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A Study of Case Analysis to Strengthen Technology Commercialization Capabilities

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Abstract

With economic development, prospects, expectations, and predictions have become active in various aspects, and continuous growth in the future economy, securing national competitiveness, and improving quality of life have emerged as important topics. In addition, as international blocking phenomena and technology protectionism intensify, especially in developed countries, there is a need to develop and foster strategic technologies that follow the current flagship business. In particular, it is urgently required to discover and foster new industries through the discovery of new growth engines. Therefore, it is required to discover and support world-class technologies that can secure continuous competitiveness in major industries, create high value-added and future new industries. Against this background, the recent increase in interest is corporate technology commercialization activities. Technology commercialization is to develop, produce, and sell products and services using the developed technology, or to improve or related technologies in the process, and a company's technology commercialization activities can be defined as commercialization risk management process, promotion system, and promotion experience. However, opinions are divided so far on these technology commercialization activities. In other words, there are various types of technology commercialization activities, and there are limitations in determining technology commercialization activities. In addition, even if

various types of technology commercialization activities are promoted, the effect of the type has not been verified. Therefore, this study aims to provide implications for technology commercialization by reviewing various preceding studies of technology commercialization.

Keywords: Technology commercialization, Technology commercialization capabilities, Strengthen technology commercialization, Commercialization

INTRODUCTION

The current business environment has experienced changes from labor-based industries to knowledge-based industries, through which only know-how and technology are considered sources of sustainable competitive gains in the long term [1]. As society enters an era where knowledge is regarded as one of the most important assets, it can be seen that each organization is investing heavily in the brain power or intellectual capital of the workforce it employs [2].

Market globalization, competition, and rapid technology development have a direct impact on corporate organizations that must face competition locally and globally. Lim et al. [3] knows that today's organizations need to view knowledge as an asset and manage knowledge effectively for success. In fact, there are many companies that transform themselves into knowledge experts [4].

Swart & Kinnie [5] said that it activates the organization's knowledge creation and sharing, and through this, it strengthens the organization's management performance by creating new products and services. In other words, it proposes a new approach to improving performance related to the ability of corporate organizations to realize strategic gains. They argue that these organizational capabilities elicit higher customer satisfaction and loyalty, induce better decisions, and improve the capabilities and performance of improved personnel. From this point of view, developed corporate organizations can eventually increase market share and revenue by efficiently using intellectual capital that can bring new products and services to maintain competitiveness in the rapidly changing business environment and global market [5].

However, Fiedler & Welpe [6] said that it is a very important study for many corporate organizations to understand how new knowledge, information, and quality improvement in the market are transformed into commercial products and benefit from technological innovation. In other words, according to previous studies, technology commercialization acts as a key competitive factor in technology-based corporate organizations, and technology commercialization is an essential and important step to benefit from technological innovation [7]. Therefore, in a corporate organization, technology commercialization is a process and activity that can benefit from technological innovation, which is a key factor that can consist of broad and potential income generation, manufacturing, and utilization values [8]. In addition, Mitchell & Singh [9] noted that technology commercialization can be used as a complementary knowledge tool as an idea. As a result, the process of commercializing technology has

been defined in developing, manufacturing, and selling products that can be sold in the market.

CONCEPT OF TECHNOLOGY COMMERCIALIZATION

In general, commercialization refers to an individual or small group with capital, management, innovation, and ideas, which are the capabilities of an entrepreneur, capturing business opportunities, setting business goals, securing capital, labor, and facilities to start a business. It is important for a company to have a lot of excellent technologies, but it depends on technology commercialization that can successfully enter the target market by commercializing the technology.

Technology commercialization is a series of processes that lead to product production, shipment, and sales by putting new technologies acquired through R&D or external procurement into production activities, and can be seen as all activities leading to R&D plans, idea creation, process improvement, and product life cycle extension [10].

Successful technology commercialization is an important factor in the survival of companies in today's competitive market structure [11]. Therefore, companies want to make the most of all internal and external resources available to companies to secure a competitive advantage through effective and rapid commercialization of new technologies [12].

Mitchell & Singh [9] defined technology commercialization as all processes of acquiring ideas, increasing complementary knowledge, developing, manufacturing, and selling products that can be sold, and Jolly [8] defined it as all activities that give value to technology. Ku [13] stipulates it as a linkage stage that occurs after technology transfer, but it is not limited to the commercialization and commercialization stage, but to include all economic performance generation that occurs later.

Technology commercialization results are derived from the process of developing, improving, producing and selling technologies, and calculating them is the result of a competitive advantage that can beat competitors through technologies such as cost reduction, new technology acquisition, and quality improvement [14].

In early studies related to the performance of technology commercialization, the successful operation of new technology venture start-ups was viewed as the performance of technology commercialization, or entrepreneurship was judged as the performance.

In a study in the 1980s, commercialization performance was judged based on the process for new product development from the perspective of technological innovation [15]. In the 1990s, performance was judged based on the process of technological innovation and R&D [8]. At this time, the overall process of R&D, prototype production and mass production, market entry, and continuous growth was considered as the performance of technology commercialization.

Meanwhile, in the 1990s, the performance of technology commercialization was studied as financial and non-financial performance. The financial performance of

technology commercialization was studied as profitability and market location, product sales growth and market growth, stock returns, total capital return, market share, and cash flow [16]. Non-financial performance was measured by the speed of new product release, marketability of new product, frequency of new product release, and number of patent applications [14].

Technology commercialization experience is a dictionary experience in which a company previously carried out technology commercialization, and in general, learning through experience has a positive effect on technology transfer, which can be a barrier to commercialization.

Radosevich & Smith [17] stated that technology developers' experience, will, and technical sense in the field are important factors in the success of technology commercialization. McEachron [18] surveyed 46 R&D projects in-depth interviews with government department programs and found three major factors promoting market transfer of R&D technology, which was a market response to R&D manager's orientation, communication, cooperation, and R&D management.

Lin & Bozeman [19] confirmed that researchers with commercialization experience showed significant differences in commercialization results compared to researchers without experience, and D'Este and Patel [20] stated that commercialization personnel's characteristics such as commercialization experience and degree status are factors that greatly influence the interaction between universities and companies.

UNDERSTANDING THE TECHNOLOGY COMMERCIALIZATION PROCESS

According to Ferguson [21], technology commercialization models are generally classified into two categories. The first is the ‘Linear Model or Process Model’, which understands the prelude to technology commercialization as a series of processes from the stage of technology ideas to product development and market entry. In some cases, auxiliary activities may be included in parallel to increase opportunities for successful technology commercialization. The second is the ‘Functional Model’, which, unlike the linear model, shows important activities and connections centered on functions rather than a series of processes.

The most commonly known linear model case is a linear model developed by Goldsmith [22], and it is schematized by synthesizing previously developed linear models. Divided into technology market companies, the commercialization process of technology was clearly analyzed and organized from stage 1 (investigation) to stage 6 (maturity). This model is more of a checklist form than a block diagram, which is a general feature of the linear model. Technology, market, and corporate activities were divided into a total of six stages (investigation, feasibility, development, introduction, growth, and maturity), and the six stages were grouped into three stages (concept phase, development phase, and commercial phase). In addition, this model is suitable as a mechanism for the development and commercialization of new products or processes, but it is somewhat difficult to apply to commercialization through technology

introduction, and many new technology commercialization are commercialized through gradual technological innovation, and there is a problem of poor flexibility.

TECHNOLOGY COMMERCIALIZATION MODEL			
COMPONENTS:	**TECHNICAL**	**MARKET**	**BUSINESS**
CONCEPT PHASE			
STAGE 1 INVESTIGATION	TECHNICAL ANALYSIS • Define Concept • Confirm critical assumptions • Survey state of the art • ID critical barriers • Evaluate applicability • Determine technology	MARKET ASSESSMENT Conduct market overview • ID pricing structure • ID market barriers • ID risks • ID distribution channels • ID trends and competitors	VENTURE ASSESSMENT • Estimate profit potential • Conduct self, enterprise and commercialization assessments • ID professional needs • ID capital needs
DEVELOPMENT PHASE			
STAGE 2 FEASIBILITY	TECHNICAL FEASIBILITY • Develop working model • Test technical features • Assess preliminary manufacturability • Conduct manufacturing assessment • Assess safety & environmental features • Finalize designs	MARKET STUDY ID and quantify: • Market size • Customers • Volume • Prices • Distribution • Competitors	ECONOMIC FEASIBILITY • Formulate financial assumptions • Develop *pro forma* • ID seed capital • Form advisory team
STAGE 3 DEVELOPMENT	ENGINEERING PROTOTYPE • Develop Prototype • ID materials and processes • Conduct tests • Develop manufacturing methods	STRATEGIC MARKET PLAN • ID marketing team • Define target market • Select market channels • Field test	STRATEGIC BUSINESS PLAN • Decide venture or license • Finalize intellectual property • ID management team • Select organization structure • Write business plan
STAGE 4 INTRODUCTION	PRE-PRODUCTION PROTOTYPE • Develop production prototype • Determine production process • Select manufacturing process • Design field support system • Demo product features	MARKET VALIDATION • Establish market relationships • Conduct limited sales • Analyze sales • Survey customers • Refine marketing	BUSINESS START-UP • Establish business functions • Hire staff • Execute contracts • Secure first-stage financing
COMMERCIAL PHASE			
STAGE 5 GROWTH	PRODUCTION • Prepare commercial design • Establish quality control • Construct facilities • Conduct full-scale production • Finalize internal distribution system	SALES & DISTRIBUTION • Expand distribution • Analyze competitor response • Assess customer satisfaction • Assess distribution satisfaction • Refine product features	BUSINESS GROWTH • Monitor enterprise position • Hire and train personnel • Execute contracts • Arrange 2nd & 3rd stage financing • Institute vision, mission, and management policies
STAGE 6 MATURITY	PRODUCTION SUPPORT • Maximize production • Establish after market support, repairs and spares • Warranty service • Implement training program	MARKET DIVERSIFICATION • Develop market retention • Establish market scan • ID new markets • ID new products	BUSINESS MATURITY • Establish SWOT • Invest profits • Monitor product life cycle • Monitor business trends • Monitor management technologies • Implement innovations

Figure 1: The Goldsmith Model[22]

Along with the Goldsmith [22] model, the Rothwell & Zegfeld model [23] is a linear process model that describes the technical commercialization process in a block diagram. What is peculiar is that a series of processes from idea in the center of 'market demand' and 'innovation technology' to Research design and development, prototype production, manufacturing, marketing and sales, and market are shaped into blocks. The Rothwell & Zegfeld [23] technology commercialization model has sequential continuity like the Goldsmith [22] model, but is somewhat less specific than the Goldsmith [22] model, which was classified into technology, company, and market. Considering that the technology commercialization model of Rothwell & Zegfeld [23] was developed first in terms of timing, it is significant in that it provided an initial model of the technology commercialization model.

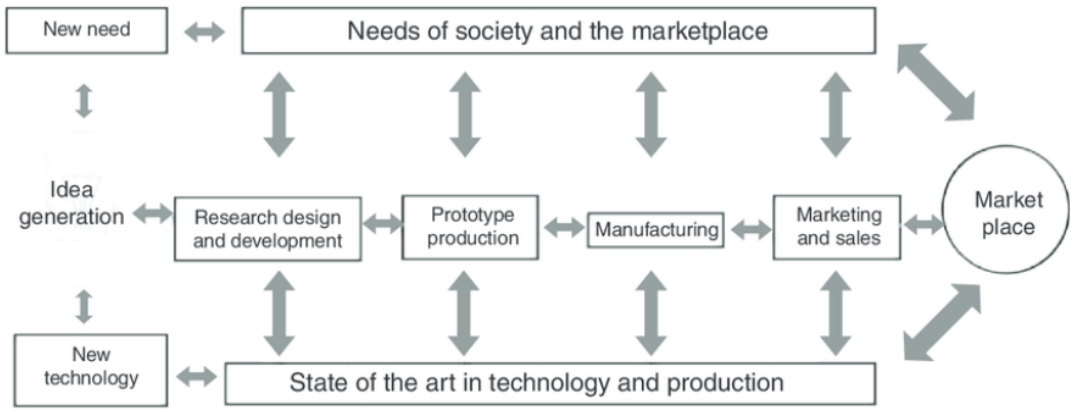

Figure 2: Rothwell & Zegfeld model [23]

Andrew & Sirkin model [24] graphically expressed the flow of cumulative investment value of traditional technology commercialization projects over time. The vertical axis represents the change in the value of the project, and the horizontal axis represents the process of realizing technology commercialization from the idea [24]. In this model, the cash flow is in the negative area at the idea-making stage, and the cash flow deteriorates sharply until the product or service is launched (or produced), but when sales offset the initial investment in the future, cumulative cash value is converted to a positive area and profits are generated [21]. In addition, this model is a useful model to explain the importance of the speed at which technology reaches the market to minimize cumulative cash losses and the importance of expanding sales to recover initial investment costs and reach net profit margins quickly. This model emphasizes the importance of product support such as advertising, marketing technical support, and product improvement.

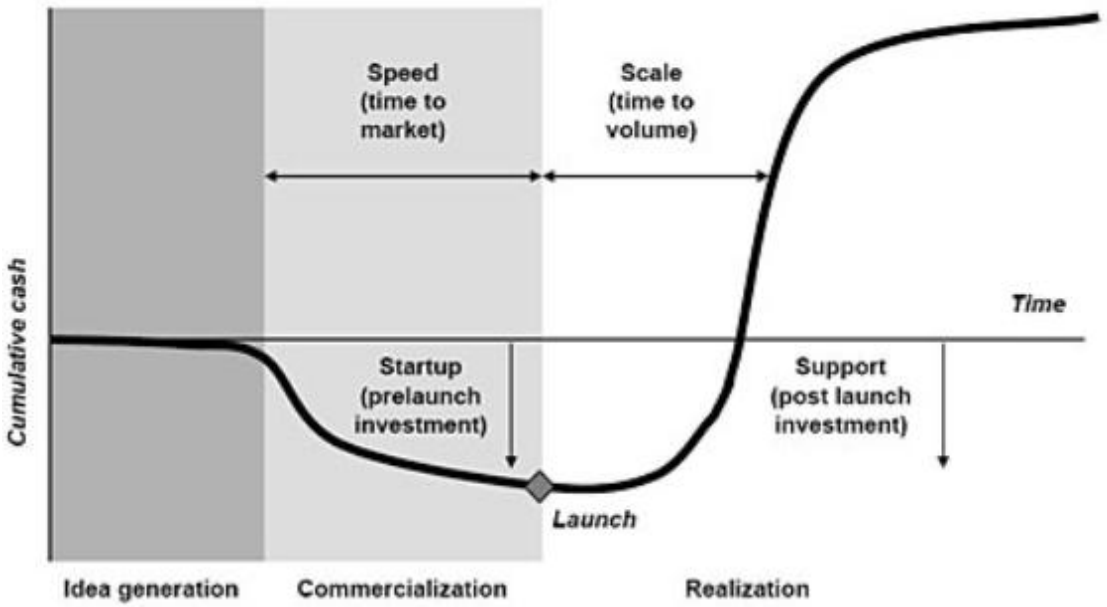

Figure 3: Andrew & Sirkin model [24]

The nonlinear functional model is not a series of process blocks or checklists presented by the linear model, but rather has the characteristic of systematizing the linkage of key functions required for technological commercialization.

In 2006, Canadian Expert Panel on Commercialization developed a functional model describing the main functions and linkages of technological commercialization rather than temporal and procedural processes. This model continues the cycle in which innovators, entrepreneurs, and investors participate in the idea conception through 'Technology (R&D)', 'Firms', and 'Market' procedures, and repeat this idea conception process [21]. In the technology commercialization model developed by the Canadian Expert Panel, ideas can be conceived at either stage of the 'commercialization process' or 'product lifecycle', and activities to improve ideas and business models will be repeated for successful technology commercialization. At this time, the idea includes all actions such as all new items and services, and gradual improvements.

The Jolly [8] technology commercialization model, widely known as a nonlinear function model, includes four bridge functions in stages that meet and utilize stakeholders at each stage with the process in five stages of creating the value of a new technology. The five-step process of creating new technology value consists of (step 1) techno-market insight, (step 2) incubation to identify the potential of technology commercialization, (step 4) product and process demonstration, (step 5) promotion of new technology or new technology application products and processes, and securing commercialization sustainability. The four-step bridge functions refer to linkage support activities that utilize available resources to ensure smooth transfer for each step in the above five steps, and help stakeholders at each step continue to be interested in technology and increase readiness for the next step. Jolly [8] A detailed analysis of the

five stages of creating new technology value is as follows. The first stage, the Imagining, is a stage of recognizing the value of technology, and the main value of technology and the market must be grasped at the same time. At this stage, each idea must compete with each other to secure budget and available resources, and demonstrate that it is effective and feasible against existing solutions. The second stage, the incubating stage, is a stage that is substantially and numerically verified, and excellence must be proven in the technical stage, not the idea. At this stage, there must be specific ideas to create the value of new technologies, through which related subsidies, venture capital, and investment from business angel investors must be obtained. The third stage, the demonstrating stage, verifies the commercial feasibility of the product by manufacturing a product to which the technology is applied. The fourth stage, promoting is a step of trying to win the hearts of consumers through products with technology. The fifth stage is the final step of the Jolly [8] technology commercialization model and is the step of securing commercialization. At this stage, it is a stage of securing the sustainability of the technology and realizing all the value of the technology. As new technologies continue to emerge, securing the continuity of commercialization of technologies is recognized challengingly [8].

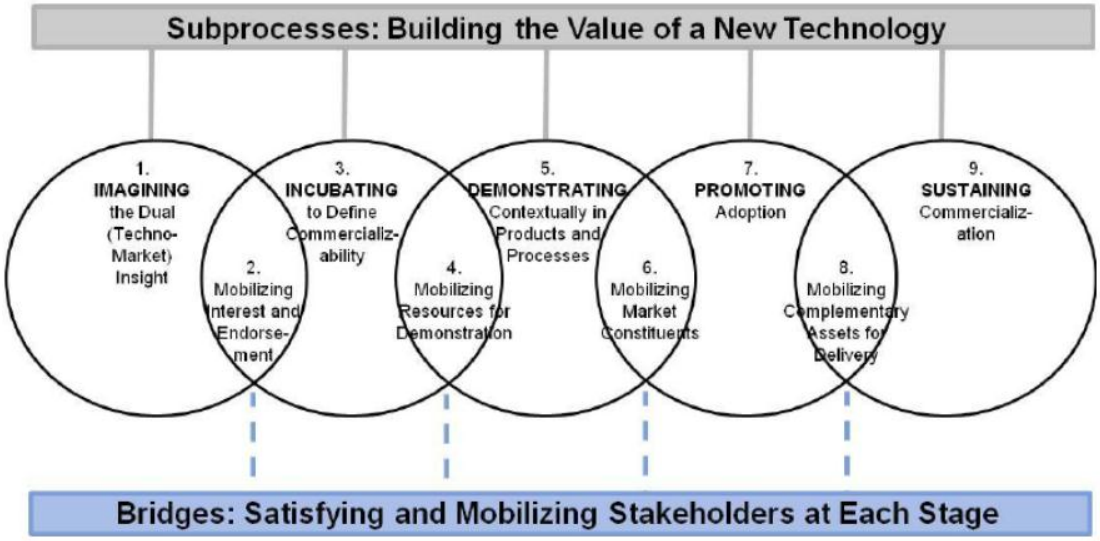

Figure 4: Jolly Model for Commercializing Technology [8]

The theory that should be noted in analyzing the consumer acceptance process for innovative new technologies is the Consumer Adoption Model proposed by Philip Kotler. Philip Kotler presented and explained a five-step process of consumer acceptance of new technologies and innovative technologies through the consumer acceptance model [25].

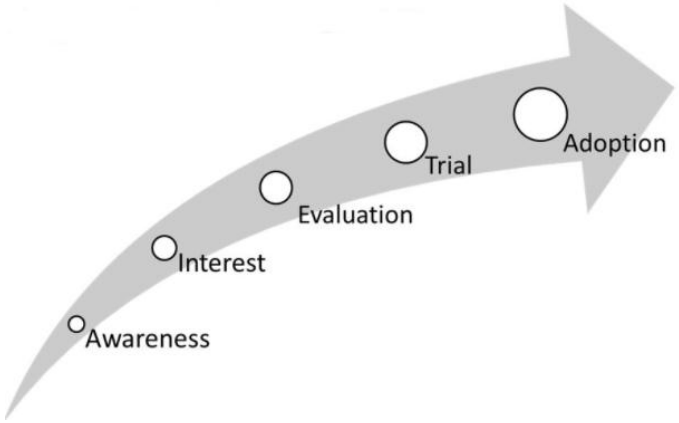

Figure 5: Consumer Adoption Model proposed by Philip Kotler[25]

Rogers [26]'s 'Innovation-Decision Process' refers to the process in which consumers perceive innovation technology, form an attitude toward innovation, decide whether to accept, execute new ideas, and confirm decisions, consisting of actions and choices during individuals or organizations. This process occurs when dealing with uncertainties that inevitably arise when determining new alternatives to existing technologies. The existence of perceived novelty and uncertainty associated with novelty for innovation differs compared to other decision-making forms [36]. Rogers [26] summarized the innovation technology decision process in five stages: Knowledge, Persuasion, Decision, Implementation, and Confirmation.

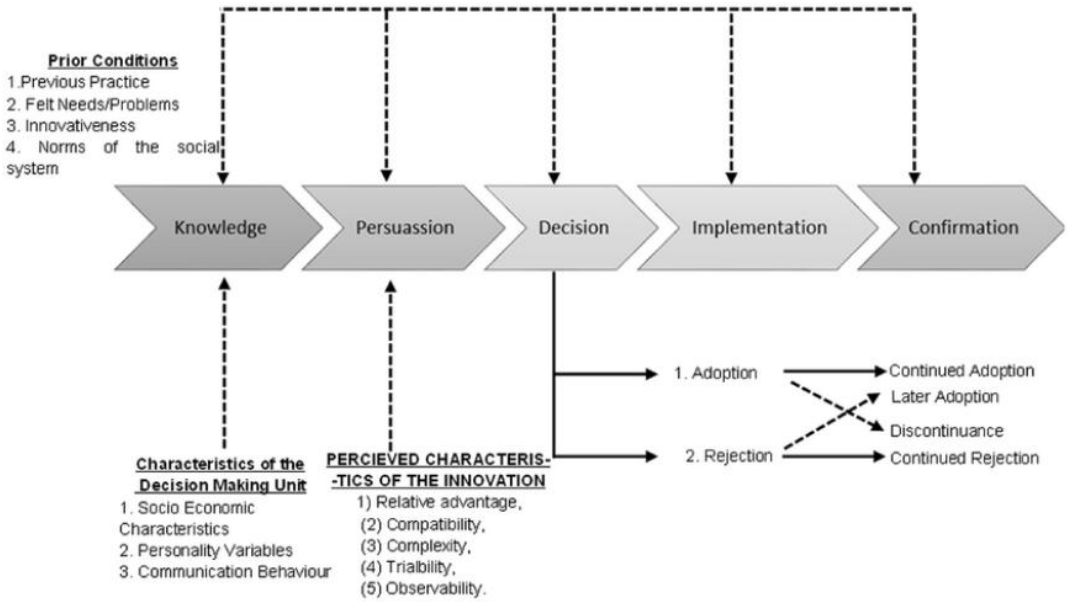

Figure 6: Rogers's Innovation-Decision Process[26]

Rogers [26]'s 'Diffusion of Innovation Model' has been accepted as one of the most important acceptance models to date [27]. Rogers [26] described the spread of innovation as a process through which ideas perceived as new spread through communication channels over time in social systems [28]. Rogers [26] classified innovation-accepting groups into five stages: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards according to technology acceptance behavior based on innovation-based social systems.

Figure 7: Rogers's Diffusion of Innovation Model[26]

TECHNICAL COMMERCIALIZATION CAPABILITIES AND ACHIEVEMENTS

Technology commercialization capability refers to the ability and capability to promote production activities, marketing activities, and various activities using technology as a process of absorbing, internalizing, and improving technologies within a company.

Commercialization is interested in the commercial success of innovative processes or products, and includes problems such as marketing and joint ventures. However, in the early stages, technological capabilities are important to the development activities of innovative processes, while marketing capabilities (market research, market testing, promotion, etc.) are important at the product launch or execution stage [29].

Technology developed through technology innovation activities can not directly affect a company's management performance, but can be directly used for production and sales activities, and technology must be improved and introduced for successful market entry and competitive advantage. Technology commercialization capability is a competitive advantage and the ability to lead, develop, and release products in a short period of time, and technology commercialization is an activity with marketing in mind by commercializing and commercializing developed technologies. [30].

Looking at previous studies, various indicators of the influence of technology commercialization capability are shown, and some of them will be examined as follows.

Song & Parry [31] presented technical capabilities, resources, and partial integration along with marketing capabilities and resources as a source of competitiveness that determines the success of new product development, while Yap & Souder [32]

emphasized the importance of engineering as a factor influencing the success of new product development. The importance of product development was also emphasized by dividing corporate capabilities into product development, marketing, competitive response, and product trust stages by factor analysis.

Yam et al. [30] recognizes R&D as the ability to convert the results of R&D into products that satisfy market needs, design requirements, and production requirements, contributions such as participation of production departments, R&D requests, technical level of equipment, latest manufacturing, manufacturing manpower, and quality management.

Kotler [33] defined marketing as a long-term process of planning and implementation to identify and meet the needs of the target market by integrating and coordinating corporate functions, and said that the effective composition of marketing consists of customer philosophy, integrated marketing organization, suitable marketing information, and operational efficiency.

By utilizing and applying feedback on market information through marketing activities in the development and production of new products, companies will be able to secure discriminatory competitiveness in competitive markets.

Nevens et al. [14] described technology commercialization capabilities as competitive advantage to win competitive markets through new technology acquisition, cost reduction, and quality improvement. Technology commercialization capability is the ability to absorb and develop technology, directly use it for manufacturing and sales activities, and Chen [34] analyzed that incubator and VC support, and technology commercialization effects were verified as resource-based parameters.

Hise et al. [35] analyzed the effect of the degree of intervention between marketing and R&D functions on corporate performance. The higher the degree of inter-departmental intervention, the higher the business performance, and Lin et al. [36] found that technology-based companies have financial data and patents of R&D. As a result of the verification, it was suggested that commercialization orientation and R&D intensity have a complementary relationship, and that corporate commercialization orientation plays a more important role than R&D in the process of creating the value of technology assets.

Adler & Shenbar [37] suggested the importance of four technology commercialization capabilities: market demand satisfaction through new product development, product manufacturing capabilities through appropriate process technology, future demand satisfaction through new technology and new product provision, and competitors and uncertain situations. In addition, Ruekert & Walker Jr [38] analyzed why marketing functions interact with other functional areas in planning, performing, and evaluating marketing activities, and is significant in integrated interaction analysis with marketing-related R&D, production, and accounting functions.

Duta & Rajiv [39] emphasized the importance of R&D capabilities as well as marketing and operational functions in the state-of-the-art market. Zahra & Nielsen [12] analyzed 119 companies for the effect of using internal and external resources.

According to previous studies, technology and product development and production capabilities are important for technology-based companies, but marketing and commercialization capabilities act as important factors as technology commercialization capabilities to increase their market share. Among the numerous management factors required by companies, marketing and technology manufacturing power can be said to be very important factors for technology-based companies from a technology management perspective.

TECHNICAL COMMERCIALIZATION, TECHNOLOGY INNOVATION AND TECHNOLOGY MANAGEMENT

Since successful technology development is an important factor in a rapidly changing market environment, various studies related to technological innovation generally say that technological innovation affects the economy by pioneering new markets or changes in product and service supply.

Hagedoorn & Schakenraad [40] analyzed and argued that new products, devices, systems, processes, and programs, and services applied with a new technology called technological innovation are newly reflected in the organization and change the organization. Feldman [41] defined technological innovation as a comprehensive activity related to technology of SMEs and a set of activities to develop new products or improve functions and designs of existing products to secure new markets and customers or increase market share. Ahire & Dreyfus [42] said that exporters should steadily develop, improve, and release products suitable for the ever-changing needs of customers in order to secure and maintain a competitive advantage by preoccupying a rapidly changing production environment. As such, for companies, commercialization through product and service development is the ultimate purpose of technological innovation, so research to analyze the success or failure factors of commercialization is very important.

Technology innovation processes related to technology commercialization lead to a phased flow of inputs, processes, and results, and in order for companies to maximize the effectiveness of R&D, they must manage activities in the technology innovation process well, away from management only targeting the R&D sector itself. Activities carried out in the process of technological innovation are defined as technological innovation activities, and R&D performance can be improved when these activities are closely linked along a series of stages of strategy establishment-R&D implementation-commercialization within the organization. Therefore, the level of technology innovation is determined by technology innovation capabilities, and the level of technology innovation activities carried out in the technology innovation process varies depending on the results of the technology innovation activities.

According to Damanpour & Even [43], the effect of technological innovation in companies brings about organizational changes by applying new products, services, programs, processes, systems, and devices. In general, if SMEs have high technology

development activities through technological innovation, it will have a positive impact on SMEs' competitive advantage.

The modern economy is changing from a traditional economic paradigm based on capital and labor to a knowledge-based economic paradigm. Companies are unable to adequately respond to new competitive environments and market structures created by technological advances with traditional management methods, and are in a situation where they have to seek change with new opportunities and challenges in the process of responding to information revolution and knowledge innovation. The speed and progress of technology led to changes in production styles and social structures, and companies needed new management methods centered on technology to cope with the new economic and social environment.

Reflecting these circumstances, recent studies have focused on how technology management activities affect technology commercialization performance. Drake et al. [44] argued that the main reason for the high or no relationship between R&D investment level and sales growth rate is because of the large difference in technology management ability between individual companies, especially process, system, person, and leadership.

Coombs & Bierly [45] argued that the reason why R&D investment and profits do not necessarily appear to be a positive significant relationship is due to individual companies' poor technology management capabilities, such as unclear strategic choices, barriers between organizations, and lack of leadership among top management.

CONCLUSIONS

This study examined the literature comprehensively and specifically to explore the factors affecting technology commercialization, and ultimately tried to find out what efforts should be made to improve the performance of technology commercialization.

Watch TV on the TV in your hand, call the other person's face, send an e-mail, check the schedule, and go to the appointment place according to the guide of the navigator who finds the way by voice. It is no exaggeration to say that the world is enjoying convenience and comfort because of the rapidly changing technology. The foundation for such a comfortable and safe world was, above all, the constantly developing 'R&D technology development'. It demands many changes from us under the motto of openness, participation, sharing and harmony.

Until now, R&D technology has led faster change and growth than any other field, and it has been possible thanks to the efforts of numerous researchers day and night until excellent technology was born. In addition, it succeeded because there was a thorough plan aimed at commercializing technologies from the research planning stage. In particular, in the era of future convergence, new technologies are created through the combination of technologies and approach humans, so we have to think about thorough commercialization from the technology planning stage. When technology meets the corporate market, it can be a true technology and becomes a living and breathing creature when visiting the home turf.

Technology commercialization is the process of realizing the potential value inherent in technology, which is the result of R&D. Therefore, it encompasses the entire process of technological growth from R&D planning to technology development, technology transfer, and commercialization, and each process consists of the participation of various economic actors and interactions between them.

Since the definition of technology commercialization and technology commercialization capabilities differs depending on the researcher's research perspective and subject, it is necessary to examine the concept of broad significance and consultation. In other words, technology commercialization in a broad sense can be seen as a wide range of activities in the entire process of selling technologies, products, and services to the market through R&D in acquiring ideas. The factors of technology commercialization capability can be defined as technology strategy planning capability, technology process capability, technology organization capability, manufacturing capability, marketing capability, and technology commercialization capability can be considered more comprehensively. Based on this, it is expected that it can be used for research on technology commercialization from the perspective of technology commercialization in the future.

In other words, in order to succeed in technology commercialization, organic cooperation between elements as well as each element constituting technology commercialization is very important.

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