **2007**, *49*, 67–89. [\[CrossRef\]](#)
89. Granstrand, O. The Economics and Management of Intellectual Property. In *Books*; Edward Elgar Publishing: Cheltenham, UK, 1999.
90. Monk, A.H.B. The emerging market for intellectual property: Drivers, restrainers, and implications. *J. Econ. Geogr.* **2009**, *9*, 469–491. [\[CrossRef\]](#)
91. Lichtenthaler, U.; Lichtenthaler, E. Technology Transfer across Organizational Boundaries: Absorptive Capacity and Desorptive Capacity. *Calif. Manag. Rev.* **2010**, *53*, 154–170. [\[CrossRef\]](#)
92. Kale, P.; Singh, H. Building firm capabilities through learning: The role of the alliance learning process in alliance capability and firm-level alliance success. *Strateg. Manag. J.* **2007**, *28*, 981–1000. [\[CrossRef\]](#)
93. Lorenzoni, G.; Lipparini, A. The leveraging of interfirm relationships as a distinctive organizational capability: A longitudinal study. *Strateg. Manag. J.* **1999**, *20*, 317–338. [\[CrossRef\]](#)
94. Gulati, R. Network location and learning: The influence of network resources and firm capabilities on alliance formation. *Strateg. Manag. J.* **1999**, *20*, 397–420. [\[CrossRef\]](#)
95. Luhmann, N. *Social Systems*; Stanford University Press: Redwood City, CA, USA, 1995.

96. Garud, R.; Nayyar, P.R. Transformative capacity: Continual structuring by intertemporal technology transfer. *Strateg. Manag. J.* **1994**, *15*, 365–385. [\[CrossRef\]](#)
97. Grant, R.M.; Baden-Fuller, C. A Knowledge Accessing Theory of Strategic Alliances. *J. Manag. Stud.* **2004**, *41*, 61–84. [\[CrossRef\]](#)
98. Powell, W.W.; Koput, K.W.; Smith-Doerr, L. Interorganizational collaboration and the locus of in-novation: Networks of learning in biotechnology. *Adm. Sci. Q.* **1996**, *41*, 116–145. [\[CrossRef\]](#)
99. Rothaermel, F.T.; Deeds, D.L. Exploration and exploitation alliances in biotechnology: A system of new product development. *Strateg. Manag. J.* **2004**, *25*, 201–221. [\[CrossRef\]](#)
100. Liu, S.J.; Shyu, J. Strategic planning for technology development with patent analysis. *Int. J. Technol. Manag.* **1997**, *13*, 661. [\[CrossRef\]](#)
101. Barney, J.B.; Arikan, A.M. The resource-based view: Origins and implications. In *Handbook of Strategic Management*; Wiley: Hoboken, NJ, USA, 2001; p. 124188.
102. Kim, S.; Kim, H.; Kim, E. How knowledge flow affects Korean ICT manufacturing firm performance: A focus on open innovation strategy. *Technol. Anal. Strateg. Manag.* **2016**, *28*, 1167–1181. [\[CrossRef\]](#)
103. Wernerfelt, B. The resource-based view of the firm: Ten years after. *Strateg. Manag. J.* **1995**, *16*, 171–174. [\[CrossRef\]](#)
104. Makadok, R. Toward a synthesis of the resource-based and dynamic-capability views of rent creation. *Strateg. Manag. J.* **2001**, *22*, 387–401. [\[CrossRef\]](#)
105. Lin, B.-W.; Chen, C.-J.; Wu, H.-L. Patent portfolio diversity, technology strategy, and firm value. *IEEE Trans. Eng. Manag.* **2006**, *53*, 17–26.
106. Agrawal, A.; Henderson, R. Putting Patents in Context: Exploring Knowledge Transfer from MIT. *Manag. Sci.* **2002**, *48*, 44–60. [\[CrossRef\]](#)
107. Yun, J.J.; Jeong, E.; Lee, C.; Park, J.; Zhao, X. Effect of Distance on Open Innovation: Differences among Institutions According to Patent Citation and Reference. *Sustainability* **2017**, *9*, 1478. [\[CrossRef\]](#)
108. Dosi, G. Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. *Res. Policy* **1982**, *11*, 147–162. [\[CrossRef\]](#)
109. Sanditov, B. *Patent Citations, the Value of Innovations and Path-Dependency*; Università Commerciale Luigi Bocconi: Milan, Italy, 2005.
110. Hall, B.; Jaffe, A.; Trajtenberg, M. Market Value and Patent Citations: A First Look. *Natl. Bur. Econ. Res.* **2000**. [\[CrossRef\]](#)
111. Harhoff, D.; Narin, F.; Scherer, F.M.; Vopel, K. *Citation Frequency and the Value of Patented Innovation*; Discussion Paper No. 97-26; Wissenschaftszentrum Berlin für Sozialforschung (WZB): Berlin, Germany, 1997.
112. Reitzig, M. The private values of ‘thickets’ and ‘fences’: Towards an updated picture of the use of patents across industries. *Econ. Innov. New Technol.* **2004**, *13*, 457–476. [\[CrossRef\]](#)
113. Gittelman, M.; Kogut, B. Does good science lead to valuable knowledge? Biotechnology firms and the evolutionary logic of citation patterns. *Manag. Sci.* **2003**, *49*, 366–382. [\[CrossRef\]](#)
114. Narin, F.; Noma, E.; Perry, R. Patents as indicators of corporate technological strength. *Res. Policy* **1987**, *16*, 143–155. [\[CrossRef\]](#)
115. Trajtenberg, M. A Penny for Your Quotes: Patent Citations and the Value of Innovations. *RAND J. Econ.* **1990**, *21*, 172. [\[CrossRef\]](#)
116. Harhoff, D.; Scherer, F.M.; Vopel, K. Citations, family size, opposition and the value of patent rights. *Res. Policy* **2003**, *32*, 1343–1363. [\[CrossRef\]](#)
117. Comanor, W.S.; Scherer, F.M. Patent Statistics as a Measure of Technical Change. *J. Political Econ.* **1969**, *77*, 392–398. [\[CrossRef\]](#)
118. Grindley, P.C.; Teece, D.J. Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics. *Calif. Manag. Rev.* **1997**, *39*, 8–41. [\[CrossRef\]](#)
119. Cohen, W.M.; Goto, A.; Nagata, A.; Nelson, R.R.; Walsh, J.P. R&D spillovers, patents and the incentives to innovate in Japan and the United States. *Res. Policy* **2002**, *31*, 1349–1367.
120. Hagedoorn, J. Inter-firm R&D partnerships: An overview of major trends and patterns since 1960. *Res. Policy* **2002**, *31*, 477–492.
121. Arora, A. Licensing Tacit Knowledge: Intellectual Property Rights and The Market for Know-How. *Econ. Innov. New Technol.* **1995**, *4*, 41–60. [\[CrossRef\]](#)
122. Johnson, D.K. “Learning-by-Licensing”: R&D and Technology Licensing in Brazilian Invention. *Econ. Innov. New Technol.* **2002**, *11*, 163–177.
123. Davenport, T.H.; De Long, D.W.; Beers, M.C. Successful knowledge management projects. *Sloan Manag. Rev.* **1998**, *39*, 43–57.
124. Zhang, S.; Yang, D.; Qiu, S.; Bao, X.; Li, J. Open innovation and firm performance: Evidence from the Chinese mechanical manufacturing industry. *J. Eng. Technol. Manag.* **2018**, *48*, 76–86. [\[CrossRef\]](#)
125. Rogers, M. Networks, Firm Size and Innovation. *Small Bus. Econ.* **2004**, *22*, 141–153. [\[CrossRef\]](#)
126. Zahra, S.A. Entrepreneurial Risk Taking in Family Firms. *Fam. Bus. Rev.* **2005**, *18*, 23–40. [\[CrossRef\]](#)
127. Decarolis, D.M.; Deeds, D.L. The impact of stocks and flows of organizational knowledge on firm performance: An empirical investigation of the biotechnology industry. *Strateg. Manag. J.* **1999**, *20*, 953–968. [\[CrossRef\]](#)