

WILL UNIFIED CONTROL OF GOVERNMENT LEADS TO GREATER KNOWLEDGE SPILLOVER? -EVIDENCE FROM CHINA

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ABSTRACT

Universities are the creator and transmitter of knowledge and technology, and their R&D activities have positive externalities which could enhance regional innovation by knowledge spillover, thus making it vital to the regional economic development. However, different from the innovation system of developed countries, the universities in China are still under the intensified control of the government, which are regarded as an obstacle to innovation due to their corruption and bureaucracy. Despite increasing attention to the role of government to firms' innovation performance, few studies have explicitly shed light on its impact to universities. Drawing on knowledge spillover theory, this study established a model to examine the moderating effect of the governmental actions to the knowledge spillover effect of the universities, and provided a clear interpretation with empirical evidence to the knowledge spillover mechanism of the universities in China.

This study utilized two different proxies to investigate the innovation performance of industrial enterprises by measuring the patent application number (intermediate outcome) and the new product sales volume (end outcome). Based on the improved Cobb-Douglas knowledge production function, the research took the ratio of planned economy as the proxy variable of the intensity of government's control. On the basis of the panel data of 30 provinces in China from 2003 to 2008, we used GLS with fixed effect model to examine whether unified control from the government will enhance or impede the knowledge spillover of universities.

This study find that the unified control of government had a positive moderating effect towards the knowledge spillover of universities in terms of both patent application number and new product sales volume of industries, thus in turn leading to greater innovation performance in enterprises. The result is robust using different rate of depreciation of R&D capital. These findings indicated that the unified control of the government enhanced the knowledge spillover of universities and improved the regional innovation performance through scale effect at the early stage of emerging economies.

Former researches tended to consider government as an obstacle to innovations, but this study showed an exception to the field that the unified control of government may not hinder

innovations at the beginning. At the early stages of emerging economies, innovation capability could be promoted rapidly when resources were pooled by unified control of government. Even so, if developing countries are to become developed countries, they still need to gradually improve their innovation system. At the later period of the development of emerging economies, the regional innovation performance may suffer because of the marginal effect decrease of only focusing on short-term profits. Therefore, the universities are still needed to increase their autonomy to make use of the moderating effect of the market itself, and improve the innovation performance via diversified and open innovation activities.

Keyword: unified control; government; universities; knowledge spillover;

INTRODUCTION

Universities are considered as the creators and disseminators of knowledge and technology. They can increase knowledge stocks, improve skill level of labor force on local area and promote technology upgrading by researches and educations, which make it vital to the regional economic development (Bresnahan and Gambardella 2004). There are lots of researches proving that universities have positive externality to regional innovation systems in developed countries (Etzkowitz 1983, 1995, 2002; Clark, 2000; Slaughter, 2004). However, different from the innovation system of developed countries, universities in China are still under the intensified control of the government. China's innovation system is built on a triple helix structure with the core of government (Etzkowitz and Zhou 2007), which means most of innovation activities are commanded and driven by the authorities. Besides, China's government could make different policies to affect innovation of universities by means of educational expenditures, project funds, technology subsidies and taxes (Wu 2007). Furthermore, all assets of universities in China, including intellectual properties and technology start-ups generated from universities, are state-owned. Therefore, the paths of knowledge spillover of universities are further influenced for that such technology companies could also be regarded as state-owned companies highly controlled by the authorities (Etzkowitz and Zhou 2007).

Unified control of government may lead to different outcomes to innovation activities of universities. On the positive side, unified control of government will set targets for innovation system to make sure a leaping development in a short time, by pooling resources and labors they need as soon as possible. More advanced knowledge and technology providing greater spillover to the region may be created based on scale effect. On the negative side, free-style innovation activities of universities may be squeezed out by government's order. What's more, government is generally considered to be an obstacle to innovations due to its corruption and bureaucracy and they may be inefficient for R&D resource allocation as well. Thus, a question arises: whether unified control from the government will enhance or impede the knowledge spillover of universities. It's important to get deeper understandings to China's innovation system and help other developing countries to design their innovation systems based on theoretical and empirical evidences.

There are so many former researches about how government affects innovation activities, but they are mostly concentrated in the impact of government to companies. Few of them are about

collaborative innovation explaining government's impact to the entire industry-university-research system, which obscures the separate impact to universities. Drawing on knowledge spillover theory, this study established a model to examine the moderating effect of the governmental control to the knowledge spillover effect of the universities, and provided a clear interpretation with empirical evidence to the knowledge spillover mechanism of the universities in China.

THEORETICAL BACKGROUND AND HYPOTHESE

Anselin (1997) found that innovation outcome of high-tech industry increased when university strengthened their R&D activities and there is positive correlation between them. Lawson (1999) thought that university as fountain of knowledge played an important role to regional innovation activities; outcome of university's R&D activity can outflow to enterprise through communication and collaboration between university and enterprise, which lift up knowledge and technology of enterprise dramatically. Dumais (2002) found out a significant correlation between R&D activity of university and innovation activity of local enterprise and suggested that they should get more connections and collaborations for win-win situation. Based on empirical research, Adams (2002) obtained conclusions that R&D activity of university will always produce knowledge spillover effect no matter in which fields or regions, and it was better to generate knowledge spillover effect within same region by comparing different data between fields and regions.

The positive moderating effect

According to former literatures, enterprise scale is significant positive to innovation, for that big enterprises with advantages of capital and resources can afford continuous investment for research and development activities and they are capable to take risk of failure of innovations, so that they have higher innovation capabilities and innovation outputs (Scherer 1965; Blundell 1999; Gayle 2003; Zhou and Luo 2005; Jefferson et al. 2006; Zhu 2006). Similar to enterprises, innovation activities of universities are constraint by scales and funds themselves. As a consequence of it, universities have to allocate their expenditures appropriately to make sure that their limited funds are used in proper way and produce due outputs they want. Those universities which can invest considerable funds into innovation activities would be more likely to achieve impressive innovation performance. However, under unified control of government, universities in the region may get abundant funding supports from local government and all be push to work on the R&D projects that the authorities expect to be productive to pillar industries of local economy and become their governance achievements. Given the more scientific researchers struggle with the same scientific fields, it's more likely to create greater knowledge of those fields in a short time.

Organization in regional network can make use of knowledge spilled from others to improve innovation performance itself (Gupta et al. 2009). Industrial policies and major scientific projects announced by government set targets for regional innovation activities and encourage universities and enterprises to be engaged in these fields, decreasing the uncertainty of blank wall because of choosing wrong technological path and lack of subsequent technology capability. Close to the fields of universities' researches, local companies are equipped with ample abilities of learning and absorbing for such knowledge. It's easier for companies with abilities of learning and absorbing to capture and integrate knowledge from outside (Powell et al. 1999). Therefore,

administrative commands may be benefit to companies obtaining knowledge spilled from universities and getting better innovation performance.

In China, except for universities, stated-owned enterprises are also firmly controlled by government (Shleifer and Vishny 1997). It makes China government become a node of national innovation system, connecting a vast and diversiform network of relationships. Cullen (2000) and Dang and Liu (2006) pointed that trust between network members is incentive to innovations. Xu et al. (2003) demonstrated that it's key to transfer tacit knowledge for innovation performance on the premise of trust within networks. Liu and Wang (2006) indicated that innovation capability of trust chain as an entirety is far more than when members are separated. Via unified control and administrative instructions, government becomes the endorser of cooperation among universities, state-owned enterprises and private enterprises, which enhances trust of network members substantially. Complex information and tacit knowledge will be shared to promote the intensity of cooperation when members have trust to each other (Rindfleisch and Moorman 2001). Stronger trust-cooperation could generate better quality of knowledge and higher efficiency of exchange, spurring knowledge spillover from universities and resulting in greater innovation performance of local companies. Based on the above analyses, we propose following hypothesis:

H1: unified control of government has positive moderating effect to knowledge spillover of universities.

The negative moderating effect

China's local government officials are engaged in a yardstick competition orienting GDP only for promotion all the time (Zhou 2007). Government officials would distribute most of fiscal resource to the public goods clearly contributing to short-term economic growth – such as transportations, infrastructures, rather than the ones like educations and social welfare that could contribute in long-term period (Fu 2010). Zheng (2008) argued that competition of local governments combining with the system of fiscal decentralization in China is dramatically negative to local education expenditure. Because universities' are mainly funded by government, reducing education expenditure to universities will limit their knowledge creation activities, and then lower the knowledge spillover effect.

Many research suggested that rent-seeking behaviors and corruptions of government are stumbling stock to innovations and will dislocate R&D resource generally (Shleifer and Vishny 1993; Rose-Ackerman 1999; Svensson 2003). The more powerful government is, the higher possibility of rent-seeking behavior and corruptions it is, and these will do harm to research and development investment directly of the whole society (Gu and Shen 2012). Under intensive control from government, whether a R&D project could be taken up is mostly decided by different ranks of the authorities. During the approval process, real investment of R&D activities may be encroached by rent-seeking behaviors and corruptions, so that knowledge creation activities will be hindered leading to lower spillover effect.

From the perspective of governance structure of China's universities, all principals of universities are appointed by government. Besides, the hierarchy of secretary of the communist party committee in university is higher than principal, which means that scientific activities and administrative system inside universities are still got command from the authorities. Even though few of secretary try to carry the reform about autonomy of universities a step forward, such governance structure put more stress on restraint to academic freedom and innovation (Abrami et

al. 2014). Limited academic freedom is hard to provide a good environment to R&D activities, therefore it might impede knowledge creation as well as knowledge spillover. Based on the above analyses, we propose following hypothesis:

H2: unified control of government has negative moderating effect to knowledge spillover of universities.

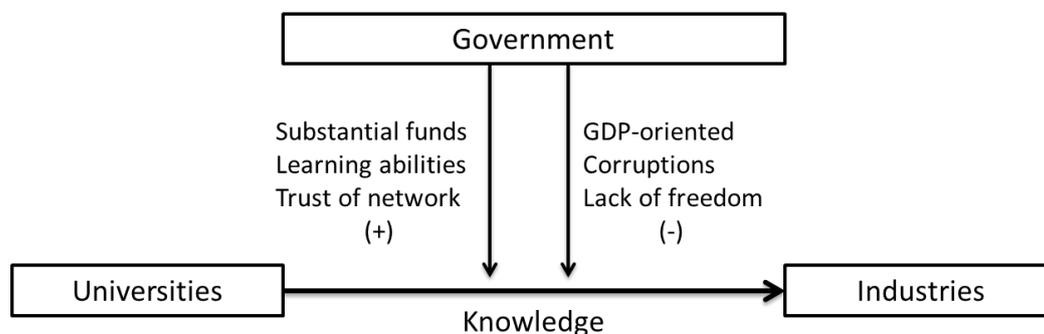


Figure1. Theoretical framework

Research Method

Regression model

Griliches (1979, 1986) proposed to use knowledge production function to analyze the theoretical framework of knowledge creations and spillover effects. Based on Griliches's works, Jaffe (1989) improved the knowledge production function to make it more suitable to measure knowledge spillover effects. In order to examine the moderating effect of unified control of government to knowledge spillover of universities, this study expanded Griliches–Jeff knowledge production function and built a following regression model:

$$\ln(Y_{it}) = \delta_{it} + \beta_1 \ln(FK_{it}) + \beta_2 \ln(FL_{it}) + \beta_3 \ln(UK_{it}) + \beta_4 \ln(IK_{it}) + \lambda GOV_{it} \times \ln(UK_{it}) + \varepsilon_{it} \quad (1)$$

Y_{it} , FK_{it} , FL_{it} , UK_{it} , IK_{it} and GOV_{it} represent innovation output of local industries, R&D capital stock of local industries, scientific labors of local industries, R&D capital stock of universities, R&D capital stock of independent research institutes and intensity of local government's control respectively. i means different regions, t means different times, δ_{it} is the constant, ε_{it} is random disturbance variable.

Variables and parameters

Next, we will introduce how we define the variables of Y_{it} , FK_{it} , FL_{it} , UK_{it} , IK_{it} and GOV_{it} .

We used the numbers of patent application and sale revenue of new products of the large and medium sized industries as two proxies of innovation output of local industries. The numbers of patent application are intermediate outcome of innovation for enterprises, indicating outputs of new knowledge in process of technology innovations (Nasierowski and Arcelus 2003; Guan and He 2005; Wang 2007; Akihiro and Shoko 2008). Sale revenues of new products are final targets and end outcomes of innovation for enterprises, which represents the outcomes of knowledge marketization and commercialization (Zhang et al. 2003; Zhu and Xu 2006). In this paper, we corrected sale revenues of new products to real values on the base period of 2003 by ex-factory price indices of industrial product and used real values for regression.

Referring to researches of Griliches (1980), Goto and Suzuki (1989) and Wu (2006), this study utilized perpetual inventory method to measure R&D capital stock. The R&D capital stock in current period can be present as the sum of the R&D capital stock in last period and present value of previous R&D expenditures.

$$K_t = \sum_{k=1}^n \mu_k RD_{t-k} + (1 - \zeta) K_{t-1} \quad (2)$$

K_t and K_{t-1} represent R&D capital stock in current period and last period respectively,

RD_{t-k} is present value of R&D expenditure in $t-k$ period, μ_k is lag operator of R&D

expenditure, ζ is rate of depreciation of R&D expenditure. We assumed that R&D capital stock lagged for two years averagely, so R&D capital stock in current period equal to present value of two years lagged R&D expenditure plus R&D capital stock in last period.

Following the idea that R&D expenditure price index can be structured by the propose it was used to (Loeb and Lin 1977; Frantzen 2003; Zhu and Xu 2003; Zhu and Xu 2006; Yu and Shen 2010), we assumed that all R&D expenditure are used for labor cost and fixed assets investment and we got the R&D expenditure price index based on the ratio of labor cost and fixed assets investment of R&D expenditure during 2003-2008. Finally, we defined R&D expenditure price index as weighted average of 0.37 of consumer price index and 0.63 of price index of fixed assets investment and use it to discount R&D expenditure to real value.

We chose 15% as the rate of depreciation of R&D capital stock, because this value was confirmed by many literatures (Griliches 1980; Hall and Maiese 1995; Hu et al. 2005; Wu 2006, 2008; Bai, 2009; Zhang 2010; Zhan et al. 2010). Besides, the rate of depreciation of physical capital is 10% approximately (Zhang et al. 2004; Gong and Xie 2004), which make it reasonable for the assumption that rate of depreciation of R&D capital is higher than physical capital (Pakes and Schankerman 1984; Wu 2006).

This study assumed the growth rate of R&D capital stock is equal to growth rate of R&D expenditure, and then R&D capital stock in base period can be calculated as:

$$K_0 = RD_0 / (g + \zeta) \quad (3)$$

This study chose scientific and technical activity internal expenditure of the large and medium sized industries to approximate R&D expenditure, as a consequence that China's yearbook of science and technology did not record the data about R&D expenditure of enterprises but record

the data about scientific and technical activity internal expenditure. What's more, in view of the definition of innovations (Utterback 1974; Freeman and Soete 1997), innovations means the entire process from R&D activity to commercialization of outcomes, matching with the contents in China's yearbook of science and technology that scientific and technical activity include R&D activity, pilot application and promotion.

This study chose R&D internal expenditure as the R&D expenditure of universities and independent research institutes.

By means of the method and parameters above, we can get the R&D capital stock of industries, universities and independent institutes.

Similar to R&D expenditure of enterprise, this study chose scientific and technical activity personnel (full-time equivalent) as the variable of scientific labors considering availability of data and statistical definition.

Because government in planned economy system will usually infiltrate their will to others when they use power, the stronger planned economy it is, the stronger and wider government intervene to the society it will be (Gao 2000; Zeng 2002). So this study utilized the proportion of planned economy as an instrumental variable to the intensity of unified control of government. We use the ratio of assets of state-owned enterprises to large and medium sized industrial enterprises as the proportion of planned economy rather than ratio of sale or profits for that assets are more stable and objective and can reduce the disturbance of macroeconomic asymmetry (Wu and Zhang 2015).

Data sources

All data we use came from the yearbook of China, the scientific and technical yearbook of China and the yearbook of state-owned assets supervision and administration of China. This study only chose provincial panel data of China from 2003 to 2008 because of changes of statistical caliber. Among them, we got total 30 provinces data valid for that Tibet miss data for many years and we delete it from samples. Descriptive statistics for all variables are presented as following on table 1.

Table1. Descriptive statistics

Variable	Mean	Standard deviation	Maximum	Minimum
<i>SALE</i>	95398436902	127147460747	680147012216	325424795
<i>PNT</i>	2955.322	5719.053	38958	5
<i>FRD</i>	23250199726	28984246447	168239820269	107649252
<i>FL</i>	16401.8	15654.826	71939	56
<i>URD</i>	2775858560	3073614975	17196265494	33701330
<i>IRD</i>	6788118477	13727403488	91453414953	69360795
<i>GOV</i>	0.29817519	0.24711115	1.93154707	0.06318089

EMPIRICAL RESULT AND ANALYSIS

Stationary test

Even though the time span of data this study used is short, but concerning about the time trend of macroeconomic data which might lead to spurious regression, we test stationarity of panel data before regression analysis. This study use LLC, IPS, Fisher-ADF and Fisher-PP to test stationarity. All variables passed stationary test so that we can use generalized least squares for regression analysis directly. The result is presented on table 2 as following.

Table2. Stationary test

	LLC	IPS	Fisher-ADF	Fisher-PP
$\ln(SALE)$	-9.191***	-1.761**	83.800**	122.534***
$\ln(PNT)$	-9.086***	-1.699**	82.007**	107.382***
$\ln(FRD)$	-9.235***	-2.130**	89.545***	125.274***
$\ln(FL)$	-9.097***	-1.778**	83.366**	121.181***
$\ln(URD)$	-11.271***	-1.951**	87.420**	121.318***
$\ln(IRD)$	-9.694***	-1.474*	78.087*	113.878***
GOV	-9.607***	-2.308**	90.735***	127.033***
$GOV \times \ln(URD)$	-8.324***	-1.601*	80.459**	109.712***

(***p<0.01; **p<0.05; *p<0.1)

Empirical results

We applied formula (1) for generalized least squares to analyze the moderating effect of unified control from government to universities knowledge spillover. The regression outcome is presented on table 3 as following.

Table3. Regression analysis

	$\ln(PNT)$		$\ln(SALE)$	
δ	1.1170**	2.0913***	-15.5629**	-15.1802*
$\ln(FRD)$	0.9849***	0.9031***	0.8973***	0.8524***
$\ln(FL)$	0.2050	0.1530	0.1430	0.0579
$\ln(URD)$	0.2029***	0.1920**	0.1531***	0.1386***
$\ln(IRD)$	0.0464*	0.0478*	0.0692	0.0615

$GOV \times \ln(URD)$		0.0968**		0.0521**
Hausman	19.835***	27.177***	15.434***	9.747*
Fix/Random effect	FE	FE	FE	FE
adjusted R^2	0.8661	0.8708	0.8798	0.8821
F-value	36.083	36.477	40.706	40.400

(***p<0.01; **p<0.05; *p<0.1)

On table 3, the first and second rows are results using patent application numbers as proxy of industrial innovation outcomes. The third and fourth rows are results using sale revenues of new products as proxy of industrial innovation outcomes. According to Hausman test, all regression models support the hypothesis of fix effect model.

The results in first row show that R&D capital stock of universities is significant positive to patent application numbers of industries, indicating that knowledge spillover of university is incentive to company's innovation performance and the incentive effect is 0.2029, which means 1% increment of R&D capital stock of university can lead to 0.2029% increment of patent application of company. As shown in the second row, the coefficient of interaction is positive and significant after taking interaction of government control into account, denoting a higher intensity of government control in China is benefit for the R&D investment of university. We deduced the reason for this is because education and technical activity will be push by mandatory plan under a strong government control and government will offer sufficient resource to university for satisfying innovation performance as well as their own governance achievement. Furthermore, due to the administrative rank of secretary and principal in China, who might be a government official before or after, they will bring forceful political ties to university. Strong political tie in a region with higher intensity of government control is more likely to get remarkable resource superiority, especially for famous university where their secretary and principal is higher hierarchy than a mayor. The incentive effect of R&D stock of university increased from 0.2029 to 0.2208¹, which indicates unified control of government is positive moderating to knowledge spillover from university when we use patent application numbers as proxy of industry's innovation performance.

The results in third row show that R&D capital stock of universities is significant positive to sale revenue of new products of industries and the incentive effect is 0.1531, which means 1% increment of R&D capital stock of university can lead to 0.1531% increment of sale revenue of new products. Comparing to the result in fourth row with interaction of government control, the coefficient of interaction is still positive and significant, and incentive effect of university changes slightly from 0.1531 to 0.1540². It demonstrated unified control from government is useful to R&D investment of university, but do not adjust knowledge spillover from university obviously when we use sale revenue of new products as proxy of industry's innovation performance.

The moderating effects of unified control of government are different for two proxies of industrial innovation performance. We believed that's because patent is direct output of new knowledge, no matter where and how it comes from. Benefit by the scale effect of R&D activities commanded by the authority on similar fields, plentiful knowledge generated from universities

¹ Partial effect equals to $0.1920+0.0968*\text{mean of GOV}$, so that $0.1920+0.0968*0.2982=0.2208$

² Partial effect equals to $0.1386+0.0521*0.2982$

and independent research institutes can be utilized by enterprises with better capability of learning and absorbing and transform to patent of enterprises. However, sale revenue of new product is determined by markets primarily, not by the government. Public research institutes will invest a large number of R&D resources into the projects with technical advancement but lack of commercial value on request of government, which squeezed out researches with commercial value decided by markets (Dominique and Bruno, 2000; Yao and Zhang, 2001). Unified control from government may restrain efficiency of market itself and lead to lower incentive effect of university's knowledge spillover. As a result, unified control of government can be obviously positive moderating to knowledge spillover of university to patent application numbers of industrial, but only slightly to sale revenue of new product.

The results are robust when we use 10% and 20% as rate of R&D capital stock depreciation. Rate of R&D capital stock depreciation did not matter to regression analysis.

CONCLUSIONS AND IMPLICATIONS

Conclusions

This study analyzed the moderating effect of government's unified control to university's knowledge spillover by provincial panel data in China from 2003 to 2008, and obtained a robust result. The conclusions of this study are as following: R&D investment of university had positive knowledge spillover effect to industrial innovation performance. Unified control of government had a positive moderating effect towards the knowledge spillover of universities in terms of both patent application number and sale revenue of new product of industries, thus in turn leading to greater innovation performance in enterprises. Nevertheless, the moderating effect of government's unified control using patent application numbers as proxy of enterprise's innovation performance is more obvious than using sale revenue of new product.

Implications

The famous 'Schumpeter hypotheses' indicated that innovation efficiency improved as the enterprise became bigger for the scale effect and vigilance against risks. Under unified control of government, China's innovation system reached bigger scale effect and stronger vigilance against risks. Gu et al. (2006) and Wu (2006) proved that government is the major force to the development of China's national innovation system and it's significant for industrial innovation activity to get support from the authority. Mahmood and Rufin (2005) confirmed the driving impact of government to innovation which can spur innovation activity by centralized controlling economy and politics, especially for the emerging economy with weak innovation capability. Moreover, historical experience of the rise of China in recent decades showed that at the early stages of developing country, economy as well as innovation capability could be promoted rapidly when resources were pooled by unified control of government.

For the country in early stage of development, government can boost regional innovation performance by means of proper centralized regulation and intervention. The authority can establish platform of collaborative innovation, which will reduce cost of transaction and searching information and then enhance efficiency of knowledge exchange between enterprise, university and independent research institute. The authority can make the innovation environment better and

offer substantial resources for university via administrative power such as policies and regulations as well. In addition, scientific and technical projects with strategic importance can be conquered by scale effect from pooling top strengths in the fields under government command and realize major breakthrough.

Even so, if developing countries are to become developed countries, they still need to gradually improve their innovation system. At the later period of the development of emerging economies, the regional innovation performance may suffer because of the marginal effect decrease of only focusing on short-term profits (Furman 2002). Given the request from the president Xi that government should reinforce the leadership of the communist party of China in university and strengthen promotion of ideology to students and teachers, this study keep reserved opinion to such policy. When government centralized controlled university too much by clamping freedom of academy and ideas, it might hinder knowledge creation activity of university and inhibit knowledge spillover effect further. If the authority of China really wants to implement the 'innovation driven development strategy', they should improve autonomy of university and make use of the moderating effect of the market itself as developed countries, and enhance innovation performance via diversified and open innovation activities.

LIMITATIONS AND FURTHER RESEARCHES

Firstly, because of availability of data, time span of this study is not long enough so that we can't examine the effect of government's unified control to university's knowledge spillover in a long-term period. Secondly, this study is based on a macroscopic perspective by using instrumental variable to analyze moderating effect of unified control of government without digging out the path of how government's unified control affects university' knowledge spillover exactly in a microscopic perspective. In the future, there should be deeper and clearer researches about how government behavior affects knowledge creation and spillover of university, including the effect towards universities in different administrative ranks, different impacts from central government and local government to university, and how their behavior influences knowledge creation and spillover of university in a microscopic perspective.

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