

Research funding programs and Innovative Outcomes: Perspectives from Resource Dependency Theory

Choe Jungin
Moon M. Jae

Abstract

Using resource dependency theory by Pfeffer & Salancik(1978) as a theoretical framework in the context of higher education, this study takes the financial resource as an important resource that universities strive to acquire for the survival and success of the organization. The major argument of this study is that different resources of research funding given to universities will result in different innovative outcomes that donor organizations pursue. Using 250 universities data in Korea, the study's results show that there are positive impacts of private sectors on domestic and international patents, while negative impacts of local governments' research funding on domestic patents. The local governments and the private sector's grants have negative effects on technology transfer outcomes. Finally, this study finds that the public and private status of universities moderate the effects of research grants only on the incomes of technology transfer. The results of this study provide practical implications for managers in universities. To ultimately ensure the survival and sustainability of universities, it is important to understand the goals and expectations of different donor organizations and to pursue different strategies depending on the amount, source of donor organizations, and the organizational characteristics (i.e. ownership type) of recipient organizations.

Key Words: Resource Dependence Theory, Innovative Outcomes, Higher Education, University Research Grants, University Outcome

I . Introduction

Korea's total R&D expenditure in 2018 ranked fifth in the world and the R&D expenditure per gross domestic product (GDP) ranked second in the world (MSIT&KISTEP, 2019). When it comes to research grants given to universities, the total amount of grants has been kept increasing over the decades. It

was the economic crisis in 1997 that increased the investment in research and development in universities. Since the late 1990s, the Korean government and private companies have put great efforts into investing in university research and development (Shin and Lee, 2015). Among three different entities, the central government has the largest share of the university's research grants. The funds from the private sector take the second share, local governments being the third one.

Using resource dependency theory by Pfeffer & Slancik(1978) as a theoretical framework in higher education, this study takes the financial resource as an essential resource that universities strive to acquire for the survival and success of the organization. In the case of universities in South Korea, the financial resource also becomes a significant source for survival. Since the half-price tuition policy in 2010, when university tuition has been cut to half-size, university tuition has been frozen for more than ten years. Along with the strong regulation over tuition in South Korea, the governments' financial resources for higher education have been provided unstable depending on the national financial policy and conditions. In addition, the COVID-19 pandemic also put universities in financial difficulties and some universities face severe survival crisis.

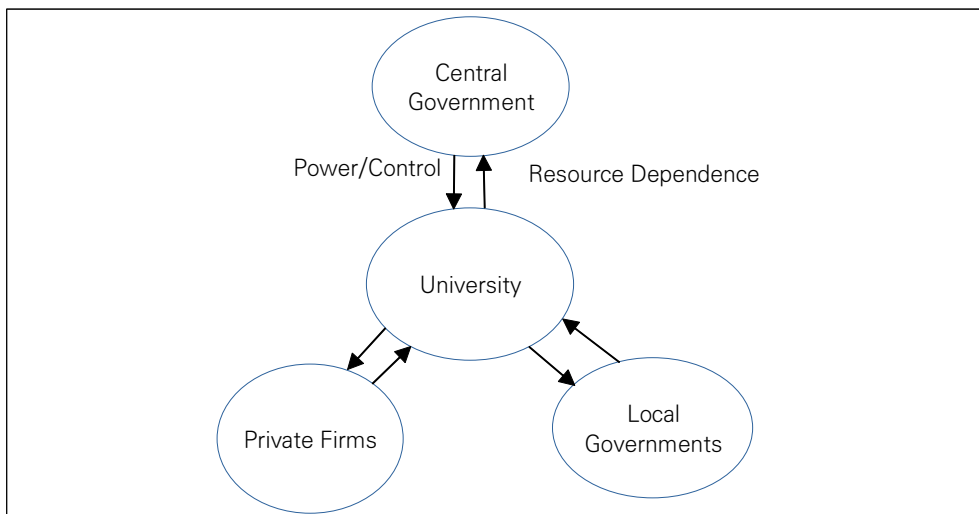
The major aim of this study is to examine the effectiveness of financial resources given to universities from governments and industry and to provide suggestions to improve the innovative outcomes of universities. The specific research questions of the study are as follows. First, what consequences do research funding programs have for higher education in Korea? The donor organizations have different goals, expectations, and requirements when they give out research grants. One of the expected outcomes in both private and the public sector pursue today is innovative outcomes. The study assumes that both governments and industries find 'innovation' as a key factor to survive in the field of higher education. This study will examine whether each source of research grant increases the innovative outcomes of the university. Second, in what conditions is the relationship between research funding and innovation change? The study assumes that different ownership types of universities, whether public or private, can change the impact of research grants on innovative outcomes. The major contribution of this study today is that it provides practical implications for universities to take strategy to utilize their financial resource and eventually survive and gain competence in the field.

The rest of the paper organizes as follows. First, the author provides a theoretical framework by Pfeffer & Salancik (1987) to explain the causal relationship between research funding, innovative outcomes and ownership type of university. Then, based on the literature review and theoretical discussion, the author presents four main hypotheses. In the following section, the research model of the study is presented. The next section describes the research method and specific variables of this study. Lastly, this study discusses the study's limitations and practical implications for regional schools, industry, and governments.

II. Theoretical Framework

The resource dependency theory framework by Pfeffer & Salancik(1987) is used as a theoretical background of the relationship between a university’s R&D funding and innovative outcomes. Although resource dependence theory has been criticized for not having sufficient empirical evidence to prove the power-dependence outcomes among organizations and explain the contextual factors that might affect the power relationship among the organizations (Ouchi, 1980; Williamson, 1995), it is a useful theory to describe different types of cooperative mechanisms that occur in public sectors. For example, universities cooperate with industries and other research institutions to get the necessary resources. The corresponding power distance relationship between universities and other organizations can be described as <Figure 1> below. <Figure 1> shows that universities depend on different types of public organizations to secure the necessary resources for survival. Such dependent relationship can shape the power or control relationship between universities and other organizations. For example, if an university obtains financial resource from the central government, such dependence on resource makes it easier for the central government to take control and power over the university.

<Figure 1> The Resource Dependence and Power Relationship Between Universities and Other Organizations



source: We modified the original figure from Yun, Choe, and Jung (2017: 233p)

Although it varies by the context and field of study, resource is a concept that include assets,

ability, organizational process, information, and knowledge necessary for the competitiveness of organizations (Barney, 1991). As we can assume from the name of resource dependence theory, the ability to control and acquire resource is a critical factor in the survival of organizations (Yun, Choe, and Jung, 2017). The competitive advantage of each university can be obtained from its ability to secure the necessary financial, human, organizational resources from external environments (Malatesta & Smith, 2014). As the Korean government has strict restrictions regarding the rise in university tuitions, getting external resources becomes a crucial strategy to survive.

Previous studies discuss different types of resources such as financial resources (e.g., Powers, 2003; O'Shea et al., 2005; Bolli & Somogyi, 2011; Li et al., 2018), human resources (e.g., Baird, 1991; Lach & Schankeman, 2003), institutional resources (e.g., Lam, 2011). Previous studies in South Korea using resource dependence theory found that public organizations in South Korea have a strong financial dependence on government organizations (e.g., Seo and Kim, 2015; Jung, Seo, and Jang, 2013; Choe and Moon, 2017).

In the context of higher education in South Korea, universities mainly interact with different groups of organizations and the degree of dependence varies by the types. First, central and local governments have a strong relationship with universities. Governments expect to get knowledge from universities as they find it as a key asset for national development. After giving out the financial resources to universities, they continually manage and monitor the process, activities, and the related outcomes universities produce. Universities, as a response, can pursue different types of strategies depending on the amount of resource they receive from the government. Choe and Moon (2017) found from the case of universities in South Korea that stronger financial dependence on government organizations makes universities take more active strategies as a response. Second, universities increasingly interact with the industry. Private firms are investing more resource on the university to get 'useful knowledge' that creates competitiveness in the market. Therefore, universities increase their partnership to obtain financial resources useful knowledge for their competitiveness in the market.

III. Hypotheses

1. The Effects of Research Grants on University's Innovative Outcomes

This study takes the financial resource as an essential resource that universities strive to acquire for the survival and success of the organization. Previous studies that empirically tested the

effectiveness of research grants in higher education have found that financial resources are the critical factor to increase innovative outcomes (e.g., O'Shea et al., 2005; Powers, 2003; Bolli & Somogyi, 2011). For example, O'Shea and their colleagues (2005) used panel data from 1980 to 2001 from 141 universities in the United States to analyze the determinants of the number of spinoff companies generated at universities. The resource-based view was adopted as a theoretical framework. The authors analyze the main argument that institutional resources, human capital, financial resources, and commercial resources affect university spinoff performances. Financial resources were measured by federal R&D funds, which are categorized into seven sub-fields of science and engineering fields and industry R&D funds. The results reveal that successful technology transfer experience from the past, high quality of human capital, federal R&D funding in the field of life science, chemistry, and computer science and industry R&D funding, and the professional staff in technology transfer jobs all have positive effects on spinoff companies outcomes.

Powers (2003) also used the resource dependence theory and resource-based view to explain the effects of four different resources on three technology transfer outcomes. Four groups of resources include financial resources (federal and industry R&D funding for university), physical resources (the presence of engineering and medical schools), human resources (the quality of science and engineering faculty), and organizational resources (university's private or public status) and the outcomes are patents, license of patented technology, and technology transfer incomes. The author gathered the data from the Association of University Technology Managers (AUTM) between 1991 and 1998. The study results show that financial, physical, human, and organizational resources all have a different impact on patents, number of technology transfer, and technology transfer incomes of universities. In addition, the study shows that both the federal and industrial R&D subsidies positively affect patents but have an insignificant effect on the number and incomes of technology transfer. On the other hand, Bolli & Somogyi(2011) used the principal-agent framework to analyze the impact of private and public third-party funding on the productivity of universities and public research institutions in Switzerland. This study finds the significant effects of public third-party R&D funding on scientific publications. Moreover, private funds increase technology transfer outcomes while third-party funding has no impact on technology transfer outcomes.

In South Korea, the effectiveness of research funding was mainly studied in terms of university and industry relationship and the performance outcomes. Han and Kwon (2009) used data of 169 universities in South Korea in 2006 to examine the impact of organizational characteristics and research funding structure on university-industry collaborative outcomes, such as patents and technology transfer income. In a similar line of thought, Cho and Jeon (2011) tried to analyze how resource, education competence, and organizational characteristics impact university-industry

collaborative performances. The theoretical model used data of 202 universities in South Korea, and the results show that research universities and public universities produce more performance outcomes than education universities and private universities. Moreover, all types of resource competence, including funding from the government and private firms, positively affect the performance outcomes of universities.

This study strives to provide a more comprehensive view of research funding and innovative outcomes using panel data of Korea's universities. The study specifically takes resource dependency theory's idea that universities strive to secure financial resources from donor organizations to increase their competitiveness in the field. As universities obtain the necessary resource from donor organizations, however, the donor organizations start to take control over universities' activities and behaviors. In the case of South Korea, the survival of universities has become strongly dependent upon the central government. As we can find from 2009 to 2016 statistics on research grants given to universities, the central government takes the major part of universities' financial resources, followed by private firms and local governments. The central government, as a result, has the strongest control over universities. As a result, the government makes requirements and specific regulations for the use of funding, as well as systematically reviews and evaluates the activities and outcomes on a regular basis (NRF, 2020). Thus, such power relationship between the government and universities will ultimately influence the types of outcomes they produce.

This study assume that each donor organization has different expectations of the university when they give out research funding. When universities strive to get financial resources from donor organizations, they will get pressure to react to their expectations. Although there are variations in the degree and types of expected outcomes, one of the common outcomes they pursue is the innovative outcomes. Innovation has been discussed as a key factor in securing a competitive advantage in the market (Bullinger, Auernhammer, and Gomeringer, 2004). It is a concept that has multi-dimensions and varies in nature, but this study defines innovation as a factor that stimulates a new way of thinking and eventually increases the survival at organizational field. To maintain the competitiveness in the field, both private firms and government organizations emphasize the importance of innovation and expect that their recipient universities will show an overall increase in innovative outcomes.

H1: Research grants from both governments and industry will positively affect the university's innovative outcomes.

Governments, however, are different from private firms in that they prioritize public values,

including equity, accountability, and responsiveness, while private firms mainly focus on efficiency and productivity (Brown, Potoski, and Van Slyke 2006). In addition, private firms concentrate more on profit-maximization to get a competitive advantage in the global market than the governments do. In the context of higher education, there are differences in the goals and expected outcomes between the government and private firms when they grant the research funding. In the power relationship of private firms and universities, for example, universities are under control of private firms to produce innovative outcomes that are valuable in the market. The government, on the other hand, gives less pressure on universities to compete in the field and produce related innovative outcomes. The government focuses more on supporting the universities' system to maintain and develop their status in their organizational field.

The empirical studies conducted in South Korea's higher education support the idea that government and private firms have differential impact on innovative outcomes. For example, Han and Kwon (2009) found from their study on research funding structure on university and industry cooperative outcomes that the research funding from the central government has no impact on outcomes while funding from the industry has a positive impact on outcomes. As a result, private firms will be more likely to expect universities to produce innovative outcomes that are useful in the market more than the government does.

Based on the previous discussion, this study present the following hypothesis.

H2: Research grants from industry will positively affect innovative outcomes than grants from governments.

2. Moderating the Effects: Ownership Type

In what conditions do the effects of research grants lead to innovative outcomes? What organizational characteristics may change the behavior of universities to donor organizations? This study argues that financial resource dependence of the public and private sectors can be categorized by the university's status of being private or public. Public and private universities have different missions, goals, and organizational characteristics. Public universities in South Korea, for example, tend to have a higher level of financial dependence on the government's financial resources.

Moreover, they are even more likely to follow the law and regulations set by the Ministry of Education. For example, public universities need to get the Ministry of Education's approval in industry-university cooperation and curriculum organization-related issues. At the same time, private schools have their board of directors to decide and autonomy on the related matters(Hwang, 2016). They also have a different relationship with governments. The closer

relationship with the governments makes public universities quickly follow the government's goals in the collaboration process.

On the other hand, private schools in Korea generally have their board of directors and have relatively greater autonomy in deciding and implementing school policy. Their foundation provides financial support to schools to conduct research and provide education. A closer relationship with the sponsored private firms compared to public universities. For example, the university budget of Chungang University significantly comes from Doosan Company, which is one of the largest private firms in Korea. High financial and institutional dependence from the private sponsorship will make private universities put more effort to achieve the outcomes that the private sector pursues. Since the foundation and operation of private universities more influenced by the private sponsored firms, they can involve in the power relationship of sponsored firms and get greater pressure to produce the expected outcomes of private firms than public universities do. However, public universities have less pressure from their donor organizations-especially the government. As a result, research funding was given more stably than private ones. All in all, it is assumed that the positive effects of public financial resources on innovation will be weakened in public schools.

Empirical studies that consider the ownership types of universities have mixed results. Thursby & Kemp's (2002) study shows a higher number of commercial licenses in private universities than in public institutions while Power(2003) found that private and public universities have an insignificant impact on patent and technology transfer outcomes. In the context of South Korea's higher education, Han and Kwon (2009) found that the ownership type is the most statistically significant variable that influences the performance outcomes of university and industry relationship. Cho and Jeon (2011) also found the difference between public and private universities in university-industry cooperative outcomes. Based on the theoretical discussion and empirical evidence, the following hypothesis is presented.

H3: private or public status of universities will moderate the effects of research grants on innovative outcome

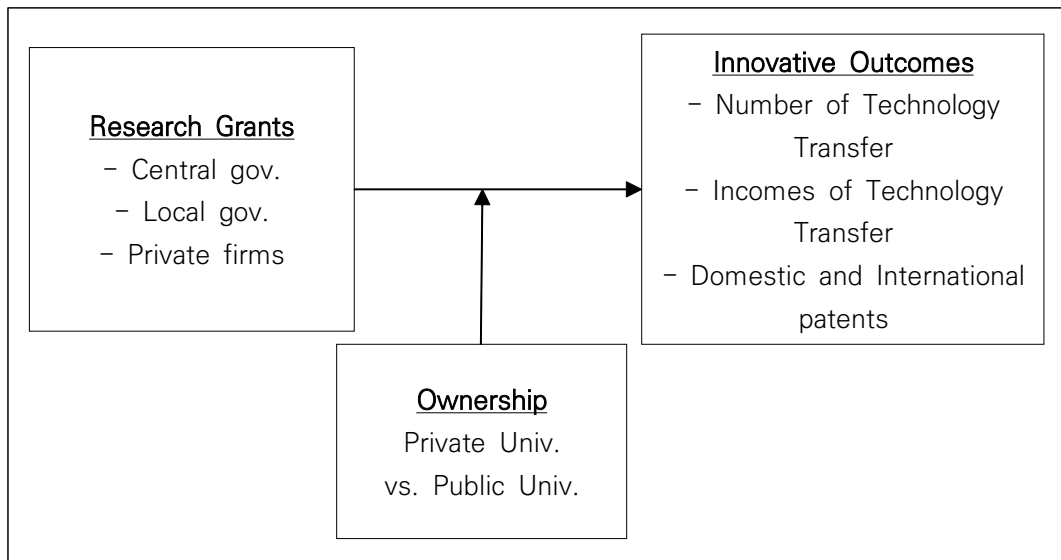
IV. Research Design

Although resource dependence theory in the field of higher education is conceptually applicable to different national contexts, the majority of empirical studies have been conducted in a decentralized political system, such as the United States and Switzerland, and the studies

have produced mixed results in regard to the relationship between research funding and its outcomes (e.g., Bolli & Somogyi, 2011; O’Shea et al., 2005; Powers, 2003). Some scholars have studied the research funding effectiveness in Korea and found that research funding in general has statistically significant impact on universities’ outcomes (e.g., Han and Kwon, 2009; Cho and Jeon, 2011). However, empirical studies using the Korean context have yet to theoretically examine the significant effects of specific sources of organizations (i.e., private firms vs. governments) on innovative outcomes.

To test the validity of resource dependence theory in a centralized political system, the research design of this study presents the causal mechanisms of research grants, innovative outcomes, and ownership types (i.e., private or public) in higher education (See <Figure 2> below). Three groups give out research grants to the universities, and these financial resources may affect innovative outcomes, including patents and technology transfer. The ownership type of each university will moderate the causal relationship between research grants and innovative outcomes. The effects of research and human capacity on innovative outcomes are controlled.

<Figure 2> Research Model



V. Data

This study compiled panel data from 250 four-year universities¹⁾ in South Korea and covers the

1) This study counts main campus and branch campus university as different universities because there

eight years from 2009 to 2016. All data were obtained from the official website of Higher Education in Korea (<http://www.academyinfo.go.kr/>). This service is open to all students, parents, corporations, governments, and higher education institutions to search and look for all types of universities in Korea under Section 6 of "Act on Information Disclosure of Educational Institutions".

VI. Measures

1. Dependent Variables: Innovative Outcomes

The dependent variable of this study is the innovative outcomes of universities. Based on our definition of innovation, the measures of innovative outcomes should indicate a new concept or an idea that changes our previous way of thinking. This study measures innovative outcomes by patents and technology transfers based on the idea that they are new inventions that change previous thoughts or practices that demonstrates the outcomes of competitiveness in the market. Patent refers to 'a proof of invention' that gets legal protection from copies. This study uses both domestic and international patents' applications in time t . The number of patents has been counted based on the individual country's Patent's Office authorization.

In addition, we include technology transfer income and the number of technology transfers as innovative outcomes. Compared to the patents, the process of technology transfer takes more time and effort. Thus, technology transfer is an indicator that demonstrates a more advanced stage of the invention that can be developed into a product with potential for sales in the market. Finally, patents and technology transfer are related to each other. Technology can be transferred from the legal protection of patents. Previous studies on the effectiveness of research outcomes have also used measures such as spin-offs (O'Shea, et al., 2005), technology transfers and technology transfer income (Powers, 2003; Bolli & Somogyi, 2011; Hwang, 2016), and patents(Hwang, 2016) while referring them by their own names individually and not categorizing them as 'innovative outcomes'.

2. Independent Variables: Research Grants as a Major Resource

Based on the logic of power relationship associated with resources among organizations, this

are differences in the size of financial and human resources and varies by organizational characteristics.

study takes financial resources as a major independent variable that explains differential impact on innovative outcomes. In the field of higher education in South Korea, research grants have been examined as the major source that changes the outcomes of universities. For example, Han and Kwon (2009) took the research funding from both the industry and the government to examine their impact on university-industry cooperative outcomes. Cho and Jeon (2011) also found that the resource capacity, including research grants from the government and the industry, has a positive impact on domestic and international patent, number of technology transfer, spin-off, and technology transfer income.

Universities in Korea continuously have their budget from college tuition cut or frozen. Therefore, most of the research budget is highly dependent upon external resources. There are mainly four groups that give research grants to the universities: the central government, local governments, private firms, and foreign countries. Foreign countries' data was minimal that we excluded this dataset and focused on the rest three groups. Each group's research grants are divided by the university's annual budget to control the university's size. As getting patents and technology transfer takes a considerable amount of time, the effects of research grants were measured in year $t-1$. Log term was also applied to get the percentage change of research grants on outcomes.

3. Interaction Terms: Public vs. Private Universities

As explained in the hypotheses section, different ownership types of universities matter in improving the outcomes of universities (Han and Kwon, 2009; Cho and Jeon, 2011). Public and private universities are based on different missions, values, goals, and organizational characteristics. In Korea, the ownership type of universities can be classified into public and private schools. We use dummy variables: public school is coded as 0 and private university as 1.

4. Control Variables: Organizational Capacity

Previous studies identify different types of resources and capacities that bring changes in patents and technology transfer outcomes. Universities having qualified human resources who conduct research will be more likely to produce better innovative outcomes. Research capacity was measured by the number of domestic and international publications per full-time faculty member.²⁾ To control the differences in human resource size between universities, this study

2) Han and Kwon (2011) measures the number of publications as one scientific capacity that affects the industry-university cooperative performance outcomes.

divided the total number of publications by the number of full-time faculty of each school.

Not only the quality of human resources but also the quantity matters in producing innovative outcomes. Big-size universities have more faculty and students to conduct research and produce outcomes than those with smaller universities(e.g., O'Shea et al., 2005; Han and Kwon, 2009). Therefore, the size of human resources was also included. In addition, the absolute number of enrolled students and full-time faculty members were considered, and the incoming student recruitment rate was included to measure the quality of the human resource.³⁾

〈Table 1〉 Definitions of variables in the model

Variable	Definition	
Innovative Outcomes (t)	Technology Transfer	Log(incomes of technology transfer) unit=1,000won
		Number of technology transfer
	Patents	Number of domestic patent application
		Number of international patent application
Research Grants (t-1)	R&D from the central government	Log(Research grants received by central government/ university budget)
	R&D from local governments	Log(Research grants received by local government/ university budget)
	R&D from the private sector	Log(Research grants received by the private sector/university budget)
University Capacity	Research Capacity	Number of Korean journals' publications (KCI) per full-time faculty
		Number of International journal's publications(SCI/SCOPUS) per full-time faculty
	Human Resources	Number of students' enrollment
		Incoming student recruitment rate
Ownership	Public	
	Private	

VII. Methods

To diagnose the appropriate method using panel dataset, this study conducted F-test and Hausman. Firstly, this study ran F-test to find the presence of fixed effects. The test rejects the null hypotheses that fixed effects are zero, and thus the pooled model is not a good match for the

3) The differences in financial conditions among universities can also affect the innovative outcomes. However, this study could not include the financial variable due to data limitations.

study. Second, the Hausman test was applied to discriminate between fixed-effects and random-effects. The null hypothesis is rejected at a p-value less than 0.01, so choosing a fixed-effect model of panel analysis becomes reasonable

VIII. Results

1. Descriptive Statistics

Table 2 presents the descriptive statistics of this study. 250 universities were analyzed in the study from 2009 to 2016, and the reference year is 2009. N refers to all numbers of observations, and n is the number of universities included in the data set. This research excluded universities that have no technology transfer incomes resulted in 158 universities. There are variations in the available data for each variable. The top universities with the highest technology transfer incomes are Hanyang University, POSTECH, and Seoul National University. The average number of technology transfers of 158 universities is 14.70. The average number of registered domestic patents is 48.69, which is 12 times more than international patents. The number of registered domestic patents has a wide range of scope from zero to 1,007(KAIST).

Regarding the number of research grants that Korea’s universities receive, central governments take the largest share among other sources when it is divided by the university’s annual budget. The second-largest research grants come from private, the third group is local governments, and only 54 universities receive research grants from foreign countries. Regarding research capacity, Korean journal publications per full-time faculty are about 2.6 times more than international ones on average. The quantity and quality of human resources have a wide range of scope. The number of students ranges from 5 to 277,382 students. The distance education university, Korea National Open University, has the most significant number of enrolled students. In addition, 197 private schools and 53 public schools were included in the analysis.

〈Table 2〉 Descriptive Statistics for period 2009–2016⁴⁾

Variable		Obs.	Mean	Std. Dev.	Min	Max	
Innovative Outcomes (t)	Technology Transfer (TT)	Log(TT incomes)	N=1052, n=158	11.66	1.86	5.58	15.70
		Number of TT	N=1575, n=158	14.70	22.23	0	141
	Patents	Domestic patents	N=1,568, n=249	48.69	97.17	0	1,007

4) NOTE: All data can be accessed on Higher Education in Korea website (<http://www.academyinfo.go.kr/>).

		International patents	N=1568, n=249	4.64	16.04	0	216
Research Grants (t-1)		Log(R&D from the central governments /budget)	N=745, n=147	-3.20	1.34	-8.70	-0.76
		Log(R&D from local governments /budget)	N=681, n=124	-5.62	1.18	-10.07	-2.32
		Log(R&D from the private sector /budget)	N=704, n=133	-5.05	1.41	-10.52	-1.64
Research Capacity		Korean journal publications(KCI)/full time faculty	N=1571, n=249	0.57	0.31	0	2.19
		SCI/SCOPUS publications/full time faculty	N=1571, n=249	0.22	0.27	0	2.10
Human Capacity	Students	Number of students' enrollment	N=1,342, n=242	13,505	18,759	51	277,382
		Incoming student recruitment rate(%)	N=1,351, n=243	96.88	11.44	0	117
	Faculty	Number of full time faculty	N=1,571, n=249	375.31	345.22	5	2,248
Ownership			N=1,575, n=250	0.77	0.42	0	1

2. The Impact of Research Grants on Patents

Table 3 presents four models that test the impacts of research grants on patents. Model one and model two include domestic patents as dependent variables. Local government research grants are negatively related to domestic patents in model one, where interaction term is not included at p-value=0.001). Universities that get higher local governments' research funding are less likely to register domestic patents. On the other hand, universities with higher portions of research grants from the private sector have more domestic patents. It means that private sectors' financial resources at time t-1 are an important stimulator for producing more domestic patents at year t. The result shows that Korean journals' publication has no significant impact on domestic patents while international journal publications are highly significant at p-value=0.001. This implies that research capacity does matter in getting more patents outcomes. Model two includes the interaction term to previous model one, but there are no significant relationships between research grants, ownership type, and domestic patents.

In Model three, involving the number of international patents dependent variable, the research grants from the private sector variable are highly significant in a positive direction. This result is in line with model one that includes domestic patents as dependent variables. The possible explanation is that private firms encourage universities to have more primary outcomes of inventions. Universities are more likely to get legal protections of their technology with the

support of private firms. Like model three, there are no moderating effects of private or public university status on international patents. It means that the relationship between research grants and patents is not significantly affected by the university's ownership type. Among control variables, only international publication is positively related to the registration of international patents. Thus, research capacity does explain the increasing number of patent registration both domestically and internationally.

〈Table 3〉 Testing the impact of Research Grants on Patents (2009–2016)

Dependent Variable: Patents		Domestic patents		International patents	
		Model 1.	Model 2.	Model 3.	Model 4.
Research Grants (t-1)	Log(R&D from the central governments /budget)	5.572	35.504	1.424	-20.608
	Log(R&D from local governments /budget)	-4.509***	-5.103	-0.544	-1.830
	Log(R&D from the private sector /budget)	3.826**	-2.367	0.849**	0.756
Moderating Effects (private=1, public=0)	Central gov. R&D(log)*ownership		-30.031		22.082
	Local gov. R&D(log)*ownership		0.624		1.281
	Private sec. R&D(log)*ownership		6.216		0.082
Research Capacity (t-1)	KCI publications per full time faculty	-9.239	-9.339	-1.398	-1.344
	SCI/SCOPUS publications per full time faculty	56.171***	55.593	35.754***	36.096***
Human Capacity (t-1)	Number of students' enrollment	0.001	0.001	0.001	0.001
	Incoming student recruitment rate	-1.588*	-1.601	-0.275	-0.265
	Number of full time faculty	0.116***	0.116	0.006	0.006
Year (dummy)	2010	19.974***	20.113***	1.808	1.728
	2011	30.406***	30.522***	1.784	1.702
	2012	33.281***	33.379***	1.447	1.426
	2013	44.800***	44.783***	2.592*	2.587*
	2014	51.820***	51.938***	1.367	1.306
	2015	38.006***	38.153***	2.690*	2.612*
	2016	37.119***	37.443***	-2.368	-2.550
	constant	118.153	119.929***	24.524	23.200
	R-square(overall)	0.6935	0.6940	0.5777	0.5053
	prob> F	0.000	0.000	0.000	0.000
	Number of Obs.	662	662	662	662
	Number of groups	119	119	119	119

* p<0.10, **p<0.05, ***p<0.01

3. The Impact of Research Grants on Technology Transfers

Table 4 presents the result of testing the impact of research grants on technology transfer outcomes. Model five and six include the number of technology transfers as dependent variables, and model seven and eight have incomes of technology transfer as dependent variables. In model five, involving only research grants and other control variables, the private sector's research grants are strongly significant in the positive direction. Universities with higher funds from the private sector do affect the following year's number of technology transfers. As presented in model six, private or public university status does not have the moderating effect of research grants on the number of technology transfers.

Model seven and eight have the amount of technology transfer incomes as innovative outcomes. For model seven, which only includes independent and control variables, funding from local governments increases the incomes of technology transfer. However, this overall positive direction is reversed when the interaction term is included. In model eight, research grants from local governments result in the decreasing incomes of technology transfer. Also, universities with a higher share of private sectors grants are more likely to get lower technology transfer incomes. The moderating effects of ownership type are strongly significant for local and private grants. The result implies that as universities get more research funds from private sectors and local governments, getting more technology transfer incomes may decrease. This negative relationship can be relieved in private universities. However, the negative impacts of local and private research grants on technology transfer incomes get severe in public universities. In both model seven and eight, I find that international journals' publications increase the technology transfer income on average.

In sum, this study reveals different directions of research grants' impacts on innovative outcomes. There are positive impacts of private sectors on domestic and international patents, while negative impacts of local governments' research funding on domestic patents. Furthermore, the local governments and the private sectors grants have negative effects on technology transfer outcomes. These results partially support the first hypotheses that assume the positive relationship between three donor organizations on the university's innovative outcomes. Hypothesis 2 states that private firms are more likely to increase innovative outcomes. The result reveals that universities with higher private firms' funding are getting lower technology transfer incomes. Thus, the second hypothesis is rejected. The public and private status of universities moderate the effects of research grants only on the incomes of technology transfer. Hypothesis 3 is partially supported as a result.

(Table 4) Testing the impact of Research Grants on Technology Transfer
(2009–2016)

Dependent Variable: Technology Transfer (TT)		Number of TT		TT Income	
		Model 5.	Model 6.	Model 7.	Model 8.
Research Grants (t-1)	Log(R&D from the central governments /budget)	-0.022	-3.678	0.047	-2.412
	Log(R&D from local governments /budget)	0.367	-1.197	0.102**	-1.312***
	Log(R&D from the private sector /budget)	1.436*	-2.052	0.028	-5.123***
Moderating Effects (private=1, public=0)	Central gov. R&D(log)*ownership		3.646		2.446
	Local gov. R&D(log)*ownership		1.577		1.421***
	Private sec. R&D(log)*ownership		3.491		5.164***
Research Capacity (t-1)	KCI publications per full time faculty	0.809	0.802	-0.441	-0.456
	SCI/SCOPUS publications per full time faculty	-2.362	-2.369	-1.007**	-1.053**
Human Capacity (t-1)	Number of students' enrollment	-0.001***	-0.001***	0.001	0.001
	Incoming student recruitment rate	0.132	0.133	0.005	0.006
	Number of full time faculty	0.046***	0.046***	0.002	0.002
Year (dummy)	2010	2.126	2.129	0.225	0.255
	2011	3.389	3.378	0.570***	0.539***
	2012	4.558**	4.595**	0.532***	0.568***
	2013	6.346***	6.331***	0.536***	0.519***
	2014	11.297***	11.307***	0.797***	0.804***
	2015	18.014***	18.024***	1.155***	1.165***
	2016	21.477***	21.492***	1.851***	1.877***
	constant	5.159	4.920	10.101***	9.990***
	R-square(overall)	0.3425	0.3226	0.2554	0.041
	prob) F	0.000	0.000	0.000	0.000
	Number of Obs.	662	662	568	568
	Number of groups	119	119	101	101

* p<0.10, **p<0.05, ***p<0.01

IX. Conclusion

This paper analyzes the impact of public and private research grants on innovative outcomes, applying it to South Korea's higher education contexts. The results show that central governments' funding has no impact on all measures of innovative outcomes. The central government may give out research grants without expecting or requiring immediate outputs from

it. On the other hand, the general research funding from central governments may have looser requirements and a monitoring system toward innovative outcomes. In addition, universities with higher local government grants are less likely to register domestic patents. After including the interaction term of private or public school status, local government grants negatively impact technology transfer income. The negative relationship between local governments' grants and technology transfer income, however, weakens private universities than public universities.

The negative relationship between local government grants and domestic patents may derive from the characteristics of local governments' research grants in South Korea. Studies in higher education have pointed out that local government grants, such as NURI(New University for Regional Innovation), CK(University for Creative Korea), and PRIME(Program for Industrial needs-Matched Education) by the Department of Education, have emphasized the relationship between local universities, the government, and the community while local governments only play minimal roles and have little discretion compared to the central government. Local governments have a limited control and power over research funding projects with universities and other private firms (Kim, 2019). Thus, we can assume that the resource dependence and power relationship between universities and local governments are vulnerable in the sense that they cannot maximize innovative outcomes.

The characteristics of the private sector seem a lot different from the public one. As the goal of private firms is profit-making and they lean toward market value, they give out money to get immediate and practical outcomes. Stronger feedback and monitoring of the use of research grants may also be followed. As a result, the research grants from the private sector increase the research and human capacity of the university's faculty and increase the number of patents. However, universities with higher private research grants get lower technology transfer income. When universities get funding from private firms, the human capacity of faculty members who conduct the researches may be improved, but they give the final products to the donor organizations, and all the related incomes belong to donor organizations, not the universities. Therefore, the negative relationship gets stronger in public universities than the private schools. This study assumes that as private universities share a common value system and have a closer relationship with the private firms, they are well aligned with the expectations that private firms pursue. As a result, the related conflicts and problems are less likely to occur. The negative relationship between private firms and innovative outcomes at model 8, thus, are more likely to be relieved in private schools.

This study contributes to the public administration as well as the higher education literature and practice in two ways. First of all, this study examines whether the significant effects of resource dependence of universities on the government and private firms in decentralized

systems, such as United States and Switzerland (e.g., Bolli & Somogyi, 2011; O'Shea et al., 2005; Powers, 2003), are still valid in the centralized political system of South Korea. Since Korea is based on a different political and bureaucratic system, organizational culture, and structure from Western countries, our study can increase the external validity of the resource dependence theory, which was mainly studied in Western countries. Moreover, the previous empirical studies using the Korean context have pointed out that their studies examined the impact of research funding and performance outcomes only based on a single year (e.g., Han and Kwon, 2009; Cho and Jeon, 2011). This study provides a more comprehensive view of the causal relationship by using panel data from 2009 to 2016. Thus, we can provide a long-term impact implications to management and higher education practitioners.

Another contribution of this study is related to practical implications in public management and higher education field. The results of this study provide managers with ideas to pursue different strategies depending on the source of funding to improve the innovative outcomes in higher education. This study specifically emphasizes the importance of ownership type of organizations: managers in public universities may experience greater goal conflicts when they receive financial resources from private firms, which ultimately affect the innovative outcomes. Private universities, however, can be better alignment with the goals of private firms of producing innovative outcomes. This study demonstrates the importance of understanding different goals and expectations of donor organizations and pursuing different strategies depending on the amount and type of research funding, and organizational characteristics (i.e. ownership type) of recipient organization to ultimately ensure the survival of organizations within the organizational field.

This study has various limitations. First, there might be a reverse causality of this research model. The innovative outcomes may also be a determinant factor to get funds from public or private sectors. Later research can extend the analysis and find the reverse causality by using the 3SLS model. In addition, the time period from 2009 to 2016 covers two presidential terms. Future research may capture the differences between Lee and Park administrations to capture the effects of political environments. Finally, more specific and practical policy implications will be derived from improving quantitative and quality results that include the various context in higher education.

References

- Baird, Leonard L. (1991). Publication Productivity in Doctoral Research Departments: Interdisciplinary and Intradisciplinary Factors. *Research in Higher Education* 32(3): 303-18. Print.

- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1): 99-120.
- Bolli, T., and Frank Somogyi. (2011). Do Competitively Acquired Funds Induce Universities to Increase Productivity? *Research Policy* 40(1): 136-47. Print.
- Brown, T. L., Potoski, M., & Van Slyke, D. M. (2006). Managing public service contracts: Aligning values, institutions, and markets. *Public administration review*, 66(3), 323-331.
- Bullinger, H. J., Auernhammer, K., & Gomeringer, A. (2004). Managing Innovation Networks in the Knowledge-Driven Economy. *International Journal of Production Research*, 42(17): 3337-3353.
- Cho, H. J. & Jeon, B. H. A. (2011). Study on Relationship between Performance of University-Industry Cooperations and Competency Factors of University-Industry Cooperation by Characteristic of Universities. *Journal of Korean Institute for Practical Engineering Education*. 3(1): 119-126. Korean Article
- Han, S. & Kwong, K. (2009). The Relationship Between Characteristics of University and Research Funding Structure on University-Industry Collaborative Outcomes: Focusing on South Korea's STEM Schools. *Korean Public Administration Review*. 43(3): 307~325. In Korean
- Hwang, Kwang-Myoung. (2016). The Influence of the factor of core competence, policy of local government, regional economic and strategic factor of University and Industry Collaboration Foundation on Performance. *Innovation Studies*. 11(2):73-105. Korean Article.
- Jung, K., Seo, I, & Jang, H.S.. (2013) The Exploratory Research for the Sustainability of Social Enterprise: Focusing on the Resource Dependent Theory. *Korea Policy Study Review*, 22(1): 176-202. Korean Article.
- Kim, J. S. (2019). Evaluation and Improvements of Local Government Support to University. *Journal of Social Science*, 30(3): 69-91. Korean Article.
- Lach, S., and Mark Schankerman. (2008). Incentives and Invention in Universities. *The RAND Journal of Economics* 39(2): 403-33. Print.
- Lam, Alice. (2011) What Motivates Academic Scientists to Engage in Research Commercialization: 'Gold', 'Ribbon' or 'Puzzle'? *Research Policy* 40(10): 1354-68. Print.
- Li, J., Fang, H., Fang, S., & Siddika, S. E. (2018). Investigation of the relationship among university-research institute-industry innovations using a coupling coordination degree model. *Sustainability*, 10(6), 1954.
- Malatesta, D., & Smith, C. R. (2014). Lessons from resource dependence theory for contemporary public and nonprofit management. *Public Administration Review*, 74(1), 14-25.
- Moon, M. & Choe, J. (2017). University Responses to the Universities Reorganization Evaluation Policy, 21(2): 305-323. Korean Article.
- MSIT(Ministry of Science and ICT) and KISTEP(Korea Institute of S&T Evaluation and Planning).

- (2019). Survey of Research and Development in Korea“
 NRF(National Research Foundation of Korea). (2020). Conversion of research fund-related environment to create an environment for research commitment. Issue Report 5. ISSN 2586-43. In Korean
- O’Shea, Rory P, et al. (2005). Entrepreneurial Orientation, Technology Transfer and Spinoff Performance of Us Universities. *Research Policy* 34(7): 994-1009. Print.
- Ouchi, William G. (1980). Markets, Bureaucracies, and Clans. *Administrative science quarterly* 129-41. Print.
- Pfeffer, J., and Anthony L. (1977) Resource Allocations in United Funds: Examination of Power and Dependence. *Social Forces* 55(3): 775-90. Print.
- Pfeffer, J., and Gerald R Salancik. (1978) The External Control of Organisations. New York 175. Print.
- Powers, Joshua B. (2003). Commercializing Academic Research: Resource Effects on Performance of University Technology Transfer. *The Journal of Higher Education* 74(1): 26-50. Print.
- Seo, J. W. & Kim, B. K. (2015). The Impact of Social Entrepreneurship on Resource Dependence Patterns. *Korean Journal of Public Administration*, 53(4): 271-298.
- Shin, J. C., and Soo Jeung Lee. (2015). Evolution of research universities as a national research system in Korea: accomplishments and challenges. *Higher Education* 70(2): 187-202.
- Thursby, Jerry G., and Sukanya Kemp. (2002) Growth and Productive Efficiency of University Intellectual Property Licensing. *Research Policy* 31(1): 109-24. Print.
- Verhoest, K., Verschuere, B., & Bouckaert, G. (2007). Pressure, legitimacy, and innovative behavior by public organizations. *Governance*, 20(3), 469-497.
- Williamson, Oliver E. (2007). The Economic Institutions of Capitalism. Firms, Markets, Relational Contracting. *Das Summa Summarum Des Management*. Springer. 61-75. Print.
- Yun, Choe, and Jung. (2017). The Causal Relationship between Knowledge Sharing and Performance: The Determinants of Knowledge Sharing and Their Impacts on Performance Using Structural Equation Mode. *The Korean Journal of Local Government Studies*, 21(1), 231-359. (Korean Article)

최정인(崔正仁): Indiana University에서 석사학위를 취득하고, 현재 연세대학교 행정학과 박사과정에 재학중이다. 학문적 관심분야는 공공관리, 정부성과, 조직론, 개발행정 등이다(choejungin@naver.com).

문명재(文命在): Syracuse University에서 행정학 박사학위를 취득하고 현재 연세대학교 행정학과 언더우드 특훈 교수로 재직중이다. 주요 관심분야는 공공관리, 전자정부, 정책도구, 조직론 등이다(mjmoon@yonsei.ac.kr).

〈논문접수일: 2021. 9. 13 / 심사개시일: 2021. 9. 15 / 심사완료일: 2021. 10. 28〉

국문요약

대학연구비와 혁신성과: 자원의존이론의 관점을 중심으로

최 정 인
문 명 재

본 연구는 자원의존이론을 이론적 틀로 활용하여 대학의 재정자원이 조직의 생존과 성공에 주요한 역할을 한다고 주장한다. 250개교의 국내대학 데이터로 패널분석을 실시한 결과, 사기업의 연구비는 대학의 국내와 해외특허에 정(+)의 영향을 미치는 것으로 나타난 반면 지방정부의 연구비는 국내특허에 부(-)의 영향을 미치는 것으로 나타났다. 또한, 지방정부와 사기업의 연구비는 기술이전수입료에 부(-)의 영향을 미치는 것을 확인하였다. 마지막으로, 본 연구는 대학의 설립유형으로 국공립대학과 사립대학의 여부가 연구비와 기술이전수입의 인과관계에 조절효과를 지니는 것을 확인하였다. 이와 같은 연구결과는 연구비를 수여하는 기관의 서로 다른 목표와 기대, 재원의 절대적 양, 조직특성(예. 설립유형)이 따라 대학이 적절한 전략을 취함으로써 혁신성과를 향상시킬 수 있다는 실천적 함의를 제공한다.

주제어: 자원의존이론, 혁신성과, 고등교육, 대학연구비, 대학성과