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Institutional Factors Affecting University Startup Types and Their Performances in Korean Universities: A Panel Data Analysis

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[Abstract]

This study adopts a resource-based framework to investigate the factors driving the prevalence of three types of startups in universities by faculty, students, and university organizations, and their subsequent performance indicator, such as employee count. Specifically, we formulate twelve hypotheses that link institutional resources and university infrastructure to each type of university startups and their performance. By analyzing data from 130 South Korean four-year universities spanning the years 2017 to 2021, we examine variations across six distinct university resource categories.

Our findings reveal that the factors influencing different types of university startups are distinct. Research funds and universities' personnel policies have a significant impact on professor startups, whereas startup education programs and faculty startup performance are significant student startups. In addition, both the level of financial resources and the existence of a technology-holding company exert a broad influence on all three types of university startups, albeit with a distinction in the nature funds. Research funds are correlated with faculty and student startups, whereas commercialization funds are associated with universities' organizational startups. Nevertheless, the presence of a technology-holding company has a significant impact on all three types of university startups and their respective performances. Furthermore, the outcomes underscore a distinct contrast between the factors influencing each type of university startups and the factors influencing their respective performances. Our results provide implications for both university and government policy-makers, emphasizing the necessity for a targeted approach in policies aimed at fostering startups across faculty, students, and university organizations.

Keywords : University Resources, Professor Startups, Student Startups, Organizational Startups, University Startups' Employment

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Ⅰ. Introduction

For over two decades, universities have been recognized for their role as "entrepreneurial universities"(Etzkowitz, 1998) in regional development. This concept emphasizes universities' active engagement in job creation and value generation by leveraging their intellectual property, either directly or indirectly. It is argued that since universities receive significant public and private resources for research and development, the outcomes of these activities, such as commercialization, should also contribute to regional development. Several universities in the US, Europe, and Asia, including MIT, UT-Austin, and others, are often cited as exemplary models of this virtuous cycle, by producing university spin-offs that create a lot of jobs and sales, where their intellectual property creation leads to substantial financial gains and a more proactive contribution to regional development compared to other universities (Grimaldi et al., 2011).

Recognizing that university inventor-entrepreneurs can overcome technology information problems and that their successful commercialization efforts can have positive economic impacts on institutions and local communities in terms of wealth and job creation, the Korean government has recently been emphasizing the provision of financial support for professor startups. In response to the active involvement of the government and universities, the number of professor startups has witnessed a significant increase of over 70% in the past four years, with the average number of professor startups per surveyed university reaching 3.5 in 2021.

In the meantime, there has been a growing interest among college students in starting their own businesses. A survey conducted in 2022 revealed that 17% of college graduates are already running their own businesses, while 16% have plans to start one, and 27% are considering the possibility. Among those who are currently running or considering a business, 43% cited their passion for the work as the primary motivation. Many of these young entrepreneurs started their ventures while still in college, indicating a trend of early entrepreneurship.

The Korean government, following the example of the United States and several European countries, has taken steps to provide increased financial support for entrepreneurial endeavors in both public and private universities. As a result, universities in Korea are now placing a greater emphasis on entrepreneurship education to enhance their competitive advantage. Various resources are being introduced and allocated to support entrepreneurial activities, including financial assistance for student startups, the inclusion of entrepreneurship-related academic courses, and the provision of faculty and staff members to assist students in their entrepreneurial pursuits. This concerted effort aims to foster a culture of entrepreneurship among students and encourage them to explore and pursue their innovative ideas.

Furthermore, after the introduction of university technology-holding company system in Korea in 2007, 82 universities have established technology-holding companies in order to more efficiently facilitate commercialization of technologies and ideas developed within universities by taking the ownership of the ventures involved in the commercialization process. Additionally, there is another type of ventures that universities can establish, known as new technology startups. These startups may be more suitable for smaller universities with a limited amount of intellectual properties to be commercialized.

Despite a significant overall increase in the number of professor startups and student startups in Korea, there exists considerable variation among universities. While some universities have seen substantial success with 24 professor startups or 77 student startups, a significant portion of 4-year universities reported no professor startups (37.5%)

or no student startups (8.8%) between 2017 and 2021. To better understand the factors influencing student, professor and organizational startups and their performance, in terms of employment, we aim to analyze the inter-university variations in Korea. Our focus will be on examining the intellectual and financial resources available for professor startups, as well as the university systems and organizational resources that may facilitate or hinder university members' efforts to establish new firms for commercializing their technologies.

In the following sections, we will provide a concise literature review related to our research topic. Section III will outline and analyze the model we have developed to explain the intensity of professor, student, and organizational startups and their performances within Korean universities. The data and methodology will be presented in Section IV, and the empirical results will be discussed in Section V. Finally, we will conclude with remarks and discussions in the last section. Through this comprehensive analysis, we aim to shed light on the factors influencing professor, student, and organizational startups and identify strategies to further promote their success within the university ecosystem in Korea.

II. Theoretical Background

Given the substantial allocation of public and private resources towards research and development activities, universities are positioned as significant potential sources for technology-based startups. Such startups are recognized for their higher quality of employment and innovative performances (e.g., Choi et al., 2020). In fact, universities have made considerable investments in developing infrastructure to facilitate spin-offs and technology licensing, contributing to both their own revenue generation and regional economic growth. As a result, there has been a substantial increase in the number of patents registered by universities, and some institutions have accumulated significant royalties. This trend has led to an increased focus on university spinoffs as a crucial subject of research, primarily due to the heightened importance of universities' role in driving regional economic development.

Historically, established firms have been the primary drivers of technology commercialization stemming from universities due to their enhanced chances of survival and economies of scale (Showalter & Jensen, 2019). This emphasis on established firms has prompted much of the research to center around technology transfers through licensing arrangements. However, another significant avenue for technology transfers is through startups initiated by an organization within universities, such as Technology Licensing Offices (TLOs), as noted by Di Gregorio & Shane (2003), despite the hurdles they confront in terms of technology transactions, including information -related challenges.

This context underscores the role of university inventor-entrepreneurs who establish new firms to facilitate technology commercialization. Such an approach becomes necessary to navigate the challenges encountered in the knowledge market and to optimally leverage their specialized knowledge of the technology, whether implicit or explicit. Thus, university inventor-entrepreneurship emerges as a pragmatic alternative for the commercialization of university technologies. Despite not universally possessing managerial skills, some university faculty members or students exhibit proficiency in management, alongside their research and study acumen. This dual competence equips them to effectively harness their tacit or explicit knowledge derived from their research and development and learning endeavors.

The disparities, however, in startup activities of professors, students and university organizations, and business outcomes among universities underscore the presence of both micro and macro-level factors contributing to these

inter-institutional variations. These potential factors affecting the establishment of new firms can be grouped into two categories: micro and macro-level considerations.

On the micro-level, previous research has highlighted the significance of factors such as the inherent attributes of technological innovations (Shane, 2001), the career trajectories of inventors (Levin and Stephan, 1991), the psychological profiles of inventors (Roberts, 1991), and the research competencies possessed by inventors (Zucker et al., 1998) as influential determinants.

Conversely, macro-level analyses have revealed that broader factors, such as technological regimes (Shane, 2002), the extent of patent protection (Shane, 2001), and the intellectual property policies of institutions (Goldfard et al., 2001) also wield substantial influence over performance outcomes.

Focusing on the realm of university technology transfer, Chukumba and Jensen (2005) established a positive correlation between the age of Technology Transfer Offices (TTOs) and the number of licenses issued as well as the creation of university startups. Meanwhile, Ahlstrom and Bruton (2006) observed that university faculty members who possess connections with local venture capitalists exhibit a higher likelihood of securing investment and achieving successful startup ventures. Moreover, Henrekson and Rosenberg (2001) discovered that providing improved incentives to faculty members for their involvement plays a role in driving licensing and startup initiatives. Similarly, Di Gregorio & Shane (2003) and O'Shea et al.(2005) ascertained that heightened faculty quality, previous successful startup experiences, augmented external funding, and larger TTO sizes positively impact the quantity of startups linked to universities.

In the case of student startups, given the strong predictive power of intentions for anticipated behavior, the Theory of Planned Behavior has been extensively utilized in entrepreneurial intention research, with a significant body of literature adopting this conceptual framework. Within this theory, two primary lines of inquiry have emerged within the entrepreneurial field. The first line delves into the association between attitudes and entrepreneurial intentions (Douglas and Shepherd, 2002), while the second line investigates the correlation between self-efficacy and entrepreneurial intentions. Notably, this theory has been frequently employed to investigate the entrepreneurial intentions of young individuals, particularly among students. For instance, Vesper and Gartner (2007) conducted an empirical examination of entrepreneurship-related course design using survey data gathered from leading universities in the United States. Nonetheless, Dickson et al. (2008) point out that prior literature reviews have identified various shortcomings in previous research and have highlighted diverse prospects for future studies exploring the interplay between entrepreneurial education and outcomes pertaining to firm establishment.

< Table 1 > Factors Affecting University Startups

Categories	Factors	Authors
Characteristics of Entrepreneurs	-Previous Experiences -Ages -Previous Tech Transfers	-Khurana & Shane (2000) -Kim & Shin (2016) -Kim & Shin (2016)
Characteristics of Business Items	-Characteristics of Idead -Degree of Tacit Knowledge	-Shane (2001) -Lowe (2006)
Institutional Factors	-Intellectual Eminence -Faculty Size -Faculty Quality -Royalty Policy -Investor's Accessibility -Patents -Startup Support Office	-Di Gregorio & Shane (2003) -Friedman & Silberman (2003) -Showalter & Jensen (2019) -Di Gregorio & Shane (2003) -Dahl & Sorenson (2013) -Cho (2012) -Lockett & Wright (2005)

In the context of universities' technology commercialization, the majority of studies have concentrated on investigating the influence of Technology Transfer Offices (TTOs) startups on

effective university entrepreneurship. These studies have examined the correlation between university startups and various aspects, including individual traits of entrepreneurs, their knowledge and opportunities, and the surrounding environmental factors, as outlined in the summarized table. Although these investigations have contributed to enhancing our comprehension of university spinoff outcomes, there exists limited research directly addressing the factors that impact the degree of startup engagement among university professors, students, and organizaitons, and their subsequent performance, in terms of their employee numbers.

The first reason may be that a significant portion of research has predominantly centered around examining the elements influencing university technology licensing or the establishment of spinoff ventures, often neglecting to thoroughly investigate the entrepreneurial endeavors of professors or students themselves. This has consequently led to a discernible gap in our understanding of the distinctive institutional factors that shape the startup activities and achievements of professors and students. Moreover, only a limited number of studies have systematically probed into the underlying reasons behind the varying degrees of success among different universities in fostering professor or student startups. Lastly, the majority of existing literature has concentrated on the initial phases of business creation, omitting an in-depth analysis of the subsequent performance of these startups as they navigate the commercialization process for their developed concepts or technologies.

This study aims to address the aforementioned drawbacks by investigating how institutional elements impact university professor and student startups and their subsequent achievements, as well as their organizational startup activities. The key novelty of this research lies in its emphasis on institutional factors, particularly financial and intellectual resources, alongside entrepreneurial education initiatives and other organizational assets, tailored to the various types of startups within universities. These factors are pivotal in molding the capacity of professors, students, and orgnizational entrepreneurs to adeptly transform their concepts into viable enterprises through the creation and management of their own ventures.

Ⅲ. The Model

The significance of resource availability for the establishment and management of a firm has garnered substantial attention ever since Wernerfelt (1984) put forth the idea that a firm's competitive advantage could stem from its resource foundation. Building upon Wernerfelt's concepts, numerous studies have explored the correlation between resource availability and firms' competitive edge or performance (Lockett et al., 2009). Given that universities possess diverse intellectual and physical resources, along with educational infrastructure that can be harnessed by university spinoffs and aspiring entrepreneurs on campus, it is plausible that a link exists between the quantity of resources universities have and the engagement of university faculty researchers in the commercialization of their developed technologies. We classify five categories of institutional resources or systems: intellectual properties, financial resources, organizatonal resources, personnel policies, and startup education programs. Subsequently, we investigate the influence of these resources and infrastructure on explaining the disparities in professor, student and organizational startup activities across different universities. In line with prior research by Di Gregorio and Shane (2003) on university professor startup activities and startup performance, we have collected data on the annual count of startup companies initiated by professors, students, and university organizations, the number of employees within these firms, sourced from the Ministry of Education under the Korean government.

3.1 Intellectual Properties

By implementing effective systems for technology ownership, intellectual property registration, and incentives for university inventors, the volume of intellectual property held by universities can be viewed as a fundamental prerequisite for the successful commercialization of technology, whether undertaken by university personnel or external entrepreneurs. Notably, Newbert (2007) and Goldfarb et al. (2001) emphasize the influence of universities' knowledge and technological resources on the formation of new companies by universities to capitalize on their technologies. However, their focus primarily centers on university spinoffs, rather than university personnel's establishment of firms for the purpose of commercializing their own technologies.

Given that professors typically publish papers following the completion of their research for individual performance evaluations, irrespective of their specific research domains, the quantity of published papers can serve as a broad indicator of the potential knowledge reservoir available to university members including professors, students, and organizations for startups, whether the ideas are patented or not. Hence, as a first conceivable cluster of factors that might impact university startup endeavors, an examination is warranted regarding the potential influence of universities' intellectual property holdings and professors' publication records on the initiation of firms by university personnel or organizations and the ensuing performance of these ventures.

In particular, patents constitute the prevalent form of intellectual property rights registration for universities' research and development outputs. Thus, we aim to ascertain the correlation between the extent of universities' intellectual property rights, gauged by international patent application counts, and university members' active participation in founding firms for technology commercialization. Furthermore, we also intend to explore any potential effects of faculty's publication records, in terms of SCI publications, on their personal or organizational startup engagements. Consequently, we formulate a first set of hypotheses, outlined as follows:

Hypothesis 1a: Universities with more patent applications or more publications have a higher intensity of professor, students and organizational startup activities.

Hypothesis 1b: Universities with more patent applications or more publications produce a better performance in terms of professor, student and organizational startups' employment.

3.2 Financial Resources

The second focus of our analysis is on the resources accessible to universities for fostering startups within their campuses by internal entrepreneurs. This contrasts with the resource-based view that often emphasizes fully appropriable firm resources. Newbert's (2007) comprehensive review of 166 empirical studies testing the resource-based view underscored the significance of financial resources in shaping firm growth trajectories. Di Gregorio and Shane (2003) further demonstrated that universities that secured research and development funding from industries were more inclined to generate a greater number of spinoffs.

In our investigation, we extend our examination to encompass external funding for technology commercialization. Research funds, as a primary source, facilitate university faculty's research and development efforts, thereby resulting in the creation of new intellectual properties, especially patentable technologies. These intellectual properties can then be leveraged directly or indirectly through technology transfers to startups or established enterprises. Furthermore, the

availability of commercialization funds from governmental bodies or industries can potentially wield substantial influence on professor, student and organizational startups and their subsequent performance. Given that technology-based ventures necessitate considerable working capital for their establishment and operation, these funds assume a pivotal role.

Accordingly, our primary aim is to dissect the impact of two types of external funding: research funds and commercialization funds, on the initiation of university professor startups and their subsequent performance, in terms of their employee counts. In light of this, we propose the following initial hypotheses:

Hypothesis 2a: Universities with higher levels of research funds or more amounts of commercialization funds exhibit a greater propensity for professor, student, and organizational startup creation.

Hypothesis 2b: Universities with higher levels of research funds or more amounts of commercialization funds demonstrate superior professor, student and organizational startup performance, as indicated by the number of employees.

3.3 Organizational Resources

Over the past five decades, there has been a significant upsurge in the establishment of spinoffs originating from universities, prompting a corresponding rise in the prevalence of technology licensing offices and other support systems within these institutions. These offices and systems seem to play a crucial role in aiding university-affiliated entrepreneurs in converting their innovative concepts or technologies into viable commercial endeavors. Numerous studies have delved into the determinants that contribute to the emergence of university spinoff companies, with a particular emphasis on university faculty and researchers, exemplified by Astebro et al.'s research in 2012. This extensive body of literature provides compelling evidence supporting the effectiveness of these initiatives in cultivating spinoff ventures within the university context. In parallel, numerous universities in Korea have embraced a distinct organizational approach known as "startup support offices" with dedicated startup support staff and allocated business space. Unlike solely focusing on technology transfer for commercialization, these offices are dedicated to delivering startup support services to faculty, staff, and students. Additionally, a novel incubation model, referred to as "university technology holding companies," has recently emerged. These entities specialize in establishing technology spinoffs as subsidiary entities by acquiring ownership of technologies developed within the university community. Son et al.(2022) demonstrated that universities adopting this technology holding company approach exhibited enhanced productivity in terms of effectively commercializing their technologies.

Irrespective of the nomenclature used, it remains imperative that these entities provide valuable services and physical space to aspiring entrepreneurs while actively fostering business creation activities on campus. In light of this, our investigation is aimed at probing the potential influence of a university's startup support organization on two significant aspects: the degree of startup activity among the institution's professors, students and organizations, and their subsequent business performance. We will delve into three primary dimensions of the startup support organization: the size of the staff engaged, the quantum of space allocated for startup endeavors, and the presence or absence of a technology holding company within the university's framework, alongside the level of research facilities. The aim is to uncover the potential influence of these variables on the entrepreneurial activities and achievements of the university's constituents. As a

result, we present the following set of hypotheses:

Hypothesis 3a: Universities with a larger size of startup support organization, offering more business space for startups, having wider business space, or introducing a technology holding company, experience a higher intensity of professor, student or organizational startups.

Hypothesis 3b: Universities with a larger size of startup support organization, offering more business space for startups, having wider business space, or introducing a technology holding company, produce a better performance of the startups in terms of their employment.

3.4 Startup Education Programs

As per human capital theory, a central concept posits that education enhances productivity. It's argued that pre-existing knowledge significantly contributes to intellectual capacities, aiding not only the accumulation of knowledge but also adaptability to novel situations. This assertion finds empirical validation in studies on entrepreneurs' business performance and income, exemplified by research such as the work conducted by Davidsson and Honig in 2003. This principle can similarly extend to entrepreneurs functioning within the academic context.

In an endeavor to foster an environment conducive to startups, universities have proactively expanded their entrepreneurship education initiatives, leveraging governmental funding and internal resources. These initiatives range from brief training courses, often tailored to adult entrepreneurs, to comprehensive academic programs designed to meet the specific needs of students. Additionally, many universities provide practical platforms like startup clubs, affording potential entrepreneurs hands-on experience with preliminary business concepts. However, despite being recognized as springboards for student entrepreneurs, startup clubs at universities have received limited research attention thus far. While a few studies have aimed to analyze their true impact, such as Hong and Seol (2014), which indicates that students engaged in entrepreneurship courses or participated in startup clubs are significantly more likely to formulate viable startup plans, these outcomes do not represent the final outcomes of venture creation.

Simultaneously, most studies have predominantly concentrated on the influence of entrepreneurship education on entrepreneurial intent among college students, rather than their actual entrepreneurial engagement (as seen in studies like Bae et al. in 2014), generally demonstrating a positive effect of entrepreneurship education on students' startup intentions.

Given our focus on universities' role in students' startup activity, our objective is to explore the direct connection between universities' entrepreneurship education initiatives and their students' startup engagement. To conduct our analysis, we intend to gauge the level of entrepreneurship education in each university based on two parameters: the count of supported startup clubs and the number of offered entrepreneurship courses annually. By using this data, we aim to probe the institutional level relationship, which may reveal correlations between institutional disparities and student startup activity, along with their subsequent performance. Therefore, we put forward the following hypotheses:

Hypothesis 4a: Universities offering a higher number of entrepreneurship courses, with a greater number of students enrolling in startup courses or with more startup clubs, demonstrate a heightened level of student startup activity.

Hypothesis 4b: Universities offering a higher number of entrepreneurship courses, with a greater number of students enrolling in startup courses or

with more startup clubs, yield enhanced performance in terms of startups' employment outcome.

3.5 Personnel Policy

Given that a significant portion of university faculty members are employed on a full-time basis, it becomes practically unfeasible for professors to actively engage in startup endeavors when universities have stringent policies regarding leaves of absence or the acceptance of dual employment. Grimaldi et al. (2011) underscore that university regulations and protocols, which facilitate the establishment of new firms by their staff through provisions for leaves of absence or the concurrent pursuit of managerial roles within startups alongside their academic positions, can significantly influence the performance of university spinoffs. In light of the fact that a considerable number of Korean universities permit professors to take leaves of absence for the purpose of founding or managing innovative startups, we aim to investigate the duration of these leaves and their potential impact on the creation of university professor startups as well as their subsequent performances. Therefore, our next set of hypotheses are as follows:

Hypothesis 5a: Universities that provide professors with an extended duration of leave for startup activities have a higher number of professor startups.

Hypothesis 5b: Universities that provide professors with an extended duration of leave for startup activities have a larger number of professor startups' employment.

3.6 Faculty Startups

Concerning the correlation between faculty-led startups and student-led startups, our initial presumption is that universities with a greater count of startups initiated by faculty members would be more adept at fostering student startups. This stems from the notion that entrepreneurial professors could directly encourage students to participate in commercialization projects or indirectly guide and mentor them towards launching their own ventures. While there are studies that compare the roles (as evident in Hasegawa & Sugawara, 2017) and performance (as observed in Roche et al., 2020) of faculty and student startups, we haven't encountered research that specifically explores the interrelation between these two categories of startups within academic institutions.

Consequently, we aspire to probe the correlation between the prevalence of faculty startups and the prevalence of student startups, as well as their respective performance, including metrics such as employment figures and sales revenue. Our objective is to gauge whether entrepreneurial professors wield a positive influence on students' venture initiation and their subsequent performance within university settings. To this end, we present the ensuing set of hypotheses:

Hypothesis 6a: Universities characterized by a higher occurrence of faculty-led startups exhibit a heightened occurrence of student startup activities.

Hypothesis 6b: Universities marked by a higher frequency of faculty-led startups manifest superior performance in terms of student startups' employment levels.

Ⅳ. Data and Methodology

In this section, we provide elucidation on the sample under consideration, as well as the variables subjected to analysis in this study. Additionally, we offer an outline of the analytical approaches we employed for our investigation.

4.1 Sample

All educational institutions, including universities and colleges, in Korea are mandated to submit comprehensive information about their students, professors, staff, educational systems, research and development activities, intellectual property rights, and technology commercialization efforts. This information is compiled in an open database accessible at www.academyinfo.go.kr. The database encompasses various aspects such as R&D funding, research facilities, academic paper publications, patent applications and registrations, technology commercialization funding, details about technology-holding companies, divisions devoted to technology commercialization support, technology transfer accomplishments, and specifics about professor startups along with their employment performance.

Employing panel data analysis methodologies, our study procured data from the years 2017 to 2021 for 130 universities. We specifically focused on universities with complete professor, student and organizational startup data available for all four years in the database. As a result, our sample consisted of 650 university-year observations.

For the assessment of intellectual prominence, we leveraged the QS World University Rankings from www.qs.com. This widely utilized assessment method gauges the strengths of academic institutions, encompassing subject-specific rankings such as those for Engineering and Technology fields. These fields encompass various disciplines including computer science and information systems, chemical engineering, civil and structural engineering, electrical and electronic engineering, mechanical engineering, and mineral and mining engineering. The ranking criteria encompass factors like academic reputation, employer reputation, and citations per faculty, collectively representing the level of academic excellence of the universities.

4.2 Dependent Variables

The response variables consist of two variables of each of three categories: the counts of university professor, student and organizational startups established within a specific year, and the employee counts of professor, student and organizational startups by the year's end. Among the 650 university-year observations, there were 406 instances where professor startups were initiated. The maximum count was 24, with the mean and standard deviation calculated at 2.3 and 3.4, respectively. Those startups employed an average of 2.5 individuals, with the maximum employment reaching 75. Regarding student startups, the database contained 593 instances where at least one student startup was established. The highest count was 77, while the mean and standard deviation were 9.9 and 11.4, respectively. They employed 8.1 individuals on average, with the and standard deviation of 42.1. Furthemore, university organizations established an average of

< Table 2 > Summary Statistics of Dependent Variables

Variable	Observ-ations	Mean	S.D.	S.D. between Schools	S.D. within Schools	Minimum	Maximum
Student Startups	650	9.88	11.39	9.47	6.35	0	77
Student Startups' Employment	650	8.09	42.08	20.69	36.68	0	883
Professor Startups	650	2.29	3.40	2.68	2.11	0	24
Professor Startups' Employment	650	2.49	6.27	4.98	3.83	0	75
Organizational Startups	650	6.08	10.07	9.24	4.06	0	68
Organizational Startups' Employment	650	26.39	57.05	52.34	23.06	0	577

6.1 firms, with a standard deviation of 10.1. Theses organizational startups employed an average of 26.4 individuals, with the maximum employment figure of 577.

The distribution patterns of professor, student and organizational startups are heavily skewed, as indicated by the means of 2.5, 9.9, and 6.1, and the standard deviations of 3.4 and 11.39, respectively. Additionally, 39.7% of the observations reported zero values, underscoring the inappropriateness of employing least squares regression analysis. The distribution of employee numbers in professor, student, and organizational startups are even more skewed, with means of 2.5, 8.1, and 26.4, and standard deviations of 6.3, 42.1, and 57.1. The maximum recorded employee counts were 75, 883, and 577, respectively.

4.3 Independent Variables

To quantify the extent of universities' intellectual properties, two indicators were employed: the number of papers published by professors, measured by the count of SCI papers published in a specific year, and the count of international patent applications filed within the same year. The average count of SCI papers published was 222.1, accompanied by a standard deviation of 330.7, indicating significant variability. Similarly, the average count of international patent applications stood at 34.0, with a standard deviation of 76.1, highlighting substantial fluctuations in this regard as well.

To assess the impact of universities' financial resources on professor startups and their performance, two metrics were investigated: the university's allocation of research and development (R&D) funds in a particular year, and the university's engagement in industrial collaboration or commercialization, reflected by the commercialization fund amount for the same year. The mean value of R&D funds was 48.5 billion Korean won, and these figures displayed notable variability, with a standard deviation of 85.2 billion won and a maximum value of 626.0 billion won.

Similarly, commercialization funds exhibited significant diversity across universities, with an average of 53.8 billion won and a standard deviation of 75.0 billion won.

The subsequent group of independent variables examined the availability of human and physical resources within universities. This included the count of commercialization support staff members,

< Table 3 > Summary Statistics of Independent Variables

Variable	Observ-ations	Mean	S.D.	S.D. between Schools	S.D. within Schools	Minimum	Maximum
SCI Paper	650	222.21	330.67	330.03	33.12	0	2353
International Patent Applications	650	34.03	76.08	74.35	17.16	0	598
R&D Fund (billion won)	650	48.50	85.20	84.70	11.80	0.35	626.00
Commercialization Fund (billion won)	650	43.80	75.00	63.80	39.60	0.01	599.00
Number of Support Staff	650	12.22	11.45	10.53	4.57	0	83
Startup Space (m2)	650	1167.98	1541.36	1268.60	881.10	0	9462
Research Facilities	650	64.22	92.97	93.27	0.22	0	717
Startup Leave Period (months)	650	29.69	30.22	28.54	10.19	0	120
Technology-holding Company	650	0.53	0.54	0.50	0.20	0	1
Startup Courses	650	86.43	250.74	248.11	41.09	0	2831
Startup Course Enrolling Students	650	1913.47	1832.09	1715.59	656.85	0	11979
Startup Clubs	650	30.00	26.50	23.24	12.88	0	185
Professor Startups	650	2.29	3.40	2.68	2.11	0	24.00

the provision of on-campus space specifically designated for university startups, the amount of research facilities, and the existence of a technology holding company. The mean count of commercialization support staff members was 12.2, with a standard deviation of 11.4 and a maximum count of 83. In terms of the on-campus area allocated for university startup activities, the mean was 1,168.0 square meters, accompanied by a standard deviation of 1,541.4 square meters. The number of R&D and prototyping facilities at universities was recorded as 64.2 on average, with a standard deviation of 93.0. Among the total of 650 university-year observations, 331 indicated the presence of a technology holding company within the university, signifying a positive value for this variable.

Another independent variable pertains to universities' personnel policies, represented by universities' policies and regulations concerning professors' leaves of absence for the purpose of establishing and managing startups. Approximately 59.2% of the universities permit their full-time faculty members to take a leave of absence for startup creation and management. The average duration of such leaves, including both the initial leave and possible extensions, is 29.7 months, with a standard deviation of 30.2 months.

4.4 Control Variables

Anticipating a potential correlation between the number of university startups and their performance and the scale of universities, we introduced a control variable representing the number of professors at each university in a given year. On average, universities had approximately 481.0 professors during a given year, with a standard deviation of 359.9. As an additional control variable in our analysis, we incorporated universities with high QS rankings. This inclusion was intended to focus on the resource-related factors' effects on university startups. In each year under scrutiny, there were 4, 4, 7, 7, and 7 universities that secured a position among the top 100 QS rankings. Additionally, we considered the potential impact of the universities' categorization as public or private institutions on university members' inclination to establish firms for technology commercialization. To account for this, we included a control variable indicating the foundation type of the universities. Notably, our sample comprised 30 public universities.

4.5 Estimation

Our analysis comprises three distinct models. For those models, we employed zero-inflated negative binomial regressions. Our selection of this analytical technique was based on several considerations: (1) the dependent variables in these models represented count data, with mean values smaller than 10, with the exception of the organizational startups' employment. (2) we expected that the standard errors might exhibit temporal autocorrelation; (3) a notable proportion (37.5% for professor startup observations, 8.8% of student startup observations, and 51.2% of organizational startup observations) of the data featured zero values during the analysis timeframe; and (4) potential unobserved variations at the university level could influence both startup rates and employment figures.

Initially, we examined the negative binomial regression and found it to be more suitable than the Poisson regression, as the likelihood-ratio test rejected the assumption of $\alpha=0$. The negative binomial regression revealed significant discrepancies between panel data estimators and pooled estimators. Moreover, the Hausman test indicated no substantial difference between random effect and fixed effect models. Subsequently, upon conducting the zero-inflated negative binomial model, we ascertained its suitability over the zero-inflated Poisson model by again rejecting the

assumption of α=0. Thus, we opted to employ the zero-inflated negative binomial model, with the cluster option applied, for our analysis.

V. Results

Table 0 presents the outcomes of the regression analysis. Model 1 offers insights into the factors influencing professor startups and their employment, while model 2 offers estimates for student startups and their employment. Model 3 shows universities' organizational startups and their employment. Those models employ the zero-inflated negative binomial technique to find out effective factors affecting each type of startups and their employment, respectively.

Collectively, the outcomes of the analysis reveal a notable disparity in the factors influencing the three categories of university startups and their employment levels, except for the presence of a technology-holding company.

In model 1, both the amount of research funds and the technology-holding company exhibited significant positive effects on professor startups and their employment. The results show that a 10% increase in the amount R&D funds resulted in an additional 0.02 professor startups and 0.04 more employment positions. Similarly, the presence of a technology-holding company correlated with 0.35 more startups by professors and 0.44 more employment positions within these startups. Furthermore, the duration of professors' startup leave, the count of commercialization staff, and the extent of startup space exerted a significant impact on professor startup counts, although not on their employment. Conversely, the quantity of SCI papers published and the number of international patent applications were not found to have substantial effects on professor startups or their employment.

In model 2, several factors emerged as significant contributors to both student startup counts and their employment. Notably, the amount research funds, the presence of a technology-holding company, and the number of startup courses showed significant effects both on student startup counts and on their employment. This could be attributed to the collaborated efforts between professors and students, as well as students and university organizations, during the establishment and operation of startups. In contrast, the number of startup support staff, the number of startup clubs, and the count of professor startups were found to influence student venture creation activities, although these variables did not have a substantial effect on their employment. Regarding startup education programs, the number of students enrolled in startup courses and the number of startup clubs were correlated with student startup counts, though not with their employment. Interestingly, the number of startup

< Table 4 > Hypotheses Acceptance/Rejection Results

Hypothesis	Acceptance/Rejection					
	Professor Startup Counts	Professor Startup Employment	Student Startup Counts	Student Startup Employment	Organizational Startup Counts	Organizational Startup Employment
H1	Rejected	Rejected	Rejected	Accepted	Partially Accepted	Partially Accepted
H2	Partially Accepted	Partially Accepted	Partially Accepted	Partially Accepted	Partially Accepted	Partially Accepted
H3	Partially Accepted	Partially Accepted	Partially Accepted	Partially Accepted	Partially Accepted	Partially Accepted
H4	–	–	Accepted	Partially Accepted	–	–
H5	–	–	Accepted	Rejected	Rejected	Rejected
H6	Accepted	Rejected	–	–	–	–

courses demonstrated an influence on both student startup counts and their employment.

In model 3, the factors that emerged as significant are notably distinct from those observed in the previous two models. Specifically, the number of international patent applications, the amount of commercialization funds, and the presence of a technology-holding company exhibited significant effects on both organizational startup counts and their employment. This outcome aligns with our expectations, as the presence of a technology-holding company is anticipated to leverage universities' intellectual properties, utilizing commercialization funds to establish venture firms. In contrast, the count of startup support staff and the quantity of research facilities exerted a significant impact solely on organizational startup counts, without significant influence on their employment.

We controlled for universities' research reputation, university size, measured by the number of professors, and the funding structure of universities. None of these factors demonstrated a consistent correlation with the three types of university startups. However, it is worth noting that the size of universities had a significant impact on universities' organizational startup counts and their performance. This suggests that as the number of professors increases, the number of universities' organizational startups within universities and their employment increase.

Based on the estimates from the three groups of models, we can outline the factors that influence the counts of professor, student, and organizational startups and their employment as follows:

First of all, the analysis outcomes indicate that the factors influencing different types of university startups are distinct. Research funds and universities' personnel policies have a significant impact on professor startups, whereas startup education programs and professor startup performance are significant student startups.

< Table 5 > Estimates of the Three Models

Variables	< Model 1a > Professor Startup Counts	<Model 1b > Professor Startup Employment	< Model 2a > Student Startups Counts	< Model 2b > Student Startups' Employment	< Model 3a > Organizatonal Startup Counts	< Model 3b > Organizational Startups' Employment
Intellectual Properties						
- SCI Papers	-.00002 (.0004)	.00041 (.0006)	.00044 (0004)	.00170 (.00086)**	-.00075 (.00047)	-.00217 (.00064)
- Int'l Patent Applications	.00058 (.0011)	.00062 (.0016)	.00005 (.0009)	.00500 (.00219)**	.00196 (.00115)*	.005836 (.00157)***
Financial Resources						
- Research Fund	.21488 (.0556)***	.39314 (.0847)***	.25985 (0271)***	.76207 (.06098)***	-.10508 (.07023)	-.04568 (.08865)
- Commercialization Fund	.01065 (.0103)	.01732 (.0157)	.01425 (.0095)	-.04650 (.0289)	.03606 (.01147)***	.04939 (.01424)***
Organizational Resources						
- Number of Startup Staff	.01169 (.0043)***	.00397 (.0064)	-.00977 (.0036)***	-.00136 (.0087)	.01121 (.00481)***	.00156 (.00657)
- Research Facilities	.00030 (0006)	.00007 (.0009)	-	-	.00158 (.00061)***	.00012 (.00088)
- Startup Space	.000085 (.00003)***	.0006 (.0005)	-.00003 (.00003)	-.00001 (.00006)	-.00001 (.00004)	-.00004 (.00005)
- Technology-Holding Com	.35322 (.1079)***	.44114 (.1587)***	.17358 (.0799)***	.87746 (.19544)***	6.6142 (.52752)***	7.26905 (.44819)***
Startup Education						
- Startup Courses	-	-	.00028 (.00016)*	.00301 (.00115)***	-	-
- Startup Course Students			.00013 (.00002)***	.00008 (.00007)		
- Startup Clubs			.00709 (.0016)***	.00164 (.00347)		
Personnel Policy						
- Professor Startup Leave Period (months)	.00424 (.0015)***	.00026 (.0024)	-	-	-.00005 (.00174)	.00231 (.00236)
Professor Startup	-	-	.04202 (.0143)***	-.00106 (.03349)	-	-
Control Variables						
- QS Ranking 100	-.09607 (.2052)	.05694 (.2481)	-.04366 (.1670)	-.25660 (36743)	.09525 (.21329)	.11669 (.31610)
- Number of Professors	.00033 (.0003)	-.00004 (.00005)	.00015 (.0003)	-.00086 (.00056)	.00077 (.00036)**	.00134 (.00049)***
- University Type(public)	-10.3686 (665.21)	-.05184 (.3962)	-13.0636 (3333.49)	-11.4185 (416.54)	14.054 (722.64)	1.3041 (1150.54)
Constant	-4.0565 (.8876)	-6.8275 (1.3751)	1.1215 (.2165)***	1.2649 (.70081)*	-3.8528 (1.2174)***	-4.7695 (1.4759)***
Log Likelihood	165.24	417.32	1892.65	7201.40	1990.83	10000.00

Number of observations, 650; number of universities, 130. Standard errors in parenthesis.
* p<0.1, ** p<0.05, *** p<0.01

Furthermore, the amount of international patent applications and the availability of commercialization funds play crucial roles in promoting universities' organizational startups.

Secondly, both the level of financial resources and the existence of a technology-holding company exert a broad influence on all three types of university startups, albeit with a distinction in the nature funds - research versus commercialization. Research funds are correlated with faculty and student startups, whereas commercialization funds are associated with universities' organizational startups. Nevertheless, the presence of a technology-holding company has a significant impact on all three types of university startups and their respective performances.

Thirdly, the outcomes underscore a distinct contrast between the factors influencing each type of university startups and the factors influencing their respective performances. The count of startup support staff exhibited a significant influence on all three categories of startup counts, while not significantly affecting employment. Furthermore, the duration of professors' startup leave and the area of startup space within universities exerted an impact on professor startup counts, albeit not on their employment. Similarly, the number of professor startups, the enrollment of students in startup courses, and the number startup clubs exhibited significant impacts on student startup counts, yet without influencing their employment. Concerning universities' organizational startups, the number of research facilities displayed an impact on their counts, though not on their employment.

VI. Conclusions and Limitations

Grimaldi et al. (2011) put forward the notion that academic entrepreneurship can be fostered through three levels of action: (a) overarching system-level measures, (b) institutional support mechanisms, and (c) individual scientist-level factors. In the context of this study, we examined six categories of institutional factors to comprehend the variances in three types university startup counts and their performances, in terms of employment across different universities in Korea from 2017 to 2021. These categories encompass universities' intellectual property holdings, financial resources, organizational resources, personnel policies, and startup infrastructure. The outcomes underline that the factors influencing each type of university startups and their performance differ. This implies that universities should strive to provide more resources and programs available for prospective startups within universities, and establish a more encouraging environment through flexible personnel policies and robust startup support infrastructure to motivate a higher number of university members or organizations to initiate their own technology commercialization ventures. Meanwhile, enhanced financial resources and intellectual property holdings are key for achieving better performance outcomes. Additionally, the presence of a university technology-holding company emerges as pivotal for boosting both the count of each type of university startups and their performance.

Our findings carry three significant implications for both research and policy regarding university professors' startup endeavors. Firstly, our results do not corroborate the notion that financial resources and intellectual property play a role in driving the counts of the three types of university startups. Instead, it appears that these factors exert their influence in a nuanced manner, contingent on the specific nature of the university startups. For instance, research funds emerge as significant drivers for faculty and student startups, whereas commercialization funds exhibit importance for the organizational startups within universities.

Secondly, our study highlights the importance of cultivating a conducive environment or framework within universities. This involves implementing flexible personnel policies and enhancing the startup support infrastructure. These measures can

effectively encourage more professors and students to embark on their own technology commercialization journeys.

Thirdly, our analysis reveals that the prominence of a university's research does not correlate with the counts of university startups or their business achievements. Lastly, we have demonstrated that certain components of university infrastructure, notably the presence of a technology-holding company, have a demonstrable impact on the establishment and performance of university startups. Policy-makers and university managers need to concentrate on their role in fostering innovative startup creation and enhancing the effectiveness in business foundation in commercializing university technologies.

While this study provides valuable empirical insights into three types of startups within universities, however, it does come with certain limitations that underscore the need for further research. Firstly, due to data limitations, the study did not account for individual attributes like age, gender, academic discipline, and family income, which are known to significantly influence startup endeavors. The absence of these individual determinants could introduce potential bias into the research findings.

Secondly, comprehending the decision-making processes behind business creation requires an examination of societal and environmental factors alongside individual and institutional contexts. While past research has delved into the impact of environmental elements such as venture capital, science parks, and incubation facilities on startups, there remains limited empirical evidence exploring the specific effects of these factors within the realm of university startups. A more comprehensive exploration of how resources and environmental factors interplay to influence startups is imperative.

Thirdly, while the study suggests a positive relationship between professor startups and student startups, a deeper understanding of the mechanisms underpinning this influence is needed. It's plausible that entrepreneurial professors may directly motivate students to embark on commercialization endeavors or indirectly guide and mentor them in starting their own ventures. Further investigation into how entrepreneurial professors shape and impact aspiring student entrepreneurs in their startup activities would provide more nuanced insights into the intricate relationship between these two categories of startups within university settings.

To enhance future research, it is imperative to obtain muti-year data for the same sets of startups. This extended timeframe will enable more comprehensive and insightful long-term analyses, addressing the limitations associated with relying on one-year sets of startup data.

References

Ahlstrom, D. & Bruton, G. D. (2006). Venture Capital in Emerging Economies: Networks and Institutional Change. **Entrepreneurship Theory and Practice**, 30(2), 299-320.

Åstebro, T., Bazzazian, N., & Braguinsky, S. (2012). Startups by recent university graduates and their faculty: Implications for university entrepreneurship policy. **Research policy**, 41(4), 663-677.

Bae, T. J., Qian, S., Miao, C., & Fiet, J. O. (2014). The Relationship Between Entrepreneurship Education and Entrepreneurial Intentions: A Meta-analytic Review. **Entrepreneurship Theory and Practice**, 38(2), 217-254.

Cho, H. (2012). An Analysis on Factors Affecting University Technology Commercialization. **Intellectual Property Research**, 7(3), 217-245.

Choi, D. S., Sung, C. S. & Park, J. Y. (2020). How Does Technology Startups Increase Innovative Performance? The Study of Technology Startups on Innovation Focusing on Employment Change in Korea. **Sustainability**, 12(2), 551-570.

Chukumba, C. & Jensen, R. (2005). University Invention, Entrepreneurship, and Start-ups, www.nber.org

Dahl, M. S. & Sorenson, O. (2013). The Who, Why, and How of Spinoffs. I**ndustrial and Corporate Change**, 23(3), 661-688.

Davidsson, P., & Honig, B. (2003). The Role of Social and Human Capital Among Nascent Entrepreneurs. **Journal of Business Venturing**, 18(3), 301-331.

Dickson, P. H., Solomon G.T., & Weaver, K. M. (2008). Entrepreneurial Selection and Success: Does Education Matter?. **Journal of Small Business and Enterprise Development**, 15(2), 239-258.

Di Gregorio, D. & Shane, S. (2003). Why Do Some Universities Generate More Start-ups Than Others?. **Research Policy**, 32(2), 209-227.

Douglas, E., & Shepherd, D. (2002). Self-employment As a Career Choice: Attitudes, Entrepreneurial Intentions, and Utility Maximization. **Entrepreneurial Theory and Practice**, 26, 81-90.

Etzkowitz, H. (1998), The Norms of Entrepreneurial Science: Cognitive Effects of the New University-industry Linkage. **Research Policy**, 27(8), 823-833.

Friedmand, J. & Silberman, J. (2003), University Technology Transfer: Do Incentives, Management, and Location Matter?. **The Journal of Technology Transfer**, 28(1), 17-30.

Goldfarb, B., Henrekson, M. & Rosenberg, N. (2001). Demand vs. Supply Driven Innovations: US and Swedish Experiences in Academic Entrepreneurship. SSE/EFI Working Paper Series in Economics and Finance, No. 436

Grimaldi, R., Kenney, M., Siegel, D. S. & Wright, M. (2011). 30 Years After Bayh-Dole: Reassessing Academic Entrepreneurship. **Research Policy,** 40(8), 1045-1057.

Hasegawa, K., & Sugawara, T. (2017). Characteristics of University Startups in Japan. IEEE Technology & Engineering Management Conference (TEMSCON) (pp. 67-72). IEEE.

Henrekson, M. & Rosenberg, N. (2001). Designing Efficient Institutions for Science-based Entrepreneurship: Lesson from the US and Sweden. **The Journal of Technology Transfer**, 26(3), 207-231.

Hong, H., & Seol, B. (2013). The Effects of Startup Education and Club Experience on Youth Startups. **Asia-Pacific Journal of Business Venturing and Entrepreneurship**, 8(2), 141-151.

Johnson, D. K., & Acri née Lybecker, K. M. (2009). Challenges to Technology Transfer: A Literature Review of the Constraints on Environmental Technology Dissemination

Khurana, R. & Shane, S. (2000). Career Experiences and Firm Foundings. Available at SSRN 172513

Kim, Y. & Shin, S. (2016). Factors on University's Knowledge-based Startups, Focusing on University's Patents. **Intellectual Property Research**, 11(1), 163-196.

Levin, S. G. & Stephan, P. E. (1991). Research Productivity Over the Life Cycle: Evidence for Academic Scientists. **The American Economic Review**, 114-132.

Lockett, A., Thompson, S. & Morgenstern, U. (2009). The Development of the Resource-based View of the Firm: A Critical Appraisal. **International Journal of Management Reviews**, 11(1), 9-28.

Lockett, A. & Wright, M. (2005), Resources, Capabilities, Risk Capital and the Creation of University Spin-out Companies. **Research Policy**, 34(7), 1043-1057.

Lowe, R. A.(2006), Who Develops a University Invention? The Impact of Tacit Knowledge and Licensing Policies. **Journal of Technology Transfer**, 31(4), 415-429.

Newbert, S. L. (2007). Empirical Research on the Resource-based View of the Firm: An Assessment and Suggestions for Future Research. **Strategic Management Journal**, 28(2), 121-146.

O'shea, R. P., Allen, T. J., Chevalier, A. & Roche, F. (2005). Entrepreneurial Orientation, Technology Transfer and Spinoff Performance of US Universities. Research Policy, 34(7), 994-1009.Roberts, E. B. (1991). Entrepreneurs in High Technology: Lessons from MIT and Beyond. Oxford University Press.

Roche, M. P., Conti, A., & Rothaermel, F. T. (2020). Different Founders, Different Venture Outcomes: A Comparative Analysis of Academic and Non-academic Startups. **Research Policy**, 49(10), 104062.

Shane, S. (2001), Technological Opportunities and New Firm Creation. **Management Science**, 47(2), 205-220.

Shane, S. (2002). Organizational Endowments and the Performance of University Start-ups. **Management Science**, 48(1), 154-170.

Showalter, D. & Jensen, R. (2019). University Startup Intensity and Faculty Quality. **Economic Inquiry**, 57(2), 855-875.

Son, H., Chung, Y., & Yoon, S. (2022). How Can

University Technology Holding Companies Bridge the Valley of Death? Evidence from Korea. **Technovation**, 109, 102158.

Vesper, K.H. & Gartner, W.B. (1997). Measuring Progress in Entrepreneurship Education. **Journal of Business Venturing**, 12(5), 403-421.

Wernerfelt, B. (1984). A Resource-based View of the Firm. **Strategic Management Journal**, 5(2), 171-180.

Zucker, L. G., Darby, M. R. & Armstrong, J. (1998). Geographically Localized Knowledge: Spillovers or Markets?. **Economic Inquiry**, 36(1), 65-86.

Academyinfo.go.kr, Retrieved on June 10th, 2023

Index.go.kr, Retrieved on July 5th, 2023

Intelligent.com, Retrieved on May 29th, 2023