Asian Journal of Innovation and Policy (2014) 3.1: 025-049
DOI: http//dx.doi.org/10.7545/ajip.2014.3.1.025

Success and Failure Factors of Technology Commercialization: A Korean Case

Chan-Ho Kim[*], Chang-Ryong Ko[**]

Submitted: January 10, 2014; Accepted: April 08, 2014; Published Online: May 01, 2014

Abstracts We wanted to show the different group dynamics of factors for success and failure cases for technology commercialization in small technology-based firms. Existing studies are based on product level, project level, division level or firm level. We deal with technology level, and at small-technology-based firms. This is a longitudinal case study based on 8 cases from Korea. Our study on technology level is a first trial in success and failure studies unlike all existing studies. As a first step, we introduced new categories and factors such as technology attributes and CEO reflecting data, and especially a new concept of launch readiness level. Finally, we adopted correspondence analysis to show the group dynamics. The results are as follows; Technology factors are the most important factors. Second, resource-based factors are more critical in failure cases than success cases and technology factors are more critical to success.

Keywords Launch readiness level, technological attributes, commercialization of technology, success and failure factors, correspondence analysis, small technology-based firms

I. Introduction

Success of innovation or new product development projects is a key to business success. Reflecting its importance, multitudes of studies have appeared since the seminal SAPPHO Project (Rothwell et al., 1974), and

[*] Korea Institute of Science and Technology Information, 66 Hoegiro, Dongdaemun-gu, Seoul, 130-741, Korea; chkim@kisti.re.kr
[**] Renovare Consulting, Korea; Koh1278@naver.com

followed by Project NewProd (Cooper, 1980) and the Stanford Innovation Project (Maidique and Zirger, 1984). In addition, some review papers such as Montoya-Weiss and Calantone (1994), Henard and Szymanski (2001), Ernst (2002) and Van der Panne et al. (2003) guide us to this subject.

Nonetheless, there are still questions on success factors of innovation or new product development, whatever it is called, if we confine our analysis to technology level and small technology-based firms. Existing studies are based on product level, project level, division level or firm level (Montoya-Weiss and Calantone, 1994). However, if we confine our discussion to commercialization of technology at technology level, especially at small technology-based firms, success and failure factors should be checked at a different dimension, since a technology should be combined with other technology, materials, parts or sub-systems to be a product.

Our first question is, if we confine our discussion at technology level and at small technology-based firms, are there any other factors not mentioned and highlighted in existing literature? We will suggest a new concept of launch readiness level, and highlight technological attributes unlike existing studies. Of course, we will not deny the resource-based factors mentioned in existing studies following Wernerfelt (1984). Our questions are partially supported by recent articles for technology commercialization which highlight technological attributes (Sohn and Moon, 2003; Sun and Wing, 2005; Slater and Mohr, 2006; Nerkar and Shane, 2007; Chen et al., 2011; Anokhin et al., 2011).

Second question comes from the saying of Maidique and Zirger (1984), "There is no one decisive factor for success." Then, how does the combination of factors work in success and failure cases differently? The first question reflects the characteristics of our cases, but the second question is our main purpose to show. We will demonstrate the interaction of factors showing success and failure cases differently. The interacting factors as groups can be called simply the group dynamics of factors. This is a study with 8 cases under longitudinal observation in Korea.

In the next section, we review existing literature on success factors for innovation and the nature of small firms. Section 3 sets forth our analytical framework and detail methods along with the source of our data: the Feasibility Study Project for Technology Commercialization from the Korean government. Here we suggest our hypotheses. Section 4 describes each case.

Section 5 shows the comparison of 8 cases along with the demonstration of group dynamics of factors through correspondence analysis, and section 6 ends with discussion and conclusion.

II. A Literature Review

1. Success Factors

As for issues on performance index to measure success or failure, Rothwell et al. (1974) pointed out 3 indices such as direct monetary gain, market share and alignment with company strategy. Griffin and Page (1993) also pointed out three indices, but they replaced alignment with company strategy with technical objective. Kakati's (2003) 4 indices are sales, production cost, market share and profit. Henard and Szymanski (2001) pointed out 4 issues from different perspectives: single index and multi-item index, subjective and objective measurement, reporting to top management and project leader, and measurement time elapsed after launch. On the other hand, Stuart and Abetti (1987) differentiated initial performance and ultimate performance.

As for success factors, aforementioned review papers enumerated many factors classified into 4 categories shown in Table 1: 18 factors from Montoya-Weiss and Calantone's (1994) review of 47 articles, 24 factors from review of 60 papers by Henard and Szymanski (2001), and 17 factors from review of 43 studies by Van der Panne et al. (2003). All three papers classified factors into 4 categories. Montoya-Weiss and Calantone's (1994) categories are strategy, process, organization and market. Henard and Szymanski's (2001) categories are product, strategy, process and market. On the other hand, Van der Panne's et al. (2003) categories are product, firm, project and market.

However, the factors stressed by each article, marked by stars in Table 1 are also very different. This shows success factors vary in different studies.

Table 1 Category and factors of success

Montoya-Weiss & Calantone (1994)	Van der Panne et al. (2003)
Strategic factors: Product advantage* Technological synergy* Marketing synergy Company resources Strategy Development process factors: Protocol Proficiency of technological activities Proficiency of marketing activities* Proficiency of predevelopment activities* Top management support/skill Speed to market Financial/business analysis Organizational factors: Internal/external relations Organizational factors Market environment factors: Market competitiveness* Market potential Environment	Product-related factors: Relative price* Relative quality* Innovativeness Technologically advanced Firm related factors: Firm culture* Experience* R&D team* Strategy towards innovation* Organization structure* R&D intensity Project-related factors: Complementarity* Management style* Top management support Market-related factors: Concentration of target market* Timing market introduction* Competitive pressure Marketing

Henard and Szymanski (2001)	
Product characteristics: Product advantage* Product meets customer needs* Product price Product technological sophistication* Product innovativeness Firm strategy characteristics: Marketing synergy Technological synergy Order of entry* Dedicated human resources* Dedicated R&D resources* Market place characteristics: Likelihood of competitive response Competitive response intensity Market potential*	Firm process characteristics: Structural approach Predevelopment task proficiency* Marketing task proficiency* Technological proficiency* Launch proficiency* Reduced cycle time Market orientation Customer input Cross-functional integration Cross-functional communication Senior management support

Note: Factors with * are stressed by each article.

These reviews, however, gave little stress to technological attributes. In Montoya-Weiss and Calantone (1994), technological synergy is the sole technology-related factor. In Henard and Szymanski (2001), product advantage, technological sophistication and product innovativeness are pointed out. Van der Panne et al. (2003) mentioned innovativeness and technological advancement.

Unlike these reviews, there have been new perspectives from technology commercialization and valuation of technology. In the technology commercialization group, Griffin and Page (1996) suggested the newness of new products based on a matrix system of two domains: technology and product. In each domain, they used 3 indices such as high, middle and low. Anokhin, Wincent and Frishammar (2011) dealt with misfit technology, which is defined as "technologies that are not aligned with a focal firm's current knowledge base and/or business model, but which may still be of great value to the firm if alternative commercialization options are considered." Sohn and Moon (2003) used the variables of technology level and technology type. Nerkar and Shane (2007) used 3 attributes of patents such as scope, degree of newness and age.

Chen, Chang and Hung (2011) used 4 variables of technological attributes such as innovativeness, genericness, compatibility and complexity for the analysis of technology commercialization. Here, genericness is defined as the wide range possibilities of applications and compatibility to the degree to which a technology is consistent with the existing technology.

The technology valuation group (Seol, 2011; Seol, Oh and Park, 2012; Park, Cho and Seol, 2013) pointed out attributes in the discussion of valuation of technology which deals with the expected earnings of technology commercialization: complexity, launch readiness level, opportunities, proprietorship, cumulativeness and knowledge base. Launch readiness level, defined as levels of readiness for launch, is a similar concept with the technology readiness level used in military or aerospace areas (Markins, 1995; US Dod 2005; UK AMS, 2006). Unlike the technology readiness level having 9 levels, Seol (2011) simply classifies the level into 5: idea, experiment, prototype, product and production.

2. Small Firm

Small firms and in particular new technology-based firms have some different characteristics (Bollinger, Hope and Utterback, 1983). Audretsch (2001) pointed out economies of scale, and Bommer and Jalajas (2004) said that small firms are dependent on outside capabilities to complement difficulties. Their innovation is less systematic and organizational and relies more on CEO's inspiration and experience (Peterson, 1988). They adapt more to technical change than market change (Meyer and Roberts, 1986). In case of technological entrepreneurs, their lack of management skill can be an obstacle to growth of firms (Jones-Evans, 1997).

As for success factors of start-up ventures, Duchesneau and Gartner (1990) classified factors into 3 dimensions such as successful entrepreneur, starting-up process and success firms. Other factors such as entrepreneurship (Stuart and Abetti, 1987; Kakati, 2003; Frank, Lueger and Korunka, 2007; Gurdon and Samsom, 2010; Palmer and Wright, 2010), organizational team (Duchesneau and Gartner, 1990; Gurdon and Samsom, 2010; Palmer and Wright, 2010), capital (Gurdon and Samsom, 2010), resources (Kakati, 2003), network (Rese, and Baier, 2011) and strategy (Kakati, 2003) are frequently reported.

If we combine lessons from studies on success factors and small firms, some different insights can be drawn. First, even small firms as larger firms need the resource-based factors as shown in table 1. They, however, in most cases lack resources and capabilities. Second, management related factors are not proper to small firms, especially in technology commercialization. For example, commitment of top management and role of team leaders may be the CEO's role. In small firms, CEO is the strategist, team leader, and the source of technology and resources and networks. Third, due to the lack of capabilities and resources, other factors not inherent in a firm may be important for technology commercialization. That is the launch readiness level and technological attributes, both of which can be called technology matters.

III. Data and Methods

1. Data

Our 8 cases come from the Feasibility Study Project for Technology Commercialization by the Korean government. Korean government has promoted technology commercialization through support by feasibility studies since 2002. Generally more than 3 experts from patents, technology and market participate and each study takes about 3 months. The costs were split between applicant and government for most of the program. The eligibility for this project is that the technology should be owned and commercialized by entrepreneurs of small and medium companies.

If a technology is evaluated as more than good for commercialization, then the technology enjoys much support from government policies or private financial institutions. Each feasibility report has been closed to the general public, since it may contain technology and business secrets. Fortunately, we could access 92 reports spanning 2002-2008.

At first stage, we screened these reports based on the evaluation of each report, "recommendable, but failed in commercialization" (hereafter r-f). We, however, could not trace many failure cases because of several reasons. Some companies or entrepreneurs had disappeared. Some firms did not talk about the reason of failure, and some companies refused any contact. We gathered 4 cases, and the result of the study was used in Kim, Ko and Seol (2011).

This study defines success of innovation as accumulated profits over accumulated inputs after three years of launching. The year three was chosen since commercialization generally needs time and in existing literature 3 years was generally used (Henard and Szymanski, 2001). It is a very tough definition. Under this definition, we could find out another 4 "not-recommendable, but success in commercialization" (hereafter nr-s) cases. In addition, we rearranged the 4 r-f cases from the first study.

2. Data Source and Ex-ante Model

Our cases and data are based on the Feasibility Study Project for Technology Commercialization, so the model of the project should be

explained. The model was made in 2 stages; Legal rights were checked through patent analysis in the first stage and the feasibility study was made at the second stage if a technology passed the first stage.

The framework of the feasibility study for the second stage had changed during the time span of our research only in some factors and elements and not on the basis of screening philosophy and domain (Yoo, 2010). The feasibility study as shown in Table 2 has two domains: technology and business opportunity. Technology domain has 3 factors such as technological attributes, technological environments and technological competitiveness, and each factor has several elements. Business domain also has 3 factors such as market attributes, market environments and market competitiveness. Also each factor of the domain has several elements.

Table 2 Ex-ante feasibility study model

Domain	Factors	Elements
Technology	Technological attributes	Type, scope of rights, degree of completion, degree of standardization
	Technological environments	Social aspects, impacts, regulation, trends
	Technological competitiveness	Innovativeness, application, substitutes, risks
Business opportunity	Market attributes	Structure, profitability, value added, growth
	Market environments	Timing, degree of competitiveness, easiness for commercialization, risks
	Market competitiveness	Nature of industry, infrastructure, policy/regulation, expandability

Source: Yoo (2010)

The model has no explicit categories for a commercialization agent. The model came from a government support program to identify commercial opportunities of certain technologies. This means that the model has no categories to check the resources and capabilities of commercialization agents grasping the market opportunities. Grasping opportunity by a company is different from the fact that the market is promising. Capabilities and resources grasp market opportunities regardless of market situation. Evaluators had considered the fact only implicitly.

3. Analytical Frameworks

We rebuilt an analytical framework based on the literature survey and ex-ante feasibility model. The framework is composed of 5 categories such as launch readiness, technology/product, market, firm and CEO with 15 factors. The categories of aforementioned 3 review articles are market, product, strategy, process, project, organization and firm.

Firm category and market category is a group of factors pointed out in a multitude of studies on success factors as seen in the literature review. Hence, the aforementioned 3 review articles show the importance of these categories.

Technology category is a reflection of the current trend in studies such as Sohn and Moon (2003), Sun and Wing (2005), Nerkar and Shane (2007), Chen et al. (2011), Anokhin et al. (2011) and Seol (2011).

CEO category was included reflecting the fact that this is a case study for small technology firms. This category or sub factors can be compared to the strategy factor. In small companies, selection of strategy is too simple and clear with limited alternatives to select, especially in our sample companies. Therefore, we will breakdown the strategy factor to technology experience and market understanding of CEO. In addition, we add entrepreneurship to success factors in small firms as seen in Stuart and Abetti (1987), Kakati (2003), Frank, Lueger and Korunka (2007), Gurdon and Samsom (2010), and Palmer and Wright (2010).

Factors in the technological attributes are innovativeness, complexity, compatibility and readiness for launching. The first 3 attributes are already mentioned in Chen, Chang and Hung (2011) and Seol (2011), and launch readiness was from Seol (2011, 2012). The degree of innovativeness, complexity and compatibility are classified into high, moderate and low. This kind of measurement was seen in Kleinschmidt and Cooper (1991), Nerkar and Shane (2007), and Chen, Chang and Hung (2011).

Factors in the market category are competition and type. Competition is a very popular factor in existing literature, but market type is new. Market type is defined as the types of market that the technology products are launched into, and is classified into common market, specific market and fusion of two types. This factor was adapted following our first study. Launching in the common market seems to be easier than the specific market, and if possible to

access both markets, the possibility of commercialization may be best. The relationship between domestic market and international market is the same with common market and specific market. Generally, launching to domestic market is easier than the international market, and if targeting both markets, that is the best among 3 types. But we omitted a factor for internationalization since 7 of our 8 sample companies targeted the international market, although it is very popular in many small firm studies (Karagozoglu and Lindell, 1998; Stray, Bridgewater and Murray, 2001; Wolff and Pett, 2006; Pellikka and Virtanen, 2009).

Table 3 Framework of analysis

Categories	Factors	Description
Launch Readiness	Product technology	Productization technology composed of several technologies, materials, parts and sub-systems.
	Production technology	Mass production technology having machinery, equipment and plants.
Technology	Innovativeness	Novelty of technology and its application products.
	Complexity	Degree of technological complexity of the products.
	Compatibility	Compatibility of new technology or products with existing technologies or equipment.
CEO	Technical experience	Degree of technological experience
	Market understanding	Degree of market experience
	Technological entrepreneurship	Degree of entrepreneurship
Firm	Technical manpower	Degree of having technicians or engineers
	Network	Relationship or ability establishing relationship with other business and R&D people.
	Financial ability	Degree of financial ability to fund market launch
	Organization	Degree of preparation of organization structure
	Marketing	Degree of the capability for creating, communicating and delivering with customers.
Market	Competition	Degree of market entry barriers and competition
	Type	Types of market of the products

Factors in CEO are technical experience, market understanding and entrepreneurship. As described above, entrepreneurship is quite often included in small firm research, but these two factors together are only used

in a few studies. Technical experience is adapted in Stuart and Abetti's (1987) study on small technology firm and market understanding by Duchesneau and Gartner's (1990) small firm study. Seol, Oh and Park (2012) pointed out both factors. In addition, experience of one of our authors in the Feasibility Study Project from which our data came led us to adapt these factors.

4. Methods and Triangulation

The purpose of this paper is to show the group dynamics of factors, exploring new factors. Therefore, we may have to test two kinds of hypothesis: First, are the 16 factors in 5 categories effective, in particular launch readiness level and technological attributes. Second, is the dynamics meaningful? As for effectiveness of new factors, there can be more than 10 hypotheses, so even the listing of the hypotheses takes considerable spaces.

Because of this fact, we omit hypotheses testing. Instead, we will show simple comparable numbers representing whether each factor is meaningful or not, and the group dynamics. These methods are possible because we adopt a new technique, cardinal number analysis to support correspondence analysis.

Even if we adopted a new technique, there will be disputes for generalization following the discussion in case study research. Therefore, we gave attention to triangulation (Modell, 2005) for generalization (Yin, 2003; Stake, 1995; Seawnght and Gerring, 2008; Hammersley, 2012) and for small business research (Perren and Ram, 2004): tight definition of success, data gathering, data measuring, data visualization and interpretation of results.

First, we tried to pay much attention to sampling. We set tight definitions of success as "after 3-years net profit" and failure as "perfect drop" in order to show the utmost sample. If we set our definition as successful or less successful like Rothwell et al. (1984), the samples would be enlarged. But we chose a tight definition for visible presentation of dynamics. The results were 8 cases among 92 cases. Therefore, our cases are a piece of the iceberg.

We gathered data with triangulation in mind. If a technology was successfully commercialized, then the commercialization agent reports the fact to various institutions including the evaluation agency to get more support. We checked the reporting, and confirmed the sales and profits of the company using firm databases. The third stage was the visit and interview

with a person in charge of the company.

Another task was measuring each factor, even if we have an evaluation table of factors as shown in Appendix. We with more than 15 years experience in this field, measured each factor independently in every case, and adjusted the degree of each factor through focused deliberation. That means we adopted a mini focus group method for measurement as shown in Morgan (1988) and Kitzinger (1995).

As a grouping method for factors, we used correspondence analysis, which is a method for data visualization (Greenacre, 1984; Bendixen and Sandler, 1995; Bendixen, 2003). One dimension is a company group of 8, and another dimension is 16 factors.

IV. Cases

All our case firms are small: sales revenue ranging 0 to 5 million US dollars, number of existing product lines ranging 0-2, and business history ranging from 0-6 years at the time of commercialization.

1. Recommendable but Failed Cases

These cases were extracted from Kim, Ko and Seol (2011) and rearranged following our framework. F1 was a start-up firm on 3D measurement technology in R&D, which was evaluated as wonderful both in technology and market. CEO had been a consultant and banker. He relied on core technology development from a professor, but it was delayed. After experiencing failure from outside development, he employed new technicians and tried to develop within the company. However, the development finally bankrupted two and half years later from the evaluation.

F2 was a 6-year old firm on 3D simulation technology for environment measurement. This technology was evaluated as wonderful in technology and good in market opportunity. CEO had been a researcher dealing with information, so he could identify the possibility of technology and market. He relied on technology development of a professor but failed. There was not even a clear contract with the professor for development. That failure led to company bankruptcy.

F3 was in absorbable and anti-adhesive materials for R&D. It was in preparation for clinical trial and finally the US Food and Drug Administration (FDA) approval. The technology was evaluated as good both in technology and market. The company having 4 years history had different products for earnings, so resources and capabilities had no problem, except few facts. CEO was a Ph.D. in humanities and the real manager was her brother who worked in a different sector. The biggest problem was they could not manage and control an electrical blackout, which destructed the existing technological basis. The sequential negative events after blackout led the company into bankruptcy.

F4 was an industrial film in R&D, which was evaluated as good in technology and wonderful in market. This was a localized trial of a Japanese product and targeted for the domestic market. CEO had worked in a slightly related sector and the product was also slightly related to existing technological basis. This 6-year-old company had no ability in financial resources for development and production and also for marketing. The customers were a few domestic, but large firms, so quality of product and marketing were essential. This was the reason why the CEO gave up investment for production facilities.

2. Non-Recommendable but Successful Cases

S1 technology is a 5-year old firm doing in-process R&D for turning sea plants to beverage, aimed at passing a stability test. The technology could be applied to functional beverage and medicine, but only functional beverage was considered first since medicine needed further time and efforts. Functional drinks market was expected to grow rapidly, but "frequent appearances and disappearance" was the characteristics of the market because of competition especially led by big companies. In summary, because of low marketability and time constraint, even the review process of the feasibility study was stopped. The follow-up interview was done with CEO of the company. Their original technology made profit without new product. He had many experiences in this field and some mentor professors were shareholders. The US Food and Drug Administration (FDA) approved the beverage. The CEO said that the key to success was the understanding of technology and market, so they could choose a step-by-step strategy to develop products.

S2 was a 4 year-old firm turning fungi into cosmetics. The technology could be applied also to food and medicine. The company, however, tried to develop only for cosmetics. The market was evaluated as launch phase and very competitive and led by big companies, so as a latecomer, the company was evaluated as weak in the market. Interview was done with R&D director. CEO of the company had worked for one of the largest cosmetics manufacturer for 27 years. They already sold base material to several domestic cosmetics companies, so they had resources. The director said that their success was due to the fact that they satisfy the market with function and quality.

S3 developed in-process R&D sensors for kits for blood measurement. This 3-year old company's existing products had enough profitability. However, the technology was evaluated as not different from competitive products in market, and the market was not promising. Interview was made with director of management strategy. He said that the product was an upgrade version of existing products. In addition, they wanted to develop not a full kit, but only sensor, because large international companies had occupied the kit market. Although the development was delayed over a year, their overall ability prevented them from bankruptcy. CEO of the company had worked for a medical instruments importing company for a long time, so he had many networks.

S4 was an in-process R&D adhesive tape start-up. However, it was evaluated as lacking differentiation from Japanese and domestic products. Interview was done with CEO. The CEO had worked for a company as a researcher to develop this technology, but the company bankrupted. This motivated the CEO to set up a new venture for this technology. Commercialization was delayed due to insufficient funds as well as production technology. The CEO said that his confidence in the market was the key to success. If he lacked confidence, he would have given up development and the company.

V. Analysis

1. Summary of Cases

We summarized each case by factors in Table 4 and 5. Generally the degrees of each factor are measured by 3 degrees: high, moderate and low. But in some cases (for example compatibility) high means the most positive status for commercialization, and in other cases (for example innovativeness) high means the worst condition for commercialization. Therefore we measured the scale of each factor with 1-3. 1 means difficulty in commercealization. 2 means moderate and 3 means positive. The details measuring with numbers is shown in the Appendix. If we transform the degree into number, many facts become clear and we can visualize, although the numbers are qualitative or ordinal.

Table 4 Summary of 4 failure cases

Category	Factor	F1	F2	F3	F4	Total	
Launch readiness	Product technology	2	2	2	3	9	13
	Production technology	1	1	1	1	4	
Technology	Innovativeness	1	1	1	2	5	17
	Complexity	2	2	1	2	7	
	Compatibility	1	1	2	1	5	
CEO	Technical experience	1	1	1	3	6	21
	Market understanding	1	1	2	2	6	
	Entrepreneurship	3	2	3	1	9	
Firm	Technical manpower	2	1	2	3	8	38
	Network	1	1	3	2	7	
	Financial ability	1	2	3	1	7	
	Organization	1	2	3	3	9	
	Marketing	1	2	3	1	7	
Market	Competition	3	3	3	1	10	14
	Type	1	1	1	1	4	
Total		22	23	31	27	103	

Note: If a factor is the most positive to commercialization, then 3, and the most negative 1.

As shown in tables, failure cases and success cases show clear differences. Total numbers of success cases are generally higher than those of failure

cases. Total of success cases is 147, and that of failure cases is 103. This means that success cases have favorable conditions for commercialization. However, S4 is unique in the success group. Rather its total is similar to failure cases. Factors in CEO category, not resources and capabilities, are the firm's best assets. This fact led us to the entrepreneurship study.

By categories, the biggest difference is found in the CEO category of 34 and 21, but the difference is 1.62 times. The total of success cases of launch readiness is 23, 2.07 times the failure cases of 13. Next difference is in the technology category with 28 and 17, 1.65 times. These numbers may mean that launch readiness, technological attributes and CEO factors are important factors in technology commercialization, especially in small technology firms.

Table 5 Summary of 4 success cases

Category	Factor	S1	S2	S3	S4	Total	
Launch readiness	Product technology (pdt)	3	3	3	3	12	23
	Production technology (pdn)	3	3	3	2	11	
Technology	Innovativeness (inn)	2	2	2	2	8	28
	Complexity (com)	3	3	3	2	11	
	Compatibility (cpb)	3	2	3	1	9	
CEO	Technical experience (te)	3	2	2	3	10	34
	Market understanding (mu)	3	3	3	3	12	
	Entrepreneurship (ent)	3	3	3	3	12	
Firm	Technical manpower (man)	3	3	3	2	11	47
	Network (net)	3	2	3	1	9	
	Financial ability (fin)	3	2	3	1	9	
	Organization (org)	3	2	3	1	9	
	Marketing (mkt)	3	2	3	1	9	
Market	Competition (cpt)	2	2	2	2	8	15
	Type (typ)	2	2	2	1	7	
Total		42	36	41	28	147	

On the other hand, the difference of firm category is only 1.24 times. In market category, little difference is found in the total with 15 and 14.

By factors, totals of each factor in success cases (horizontal in the table) are greater than those of failure cases except 1 factor, competition. This fact means that the factors in the analytical framework work for commerce-alization. However, the success cases with the total of 8 had tougher competition than failure cases having 10. If a market is more competitive, generally market penetration is difficult which makes commercialization of

technology difficult. This finding, therefore, is very unusual, not found in existing literature.

2. Correspondence Analysis

We used correspondence analysis to figure out the combination of factors developed and explained in Greenacre (1984) and Bendixen (2003). Two domains for the analysis are 8 different cases and 16 factors.

As shown in Figure 3, failure cases are in the left and 4 success cases are in the middle and right. However, F4 is quite different from failure cases. As for factors, most factors are cluttered and show 3 patterns. First, 2 factors such as competition (cpt) and technological experience (te) look alien. Second, the factors close to failure cases are resource-based factors quite often mentioned in existing literature such as financial ability, marketing, organization and network. Third, most factors highlighted in this article such as launch readiness level and technology attributes are located on the right side close to success cases. We especially give attention to the close distance between product technology and production technology in the launch readiness level category, and innovativeness and complexity in the technology/product category. But factors in CEO category such as entrepreneurship, market understanding and technological experience are located here and there.

Between two alien cases on the right side, S4 is a case for victory of entrepreneurship, and F4 is a decision for entrepreneurship. So, CEO factors such as market understanding and technological experience are close to them.

This Figure may be interpreted as resource-based factors being more critical in failure cases than success cases and technology factors such as launch readiness level and technology attributes as being more critical to success.

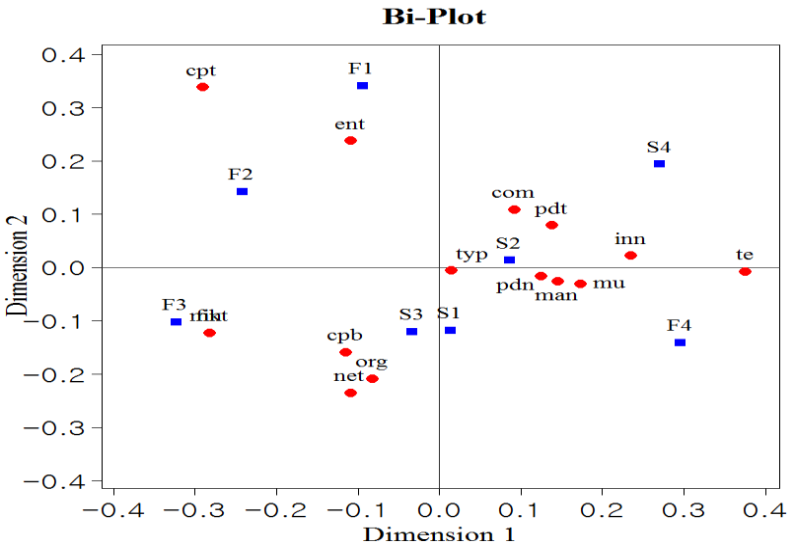

Figure 1 Result of Correspondence Analysis

Note: The result of 5-scale measurements is similar to this figure, although location of the cases and factors is different.

IV. Discussion and Limitations

1. Discussion

The results are summarized as follows: First, launch readiness level, technological attributes such as innovativeness, complexity and compatibility to existing capabilities are very important in commercialization of technology, especially in small technology-based firms. This is the reason why we are targeting technology level unlike existing studies. Second, various aspects of CEO is also important in technology commercialization, since our samples are from small technology-based firms. Third, factors in resource and capability categories and market categories are also positive for commercialization. Fourth, resource-based factors are more critical in failure cases than success cases and technology categories are more critical to success.

This study is a new trial in many aspects. As for subject, we targeted success factors of commercialization of technology in small technology-based firms not found in the existing literature. Stuart and Abetti (1987) already linked new product development and new ventures. Our research, however, goes further from their study adding new factors and analysis. As for factors and categories, we introduced new concept of launch readiness level, and highlight technological attributes and CEO.

In existing studies for success and failure factors, the lowest level is product, and they do not go a step below to technology level. We hope innovation studies encompass this difference like the new trend of research (Parker and Mainell, 2001; Zara and Nielson, 2002; Sohn and Moon, 2004; Gans and Stern, 2003; Goldfarb and Henrekson, 2003; Sun and Wing, 2005; Slater and Mohr, 2006; Nerkar and Shane, 2007; Lichtenthaler and Ernst, 2007; Chen et al., 2011, and Anokhin et al., 2011).

As for usage, our findings can be used as an ex-ante screening model for technology commercialization or feasibility studies like Sohn and Moon (2003), Altuntas and Dereli (2012), Galbraith et al. (2012) and Frishammar et al. (2012). In every instance of technology commercialization, firms want to screen the possibility of success for each technology while investors also seek to find out the best technology among the varying options.

Our results suggest that a screening model should contain the role of commercialization agent. Even if the technology and market shows promise, taking the opportunity and becoming profitable is an entirely different mater. In our framework, the role of the CEO as the commercialization agent is essential for successful technology commercialization.

2. Limitations

This is a case study, so this study may have the general weakness of case study research. Nevertheless, our results are robust. First, we are aware of the strength and weakness of case study research, so we tried to avoid the weakness by a tight definition of success, and by careful data gathering and measured longitudinal observations. Second, the most important thing is that our cases are revealed pieces of the iceberg chosen to show group dynamics with a limited number of cases. Third, this is the comparative study between

success and failure cases. Fourth, we draw results from a visible diagram. (Fourth, we draw results to a visible diagram?)

Our samples are from only small firms below 5 million US dollars in yearly sales revenue at the starting time of commercialization. Thus, some factors in CEO categories reflected this situation. We, however, are sure that our factors and analysis can be used on larger firms, although the role of each factor may change. For example, importance of CEO categories may be weakened and to the contrary factors in resources and capabilities categories may be strong. Nonetheless, we think the importance of technology factors will remain, if we confine our concern on technology level.

This article uses new analytic techniques with cardinal numbers. Although this technique gives us very simple comparisons and further analysis, transforming the degree to cardinal data may be the biggest task. We adopt a mini focus group method (Morgan, 1988; Kitzinger, 1995) for the transformation. If we can get data from each company, the data may be more realistic. But it was impossible in failure cases.

VII. Conclusion

We wanted to figure out the group dynamics of factors at technology level, for technology commercialization in small technology-based firms. As a first step, we introduced new categories and factors such as launch readiness level, technology attributes, and CEO reflecting data. As a second step, we converted each factor to cardinal numbers, and compared the importance of each category and factor. As a third step, we adopted correspondence analysis to show the group dynamics of factors.

Our study on technology level unlike existing studies is a first trial in success and failure studies. Therefore, we expect more case study research from innovation studies, and also from technology commercialization studies. This may overcome the possible weakness of case contextual matters.

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Appendix

Factors	Scoring
Product technology	Low: Only concepts of product Moderate: Prototype of products High: Completion of products
Production technology	Low: Only knows machinery and equipment. Moderate: Acquiring engineering technology for mass production. High: Completion of equipment and plants for the products.
Innovativeness	Low: Replacement of existing technology or products. Moderate: Improvement of existing technology or products. High: Invention of new products.
Complexity	Low: Single or few technology/parts product. Moderate: Improvement of existing technology or products. High: Combination of many technologies, parts and sub-systems.
Compatibility	Low: New technologies or products using existing technologies. Moderate: Partly using existing technologies. High: Not using existing technologies.
Technical experience	Low: Little experience in the technological areas. Moderate: Partial or few in the technological areas. High: Much experience in the technological areas.
Market understanding	Low: Little experience in the market. Moderate: Experience in the similar market. High: Work in the market.
Technological entrepreneurship	Low: Want to keep existing products line. Moderate: Want minor changes of existing products line. High: Want to develop perfectly new market.
Technical manpower	Low: Only no or few technicians and engineers. Moderate: A few technicians and engineers. High: Enough full time technician and engineers.
Network	Low: No or few relationships. Moderate: A few relationships High: Enough relationships
Financial ability	Low: Less than 50% Moderate: More than 50% High: Over 100%
Organization	Low: No organization structure Moderate: Not enough or proper organizations High: Having proper organizations
Marketing	Low: No capability at all Moderate: Not enough or proper organizations and experiences High: Having proper organizations and strategies.
Competition	Low: Tight barriers and competition. Moderate: Market share to sustain the business. High: No barriers and competition.
Type	1=common 2=specific 3=fusion