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Multivariate Analysis of Covariance on Characteristics Influencing Technological and Managerial Barriers of Technology Startups

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Abstract

This study investigated technological and managerial barriers in technology startups through a survey of 151 companies, yielding 118 responses (78.1% response rate). Factor and multivariate analyses identified two distinct barriers: technological and managerial. Reliability analysis validated the measurement tool. Using MANCOVA, 12 hypotheses were tested, incorporating six independent variables. Results revealed significant disparities in technological and managerial barriers based on establishment type, commercialization goals, growth stage, and commercialization stage, with 5 hypotheses supported. This study highlights the crucial role of these variables in understanding barriers within technology-based startups.

Keywords : Technology Startups, Technological and Managerial Barriers, MANCOVA

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1. Introduction

Previous research on established startup companies has primarily focused on analyzing performance outcomes based on individual influencing factors, emphasizing specific directions for research. However, the operational structure of general startups is not extensive or complex, allowing for the attainment of operational efficiency through the analysis of representative quantitative and qualitative factors. In contrast, for technology-based startup companies, external influences, such as the technological environment and social structure, become more intricate. Beyond typical operational elements, various internal and external variables interact in a compound manner, introducing multiple barriers that inevitably impact technology startup management. Furthermore, the proposed solutions may be deemed inadequate. In light of this, the present study aims to analyze variations in technological and managerial barriers based on the characteristics of technology startup companies, considering factors such as startup form, commercialization goals, key technology introduction methods, growth stages, commercialization phases, and research organization types.

2. Backgrounds

In the scope of this study, the conceptualization of corporate barriers encompasses diverse terms, including success factors, failure factors, obstacles, and impediments. The literal definition of corporate barriers refers to the difficulties and hindrances arising from the scarcity of production factors in the process of expanding production. Production activities are reliant on factors such as labor, capital equipment, raw materials, and finances. If any of these production factors is insufficient, it is defined as a 'challenge,' thereby constraining the production process. In international contexts, the pre-existing terminology for barriers utilizes a variety of terms, such as Bottleneck, Difficulty, Barrier, Problem, signifying analogous conceptualizations.

Since the 1970s, discussions on the transfer of 'public technology' derived from national R&D projects and the subsequent success or failure of commercialization have initiated various research studies examining the 'influencing factors' expressed through success factors, failure factors, and barriers. Numerous studies have been conducted in this area. Some researchers, intrigued by the effectiveness of public development technologies and factors contributing to successful commercialization based on the outcomes of federal projects in the United States, conducted surveys targeting technology developers to identify key influencing factors in related papers. Existing paper proposed factors such as technical problem-solving, commercialization costs, a robust industrial infrastructure, participation opportunities in research and development planning, and resolution of time constraints as elements contributing to commercialization success. Ac advocated for market-oriented research and development outcomes, effective communication and collaboration between technology adopters and providers.

2.1 Technology Startups

Before delving into the definition of technology entrepreneurship, this chapter aims to precisely define the concept of entrepre-

neurship. The literal definition of entrepreneurship is articulated as 'the act of initiating a business or the like for the first time.' Generally, the commonly accepted notion of entrepreneurship in society is understood as the creation of a new business entity. Similarly, as defined in Korean law, the concept of entrepreneurship involves 'establishing a new small and medium-sized enterprise and commencing business activities.' In a similar context, domestic entrepreneurial institutions in Korea often define entrepreneurship as the act of 'creating a new individual or corporate entity for profit' or 'an entrepreneur combining resources with a business idea to initiate business activities. As seen in the table below, researchers abroad are also providing various definitions for technology entrepreneurship. Similar to the preceding domestic studies on technology entrepreneurship, there is a diverse range of definitions for the concept of technology entrepreneurship. While many researchers define the concept of technology entrepreneurship in a similar manner, slight conceptual differences exist depending on the purpose and context of the research.

〈Table 1〉 Literature Review of Technology Startup

Authors	Description
Cooper〔1971〕	Companies with a strong emphasis on R&D or a high tendency to pursue new technological knowledge
Sheaman and Burrel(1988)	Independent startups that contribute to the development of new industries
Butchart 〔1987〕	Small and medium-sized enterprises (SMEs) active in the high-tech sector
Jones-Evans 〔1995〕	Establishment of new technology ventures
Maula 〔2001〕	Enterprises with less than 6 years of history in industries such as biotechnology, medical science, IT, computer, software, and services
Nicholas and Armstrong 〔2003〕	Organizations involved in technology-based business with considerations for organization, management, and associated risks

2.2 Technology Commercialization

Cooper 〔1986〕 and Lester 〔1998〕 argued that the commercialization of technology, from the perspective of the technological innovation process, involves the execution of the 'new product development process.' Jolly 〔1997〕 stated that it encompasses the overall process of 'idea proposal, research and development, prototyping/market entry, mass production, and sustained growth,' while Farrukh et al. 〔2004〕 defined it as a process including manufacturing and market supply after research and development. Kimura 〔2010〕 described technology commercialization as the evolution of technology, under an R&D program, beyond the prototype level to function as a crucial part of the commercial product entering the market. Thus, the commercialization of technology cannot be separated from the ultimate goals of successful product development and market supply. It seems only natural to trace whether the introduced technology is effectively utilized by the company. Therefore, recent research has focused on the success of commercialization, aligning with this purpose.

On the other hand, the most crucial aspect lies in establishing the criteria for the success of technology commercialization. Spann et al. 〔1993〕 summarized previous studies, indicating that judgments about the success of technology commercialization can vary based on different perspectives such as progress achievement as a measure of commercialization success for the company, performance metrics relative to inputs such as financial gains, com-

petitiveness metrics like market share, the number of new product developments, and the number of patents generated. In other words, the success of technology transfer and commercialization is closely tied to various meanings associated with commercialization. This conceptualization of technology commercialization in Korea is also organized as mentioned above. It is evident from most of the definitions that the specific outputs corresponding to each stage, such as 'prototype' and 'product,' are mentioned.

In this study, we determined that the discussion on technology commercialization goals and success, as perceived by technology startup companies, is an inseparable factor in understanding technological and managerial barriers. The results of the research indicate that each startup company has different goals and criteria for success. Some express success as achieving product completeness, while others define it based on revenue generation.

2.3 Technology and Managerial Barriers

In this study, the concept of business barriers, also referred to as success factors, failure factors, obstacles, and challenges, is characterized by various terms. The preconceived notion of business barriers refers to the difficulties or obstacles arising from the scarcity of production factors in the process of expanding production. Production activities rely on factors such as labor, capital equipment, raw materials, and funding. If any of these production factors is insufficient, it becomes a 'challenge,' constraining the production process. The terminology in overseas contexts uses various terms interchangeably, including Bottleneck, Difficulty, Barrier, Problem, indicating similar concepts

2.4 Technology Commercialization with Barriers

This study started with Cooper's [1986] three-stage model and restructured the stages to align with the commercialization situation of domestic technology startups. In other words, we applied the criteria for stage construction by dividing the process into four stages: technology acquisition, prototype testing, product manufacturing, and market testing, using 'prototype' and 'commercial product' as intermediate metrics for commercialization following technology adoption.

However, Cooper's [1986] stage model, constructed as a model for the commercialization process utilizing internally developed technology, broadly includes early stages such as idea formulation and business planning. Since this study focuses on situations where technology startups use both internally developed technologies and externally transferred technologies for commercialization, we applied a narrower definition of the commercialization stage, starting from the development stage.

Meanwhile, with growing interest in the commercialization process after technology transfer, research has emerged on phenomena occurring at various commercialization stages described earlier, and on key success factors for commercialization success at each stage or specific stages. Benedetto [1999] emphasized that high-level sales efforts, advertising, technical support, and optimal release timing considering customers and competitors are critical success factors for a successful product launch. Kirihata [2007] divided the commercialization stage into three stages: basic research, product development, and commercial product sales, researching

barriers at each stage such as financial condition and lack of research personnel. While there is no definitive answer to stage-specific barriers faced by companies in various commercialization conditions, this study outlines common experiences in stages and major barriers in the industry, contributing to a better understanding of commercialization conditions.

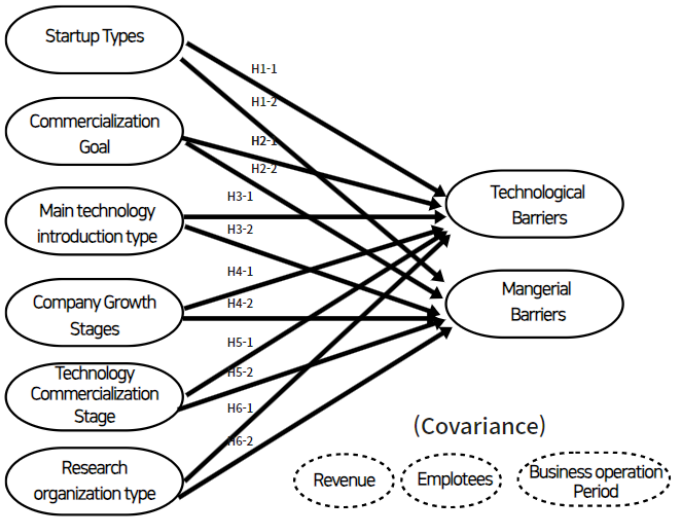
3. Methods and Data Collection

In this study, a survey was conducted among 151 technology-based startup companies in Korea, resulting in the acquisition of 118 valid responses (a response rate of 78.1%). Empirical analyses, including factor analysis and multivariate analysis of covariance, were performed utilizing these 118 survey responses. Exploratory and confirmatory factor analyses were conducted based on the 118 valid survey results, leading to the identification of two factors: technological barriers and managerial barriers. Through reliability analysis, the study ensured the validity and reliability of the measurement tool. Additionally, the two identified challenge factors (technological barriers and managerial barriers) were designated as dependent variables.

To analyze potential significant differences based on six independent variables (startup form, commercialization goals, key technology introduction methods, growth stages, commercialization phases, and research organization types), 12 specific hypotheses were formulated. Subsequently, Multivariate Analysis of Covariance (MANCOVA) was employed for the analysis. To substantively control for variables, the revenue, number of employees, and business tenure of technology-based startup companies were introduced as covariates

4. Research Model and Hypotheses

The objective of this research is to analyze differences in technological and managerial barriers among technology startup enterprises based on their entrepreneurial forms, commercialization goals, key technology adoption forms, growth stages, commercialization stages, and research organizational



〈Figure 1〉 Research Model

structures, grounded in previous literature. Therefore, this study formulates hypotheses and establishes a research model regarding the barriers faced by technology startup enterprises. The research model and hypotheses are as follows

H1-1: There will be significant differences in Technological Barriers depending on Startup Types.
H1-2: There will be significant differences in Managerial Barriers depending on Startup Types.
H2-1: There will be significant differences in Technological Barriers depending on Commercialization Goals.
H2-2: There will be significant differences in Managerial Barriers depending on Commercialization Goals,
H3-1: There will be significant differences in Technological Barriers depending on Main technology introduction types.
H3-2: There will be significant differences in Managerial Barriers depending on Main technology introduction types.
H4-1: There will be significant differences in Technological Barriers depending on Company Growth Stages.
H4-2: There will be significant differences in Managerial Barriers depending on Company Growth Stages
H5-1: There will be significant differences in Technological Barriers depending on Technology Commercialization Stages.
H5-2: There will be significant differences in Managerial Barriers depending on Technology Commercialization Stages.
H6-1: There will be significant differences in Technological Barriers depending on Research Organization Types
H6-2: There will be significant differences in Managerial Barriers depending on Research Organization Types

4.1 Variables and Measurements

In this study, six independent variables and two dependent variables were established

〈Table 2〉 Definition of Independent Variables

Variables	Operational Definition	Measurement
Startup Types	Initial type of startup	General startups, Researcher startups, Technology-based joint ventures
Commercialization Goals	Goal through the commercialization of technology.	Technology Sales, Technology, Acquisition, Business Rights Sale, Revenue Increase
Main Technology introduction types	Form of introducing main technologies for technology commercialization	External adoption, In-house Development, Collaborative Development
Company Growth Stages	Current growth stage in terms of technological and managerial aspects of the company	Startup Stage, Early Growth Stage, High Growth Stage, Mature Stage, Stagnant Stage
Technology Commercialization Stages	Present stage of technology commercialization	Technology Adoption, Prototype Production, Commercial Product Development, Market Validation
Research Organization Types	Phase of establishing a research organization within the company for the purpose of technology research	Corporate Research Institute, Dedicated Research Department, Unauthorized Research Organization, No Research Organization

based on previous research. The operational definitions of the independent and dependent variables are as follows

〈Table 3〉 Definition of Dependent Variables

Variables	Operational Definition
Technological Barriers (TB)	Degree to which individual companies experience technical difficulties during the process of technology commercialization
Managerial Barriers (BB)	Degree to which individual enterprises encounter managerial difficulties in the process of technology commercialization

5. Results

5.1 Reliability and Validity Analysis

In this study, exploratory factor analysis (EFA) was conducted to extract the factors associated with barriers in technology-based startups. Out of the 16 scale items used in the factor analysis, two technological challenge measurement items (T6, T7) and one managerial challenge item (B8) with factor loading values below 0.5 were excluded. A total of 13 items were utilized for factor analysis to extract latent factors. Principal component analysis was employed as the factor extraction method, and Varimax rotation with Kaiser normalization was applied.

The results of the factor analysis indicated a sample adequacy (MSA) Kaiser-Meyer-Olkin (KMO) measure of 0.870, suggesting that the data is suitable for factor analysis. Additionally, Bartlett's test of sphericity yielded an approximate chi-square value of 894.550 with a p-value of 0.000, indicating that the correlation between variables is significant at the 0.05 significance level and validating the appropriateness of factor analysis. The cumulative explained variance of the two extracted factors was 29.836% for technological barriers and 32.002% for managerial barriers, totaling 61.838% of variance explained, supporting the extraction of two factors. The results revealed two factors, with Factor 1 labeled as 'Technological barriers ' and Factor 2 as 'Managerial barriers.'

〈Table 4〉 Results of Exploratory Factor Analysis

Factor	Mesurement	Factor Loading
Technological Barriers (TB)	Insufficient additional technology for technology commercialization(T2)	.911
	Lack of optimization technology for technology commercialization(T3)	.899
	Inadequate initial technology completeness(T1)	.833
	Lack of technology management skills in technology development projects(T4)	.718
	Shortage of technical personnel in research and development(T5)	.631
	Inadequate securing of intellectual property rights(T8)	.523
Managerial Barriers (BB)	Lack of financial management capabilities(B1)	.891
	Insufficient expertise in legal, taxation, and labor-related matters(B2)	.865
	Inadequate marketing capabilities(B4)	.730
	Deficiencies in organizational management capabilities(B6)	.726
	Insufficient production capacities and workforce(B5)	.669
	barriers in fund procurement(B3)	.650
	Deficient management of domestic and international standards and certifications(B7)	.613

* Extraction Method: Principal Component Analysis
**Rotation Method: Varimax with Kaiser Normalization

To assess the reliability of the measurement tool for the two extracted factors, a reliability analysis was conducted. The results indicated a Cronbach's alpha value of 0.876 for Factor 1 (Technological barriers) and 0.879 for Factor 2 (Managerial barriers), both surpassing the threshold of 0.6, confirming the reliability of the measurement tool. This analysis ensures the validity and reliability of the study's findings.The results of Exploratory Factor Analysis (EFA) are presented in 〈Table 4〉 as follows:

To examine the correlation between variables of barriers factors, a correlation analysis using Pearson correlation coefficient was conducted. Correlation analysis is a statistical method to test the degree of linear relationship between two variables. In this study, correlation analysis was performed to investigate the correlation between two factors derived from exploratory factor analysis: technological barriers and managerial barriers. The technological barriers factor showed a mean of 3.1012 and a standard deviation of 0.77617, while the managerial barriers factor exhibited a mean of 3.1307 and a standard deviation of 0.77418.

The Pearson correlation coefficient, calculated to understand the correlation between the two factors, was 0.488, indicating a significant correlation at the 0.01 significance level. However, it was deemed that there were no issues affecting the progress of this study despite the observed correlation between the variables, and thus the analysis proceeded.

Additionally, Confirmatory Factor Analysis (CFA) was conducted by excluding three variables (T6, T7, B8) from the initial measurement model to assess its fit. The final model for technological and managerial barriers in technology startups demonstrated good overall fit (χ^2=148.615, p〈0.001), incremental fit indices (TLI=0.880, CFI=0.901), and an RMSEA of 0.106. Standardized regression weights for the measurement variables were all above 0.4, significant at the 0.001 level. Latent variables TB and BB showed good AVE values (0.558286 and 0.517744), concept reliability above 0.7, and a correlation of 0.343. Although some variables had lower explanatory power, the high model fit justified proceeding with the study.

5.2 Multivariate Analysis of Covariance (MANCOVA)

To understand the impact of technological and managerial barriers on technology startups, this study conducted Multivariate Analysis of Covariance (MANCOVA). Covariance analysis is a method used to control for the influence of continuous variables and identify the pure effects of independent variables on dependent variables. In this study, three continuous variables (revenue, number of employees, tenure) were set as covariates to control for their effects, and six independent variables (startup type, commercialization goal, technology adoption type, growth stage, commercialization stage, research organization type) were set as predictors. The dependent variables were technological barriers and managerial barriers. The MANCOVA was performed to analyze the multivariate effects.

Initially, a test for the homogeneity of covariance matrices was conducted to ensure that the analyzed data possessed a structure suitable for covariance analysis. Upon examining the results of Box's test for the equality of covariance matrices below, the significance level was determined to be 0.100, with a p-value exceeding 0.05. Consequently, it was ob-

served that there was no significant difference in the covariance matrices, affirming the consistency of the matrix structure in explaining the dependent variables by the independent variables. This substantiates the appropriateness of the data for covariance analysis.

〈Table 5〉 Results of Box's Test for the Equality of Covariance Matrices

Box's M	F	df1	df2	P value
19.063	1.783	6	661.596	0.100

Additionally, a Levene test for the equality of error variances was conducted. The results indicated that the significance level for all dependent variables (technological barriers and managerial barriers) was above 0.05. With the covariates (revenue, number of employees, tenure) controlled and considering six independent variables (startup type, commercialization goal, technology adoption type, growth stage, commercialization stage, research organization type), it can be interpreted that the error variances of all dependent variables are homogenous (homoscedasticity). In conclusion, there were no structural issues in the data that could impede the validity of the Multivariate Analysis of Covariance (MANCOVA)

〈Table 6〉 Levene's Test for the Equality of Error Variance

Dependent Variables	F	df1	df2	P value
TB	1.620	96	21	.103
BB	.822	96	21	.744

In this study, we sought to examine whether there are significant differences in the dependent variables (technological barriers and managerial barriers) based on six fixed independent variables (startup type, commercialization goal, technology adoption type, growth stage, commercialization stage, research organization type). As previously mentioned, revenue, number of employees, and tenure were set as covariates and treated as controlled variables in the analysis. Additionally, the analysis model exclusively addresses main effects analysis, excluding interaction effects among independent variables.

Upon reviewing the analysis results, the covariance analysis model with the six independent variables and technological barriers as the dependent variable yielded an R-squared value of .665 and an adjusted R-squared value of .595. This suggests that the covariance analysis model explains 59.5% of the variance in technological barriers. Similarly, when the six independent variables were used with managerial barriers as the dependent variable, the model's R-squared value was .630, and the adjusted R-squared value was .554, indicating that the covariance analysis model accounts for 55.4% of the variance in managerial barriers.

〈Table 7〉 Results of Multivariate Analysis of Covariance Model (Main Effects)

Dependent Variables	Sum of Squares	R2	P value
TBa	1.620	**.665**	**.000******
BBb	.822	**.630**	**.000******
a. R-squared = 0.665 (**Adjusted R-squared = 0.595**)			
b. R-squared = 0.630 (**Adjusted R-squared = 0.554**)			

*p<.1, **p<.05, ***p<.01, ****p<.001.

To assess the significance of discriminant power of the fixed independent variables used in the analysis and determine whether an appropriate function for covariance analysis was employed, multivariate tests were conducted. The multivariate tests were performed using Pillai's Trace, Wilks' Lambda, Hotelling's

Trace, and Roy's Largest Root. A significance level of p 〈 0.05 was applied for measurement. According to the results of multivariate tests, for the variable 'startup type,' excluding Roy's Largest Root, other methods did not show significant results; however, the outcome by Roy's Largest Root was found to be significant at the 0.05 level, suggesting the suitability of the function for covariance analysis. Variables such as 'commercialization goal,' 'company growth stage,' and 'technological commercialization stage' were found to be significant (p 〈 0.05) across all test methods (Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root). Furthermore, 'main technology adoption type' and 'research organization type' showed non-significant results across all test method.

Also, We conducted tests to examine whether there were differences in the dependent variables, technological barriers, and managerial barriers, based on the six independent variables. The analysis results indicated that there was no significant difference in technological barriers based on 'startup type,' whereas a significant difference was observed in managerial barriers according to 'startup type' (F=2.581, p〈0.1). Additionally, significant differences were found in technological i barriers (F=2.217, p〈0.1) and managerial barriers (F=2.421, p〈0.05) based on 'commercialization goal.' Although no significant difference was observed in technological barriers based on 'company growth stage,' a significant difference was noted in managerial i barriers (F=3.263, p〈0.05). Regarding 'technological commercialization stage,' a significant difference was observed in technological barriers (F=4.207, p〈0.01), while no significant difference was found in managerial barriers. Finally, there were no significant differences in technological and managerial barriers based on 'main technology adoption type' and 'research organization type.

5.3 Results of post-hoc test

Following the significant differences identified in the preceding multivariate analysis of covariance results, post-hoc tests were conducted. The Bonferroni multiple comparison method was utilized for the post-hoc tests, with consistent control of covariates in-

〈Table 8〉 Main Effects of Technological and Managerial Barriers Based on Independent Variables

Independent variables	Dependent Variables	F	R^2	P value
Startup type	TB	1.646	.033	.198
	BB	**2.581**	**.051**	**.081***
Commercialzation goal	**TB**	**2.217**	**.064**	**.091***
	BB	**3.017**	**.085**	**.034****
Main technology adoption type	TB	.273	.006	.762
	BB	.490	.010	.614
Company growth stage	TB	.721	.029	.580
	BB	**3.263**	**.119**	**.015****
Technological Commercialization Stage	**TB**	**4.207**	**.115**	**.008*****
	BB	1.497	.044	.220
Research organization type	TB	1.226	.037	.305
	BB	.456	.014	.713

*p<.1, **p<.05, ***p<.01, ****p<.001.

cluding revenue, number of employees, and tenure. Examining the estimated mean values of managerial barriers based on 'startup type,' it was revealed that, in the case of general startups, managerial barriers was higher compared to researcher startups. However, no significant difference was observed in managerial barriers for technology-based joint ventures

〈Table 9〉 Multiple Comparisons of Estimated Mean Managerial Barriers Based on Startup Type

Dependent Variables	Startup type	Sample size	Mean	SE
BB	General startups	47	**2.976^{b}**	.135
	Researcher startups	46	**2.671^{a}**	.134
	Technology-based joint ventures	25	2.841^{ab}	.167

Bonferroni's Multiple Comparison: a 〈 b
Covariates: Revenue, Number of Employees, Tenure

Next, when examining the estimated mean values of technological barriers and managerial barriers based on commercialization goals, it was found that technological barriers differed significantly between groups aiming for business rights sale and those with the goal of technology sales as a means of commercialization. Furthermore, managerial barriers was higher in the group targeting technology acquisition and revenue increase as commercialization goals compared to the group targeting technological sales.

The following post-hoc analysis results present an estimated mean comparison table of managerial barriers based on growth stages. The high-growth and stagnant groups did not show significant differences. However, the startup and early startup groups exhibited a significant difference in post-hoc testing when compared to the group in the mature growth stage. It was found that the startup and early startup groups had higher managerial barriers in the mature growth stage than the group in the growth stage

〈Table 10〉 Multiple Comparisons of Estimated Mean Technological and Managerial Barriers Based on Commercialization Goals

Dependent Variables	Commercialization Goals	Sample size	Mean	SE
TB	Technology Sales	6	**2.562a**	.231
	Technology Acquisition	28	3.026^{ab}	.142
	Business Rights Sale	9	**3.292^{b}**	.201
	Revenue Increase	75	3.037^{ab}	.105
BB	Technology Sales	6	**2.469^{a}**	.242
	Technology Acquisition	28	**3.109^{b}**	.149
	Business Rights Sale	9	2.700^{ab}	.210
	Revenue Increase	75	**3.040^{b}**	.110

Bonferroni's Multiple Comparison: a 〈 b
Covariates: Revenue, Number of Employees, Tenure

〈Table 11〉 Multiple Comparisons of Estimated Mean Managerial Barriers Based on Growth Stages

Dependent Variables	Growth Stages	Sample size	Mean	SE
BB	Startup Stage	21	**3.209^{b}**	.152
	Early Growth Stage	50	**3.137^{b}**	.124
	High Growth Stage	34	2.808^{ab}	.143
	Mature Stage	6	**2.340^{a}**	.288
	Stagnant Stage	7	**2.653^{ab}**	.231

Bonferroni's Multiple Comparison: a 〈 b
Covariates: Revenue, Number of Employees, Tenure

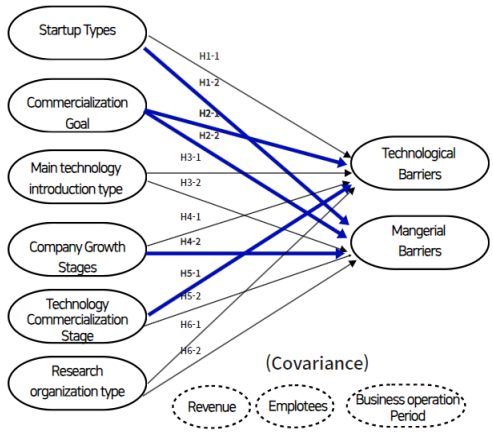
Finally, here are the post-hoc test results for technological barriers based on the stage of technological commercialization. In the case of market validation, no significant differences were observed. However, the groups involved in technology adoption and prototype development showed a significant difference compared to the group involved in commercial product development. Specifically, the group in the technology introduction and prototype development stages exhibited higher technological barriers compared to the group engaged in commercial product development.

〈Table 12〉 Multiple Comparisons of Estimated Mean Technological Barriers Based on Technological Commercialization Stages

Dependent Variables	Technological Commercialization Stages	Sample size	Mean	SE
TB	Technology Introduction	27	**3.277^{b}**	.136
	Prototype Development	48	**3.174^{b}**	.129
	Commercial Product Development	31	**2.750^{a}**	.157
	Market Validation	12	2.717^{ab}	.210
Bonferroni's Multiple Comparison: a 〈 b Covariates: Revenue, Number of Employees, Tenure				

5.4 Hypothesis Verification

Multivariate Analysis of Covariance (MANCOVA) was conducted, including tests for the homogeneity of covariance matrices and error variance, discriminant power of independent variables, analysis of multivariate covariance model effects, and post-hoc testing (Bonferroni's multiple comparisons) to derive the results. The determination of the acceptance or rejection of hypotheses indicating significant differences is as follows.



〈Figure 2〉 Hypothesis Verification for Research Model

H1-1: There will be significant differences in Technological Barriers depending on Startup Types. (Rejected)

H1-2: There will be significant differences in Managerial Barriers depending on Startup Types. (Accepted)

H2-1: There will be significant differences in Technological Barriers depending on Commercialization Goals. (Accepted)

H2-2: There will be significant differences in Managerial Barriers depending on Commercialization Goals (Accepted)

H3-1: There will be significant differences in Technological Barriers depending on Main technology introduction types. (Rejected)

H3-2: There will be significant differences in Managerial Barriers depending on Main technology introduction types. (Rejected)

H4-1: There will be significant differences in Technological Barriers depending on Company Growth Stages. (Rejected)

H4-2: There will be significant differences

in Managerial Barriers depending on Company Growth Stages (Accepted)

H5-1: There will be significant differences in Technological Barriers depending on Technology Commercialization Stages. (Accepted)

H5-2: There will significant differences in Managerial Barriers depending on Technology Commercialization Stages. (Rejected)

H6-1: There will be significant differences in Technological Barriers depending on Research Organization Types (Rejected)

H6-2: There will be significant differences in Managerial Barriers depending on Research Organization Types (Rejected)

6. Conclusions and Implications

This study conducted exploratory and confirmatory factor analyses based on 118 survey responses to analyze the types of technological and managerial barriers faced by technology startups. Two factors, technological barriers and managerial barriers, were identified, and the reliability analysis ensured the validity and reliability of the measurement tool. Subsequently, 12 hypotheses were formulated to investigate significant differences in the two derived challenge factors (technological and managerial) based on six independent variables (entrepreneurial type, commercialization goal, dominant technology adoption, growth stage, commercialization stage, and research organization type). Multivariate Analysis of Covariance (MANCOVA) was employed, with revenue, number of employees, and company tenure as covariates to control for practical variations among technology startups.

Statistically significant results were obtained, and Bonferroni's post-hoc tests were conducted to validate the accepted hypotheses. Out of the 12 hypotheses, 5 were accepted (Hypotheses 1-2, 2-1, 2-2, 4-2, 5-1), while 7 were rejected. Notably, one accepted hypothesis verified that there is a significant difference in managerial barriers faced by technology startups based on their entrepreneurial type (Hypothesis 1-2). Convertsely, no significant difference in technological barriers based on entrepreneurial type was observed and, therefore, was rejected (Hypothesis 1-1). Furthermore, hypotheses testing the significant differences in technological and managerial barriers based on the commercialization goal of technology startups (Hypotheses 2-1, 2-2) were accepted. This suggests that companies with goals beyond simple revenue increase, such as prioritizing technology sales or business rights acquisition, face different barriers based on their objectives and factors. Additionally, the accepted hypothesis about the significant differences in managerial barriers based on the growth stage of the company (Hypothesis 4-2) indicates that, in contrast to technological barriers, managerial factors become increasingly crucial as companies progress quantitatively. However, no significant difference in technological barriers based on growth stage was observed, suggesting that technological barriers are more likely associated with individual products or the commercialization process. Finally, all hypotheses related to the organizational type were rejected (Hypotheses 6-1, 6-2), emphasizing that the company's research organization is more likely a result rather than a precursor to technological and managerial barriers, requiring a different perspective for interpretation.

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