Public Private Partnerships and Absorptive Capacity as Catalysts for Technology Transfer

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Abstract – We examine and determine the aspects that have influenced the successful technological transfer of technologies developed by Universities and Public Research Institutions (U&PRIs) to industries in Korea between the year 2019- 2023. Analyzing the sample of 5340 technology transfers within 3347 firms, the paper explores the link between internal innovation capacity, absorptive capacity, and Public-Private Partnerships (PPP) in relation to commercialization performance. Data gathered from a survey with 1038 organizations provide valuable insights into 514 technologies as well as their impact on the growth of organizations. Our results show that partnership with private firms is always required for commercialization to take place, regardless of the competition level. Absorptive capacity exerts positive influences on success in commercialization and long-term business growth in high competition while internal innovation capacity exerts a complex relationship, with positive impacts in high competition but negative impact in low competition. These findings underpin the need for an innovation approach that responds to the competitive context and equally shed light on the dynamics among absorptive capacity, internal innovation and external partnerships in technology transfers.

Keywords – Public-Private Partnerships, Absorption Capacity, Universities and Public Research Institutions, Research and Development Projects.

I. INTRODUCTION

Public Private Partnerships (PPPs) [1] are cooperative organizational provisions among private and public sector entities that have garnered significant global attention. However, there is a lack of consensus among individuals over the precise definition of a PPP. Many scholars define it as a novel form of governance that will replace the conventional approach of procuring public services via competitive bidding. According to [1], PPPs are considered a novel concept in the field of public administration, and include traditional methods of using private organizations in providing public services. However, scholars see PPPs as a novel approach to managing infrastructure endeavors, such as constructing tunnels and revitalizing harbors. Additionally, there is a subset of individuals who seem to use the phrases "contracting" and "public-private partnership" in a nearly interchangeable manner.

In order to improve their ability to compete, corporations should not only develop their individual Research and Development (R&D) capabilities, but also engage with other establishments, such as Universities and Public Research Institutions (U&PRIs), to get resources for ongoing innovation. The literature on organizational strategy for small company connections was found to be scarce. A limited number of publications analyzed prevalent partnership tactics and their corresponding effects. Internationalization techniques, often used by small enterprises to expand their market reach rather than focusing on product development [2], have a direct correlation with company success. The choice of alliance strategy for small enterprises is contingent upon the degree of ecological uncertainty or the process of strategy creation. The research only identified one technique, which included using external ties to mitigate economic uncertainty. This strategy aimed to expand the pool of accessible partners and decrease reliance on specific resources.

Companies are increasingly using cooperative R&D initiatives, contract-based research, joint investments, and licensing as new ways to acquire new information. Licensing is a prevalent method of cooperation among U&PRIs and industry, which stands for PPP in short. PPP contracts, due to their long-term nature, need periodic adaptations. This results in frequent renegotiations in various geographical regions as seen in **Table 1**. The renegotiations might be seen as proof of opportunistic conduct by the parties involved in the contract. In 1980, the Stevenson-Wydler Technological Innovation Act and the Bayh-Dole Act. were passed by the US Congress. These acts acknowledged the rights of U&PRIs to claim ownership of innovations, which laid the foundation for technology transfer in the United States.

Table 1. A Selection of Publications on the PPP Renegotiation Frequency

Geographical domain	Sectors	Renegotiated contracts %	References
Latin and Caribbean America	All	68	[15]
	Water	92	
	Electricity	41	
	Transportation	78	
France	Car Parks	73	[16]
	Highways	50	
United states	Highways	40	[17]
United Kingdom	All sectors	55	[18]

Before the implementation of the Stevenson-Wydler Act, the national labs did not have a specific objective to transfer technology. However, the Act required every national laboratory to create an Office of Research and Technology Applications with the purpose of sharing information about products, processes, and services owned or developed by the federal government that could be useful go local and state governments and the private industry [3]. The Federal Technology Transfer Act of 1986, which modified Stevenson-Wydler, offered monetary incentives to laboratory scientists. Specifically, it mandated that inventors who were employees of agencies during intervention receive a minimum of 15% of income and royalties generated by the agency as a result of the invention.

Technology transfer facilitates productive cooperation among the parties engaged in public-private partnerships (PPP). The process of private enterprises adopting and commercializing public innovations is filled with many dangers of market failure. According to a recent study done. It was noticed that business partnership in European universities is not very common and is mostly focused on biomedical research. The license revenue represents a mere 1.5% of the research costs incurred by public study performers. Approximately 85% of all license money (€ 346 million) is earned by the top 10% of European U&PRIs, with 88.8% of this cash coming from biomedical discoveries. The aim of this research is to assess the effect of absorbent capacity, partnership intensity and internal innovation on the effective development of technologies shifted from U&PRIs to the Korean industry, contingent upon the level of market competition.

The rest of the paper have been arranged as shown: Section II discusses the Absorptive Capacity (AC), Internal Innovation Capacity (IIC), Public Private Partnerships (PPPs), Market Competition Intensity (MCI). Section III reviews the data, variables and methods employed when composing this paper. Section IV presents a detailed account of research model validity, as well as multi-group analysis based on the degree of market competition [4]. Section V discusses NFI, CFI, RMSEA, PNFI, and multi-group analysis for market competition intensity. Lastly, Section VI concludes the paper and summarizes PPPs and absorptive capacity as catalysts for technology transfer success.

II. THEORETICAL MODEL

Absorptive Capacity

Absorptive Capacity (AC) is a crucial competence for companies that pursue an innovation strategy. Companies enhance their expertise by using their existing knowledge base. The acquisition of novel knowledge is dependent on the process of learning from external sources, particularly when the new knowledge surpasses the current capabilities of a company. In a technologically advanced environment, the innovative success of an association is determined by its ability to absorb and integrate this new knowledge, as described. The [5] defined absorptive capacity as a dynamic competence that involves the generation and use of data. In [5] identified two components of absorptive capacity: 'realized' absorptive ability, which focusses on the internalization, conversion, and utilization of knowledge, and 'potential' absorptive capacity, which encompasses the attainment and comprehension of external information.

Internal Innovation Capacity

The presence of innovation capacity endowment is evident not just in basic international company operations like manufacturing and sales, but also in more advanced international research and development activities that need a greater allocation of resources. It is essential for the enhancement of global research and development initiatives. Firstly, the ability to innovate may assist companies in efficiently segmenting international markets based on technological qualities, manufacturing capabilities, and product advantages. This enables them to identify prospective markets that align with their research and development goals, as outlined in their strategic objectives [6]. Generally, market-oriented enterprises prefer countries and regions with a large-scale market, while technology-oriented enterprises seek to monitor and obtain competitors' technology and information, so they typically favour regions and countries with higher levels of expertise to establish international R&D institutions. Businesses with a higher innovation capacity will have a more precise ability to divide abroad markets.

Furthermore, it is essential for an organization to thoroughly evaluate the target market by conducting a meticulous analysis of both the worldwide R&D landscape and its own technological capabilities. This evaluation will determine if it is prudent to engage in R&D activities within the target market. Enterprises that possess exceptional innovation capabilities

typically demonstrate superior information processing capabilities. They employ scientific analysis methods to swiftly and efficiently analyses data, enabling them to ascertain whether they can achieve market acquisition or pursue technological advancements in the target market [7]. After successfully implementing an international research and development strategy, enterprises can enhance their ability to identify and obtain valuable market information and external knowledge in a rapidly changing and intricate global market. Additionally, they can also uncover new combinations or applications of existing knowledge.

Public–Private Partnership

Public-Private Partnership (PPP) encompasses many frameworks that may be used to execute a project or provide a service. The term can encompass a range of arrangements, depending on the country and political context. These arrangements can include short-term management contracts with minimal capital investment, concession contracts that involve the construction and operation of significant assets, provision of services, and financing, as well as partial privatizations and joint ventures where ownership is shared among the private and public sectors [8]. PPP, in its broadest sense, serves as a middle ground between conventional public procurement carried out by public entities and complete privatization, as seen in **Table 2**. This partnership may be described as the attainment of services and goods by the public sector. However, instead of purchasing long-term assets and paying the whole amount upfront, the public sector is capable of establishing and operating a separate firm that is financed and controlled by the private sector via the use of a PPP mechanism. Therefore, a consumer of the public sector receives services in return for a price that matches the degree and quality of the service. Efforts have been undertaken to identify diverse types of PPP in relation to the privatization of public assets.

Table 2. PPPs Definitions

Author/source	Description
[9]	Long-term contracts supporting cooperative business endeavors where public services are provided in response to well-defined needs.
[10]	Traditionally, the public sector has been tasked with creating and developing high-quality services and providing the necessary infrastructure. The partnership's primary goal is the effective completion of the assigned assignment.
[11]	An instrument of governmental intervention for modernization and renewal that permits public firms to take on new organizational structures in order to forge different kinds of connections with businesses in the private sector.
[12]	Forms of collaboration between business and government that are intended to guarantee the location, building, remodeling, administration, or upkeep of an infrastructure or the delivery of a service.
[13]	Term used to describe ties that are developed among the public and private sectors, regularly with the intention of bringing in resources from the private sector or/and expertise to assist in the delivery of services and public sector assets. PPP refers to a broad range of collaborative arrangements, including formal joint venture businesses, loose, and tactical corporations, as well as Design, Build, Finance, and Operate (DBFO) type service agreements.
[14]	PPP agreements are essentially contracts among an administration agency and a private partner that require the private partner to provide a requested service and bear the related risks.

Intensity of Market Competition

The firm's rivalry in the marketplace might be a factor that influences the usage of numerous performance measurements. Organizations confronted with intense rivalry are inclined to use a variety of performance indicators. This is because these metrics improve competitiveness by effectively monitoring the organization's static competences (such as efficient production and meeting time objectives) and dynamic competencies (such as enhancing and creating future static abilities). It is essential to monitor these skills in order to detect areas where the cost of the product or service is growing without adding value, such as quality, dependability, or other factors [9]. Available data indicates that rivalry in an industry may lead enterprises within the sector to adopt comparable performance indicators.

As market rivalry becomes more intense, businesses must become more proactive in identifying consumer wants and improving customer satisfaction. According to [9], enterprises must manufacture and promote high-quality goods in order to fulfil consumer and competitive quality requirements when they encounter market competition. They propose that investments in quality (specifically, Total Quality Management methods centred on customer focus and product design) that are linked to heightened market rivalry should yield better goods and services. Consequently, this should lead to elevated levels of customer satisfaction. According to [10] and [11], there is a positive correlation among organizational performance and customer satisfaction. greater levels of customer satisfaction are often linked with greater levels of structural success.

This empirical research provides different outcomes reliant on the frameworks of study, constants, or data sets used. While the level of market rivalry is a significant aspect, it alone cannot fully account for the results of enterprises' inventive

endeavors. There is less knowledge about the results of technology transfer between firms and U&PRIs in different market rivalry settings. Although enterprises may not prioritize technology transfer from U&PRIs, increased market rivalry may prompt some of them to seek out new technologies from other sources, including U&PRIs [11]. In this analysis, we investigate how the level of market competition interacts with enterprises' strategic choices to determine certain results.

Research Model

Considering the information provided above, we established a study model as seen in **Fig 1** and suggested the following hypotheses

H1: The capability of firms to absorb new knowledge and skills from external sources has a beneficial impact on their likelihood of successfully commercializing transferred innovations.

H2: Effective communication among the private receiver and the public source of the technology enhances the likelihood of successful commercialization of the relevant innovations.

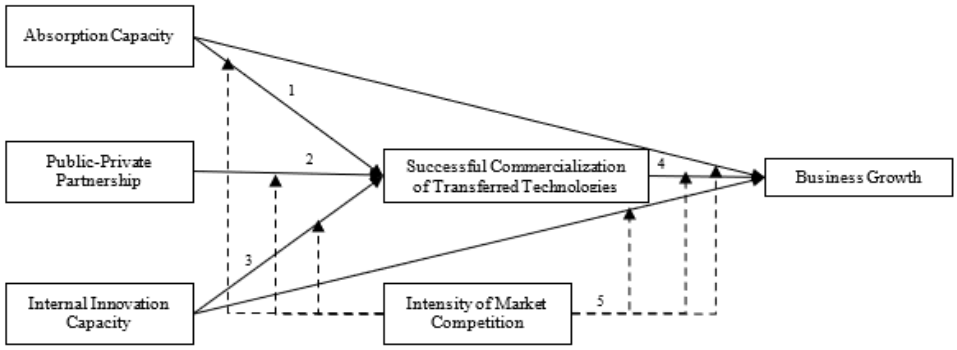

Fig 1. The Research Model, which is a Multi-Group Operational Model

Table 3 presents the outcomes of the second survey, specifically showing the distribution of 514 technologies that were included in the survey responses.

Table 3. Results of the Second Survey

Type		**N**	**%**	**Type**		**N**	**%**
Mode of transfer	Exclusive license	140	27	Company Size	Large	40	11.4
	Non-exclusive license	283	55		Medium	44	13.0
	Transfer patent	33	6.4		Small	256	75.5
	Technical support or other	56	10.9	Overall (firms)		340	100.1
Type of Tech.	Patent	250	48.7	Tech. Area	Machinery/materials	113	22.0
	SW Program	59	11.5		Electric/electronics	121	23.5
	Know-how	200	38.9		ICT	132	25.7
	Other	5	1.0		Chemicals	46	8.9
	Overall (Technology Transfers)	514	100.0		Biotechnology	54	10.5
					Knowledge services	28	5.4
					Other	11	2.1

H3: The internal innovation capabilities of firms have a beneficial impact on the likelihood of successfully commercialising innovations obtained from other sources.

H4: The effective commercialisation of innovations obtained from external sources has a favourable impact on the expansion of a firm.

H5: The competitiveness level in the market influences the relationships between H1-H4.

III. DATA AND METHOD

Data and Sample

This study examines the process of knowledge transfer from 43 prominent U&PRIs to the Korean industry between 2019 and 2023.Two Within that specific timeframe, a total of 3347 enterprises implemented 5340 officially transferred technologies from U&PRIs. These numbers include all occurrences of knowledge transfer recorded in the nation. (a whole population). Approximately 33% of the firms implemented two or more knowledges from the same U&PRIs. A study was undertaken between September and July 2023 to evaluate the development of shifted innovations, irrespective of their success in commercialization [12]. A total of 1038 corporations provided data on the 1433 innovations they acquired from universities and public research institutions. The study presented here is derived from a dataset of 514 technologies, which corresponds to 339 businesses. These firms were selected because they had extensive financial records that were accessible for analysis.

Variable Definition

Absorptive Capacity (AC)

The notion of Absorptive Capacity (AC) is a fundamental aspect of the discussion around dynamic capacities [13]. Dynamic capacities are derived from the evolutionary theory of the company as proposed. Dynamic capacity allows organizations to adapt to transformations in the business landscape. They prevent falling into a competence trap, when their skills and abilities become obsolete because of changes in the corporate environment. The management capacity to rearrange a company's resources and routines in a way that is envisioned and considered suitable. Dynamic skills are advantageous in very volatile environments. Absorptive Capacity (AC) was first described as a corporation's aptitude to perceive the worth of novel knowledge, integrate it, and use it for business objectives [14]. Multiple conceptualizations of absorptive capacity have arisen since its initial definition Lane, Salk, and Lyles. Initially, the emphasis of early conceptualizations was on challenges related to research and development. However, subsequent study expanded the notion to include the advancement of AC at the business level.

This research conceptualizes absorptive capacity as a multifaceted construct, including several elements, as formerly mentioned. Our main emphasis is on the idea of "potential absorptive capacity," that refers to the capacity to recognize and acquire information from external settings, as well as the capability to grasp and assimilate that knowledge [15]. Based on the qualitative survey results mentioned in absorptive capacity is a comprehensive concept that is assessed across five dimensions based on a 5-point Likert scale. These dimensions include: (1) the capability to quickly identify market changes, (2) the capability to respond to rival companies, (3) the ability to adopt successful examples, (4) the ability to change execution strategies, and (5) the ability to take into account cyclical market changes.

Public Private Partnerships (PPP)

We investigate whether the Public Private Partnerships (PPP) facilitated corporations in acquiring and effectively using both codified and tacit knowledge associated with transferred technology. Researchers dedicated to activities between the execution of license arrangements and the creation of first income (attained via interviews with researchers) as an illustrative factor. For licensors, a well-crafted financial agreement establishes precise conditions under which royalties or profits will be paid, and it also gives strong incentives to the licensee to properly use the branded rights. This encompasses well-defined financial clauses and the elimination of vague terminology from a license agreement, resulting in an augmentation of royalty income and the prevention of superfluous arguments in the future. Well-crafted agreements also facilitate the licensor's ability to regain certain rights or terminate the agreement if the licensee fails to meet sales or other objectives for the given rights, all while safeguarding the value and integrity of the licensor's trademarks, logos, and personalities. Furthermore, a comprehensive agreement would have financial clauses that optimize royalty income while deterring, restricting, or penalizing certain actions that may jeopardize these precious resources.

Consistent and diverse communication via several channels is essential for the efficient transfer of technology and the successful commercialization of shifted knowledges. The practice of commercialization with a focus on relationships is based on the implicit assumptions that the process of innovation is not straightforward, but rather involves interaction. It also assumes that scientific discoveries should align with the needs and capabilities of the industry, and that effective communication and collaboration between academia and industry, as well as between market and research and development experts, are essential. This study quantifies the level of partnership intensity based on five variables: (1) researchers providing extra technical instruction, (2) exchange of human resources, (3) provision of additional policy funds, (4) provision of technical data, and (5) sustenance for extra joint research and development projects (measured on 5-point Likert scale). The mean score is employed as the corporation variables.

Internal Invention Capacity (IIC)

In several sectors, innovation is the crucial factor for achieving success. It has the ability to bypass obstacles to entrance and serve as a long-lasting competitive advantage [17]. The knowledge base of a corporation is a fundamental factor in its capacity to innovate. Management researchers have recognized the growing significance of firm knowledge, particularly technical information, in determining the performance of a company. Academic researchers and practical managers have difficulties in effectively measuring and evaluating a company's technical capabilities, despite its significant value. A firm's

technical competence, together with its store of organizational knowledge, is an intangible asset due to its inherent nature. Consequently, it becomes necessary to use a proxy or indicator when attempting to evaluate Firm Technical Competency (FTC).

In recent decades, several technical indicators have been suggested and used. Nevertheless, the reliability of these indicators in many businesses has not been sufficiently validated. As a result, researchers and managers who are actively working in the field may face the danger of using indicators that are not suitable for all types of industries. Employing inappropriate indicators in certain sectors may result in erroneous study conclusions or deceptive competition assessments. In their study, Penner-Hahn and Shaver used R&D expenditure, patent count, new product count, and R&D intensity as measures of IIC. They found a positive correlation between these measures and both the growth rate of revenue and the ROI (return on investment).

Transferred Technological Commercialization

Defining the success of commercializing a transferred technology is a challenging task [18]. By adopting technology shifted from U&PRIs, enterprises may decrease research and development expenses, expedite market entrance, get additional assets, minimize business volatility, and collaborate on resource sharing. These accomplishments may be categorized into technological, financial, and physical performance. The effectiveness of commercialization may be determined by evaluating the extent to which the adopting enterprises have accomplished their intended aims or ambitions. Technology transmission is frequently used to fulfil various purposes. This research followed this path and used the defendants' overall evaluation of whether the implemented technology aided them in attaining their original objectives. The benefits that these organizations obtained from purchasing the technology, in terms of increased revenue or reduced business expenses, were evaluated using a 5-point Likert scale (see **Table 4**).

Table 4. Various Degrees of Achievement in The Process of Commercializing Transferred Innovations

N	**Failed**	**On a par with investments**	**< Investment**	**< 10x the Investments**	**< 3x the Investments**	**10x the Investments or Higher**	**Subtotal**
Frequency	349	20	8	39	65	33	514

Business Growth (BG)

Business Growth (BG) has been assessed using several measures, including market capitalization, staff count, revenue growth, and value contributed. Previous empirical findings have shown significant variability based on the specific measures used to assess the development of firms. For example, Walasek and Barszcz used the return-on-investment (ROI) rate. Several studies support and use accounting methods that aim to mitigate the distortions created by book depreciation expenditure. This estimation, which has an impact on both the numerator and denominator in the ROI calculation, is sometimes seen as nothing more than a financial accounting artefact. The growth rate in operating income and operating income/sales, which indicates the profit margin or return on sales, are two often used alternative measures of profitability. In contrast to net income, which is utilized to calculate return on investment, operating income is exclusive of non-operating expenses such as taxes, interest expense, and depreciation. Aubert, Kern, and Hollandts [19] used the measure of increase in firms' value-added. Lechner and Dowling used the probability of firms' longevity in conjunction with each kind of engagement with external partners. For this research, we choose the mean yearly increase in sales, spanning from 2013 to 2015, as the metric for gauging firm growth.

Market Competition Intensity (MCI)

This study examined five different ways to measure the market competition level, based on the research of Chong and Rundus. These measures include: (1) product life cycles; (2) the rate at which customer demand changes; (3) the speed of technological advancements [20]; (4) the level of participant activities; and (5) the rate at which new products are introduced (measured using five-point Likert scales). Following that, the firms were divided into two groups based on the total average degree of competition, as determined by the aforementioned fine measurements. One group faced intense market rivalry, while the other group faced little competition. **Table 5** provides a concise outline of the variables and their operationalization used in this study.

Table 5. Variables Employed in the Research

Variables	**Type**	**Descriptions**
(Independent variables) AC	5-point Likert scale	○ Quickly recognizes market changes ○ Regularly considers market outcomes ○ Quickly responds to competitor`s changes ○ Modifies execution tactics in response to client input ○ Adopt successful examples
PPP	5-point Likert scale	○ Acquired technical guidelines from the technology supplier ○ Acquired financing for commercialization (operation and facilities) policies

		○ Traded research personnel with the supplier of technology ○ Started more collaborative R&D initiatives ○ Received relevant and additional information
IIC	Ordinal scale	○ The R&D investments to revenue ratios, which were divided into five categories between 2010 and 2012: less than 1%, less than 3%, less than 5%, less than 10%, and 10% or higher
(Depedent variable) Commercilization level	Likert scale	○ Gains according to the costs of technology (either lower company expenses or higher revenue), with 0 denoting failure, 1 being extremely low, 2 being low, 3 being moderate, 4 being high, and 5 denoting very high.
(Moderator variables MCI	5-point Likert scale	○ The life cycle of a product is quite short ○ The speed of technological transformation is fast ○ Consumers frequently request new goods and services ○ The only way to achieve success is to consistently provide new goods and services ○ There is fierce competition and unpredictable competitor conduct.
BG	Ratio scale	○ The revenue growth rate of the company from 2013 to 2015

Testing Variable Reliability and Validity

Table 6 provides a concise overview of the validity and reliability assessments conducted on a selection of variables. A validity evaluation of the ideas was performed using exploratory factor study. With the exception of the item that had a commonality of 0.4, all other items had factor loadings over 0.6 and the explained variance was more than 59%, confirming the theoretical validity of the constants utilized. The Cronbach's alpha value, which is employed to assess the reliability of replies from the participating firms, exceeded 0.7, suggesting a high degree of dependability. **Table 7** presents the average values, correlation coefficients, or measures of variability for all variables. The coefficients exhibit a general value of 0.4 or below, indicating that the probability of multicollinearity in the following route study was not substantial.

IV. RESULTS

Assessement of the Research Model Validity

In an effort to test the fitness of our study model as outlined in **Fig 1** above, we used the Comparative Fit Index (CFI) and the Normed Fit Index (NFI). Furthermore, we used the Root Mean Square Error of Approximation (RMSEA) where it also acts as the Parsimonious Normed Fit Index (PNFI) and an absolute fit index. The RMSEA has turned out to be the most commonly applied measure for evaluating the extent of misfit or fit in the SEM applications [21]. Different from other fit indices, RMSEA is special in that it has descriptive function of offering sample estimates as well as the inferential function of using confidence interval and hypothesis testing. The RMSEA has two key characteristics: first of all, it is an index that does not depend on the scales of the measured or latent variables; second of all, the distribution of SMD is rather close to normal, so it is possible to calculate the confidence intervals of parameters and perform hypotheses testing.

Table 6. Results of Consistency and Validity Tests Conducted on the Variables

Factors	**Variables**	**Factor Analysis**				**Reliability**
		Loading	Similarity	Eigen value	Explanatory variables	**Cronbach`s**
MCI	The lifecycle of the product is quite short	.638	.407	2.367	59.184	0.766
	The only technique to thrive is to consistently provide new goods and services	.781	.611			
	Consumers frequently request new goods or services	.807	.651			
	It is a highly competitive environment with unexpected competitor behavior. (Deleted)	(0.587)	(0.344)			
	Technological transformation is occurring quickly	.836	.699			
AC	Quickly reacts to market alterations	.830	.687	3.250	65.018	0.861

Changes implementation approaches based on customer feedback	.824	.680
Quickly respond to competitors` changes	.825	.681
Actively adopts successful examples	.696	.484
Regularly considers market outcomes	.848	.719

Typically, in case the progressive fit index value, which includes the CFI and the NFI, exceeds 0.9, it shows that the model fit is satisfactory. The RMSEA, designed to address the limitations of the x^2 statistics caused by the large number of observed constants or the size of the sample, shows a high level of fit when it is 0.05 or lower, a moderate to good level of fit when it is 0.08 or lower, and a lack of fit when it is .10 or higher [22]. In proposed an approach to account for the loss of degrees of freedom in the NFI. The NFI for Model j is multiplied by the ratio of the framework's degrees of freedom (d_j) to the null model's degrees of freedom (d_0).

Table 7. Pearson Correlations and Descriptive Statistics

Variables	**Mean**	**SD**	**1**	**2**	**3**	**4**	**5**
AC	3.72	.63	1				
PPPs	2.81	.92	.21**	1			
IIC	3.52	1.37	.13**	.01	1		
Effective commercialization	1.11	1.72	.07	.36**	-.12*	1	
BG	2.39	12.21	-.01	.05	-.010	.11**	1
N=514							

*** p < 0.01, * p < 0.05 (both sides)*

The model's parsimony index refers to a ratio that ranges from zero to one. The index that is obtained may be referred to as a PNFI. Multiplying the NFI by the parsimony index results in a decrease in the normed-fit index, bringing it closer to zero. The decrease in the value of NFIO compensates for the advancement in the fit of a less constrained model, which comes at the cost of losing degrees of freedom in estimating the free parameters. The PNFI symbolizes the simplicity of the provided study model. The model's fitness, as shown in **Table 8**, increases as its size decreases. We aimed to explore the relation among internal invention, partnership, and absorptive dimensions and the development of corporations through the effective commercialization of shifted knowledges. This study examined the entire sample and also differentiated between two market situations: strong competition and weak competition.

Table 8. Fitness Tests of the Study Model

Index	**X^2**	**df**	**NFI**	**CFI**	**RMSEA**	**PNFI**
Overall	2.128	2	.985[a]	.999[b]	.012[a]	.100
High MCI	.150	1	.997[a]	1.000[b]	.0001[a]	.1001
Low MCI	1.975	1	.968[a]	.981[b]	.068[b]	.098

[a] Good [b]Normal

Multi-Group Analysis Dependent on the Degree of Market Rivalry

The multi-group operational model study entails examining numerical disparities among the groups by evaluating path constants. The research used a route model as its structural model, which does not need the verification of measurement invariance for each component. Consequently, we used the path constants among the components to examine variations across the groups under conditions of high and low market rivalry intensity. The results of the research are shown in **Table 9**. Initially, we conducted a comprehensive analysis of the whole sample, without making any distinctions between the two groups of technology users who are experiencing varying levels of market rivalry. The IIC coefficient (β = −.111, p .10), and the partnership coefficient (p < .01, β = .372) were observed.

The transfer of technology to the commercial sector has a statistically substantial favorable impact on company growth (β = .128, p < .01). Furthermore, we did a supplementary study of the two groups with distinct levels of market intensity. In a highly competitive market, both absorptive ability (p < .10, and β = .093) and collaboration (p < .010, β = .391) have a favorable and statistically substantial impact on the effective development of shifted innovations. Successful development has a statistically substantial beneficial impact on firm growth (β = .176, p < .01). In the category of markets with little struggle, both partnership (p < .010, β = .375) and internal innovation capability (p < 0.010, β = −0.178) have a statistically substantial impact on the effective development of shifted innovations.

Table 9. The Model Characteristics Associated with Both Low and High Levels of Market Struggle

Paths	**Total (N = 514)**			**Lower MCI (N = 205)**			**Higher MCI (N = 309)**		
	β	CR	ρ	β	CR	ρ	β	CR	ρ
AC → Succ.Comm.	.040 (.014)	.329	.742	.251	1.748	.081	-.206	-.988	.323
PPPs → Succ. comm	.696 (0.370)	8.884	···	.698	7.381	···	.753	5.578	···
IIC → Succ. Comm.	-.142 (-0.113)	-2.771	.006···	-.049 (-.039)	-.739	.460	-.222 (-0.178)	-2.716	.007···
Succ. Comm. → BG	.912 (.128)	2.888	.004···	1.632	3.080	.002···	.211	1.175	.240
IIC →Business development	.107 (0.012)	.273	.785	-.498 (-.04)	-.75	.45	.62 (.191)	2.757	.006···
AC →Business development	-.648 (-.032)	.721	.471	-1.385 (-.55)	-.963	.336	-.645 (-.079)	-1.154	.249

··· $\rho < 0.01$., ·· $\rho < 0.05$, · $\rho < 0.1$,

Now, the internal innovation capability has a negative influence, similar to the complete sample mentioned in the previous paragraph. The impact of successful development on firm growth is favorable, although it is not scientifically significant (β = .081, p > .1). The partnership is the primary and constant factor that determines successful development, irrespective of the level of market rivalry. The high β value is .391, while the low β value is .375. Consistently prioritizing successful commercialization is crucial for enhancing company development [23]. Absorptive ability has a beneficial effect in both the whole sample and the subset with significant market struggle. The impact of internal invention capacity shifts from a positive to a negative direction when transitioning from high to low stages of market struggle. We have further confirmed that the route constants in the mechanical model exhibit statistical significance when comparing the two groups categorized by low and high degrees of market struggle.

V. DISCUSSION

The assessment of the research model fitness employed several SEH indices that offered different perspectives into the model's goodness of fit and generalizability across various market contexts. The employed key indices, namely PNFI, NFI, RMSEA and CFI confirmed the model's high fit in modelling the underlying relationships between partnership, absorptive capacities, internal invention, and business growth through achievement technology commercialization.

NFI and CFI

The Normed Fit Index (NFI) and Comparative Fit Index (CFI) are two important incremental indices of fit and compare how well the proposed model fits the observation in relation to a null model where there are no relations among the constants of interest. The NFI or CFI value higher than 0. 90, meaning that the model provides a significant improvement over the null hypothesis. In this study, both NFI and CFI values are more than this threshold, supporting the argument that the framework gives a good fit to data. The high values of these indices demonstrate that the model captures the interactions in the data set which in turn supports the validity of the structural relationships presented. Another concern and a weakness of the NFI is that it relies on chi-square statistics and therefore can be influenced by sample size, fitting better with samples of a larger size. However, the CFI corrects for this aspect by taking into consideration the model's complexity and model size, thus measuring model fit more accurately. The parallel movement of both indices in this study supports the assertion that the model is not only significant in terms of statistical value but also significant in terms of real-world application to offer a framework that effectively explains the effects and relationships of internal and external capacities to the business.

RMSEA

Another essential fit index is the RMSEA, which is considered one of the most useful indices in SEM. While NFI and CFI indicates the degree of fit of the population framework to the sample data, RMSEA offers an understanding of how perfectly the framework would fit if the parameters were chosen optimally. A value of RMSEA below 0.05 is regarded as a good fit while ethics among 0.05 and 0.08 are suitable and those above 0.10 are a poor fit. In this research, the RMSEA value was less than 0.08 in all cases of market competition intensity, which represents a reasonable error of approximation, thus confirming the model suitability. RMSEA also facilitated construction of confidence intervals, which provided an additional

inferential aspect to the evaluation of the model. This aspect of RMSEA is particularly important because it offers a range that encompasses the true population RMSEA and gives a better perspective of model fit.

PNFI

The PNFI is an alteration of the NFI in that it factors in the degrees of freedom of the framework, hence downsizing complex models. This adjustment is important to prevent overfitting or when the framework has too many constraints to estimate, then the model is said to be overfitted [24]. A lower PNFI indicates that the proposed model succeeds in this respect, in the sense that it does not over-fit the data while at the same time retaining important relationships between variables. As for the PNFI values, they revealed that the proposed model kept this balance properly. Although there is always some level of difficulty in capturing the dynamics of internal innovation, partnership, absorptive capacities and business growth in a single model, the PNFI indicated that the model did not compromise on the issue of parsimony of the model. This is a useful observation since it points to the model's capacity to deliver valuable analysis while avoiding excessive complication.

Multi-Group Analysis – Market Competition Intensity

The analysis performed using multiple groups to study the effects of varying levels of market competition intensity provided crucial factors that pointed out the differences in the performance of the model. The path coefficients showed that absorptive capacity and partnerships were the most influential factors in the high competition environment of technology commercialization of the transferred technology. In low competition settings, the coefficient of partnership was still positive, while the Internal Innovation Capacity (IIC) had a negative sign. This shift also aptly highlights the fact that innovation and commercialization processes are not always linear and cut across various contextual domains. The fitness indices and multi-group analysis support the overall conclusions that the research model is both sound and generalizable that is, the framework can be employed across a range of competitive environments to explain the dynamics of technology commercialization. The importance of partnership partnerships remains constant across all scenarios that supports the key role of collaboration networks in business development. In contrast, internal innovation and absorptive capacities differ across the scenarios, which underlines the need for context-sensitive strategies.

VI. CONCLUSION

The findings of this study contribute to the comprehension of the factors that influence the success of knowledge developed by U&PRIs and transferred to the Korean industry. The results of the research indicate that partnership intensity exerts a significant positive impact on commercialization at all the levels of market competition. This requires enhancement of effective PPP to enable effective technology transfer and commercialization. Absorptive capacity should be discussed in the context of high competition environments to enhance the organizations' capacity to identify and benefit from novel technologies. However, the impact of this variable declines where there is no competition, meaning that the benefits of innovation are realized where firms face competition. IIC has a positive influence on commercialization success in the competitive markets; and a negative influence in the less competitive markets. These fluctuations suggest that firms need to adopt innovation strategies based on the nature of the market environment in order to optimize the process of knowledge transfer. In conclusion, it is crucial to comprehend that the process of technology commercialization is complex and that firms need to manage their absorptive capacity, partnerships, and innovations to balance and plan the business and technology opportunities that exist in different contexts.

CRediT Author Statement

The author reviewed the results and approved the final version of the manuscript.

Data Availability

No data was used to support this study.

Conflicts of Interests

The author(s) declare(s) that they have no conflicts of interest.

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