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Institutional Factors Affecting Faculty Startups and Their Performance in Korea: A Panel Data Analysis

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Abstract

This paper adopts a resource-based approach to analyze why some universities have a greater number of faculty startups, and how this impacts on performance, in terms of indictors such as the number of employees and revenue sales. More specifically, we propose 9 hypotheses which link institutional resources to faculty startups and their performance, and compare 5 different groups of university resources for cross-college variation, using data from 134 South Korean four-year universities from 2017 to 2020. We find that the institutional factors impacting on performance of faculty startups differ from other categories of startups. The results show that it is important for universities to provide a more favorable environment, incorporating more flexible personnel policies and accompanying startup support infrastructure, for faculty startups, whilest it is more effective to have more financial resources and intellectual property for other categories of startups. Our findings also indicate that university technology-holding company and technology transfer programs are crucial to increase the number of faculty startups and their performance. Our analysis results have implications for both university and government policy-makers, endeavoring to facilitate higher particaption of professors in startup formation and ultimate commercialization of associated teachnologies.

Keywords: Academic Entrepreneurship, Technology Commercialization, Faculty Startup, University Resources, Startup Infrastructure

Ⅰ. Introduction

It has been more than 20 years since the role of universities "entrepreneurial university(Etzkowitz, 1998)" was recognized in regional development, which focuses on universities' active involvement in creating jobs and value-creation by utilizing their intellectual property both directly and indirectly. It has been argued that since universities utilize significant amounts of public and private resources, for their research and development activities, the outcomes of these activities such as commercialization should also benefit the regional development[1].

A number of US universities, such as MIT and UT-Austin, and others in Europe and Asia are often illustrated as good exemplars of a virtuous cycle generated from their intellectual property creation, reaping substantially larger financial gains and contributing regional development more actively, compared to other universities(Grimaldi et al., 2011)[2].

Upon enactment of new systems, permitting universities' ownership by contractors of inventions arising from government-funded research, such as the Bayh-Dole Act in the USA, universities have been incentivized to utilize the results of the research. However, commercialization of university inventions has mostly been in the form of technology licensing, with each university annually licensing 23.8 inventions to established or start-up firms in the USA(AUTM, 2019), which is a small fraction of the funded inventions. Korea has experienced a similar trend of around 4.8% of university inventions were transferred for commercialization in 2019, as shown in the table below, even though the total number of patents universities owned has increased significantly.

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1) Siegel & Wright(2015) compares the traditional and emerging perspectives on "academic entreprneurship", including universities' aims to "provide a wider social and economic benefit to the university ecosystem".

2) Siegel & Wright(2015) pointed out reasons for the higher level of academic entrepreneurship: (a) competivie pressure from successful universities, (b) increasing pressure on universities to generate more resources from private doners, and (c) growth of funding from government to support academic entrepreneurship.

<Table 1> University-owned Patents and Technology Transfers in Korea

Year	Universities Surveyed	Domestic Patent	International Patent	Patent Total	Technologies Transferred
2015	424	63,173	5,635	68,808	4,017
2017	418	73,518	9,639	83,157	4,310
2019	416	87,125	12,149	99,274	4,818

* Source: Report on University-Industry Collaborations (Ministry of Education, 2019)

It has been asserted that technology transfer is difficult because of asymmetric information, market power, and externalities (Johnson & Lybecker, 2009), in addition to the fundamental constraints associated with tacit knowledge transfer(Lowe, 2006). Recognizing universities' potential role in economic development, the Korean government enacted policy measures to enhance infrastructure, in order to overcome constraints related to technology transfer. Specifically, the Korean government has introduced the technology evaluation system and encouraged universities to found technology licensing office(TLO) so that universities can actively commercialize their intellectual property, by transferring them to mostly established companies. Later, it has also started funding for inventor-founded firms in universities so that more inventors of the technologies in universities can create new companies and manage startups, utilizing the technologies they have created.

However, the inventors of university technologies, on average, do not have enough skills in technology commercialization or business management. Management in technology commercialization requires a specific set of skills, including identification of customer needs, development of product concepts, design of products and processes, prototyping, and manufacturing, which is the main reason why university inventions have been commercialized through technology licensing after they are patented. But technology transactions may incur information problems related to the technology, such as adverse selection, moral hazard, and hold-up, in the process of transferring technologies, even with the use of patent(Shane & Stuart, 2002) because implicit knowledge may not be sufficiently transferrable, which is an intrinsic issue in transferring technologies.

Because of the market failure in technology transactions, it is suggested that inventor-entrepreneurship in universities can be a second-best solution for the commercialization of new inventions in universities. Traditionally, there have been two perspectives on who becomes an entrepreneur; one focuses on the availability of information and opportunities, while the other focuses on personal attributes, such as tolerance of uncertainty, need for achievement and locus of control, among others(Walter & Heinrichs, 2015). We may, however, add another perspective on the role of the institutions on the level of entrepreneurship among the staff for research and development, especially with the resources they have and the personnel policy to allow the staff to create and manage startups.

Since inventor-entrepreneurs can overcome the technology information problems, and since successful commercialization by inventor-entrepreneurs can bring positive impacts on the institutions and the local area in terms of wealth and jobs, the government of Korea has recently been focusing on the provision of financial supports for faculty startups, and universities have introduced more lenient policies to allow faculty to start technology-based startups. Due to the active involvement of the government and universities, there was more than 70% increase in the number of professor startups for the past 4 years, with the average professor startups per surveyed university being 3.5 in 2020.

< Table 2 > Recent Trend in Faculty Startups in Korea

Year	2016	2018	2020
Universities (having faculty startups)	80	83	89
Faculty Startups	185	239	315

* Source: stat.kosis.kr

With a significant increase in the number of faculty startups in Korea, however, the variance among universities is very large; the most active university had 24 faculty startups, while 47.1% of the whole 4-year universities had no faculty startups in 2020. Therefore, we are going to analyze the inter-university variations to find out the factors affecting faculty startups and their performance, such as employee numbers and sales, in the universities in Korea, focusing on the financial and intellectual resources available for faculty startups, and university systems which may or may not be favorable for professors to create new firms to commercialize their own technologies.

In the next section, we provide a brief review of the relevant literature. In Section III, we develop and analyze the model to explain the intensity of faculty startups and their performances in universities in Korea. In Section IV, we present the data and methodology, and the empirical results are explained in Section V. We end with concluding remarks and discussions in the last section.

Ⅱ. Literature Review

Considering universities' role in research and development activities with more public and private resources, they may become significant sources of technology-based startups, which are known to have a higher employment quality and innovative performances(for example, Choi et al., 2020). In fact, universities themselves have invested substantial resources to build infrastructure to facilitate more spin-offs or technology licensing, which in turn can create revenue for themselves and economic growth for their regions. Accordingly, the number of patents registered by universities has dramatically increased, and a few universities have a significant amount of money from royalties. Consequently, university spinoffs have recently been one of the major research topics due to a higher importance of universities', and their role in regional economic development.

Traditionally the commercialization of university generated technology has been dominated by established firms which have a greater chance of survival and can exploit economies of scale(Showalter & Jensen, 2019), which is the reason for most studies to have focused on technology transfers through licensin g[3].

However the Technology Licensing Office(TLO) startups is another important vehicle for technology transfers(Di Gregorio & Shane, 2003), despite the obstacles they face related to technology transactions, including information problems-adverse selection, moral hazard, and hold-up, in the process of transferring technologies, or difficulties in transferring implicit knowledge for commercialization. Therefore, university inventors can create new firms to commercialize their technologies in order to overcome failure in the market for knowledge and to fully utilize their superior knowledge of the technology which may be implicit, suggesting that university inventor-entrepreneurship can be a second-best solution for the commercialization of university technologies. Even if management skills are not common traits of university faculty, there have been a growing number of success of university faculty startup s[4]. Some professors may have management aptitude, in addition to their research capability, which can lead them to be fully able to utilize their tacit or explicit knowledge from their own research and development activities.

All universities are not equal in terms of their professor startup intensity, their employment, and their business performances, such as employment and sales. Then what has caused the inter-institutional differences in startup activities and performances in universities? Possible factors affecting new firm formation can be categorized into micro and macro-level elements. At the micro-level, studies have shown that the characteristics of technological inventions(Shane, 2001), inventors' career experiences(Levin & Stephan, 1991), inventors' psychological make-ups(Roberts, 1991), and inventors' research skills(Zucker et al., 1998) are the factors. At the macro-level, analyses have shown that technological regimes(Shane, 2002), the level of patent protection(Shane, 2001), and institutions' intellectual property policies(Goldfarb et al., 2001) influence the performance.

Focusing on university technology transfer, Chukumba & Jensen(2005) find that the number of licenses and university startup formations are positively related to the age of the TTOs, and Ahlstrom & Bruton(2006) found that university faculty with relationships to local venture capitalists are more likely to receive investment and create successful startups. In addition, Henrekson & Rosenberg(2001) found that that offering better incentives for faculty's involvement drives licensing and startup activities, and Di Gregorio & Shane(2003) and O'Shea et al.(2005) find that increases in faculty quality, previous startup successes, the amount of external funding, and the TTO size positively impact the number of university-related startups.

<Table 3> Factors Affecting University-Spinoffs

Categories	Factors	Authors
Characteristics of Creators	-Previous Experiences -Ages -Previous Tech Transfers	-Khurana & Shane(2000) -Kim & Shin(2016) -Kim & Shin(2016)
Characteristics of Technologies	-Charateristics of Inventions -Degree of Tacit Knowledge	-Shane(2001) -Lowe(2006)
Insitutional Factors	-Intellectual Eminence -Faculty Size -Faculty Quality -Royalty Policy -Investor's Accessibility -Patents -Long-term Leave Policy -Startup Support Office -IP and Resources	-Di Gregorio & Shane(2003) -Friedman & Silberman(2003) -Showalter & Jensen(2019) -Gregorio & Shane(2003) -Dahl & Sorenson(2013) -Cho(2012) -Kim & Shin(2016) -Lockett & Wright(2005) -Lim & Hong(2023)

When we focus on universities' technology commercialization, most papers have focused on the role of Technology Transfer Offices startups in successful university entrepreneurship, analyzing the relationship between university startups, and entrepreneurs' individual characteristics, their knowledge or opportunities, and environmental characteristics, as summarized in <Table 3> above. While these studies have advanced our understanding of university spinoff performance, there is sparse

3) US universities have licensed 20.1 inventions to established firms, but only 3.7 inventions to startup firms, and formed 2.6 startups annually, on average(Showalter & Jensen, 2019). But it is not clear how many startups were by faculty invenors.

4) Stanford University cases: www.inc.com/peter-cohan/silicon-valleys-success, and Indian Institute of Technology cases: www.livemint.com/education/news/professors-join-the-startups

literature which focuses directly on the factors affecting university professors' startup intensity and their performance, in terms of employee numbers and sales. Firstly, most studies have examined the factors affecting university technology licensing or spinoff activities, rather than their own professor researchers' business formation. As a result, a marked void exists with respect to university factors impacting on university faculty startup behaviors and their performance. Secondly, few articles have systematically attempted to find out why some universities have been more successful than others at creating technology-based startups by their professor researchers. Lim & Hong(2023), for example, analyzed some factors of universities affecting students and faculty, showing that research funds and supporting staff are significant. However, they focused more on student startups and included only a few factors on faculty startups. Third, most articles focused on the business formation stage in the process of technology transfer, rather than on the spinoffs' performances while they are commercializing universities' intellectual properties.

This article aims to address the limitations by analyzing the impact of institutional factors, including various resources and infrastructrure of universities, on university professor startups and their performance. The contribution of this paper is our focus on institutional factors, including financial and intellectual resources as well as their policies and infrastructure, which affect professor researchers' technology commercialization, via founding and operating their own ventures. In addition, we included university startups' performance, in terms of its job creation and sales, as well as startup counts, using a panel of all faculty-startup 4-year universities in Korea.

Ⅲ. The Model

The importance of resource availability for a firm formation and management has drawn a lot of attention since Wernerfelt(1984) argued that a firm's competitive advantage can come from its resource base. Drawing on Wernerfelt's work, a series of papers have analyzed the relationship between resource availability and firms' competitive advantage or performance(Lockett et al., 2009). Since universities have various physical and intellectual resources, and educational infrastructure which can be leveraged by university spinoffs and prospective entrepreneurs around campus, there may be a relationship between universities' amount of resources and infrastructure available for university faculty researchers and their participation in the commercialization of the technologies that they develop. We categorize four types of institutional resources: financial resources, intellectual resources, human capital, and university's infrastructure and policies, and we then analyze what role those resources and infrastructure plays in explaining inter-university variations of their faculty startup activities. Consistent with Di Gregorio & Shane(2003), work on university faculty startup activities and the startups' performance, we measured the number of startup companies generated by professors, the number of employees of the firms, and the amount of sales of the firms, on an annual basis, collected by the Ministry of Education of the Korean government(2019).

3.1. Financial Resources

The resource-based view considers resources which are fully appropriable by the firm, but we want to analyze the resources that universities have available directly or indirectly for the startups on campus by inside entrepreneurs. According to Newbert(2007), which assessed 166 empirical articles that test the resource-based view of the firm, financial resources are one of the most important factors affecting firm development. Di Gregorio & Shane(2000) also found that universities that received research and development funds from industries were more likely to produce more spinoffs.

In addition to external research funds, we want to include external funds for technology commercialization for our analysis. First of all, the availability of research funds is the source of university faculty' research and development activities leading to new intellectual properties, especially patented technologies. Universities own those properties that can be commercialized directly or indirectly through technology transfers to startups or existing companies. In addition, the availability of commercialization funds from central or local governments or from related industries may play an important role in professor startups and their performances because creation and operation of technology-based firms needs a significant amount of working capital[5].

Therefore, we first want to analyze the effects of universities' amount of research funds available and their amount of commercialization funds from outside which can be used for firm creation and operation on university faculty startup creation activities and the startups' performances in terms of their employees and the amount of sales. So, our first hypotheses are as follows:

5) Since one of the most important elements for technological startup policies of Korean government is university technology commercialization, Korean government has provided a significant amount of funds for research and development, and technology commercialization as well.

Hypothesis 1-1: Universities which have larger funds for research and development or for technology commercialization have a higher intensity of professor startup activities.

Hypothesis 1-2: Universities which have larger funds for research and development or for technology commercialization produce a better performance in terms of professor startups' employee nuambers and their sales.

3.2. Intellectual Properties

With apropriate systems for technology ownership, intellectual property registration and incentives for university inventors, the size of intellectual property that universities have may be the prerequisite for technology commercialization by university personnel or outside entrepreneurs. Newbert(2007) and Goldfarb et al.(2001) show that universities' knowledge and technological resources influence universities' creation of new companies to commercialize their technologies, focusing on university spinoffs rather than on university inventors' creation of firms for their own technologies. Since professors publish papers after finishing their research for their individual performance evaluations, regardless of their research sectors, the number of papers published can be a broad indicator for universities' potential knowledge base available for professor startups, whether they are patented or not.

Therefore, as a second possible group of factors impacting university faculty startup activities, which requires analyze, is the influence of the amounts of universities' intellectual property rights and professors' publication performance on their own personnel's firm creation and the firm's subsequent performance. Patents are considered the most common form of intellectual property right registration for universities'research and development results, thus we measure the relationship between universities'amount of intellectual property rights, in terms of patents, and their professors'direct involvement in the creation of firms for technology commercialization. We also want to investigate possible effects of professor publications on their own startup activities. So, we have a second group of hypotheses which are as follows:

Hypothesis 2-1: Universities which have more patents or more publications have a higher intensity of faculty startup activities.

Hypothesis 2-2: Universities which have more patents or more publications produce a better performance in terms of faculty startups' employment and their sales.

3.3. Research Excellence and Human Resources

It is a reasonable conjecture that more research-intensive universities are also more actively involved in academic entrepreneurship to create more technology-based spinoffs, from their faculty's research results. Zucker et al.(1998) analyzed the effect of successful university bioscience programs on university researchers'firm foundation, and Di Gregorio & Shane(2003) used the overall academic rating score to measure universities'research eminence to analyze its effect on the TLO startup rate. Newbert(2007) also confirms that universities' research and development capability is potentially affected by university firm foundation. Since a majority of university patents are registered in the fields of engineering and technology, we are going to focus on the research reputation of universities in those academic fields to analyze if high quality research universities produce more university professor startups.

In addition, we want to investigate the effectiveness of university administrative stucture to support startups on campus, in terms of the size of the division. This is in line with Di Gregorio & Shane(2003) who use the number of technology licensing office staff to investigate the relationship with the TLO startup rate. Grimaldi et al.(2011) also specified that greater pressures on universities and institutions' financial incentives have stimulated the creation of supporting organizations with universities dedicated specifically to technology licensing and academia-industry collaborations including technology commercialization on campus. Since university personnel can get business-support services to found and operate new firms by the startup support division, the presence and the human resources may affect the creation and performance of university professor startups. Therefore, we want to include the internal startup supporting unit' staff number as an independent variable. So, we a third group of hypotheses as follows:

Hypothesis 3-1: The level of intellectual eminence affects university professor startups and their performance.

Hypothesis 3-2: The size of startup support division of universities affects university professor

startups and their performances.

3.4. Personnel Policies and Startup Infrastructure

Since most university faculty are full-time employees, it is practically impossible for professors to engage in startup activities if the universities have a strict policies regarding professors' leaves of absence or dual jobs. Grimaldi et al.(2011) shows that university rules and procedures which allow its personnel to establish new firms, via leaves of absence or their dual job positions in order to commercialize her own technologies, and permitting to take management positions of startups while they work as professors, affects university spinoff performance. Considering most universities in Korea allow professors to have leaves of absence to found or manage innovative startups, we investigate the period of leaves of absence, in terms of the maximum leave of months for firm creation and management that university inventor entrepreneurs can take and its impact on university faculty startup formation and their performances.

In addition, we analyze possible impacts of university startup infrastructure: namely the physical infrastructure of research and development facilities that the university have available for researchers for their further research or technology commercialization, and the structural system of technology-holding company which is the main channel for technology commercialization, encouraged by law in Korea[6]. So the fourth group of hypotheses are as follows:

Hypothesis 4-1: The longer period of leaves of absence for faculty startup activities that universities allow, the more faculty startups are created, and the better their performances are.

Hypothesis 4-2: Universities which have more R&D facilities or their own technology-holding companies produce more and better performing faculty startups.

3.5. Technology Transfer Performances

Even if we include financial, intellectual, and physical resources, in addition to universities' personnel policies, to analyze their effects on university professor startups and their performances, we want to add the performances of universities in technology transfers in terms of the number of technologies transferred. This is because we want to know if there is any relationship between universities' technology transfer performances and their own faculty startup performances. We also want to incorporate other components of universities, such as other kinds of resources and institutional priority for technology commercialization, into the model, measuring the level of technology transfer activities and their performances. So the fifth hypothesis is as follows:

Hypothesis 5: The more the number of technologies transferred is, the more faculty startups are produced or the better their performances are.

When we analyze the above factors, we control for the size of the university, in terms of the number professors, the type of the university, whether it is public or private, to exclude possible effects from institutional size difference and the difference in the institutional governance and operation.

We make a model including the independent, dependent, and control variables:

$$yit = \alpha + \beta x'it + ui + ut + \varepsilon it,$$
$$ii= 1,2,3,..,n \text{ and } tt=1,2,3,..,n$$

(y: startup performance vector, x: independent and control variable vector)

Ⅳ. Data and Methodology

In this section, we explain the sample and the variables analyzed in the article, and present an overview of the analytical methods we used.

4.1. Sample

All universities and colleges in Korea are required to report the information rregarding students, professors and staff, in addition to their educational system, R&D performances, intellectual property rights, and technology commercialization performances, among others, via an open database(www.academyinfo.go.kr). It also includes each institution's R&D funding, R&D facilities, academic paper publications, patent applications and registrations, technology commercialization funding, technology-holding company information, technology commercialization support

6) Universities that own the intellectual property rights do in-kind investments, using their IPRs for results of research and development, to the technology-holding companies so that they can commercialize the IPRs via startups('son companies') or other companies. In addition, there are several organization in universities which are related to technology commercialization, including the technology-holding companies, technology-transfer units, and business incubators. Among them, we focus on the role of technology-holding companies which focuses directly commercialization of university technologies by university memebers.

division, technology transfer performances, and professor startups and their performances in terms of their employment and sales as well.

Because we use panel data analysis techniques, we obtained university data on their academic, research, and commercialization activities from 2017 to 2020 for the 134 universities for which all the four years of professor startup data are available from the database[7]. So our sample consists of 536 university-year observations.

To gather data on intellectual eminence, we utilized the QS world university rankings(www.qs.com), which is a widely used assessment to measure academic institutions' strengths. They publish academic subjects' rankings as well, so we use the rankings for Engineering and Technology subjects, which include computer science and Information systems, chemical engineering, civil and structural engineering, electrical and electronic engineering, mechanical engineering, and mineral and mining engineering. Their evaluation criteria include academic reputation, employer reputation, and citations per faculty, among others, which are believed to measure the level of academic excellence of the universities.

4.2. Dependent Variables

The dependent variables are a count of the number of university faculty startups founded in a given year, the number of employees of the faculty startups at the end of the year, and the amount of sales in a given year. 323 university-year observations had positive numbers of faculty startups, and the maximum was 24, with the mean and standard deviation being 2.0 and 3.1, respectively. They employed 2.3 people on average, with the maximum employment of 75, while they had 24.4 million won of sales, with the maximum sales of 1.7 billion won for a year.

<Table 4> Summay Statistics of Dependent Variables

Variable	Mean	S.D.	S.D. between Schools	S.D. within Schools	Minimum	Maximum
Professor Startups	2.011	3.105	2.527	1.814	0	24
Pofessor Startups' Employment	2.343	6.211	4.900	3.835	0	75
Professor Startups' Sales (million won)	24.400	105.000	56.600	88.600	0	1,700.000

The distribution of professor startups is heavily skewed with the mean 2.0 and the standard deviation 3.1, and 39.7% of the observations have zero values, which implies that least square regression analysis is not appropriate. Faculty startups' employee numbers shows an even more skewed distribution, with the mean 2.3 and the standard deviation 6.2, and its maximum value is 75. The third dependent variable of professor startups' sales is not normally distributed, with the rejection of the normality by the Shapiro-Wilk test.

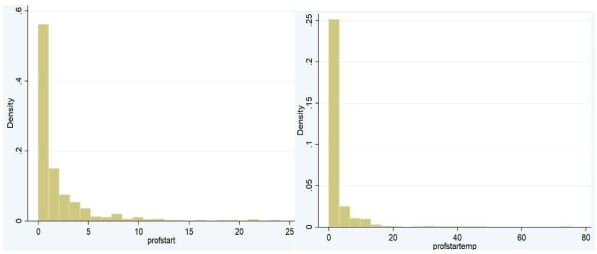
4.3. Independent Variables

<Table 5> Summay Statistics of Independent Variables

Variable	Observ-ations	Mean	S.D.	S.D. between Schools	S.D. within Schools	Minimum	Maximum
R&D Fund (billion won)	536	44.900	80.200	80.000	7.892	0.350	593.000
Commercialization Fund (billion won)	536	39.100	70.800	57.700	41.100	0.001	599.000
Research Publications	536	209.738	318.105	318.078	24.187	0.080	2271.310
International Patent Applications	536	31.104	69.523	68.478	13.059	0.000	504.000
Research Excellence	536	0.0410	0.199	0.184	0.075	0.000	1.000
Number of Startup Support Staff	536	11.667	11.242	10.328	4.506	0.200	82.900
Period of Startup Leaves (months)	536	29.720	30.616	28.764	10.704	0.000	120.000
R&D Facilities	536	64.953	93.038	93.310	0.000	0.000	717.000
Technology-Holding Company	536	0.494	0.500	0.485	0.128	0.000	1.000
Technologies Transferred	536	33.886	34.671	32.908	11.189	0.000	243.000

7) We focused on 190 4-year universities for our analysis, excluding other types of universities which specialize in educational and industrial purposes, and cyber and open universities. We also excluded those universities who have not reported about their professor startup information all the 4 years, and finally used 134 universities' data.

To measure the effects of universities' amounts of financial resources available on the professor startups and their performances, we examined two indicators: the university's amount of research and development fund in a given year, and the university's amount of industrial collaboration or commercialization fund in a given year. The mean of R&D funds was 44.9 billion Korean won, and their variations were significant with the standard deviation being 80.2 billion won and the maximum value being 593.0 billion won. The commercialization funds also showed big variations among universities, with the mean being 39.1 billion won, and the standard deviation being 70.8 billion won.



<Figure 1> Histograms of Dependent Variables

In order to measure universities' amount of intellectual properties, we used two indicators: professors' publications of papers, by the number of SCI papers published in a given year, and the number of international patent applications in a given year. The mean of SCI papers published was 209.7, and their standard deviation was 318.1, while the mean of international patent applications was 31.1 and their standard deviation was 69.5, which again showed large variations.

Next set of independent variables are universities' research excellence and their human resources available for technology commercialization activities. To measure if universities' research eminence increased professor startups and their performances, we examined universities' QS rankings in the fields of engineering and technology, which is produced annually. We checked if a university was among the top 100 each year. There were 4, 4, 7 and 7 universities each year of our analysis. In addition, we examined the number of university staff to support startup and commercialization activities and industry-academia collaboration activities in a given year. The mean of supporting staff was 11.7 and the standard deviation was 11.2, with the maximum number being 82.9.

Another set of independent variables are universities' personnel policies and their startup infrastructure, the first one of which is universities' policy and regulations about professors' leaves of absence for the creation and management of startups. 59.5% of the universities allow their full-time faculty to take some period of leave of absence for startup creation and management, the mean of which is 29.7 months, including the initial leave and the possible extension, with the standard deviation being 30.6 months. To measure physical infrastructure, we checked the number of research and development facilities. Universities had 64.9 facilities for R&D and prototyping, and the standard deviation was 93.0. Another independent variable to inspect university infrastructure was if they have founded a technology-holding company. 49.4% of the universities had one for their technology commercialization. We also checked universities' performance of technology transfers, in terms of the number of technologies transferred in a given year. Universities transferred 33.9 technologies on average in a given year, with the standard deviation being 34.7 technologies and the maximum value being 243 technologies.

4.4. Control Variables

Because we expected that the number of faculty startups and their performances would be related to the size of the universities, in terms of the size of the faculty of the universities, we controlled for the number of professors of the universities in a given year. Universities had 480.9 professors on average in a given year, with the standard deviation being 365.4. We also expected that the type of universities, whether they are public or private, might affect professors' intension to found firms to commercialize technologies, we controlled for universities' foundation types for our analysis. Our sample included 30 public universities.

4.5. Estimation

We have three models for the analysis. For the first two models, we utilized zero-inflated negative binomial regressions. Our choice of analytic technique depended on the following factors: (1) for the first two models, our dependent variables took the form of count data, with the means being around 2; (2) the standard errors are likely to be auto-correlated over time of our analysis; (3) 39.7% of professor startup observations and 61.0% of professor startup employment observations were zero during our analysis period; and (4) unobserved university-level heterogeneity may influence startup rates and startups' employment.

We investigated with the negative binomial regression first, and confirmed that it is more appropriate than the Poisson regression because the likelihood-ratio test rejected alpha=0. And the negative binomial regression leads us to conclude that panel data

estimators are significantly different from the pooled estimators, and that the random effect and fixed effect models don't have a significant difference by Hausman test. Executing the zero-inflated negative binomial model shows us that it is more appropriate than the zero-inflated Poisson model by rejecting alpha=0. So, we decided to us the zero-inflated negative binomial model to analyze.[8].

For the third mode which analyzes effects of institutional factors on professor startups' sales, we initially employed the cross-sectional time-series generalized least square regression to find out that there is heteroskedasticity and auto-correlation. Hausman test reveals that the random and fixed effect models do not have significant differences in estimation. So, we used the cross-sectional time-series feasible generalized least square(FGLS) estimator for the random-effects model with non-normal errors to examine the relationship between professor startup sales and institutional factors.

Ⅴ. Analysis Results

In Table 6, model 1 provides the results of the regression analysis for the factors affecting professor startups, and model 2 presents estimates of the predictor and control variables, both using the zero-inflated negative binomial technique with the cluster option. Model 3 shows the analysis results for the factors affecting professor startups' sales, using the cross-sectional time-series FGLS technique.

Overall, the results provide substantial evidence that the factors affecting the professors' startups and the factors affecting their performances are different. First of all, the amounts of R&D resources and external project funds for commercialization didn't affect the number of professor startup counts or their employment performance, while the amount of external funds showed a very significant relationship with professor startups' sales, which was against our expectation that institutional fund availability could be a major contributor[9]. This results support partially for the first group of hypotheses.

< Table 6 > Faculty Startup Performance Estimates

Variables	<Model 1> Professor Startups (zero-inflated negative binomial model)	<Model 2> Professor Startups' Employment (zero-inflated negative binomial model)	<Model 3> Professor Startups' Sales (Cross-sectional Time-series FGLS model)
Financial Resources			
- Research Fund	.00031 (.00064)	-.00012 (.00006)*	-.07485 (.5043)
- External Project Fund	.00008 (.00009)	-.00002 (.00001)	.0503 (.0184)***
Intellectual Properties			
- SCI Papers	.00031 (.00082)	.00244 (.00138)*	42.3150 (11.3909)***
- Int'l Patent Applictions	.00216 (.00175)	.00871 (.00319)***	26.8363 (41.0788)
Human Capital			
- QS Ranking 100	.25662 (.34876)	.71487 (.58211)	-104.0000 (820.6816)
- Number of Startup Staff	.01483 (.00509)***	.00430 (.00846)	-233.2255 (60.5294)***
University Infrastructure			
- Maximum Startup Leave	.00589 (.00164)***	.00086 (.00273)	-9.5362 (19.0118)
- Research Facilities	.00031 (.00064)	-.00135 (.00115)	7.1375 (12.9142)
- Technology-Holding Com	.51416 (.13309)***	.51353 (.20477)***	53.2317 (13.6677)***
- Technology Transfer	.00263 (.00196)	.01158 (.00341)***	57,872.55 (26,230.01)***
Control Variables			
- Number of Professors	.00041 (.00041)	-.00017 (.00065)	-.3263 (.0310)***
- University Type(public)	-1.29369 (5.33116)	-1.14560 (6.27208)	-14.0000 (16.5589)***
Constant	-2.30469 (.68614)***	-1.33312 (.54425)*	1,830.00 (688.95)***
Log Likelihood	-869.8567	-795.2474	-

- Number of observations, 536; number of universities, 134. Standard errors in parenthesis.
* *p<0.1*, ** *p<0.05*, *** *p<0.01*

Second, in model 1, international paper publications or international patent applications didn't affect professor startup counts, but both of them affected professor startups' employment and their sales significantly. The estimated coefficients of these variables show that, ceteris paribus, an increase in the number of international paper publications is associated with a 0.002 more jobs by professor startups, and that an increase in the number of international patent applications is associated with a 0.009 more

8) Because Stata doesn't provide "cross-sectional time-series zero-inflated negative binomial" command, we used an alternative way to use the zero-inflated negative binomial regression with the 'cluster' option.

9) The effect of the amount of research funds on professor startup employment was significant, but the direction was negative against our expection, which needs further analysis and clarifications.

jobs. In addition, the number of international paper publications affected the amount of professor startups' sales very significantly. It is estimated that a one more paper is associated with 42.3 million won more of sales. So, we partially support for the second group of hypotheses.

Third, the research eminence, represented by the QS ranking, was not significant in any of the three models, which was different from Di Gregorio & Shane(2003). However, the effects of the number of startup support staff on professor startups or their performances was partially significant. In models 1 and 3, it was shown that it affected the number of professor counts and the amount of professor startups' sales very significantly, which confirmed O'shea et al.(2005) showing that the magnitude of resources invested in TLO personnel increases university spinoff activities, while it didn't affect professor startups' employment[10].

It is interpreted that a one more startup support staff leads to a 0.015 more professor startups.

Finally, the results showed that universities' personnel policy, in term of the months of leaves of absence for startup foundation or management affected the number of faculty firm foundation very significantly, but it didn't affect professor startups' employment or their sales. The estimated coefficient implies, ceteris paribus, that a one more month in the maximum leaves of absence is associated with 0.07 more professor startups, which shows a similar result with Grimaldi et al.(2011). In addition, whether a university has a technology-holding company or not affected all the three dependent variables: professor startup counts, their employment, and their sales, which may be because of their active role in university technology commercialization. It is estimated that if a university has the technology-holding company, it has 0.5 more professor startups, 0.5 more employment, and 53 million won more of sales. Furthermore, the number of technologies transferred didn't show a significant relationship with professor startup counts, but it showed a strong relationship with professor startups' employment and their sales. By the way, universities' amount of research facilities didn't affect any of the three dependent variables. So, the results partially support the fourth group of hypotheses, but the 5th hypothesis was not supported.

We controlled for the size of universities, in terms of the number of professors, and their funding types. None of them are associated with professor startup counts or their employment. However, both of them affected professor startups' sales very significantly. Other things being equal, a university has 0.3 million Korean won less of professor startups' sales with one more professor, which may be because some small-size technology-oriented institutions have more professor startups in Korea recently. And public universities had a significantly smaller amount of professor startups' sales, with the difference being 14 million won.

From the estimates in the three models, we can summarize the factors affecting university professors' startup counts and their performances as follows:

(a) In order for universities to encourage more professor startups, they should focus on building a better startup support ismechanismsm and flexibility in their personnel regulations, rather than on increasing financial and intellectual resources. It seems that it is more effective to provide better administrative supports so that professor entrepreneurs can decide to start their own technology commercialization by keeping a significant size of startup support division and allowing a significant period of leaves of absence for startup activities. In addition, the creation of a university technology-holding company can encourage prospective inventor entrepreneurs to get involvement in the in commercialization of their own technologies.

(b) In order for professor startups to produce better performance, in terms of their employment and sales, universities need to focus now on their amount of financial resources and intellectual properties because international paper publications and international patent applications have a significant relationship with faculty startups' employment, and because international paper publications and external project funds show a significant effect on professor startups' sales[11].

(c) The performance of technology transfer shows a very significant relationship with faculty startups' employment and sales, but not with faculty startup counts. It may be because professor startups, to some degree, are in competition with technology transfer, in terms of university business items, but once their business is initiated, they provide positive effects on each other's' business performances.

Ⅵ. Conclusions and Discussion

Grimaldi et al.(2011) proposed that academic entrepreneurship can be encouraged at three levels: (a) system-level actions, (b) institutional level of support mechanisms, and (c) individual scientist level factors. Among them, in this study, we analyzed five groups of institutional factors for cross-college variations in professor startup counts and their performances over 2017-2020 in Korea-universities' financial resources, their intellectual

10) The strong negative relationship between the number of startup support staff and professor startups' sales is puzzling, which needs further analysis.
11) A referee suggested a causality test to check the direction of the effect. However, our data periods are not enough to do a Granger causality test.

properties, human capital and resources, universities' personnel policies and startup infrastructure, and technology transfer performance. The results show that the groups of factors affecting university professor counts and their performances are different; it is important for universities to provide a more favorable environment with more flexible personnel policies by introducing the system allowing a leave of absence for creating and operating a new business, and better startup support infrastructure so as tha more professors are encouraged to begin their own technology commercialization through firm formation, while it is more effective to have more financial resources and intellectual properties for their better performances. It is also found that university technology-holding company and technology transfer programs are crucial to increase the number of professor startup counts and their performances as well. Therefore, universities need to create a better infrastructure for innovative startups by faculty, by for example founding a technology-holding company and providing a sufficient amount of resources for a good performance. In addition, universities also need to provide more resources for innovative startups from inside and outside as well.

<Table 7> Significance Table

Variables	Model 1	Model 2	Model 3
Research Fund	-	*	-
External Project Fund	-	-	***
SCI Papers	-	*	***
Int'l Patent Applictions	-	***	-
QS Ranking 100	-	-	-
Number of Startup Staff	***	-	***
Maximum Startup Leave	***	-	-
Research Facilities	-	-	-
Tech-Holding Com	***	***	***
Technology Transfer	-	***	***

* *p<0.1*, ** *p<0.05*, *** *p<0.01*

However, our research has some limitations because we constrained our data mainly on institutional factors. We believe that university faculty startup activities can be significantly affected by the university's goals. But we didn't include the role of university-level governance for university entrepreneurship goal setting in our analysis. In addition, we didn't analyze the characteristics of technology or knowledge which were commercialized by the professor researchers which may reveal academic fields that attract more professor entrepreneurs. Furthermore, since we focused on institutional factors, we didn't include entrepreneurs' characteristics and local socio-economic conditions in our analysis. Finally, we have used aggregate data at the institutional level of universities' startups and their performances in a given year. Firm-level panel data on university faculty startups and their performances would produce more robust analysis on university professor startups' counts or performance.

Nonetheless, our findings have three important implications for research on and policy for university faculty startup activities. Firstly, we find no support for the argument that financial resources and intellectual property contribute to university faculty startup counts, but rather that they impact on startup subsequent performance. Secondly, we find that it is important for universities to provide a more favorable environment or system with more flexible personnel policies and better startup support infrastructure, to facilitate more professor entrepreneurs to begin their own technology commercialization. Thirdly, our analysis shows that universities' research eminence has no relationship with professor startup counts or their business performances. Finally, it is shown that some elements of university infrastructure, such as the technology-holding company and technology transfer system, is effective in the creation professor startups and in increasing their performance.

REFERENCE

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

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*. Retrieved from https://www.nber.org/papers/w11475.

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

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

Etzkowitz, H.(1998). The Norms of Entrepreneurial Science: Cognitive Effects of the New University-industry Linkage's. *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*, 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

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.

Johnson, D. K., & Acri née Lybecker, K. M.(2009). *Challenges to Technology Transfer: A Literature Review of the Constraints on Environmental Technology Dissemination*. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1456222.

Khurana, R., & Shane, S.(2000). *Career Experiences and Firm Foundings*. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1456222.

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.

Lim, H., & Hong S.(2023). Analysis of Factors Influencing Entrepreneurial Performance at the University Level for Becoming Entrepreneurial Universities. *Asia-Pacific Journal of Business Ventureing and Entrepreneurship*, 15(2), 19-32.

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

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.

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.

Ministry of Education of the Korean Government(2019). Report on University-Industry Collaborations, Retrieved (2024.05.20) from www.moe.go.kr.

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: Oxford University Press.

Rothaermel, F. T., Agung, S. D., & Jiang, L.(2007). University Entrepreneurship: a Taxonomy of the Literature. *Industrial and Corporate Change*, 16(4), 691-791.

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

Shane, S.(2002). Selling university technology: Patterns from MIT. Management science, 48(1), 122-137.

Shane, S., & Stuart, T.(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.

Siegel, D. S., & Wright, M.(2015). Academic entrepreneurship: time for a rethink?. *British journal of management*, 26(4), 582-595.

Walter, S. G., & Heinrichs, S.(2015). Who Becomes an Entrepreneur? A 30-years-review of Individual-level Research. *Journal of Small Business and Enterprise Development*, 22(2), 225-248.

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.

Association of University Technology Managers(2019). *University Startups*. Retrieved (2023.09.16.) from www.autm.net.

Statistics Korea(2023). *University Startups*. Retrieved on (2023.08.20) from stat.kosis.kr.

Ministry of Education(2023). University Startups. Retrieved on (2023.12.15.) from www.academyinfo.go.kr.

대학의 기관특성이 교원창업 성과에 미치는 영향에 관한 패널 데이터 분석

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국문 요약

본 연구는 기관으로서 대학의 보유 자원과 제도가 교원창업과 그 매출 성과에 미치는 영향을 분석하기 위하여 한국의 134개 4년제 대학의 2017년부터 2020년까지의 패널 자료를 분석하였다. 대학의 금전적 인력적 지식적 자원의 규모를 포함한 각종 자원과 인적자원관리를 위한 제도 등이 대학의 교원창업 숫자에 어떤 영향을 미치는지, 그리고 교원창업 기업들의 매출 규모에 유의한 영향을 미치는지를 확인하기 위하여 9개의 가설을 설정하고 검증하였다.

본 분석에서는 종속변수로서 각 대학의 교원창업기업 수, 교원창업기업이 고용하고 있는 근로자 수, 그리고 교원창업기업의 경영성과로 그 매출액 규모를 사용하였고, 독립변수로는 연구 활동 및 기술사업화 자금의 규모, 저명 국제저널에 게재한 논문 건수와 국제 특허 실적, 그리고 대학의 연구역량 순위와 창업지원 직원의 수와 함께 교원창업 휴직기간, 연구시설, 기술지주회사 보유 여부 등을 사용하였다. 교원창업수와 창업기업 고용인원에 대한 영향 분석을 위하여는 그 숫자가 영인 비중이 머서 영과잉 음이항 분석 방식으로 수행했고, 교원창업기업의 매출액에 미치는 영향 분석을 위하여 비정규적 오차항을 고려한 확률효과모델을 사용하여 횡단면 시계열 FGLS 추정량을 사용하였다.

본 논문의 분석 결과는 대학의 교원창업 숫자에 미치는 요인과 교원창업기업의 고용이나 매출액 등의 경영성과에 미치는 영향에는 다소 차이가 있다는 점을 보여주었다. 교원창업기업의 숫자에 유의하게 영향을 미치는 요인은 창업을 위한 휴직 허용기간과 기술지주회사 보유 여부, 그리고 창업지원조직의 규모 등이었고, 교원창업기업의 고용 규모에 유의하게 영향을 미치는 요인은 연구자금의 규모, 국제 특허 실적, 그리고 기술지주회사 보유 여부 등이었다. 한편, 교원창업기업의 매출액 규모에 유의하게 영향을 미치는 요인은 창업사업화 지원을 위한 외부자금 확보 규모와 함께 창업지원조직의 규모, 기술지주회사 보유 여부 등이었다.

본 연구의 시사점으로는, 교원의 창업 촉진을 위하여는 유연한 인사제도를 마련하고 기술지주회사 설립을 통하여 교원들의 창업 인프라를 개선하는 것이 중요하고, 교원창업기업의 성과 제고를 위하여는 경쟁력 있는 기술 아이디어를 개발할 수 있도록 연구 및 사업화 자금을 확보하거나, 창업 사업화 과정을 도울 수 있도록 창업지원조직 및 기술지주회사를 구축할 필요가 있다는 점을 보여준다.

핵심주제어: 대학창업, 대학기술사업화, 교원창업, 대학 자원, 교원창업휴직, 대학창업인프라

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