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# **Does the geographic clustering of universities promote their scientific research performance? Evidence from China\***

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## **Abstract**

The fundamental purpose of university geographic clustering is to gather resources through "agglomeration" to improve the performance of higher education and scientific research. However, it has been debated whether university clusters can achieve the latter goal. With the help of the "quasi-experiment" of Chinese "University Towns" project in the 1990s, this study determines the impact of university clusters on scientific research performance. Panel data of 2000 colleges and universities from 1993 to 2017 in the compilation of scientific and technical statistics of Chinese higher education and time-varying difference in differences method are used. The results show that the cluster of colleges and universities have a significant negative impact on the scientific research performance due to technological dis-proximity and rising commuting costs. And the clustering effect is related to the number of participating schools and the level of the university. Therefore, university clustering cannot effectively promote the performance of scientific research and unable to bring agglomeration economies.

**Keywords:** University cluster; Economies of agglomeration; Scientific research performance; Time-varying difference in differences method

**JEL-Codes:** I23, O38, O53

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## 1. Introduction

As a major source of advanced science and technology, universities are essential in fostering innovation and growth. R&D conducted by universities is a key component of the overall R&D system of the United States. Universities have long been responsible for performing about 10% to 15% of total U.S. R&D, including about half of all U.S. basic research<sup>1</sup>. American universities still maintain numerous scientific research outputs. On the one hand, in terms of patent applications, United States Patent and Trademark Office (USPTO) report that the number of patents granted of American universities reached 6,885 in 2018, almost twice that in 2002. On the other hand, in terms of knowledge transfer, National Science Foundation (NSF) report that the U.S. business sector coauthored 27,000 S&E articles with U.S. academics, two-thirds of citations to research articles in patent applications are to articles with academic affiliations. Moreover, the university shared technologies and inventions it developed in 2017 through the issuance of 46,000 active licenses and more than 1,000 University-affiliated startups using licensed technologies. The United States remains the world's top R&D performer. However, China, the largest developing country, continues to close the gap, with an average annual growth rate that is currently nearly three times higher than that of the United States. As an important force in the development of patented technologies in China, the role of universities in the advancement of science and technology cannot be ignored. Chinese universities maintain leading positions in science and technology, which received about 23% of the country's total number of patents in 2018.

On this basis, the strength of a university's research capacity has considerable significance for the innovation capacity of a country or region. Theoretically, the positive role of universities on the innovation performance of a country or region has received wide confirmed (Jaffe, 1989; Acs et al., 1992; Etzkowitz and Leydesdorff, 2000; Belenzon and Schankerman, 2013). The three main ways are as follows: First, colleges provide human capital to students; more educated alumni can go on to become inventors (Cowan and Zinovyeva, 2013); second, faculty research may be commercially applied through collaboration with companies (Dorfman, 1983; Drucker, 2016); third, creative people or businesses may relocate to the vicinity of the university (Audretsch, 2012). A few well-

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<sup>1</sup> <https://nces.nsf.gov>

known 'success' cases such as Silicon Valley in California, Route 128 in Massachusetts and the Research Triangle in North Carolina, USA, have led most policy makers to believe that universities are engines for innovation.

In order to improve the basic research capacity and comprehensive strength of universities, a series of reforms have been carried out in higher education in various countries. On the one hand, the introduction of incentives to continuously increase investment in higher education, such as China's "211 Project", "985 Project" and "Double-First-Class Plan", Germany's "Elite University Program", Russia's "5-100 Program", etc<sup>2</sup>. On the one hand, the restructuring of the spatial distribution of higher education institutions is also in progress. Geographical clustering of universities or research institutions is widely used in national higher education systems. The core logic is as follows: geographical clustering can reduce the cost of communication between different universities, facilitate the sharing of academic and disciplinary resources among universities, increase average research output, and achieve the "agglomeration effect" (Johnston, 1994; Bonaccorsi and Daraio, 2005). This policy preference is not only widespread in developing countries, such as South African (Adendorff and Donaldson, 2012) or China (Cai and Liu, 2015) but also in developed countries such as the United States, Russian<sup>3</sup>. For example, since 1979, the Italian The National Research Council (Italian: Consiglio Nazionale delle Ricerche, CNR) has concentrated research institutions geographically agglomerated areas in Italy through the establishment of "research areas"<sup>4</sup>. Japan's Tsukuba Science City, with the University of Tsukuba at its core, is home to approximately 30% of Japan's government research laboratories and over 40% of government researchers (Bloom and Asano, 1981). After the 1960s, the Indian government established Bangalore as the "Silicon Valley of India" by clustering 125 universities in Bangalore,

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<sup>2</sup> The "Double-First-Class Program" was first proposed in 2015, with the aim of bringing the number and strength of China's first-class universities and disciplines to the forefront of the world, and basically building a higher education powerhouse. 2019 data released by the Ministry of Education show that the central government has provided the "Double-First-Class Program" for the selected universities. The financial allocations made by the "universities" amount to tens of billions of RMB, with Peking University receiving the largest allocation of 5.833 billion RMB and the Central Academy of Drama receiving the smallest allocation of 338 million RMB. The other programs mentioned above are described with reference to Kang and Liu (2021).

<sup>3</sup> The most prominent case of geographic clustering of universities in the United States is Silicon Valley, which is recognized as a world hub for higher education as well as high technology and contains eight prestigious universities, including Stanford University, the University of California and Santa Clara University. Novosibirsk Science City is the Siberian Branch of the Russian Academy of Sciences. The institution was founded in 1957 and currently has 30 comprehensive scientific research entities. Approximately 400 universities, scientific research institutions, and high-tech development companies are concentrated in the Carlton high technology zone, which is known as the North Silicon Valley.

<sup>4</sup> <https://www.cnr.it/en/areas>

represented by the Central College of Bangalore and Indian Institute of Science<sup>5</sup>.

An important question is as follows: do university geographic clusters really bring economies of agglomeration and promote scientific research performance? There have been many studies convinced that geographical proximity is essential to achieve knowledge flow (Jaffe et al., 1993; Biggiero and Sammarra, 2010; Aldieri, 2011; Belenzon and Schankerman, 2013), but these studies have focused mainly on the impact of industry-university geographical proximity on firm innovation (Vedovello, 1997; Ponds et al., 2007; D'Este and Iammarino, 2010; Laursen et al., 2011; Mahdad et al., 2020), while the impact of geographical proximity between universities on university scientific research performance has not been well studied (Bonaccorsi and Daraio, 2005; Brekke, 2021), and the only studies that exist mostly use a case study approach (Petruzzelli, 2008; Mei and Symaco, 2021) and draw ambiguous conclusions (Cai and Liu, 2015; Hinzmann et al., 2019; Tomás-Miquel and Capó-Vicedo, 2021).

In general, the existing literature lacks attention to the impact of university geographic clustering on the scientific research performance of universities in terms of research questions. Theoretically, although most studies argue that geographic clustering can produce agglomeration effects (Ellison and Glaeser, 1999; Hanson, 2001; Jang et al., 2017), however, most of these findings are industry-specific because the production of products in industry is characterized by assembly lines and a high degree of division of labor (Bonaccorsi and Daraio, 2005), so agglomeration benefits may exist (Jang et al., 2017), but the production of knowledge in scientific research is not, and it is not clear to us whether such geographical clustering would enhance efficiency. In a policy sense, previous studies have focused on the effects of government funding (Auranen and Nieminen, 2010; Zhou et al., 2016) or university size, such as university mergers (Abbott and Doucouliagos, 2001; Liu et al., 2018; Kang and Liu, 2021), on university scientific research performance. Several studies have pointed out that geographical proximity is one of the most important factors influencing individual and organizational academic collaborative cooperation (Katz, 1994; Liang and Zhu, 2002; Khosrowjerdi et al., 2017). However, on the one hand, academic collaboration is not a good indicator of university research performance, and on the other hand, it is not clear what happens when researchers are clustered in a region. Based on our limited knowledge, only Bonaccorsi and

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<sup>5</sup> <https://wikipedia/en.wikipedia.org/wiki/Bangalore>

Daraio (2005) discusses the impact of Italian National Research Council and French INSERM in biomedical research on public research productivity and concludes that geographic clustering does not enhance public research productivity.

The empirical challenges prevalent in the aforementioned studies are related to issues of sample representativeness and endogeneity. First, existing empirical studies are often based on case studies or a small number of research institutions and lack representativeness. This weakens external validity and prevents reliable conclusions from being drawn. Second, university or research institution cluster projects conducted at the national level suffer from serious endogeneity problems in sample selection, making it difficult to effectively identify the net effect of clustering. Indeed, examining the impact of geographic clustering on university scientific research performance should be of interest not only to scientific scholars but also to policy makers. Therefore, the effects of geographic clustering of universities need to be further explored.

The answer to this question does not only involve the evaluation of university geographic cluster policy but also determining whether the basic innovation ability of the country can improve through place-based policies. This study uses the empirical evidence of Chinese universities to answer this question. On the one hand, Chinese universities experienced the largest university geographic cluster. From 1999 to 2018, more than 400 universities were geographically clustered in 41 cities and involved far more areas than those of other countries, thereby providing an excellent opportunity to answer the above-mentioned questions. On the other hand, China's public universities have several common characteristics with other countries in the relationship between the government and school, organizational form, and other aspects, especially after recent years of development, when Chinese universities are responsible for more than half of the basic research work with less investment in R&D (Kang and Liu, 2021). This finding provides important intellectual support for China's innovation and economic development. Furthermore, the research conclusions of China, as the largest developing country, can provide more reference and guidance for policy makers in other countries, especially in developing countries, when making similar policies.

In comparison with existing literature, the main contributions of this study are as follows. First, while economies of scale represented by institution merge have received extensive attention, the analysis of agglomeration economy is very small. The sample size of existing few literature that

focus on analysis of agglomeration economy is relatively small. The present study uses panel data from 2279 universities in China from 1999 to 2017, 411 of which are geographically clustered in 41 cities. To our knowledge of literature, this number is thus far the largest sample size in this field. While avoiding immeasurable missing variables caused by institutional and cultural aspects in cross-country comparisons, our findings ensure as much as possible the representativeness of the sample and make the study results reliable.

Second, in terms of method and index selection, this paper studies the effect of university geographically cluster with the time-varying difference in differences method, which can eliminate the interference factors that simultaneously affect all universities. Such a framework can solve the missing variable errors caused by the before–after comparison of case study to obtain the net effect of university geographically cluster. Following Kang and Liu (2021), indicators with clear economic significance, such as publications, projects and awards, are chosen to reflect the academic performance of universities.

Third, the main findings indicate that university geographically cluster have a significant negative impact on scientific research performance and are affected by the number of participants and administrative hierarchy of a city. This finding responds to recent research findings that the scale and agglomeration effects of scientific production may ineffective. After a series of robustness tests, the above-mentioned conclusions remain valid, indicating that university geographically cluster cannot effectively promote the scientific research performance of universities. This finding leads us to reflect on existing education reforms and place-based policies and provides lessons and warnings for other countries when developing similar policies.

## **2. Institutional background and hypothesis**

### **2.1 Institutional background**

The transition from a low-cost manufacturing economy to a technological and innovative economy is an urgent task for developing countries, such as China. Inspired by the important role of universities in high-tech and high growth regions, such as Silicon Valley, Chinese Ministry of Education put forward an ambitious plan for the development of China's higher education system at 1999. In the same year, the Ministry of Education defined higher education institutions as providing 4-year academically oriented universities and 3-year application-oriented colleges, and

greatly expanded the enrollment of both types of higher education institutions after 1999.

In order to meet the large demand for university space expansion, and to exert the agglomeration effect by strengthening face-to-face communication between various higher education institutions, many local governments in China have set up government-led agglomeration areas of university and college (i.e., University Town), under the support of the central government. It follows the conception of '1+1>2', meaning that extra value could be added and productivity gains could be achieved by gathering several universities together in one campus in the hope of triggering the development of innovative industries (Cai and Liu, 2015). In order to attract local or outside higher education institutions to locate locally, local governments often build university towns (UTs) on the edge of cities or close to rural areas to ensure the availability of urban infrastructure and cheap land. Thus, the university towns involve the agglomeration of several universities and are often located in places where significant urban development has not yet taken place. The building of UTs began in 1999 in Langfang of Hebei province, from 1993 to 2017, 50 UTs were built in 41 cities in China. UTs have absorbed 411 universities or colleges, accounting for roughly 16% of the total number of higher education institutions in China.

Although the enthusiasm of local governments for the construction of university towns has never dissipated, the central government has started to tighten its support for the construction of UTs due to some political and economic issues<sup>6</sup>. Almost no new UTs have been approved for establishment after 2016, and in fact, there are huge differences in the scale and development of university towns in China due to the differences in educational resources and regional development among Chinese cities<sup>7</sup>.

## 2.2 Hypothesis

A prominent feature in this field is the geographic cluster of public universities under

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<sup>6</sup> Since the construction of UTs often drives up the price of the surrounding land (Wang and Tang, 2020), some local governments have resorted to real estate development under the guise of setting up UTs. For example, in Zhengzhou, Henan Province, the local government illegally and forcibly expropriated nearly 991.8 hectares of land under the guise of developing a UTs in order to acquire agricultural land that was supposed to be prohibited for commercial activities. That case has since become one of the highest-ranking cases in which the central government has investigated and punished government officials for illegally approving land expropriation.

<sup>7</sup> For example, in terms of city distribution, China's UTs are located in first-tier cities such as Beijing, Shanghai and Guangzhou, as well as second- and third-tier cities such as Kunshan and Langfang; in terms of land size, there is a 4,300-hectare UTs in Guangzhou and a 180-hectare UTs in Shenyang; in terms of enrollment size of UTs, it ranges from 20,000 to 250,000.



governmental intervention. The geographical clustering of universities actually reflects the government's hope that universities can directly serve local economic and social development, which can often be achieved through top-down government intervention (Sun et al., 2019). Considering universities as the fundamental institutions for scientific research, proximity favors their productivity, insofar as it maximizes personal interaction, face-to-face communication, and the dissemination of tacit knowledge (Bonaccorsi and Daraio, 2005). Moreover, the clustering of universities tends to attract more companies, thus promoting university-industry interactions, and increasing the source of university research funding. Thus, geographic cluster of universities should have better research performance.

However, excessive government intervention for its own motives may not always work out as it wishes. First, the UTs building of China by simply geographically cluster many universities without considering the huge heterogeneity that exists between those universities. Simple geographic clustering does not lead to technological proximity, which may lead to a failure of the aggregation effects. Secondly, UTs in China are often built on the edge of cities, while most universities adopt the satellite-campus approach. That is, the original campus in the city center remains, but a new campus is set up in the UTs. The campus in the city center is often responsible for the core research and administrative work, while the campus in the UTs is mainly responsible for student life and teaching. This will result in researchers running at both campuses, increase in commuting costs for them.

We first discuss the importance of technological proximity. Marrocu et al. (2013) points to technological proximity as a key factor in the geographic clustering of innovation. Unlike industrial activities, the tasks of scientific research do not have a clear boundary division, which requires that the skills and knowledge of project participants must be highly matched, or some degree of overlap. Before moving to the UTs, each university had its own main focus of research and developed its own comparative advantages in different disciplines<sup>8</sup>. The great differences in the schools'

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<sup>8</sup> The development model of Chinese universities was heavily influenced by the Soviet Union model, after 1952, the adjustment of colleges and departments in China separated some comprehensive universities into specialized universities (for example, Nanjing University was divided into Southeast University, Hohai University, Northwestern Polytechnical University, Jiangnan University, Jiangsu University, Nanjing University of Technology, Nanjing Normal University and Nanjing Agricultural University), and specialized universities are often entrusted with the mission of conducting research and development in specific disciplines. Since 1986, the Ministry of Education has further put forward the plan of building "key disciplines" in colleges and universities, that is, to further strengthen the construction of specific disciplines in colleges and universities. As a result, different universities in China have an increasingly strong comparative advantage in different disciplines.

disciplinary strengths, development philosophy, and even culture (Kang and Liu, 2021), which lead to the situation that universities geographically clustered but fail to form technological proximity. Second, we discuss the impact of satellite campuses. Before moving into UTs almost all universities were set up in urban centers, and UTs were initially set up to accommodate the demand brought by expansion. As a result, many schools adopted the practice of setting up satellite campuses in UTs, where students live and teach in a satellite campus in the UTs, while the core administrative and research activities remain on the campus in the city center. Because UTs are often located on the edge of cities, this results in faculty and researchers having to commute between the satellite campus and the city center campus, and the cost of commuting can significantly reduce research output (Fu and Viard, 2019). This geographic clustering pattern that spatially separates teaching and research has a direct impact on the productivity of researchers.

For this reason, we hypothesize that:

**H1:** Geographic clustering of universities does not improve scientific research performance.

The original purpose of the UTs was to meet the large demand for university spatial expansion, but as the development of the UTs led to the formation of edge cities around it, the government began to lobby for the relocation of universities to the UTs and formed a "who relocates, who benefits" orientation. As a result, a large number of colleges and universities are moving into some UTs. Compared with a UTs with a small number of schools, a UTs with a large number of schools expands the "labor pool" and increases the probability of technological proximity. Moreover, as the number of universities in UTs increased, the demand for students and teachers to travel between UTs and city centers grew rapidly, and local governments began to provide transportation services to meet this demand.

For this reason, we hypothesize that:

**H2:** The number of geographic clusters of universities is positively correlated with research performance.

The effect of geographic clustering of universities heavily depends on the rank of the university. Chinese universities can be roughly divided into elite universities and ordinary universities according to whether they are supported by the 211 Project, 985 Project or Double-First Class Project. Compared with ordinary universities, elite universities have outstanding research capabilities and undertake most of China's research projects. In addition, elite universities tend to

be located in the most central areas of cities, and all of the elite universities that have moved into university towns have adopted the satellite campus approach. This makes it more difficult for elite universities to form a technical proximity to other ordinary universities and make elite universities have a higher commute costs elasticity of research performance

For this reason, we hypothesize that:

**H3:** The negative impact of geographic clusters on the research performance of elite universities is greater than ordinary universities.

### **3. Data, variables, and identification strategies**

#### 3.1 Data

First, using The compilation of scientific and technical statistics of Chinese higher education by MOE, we compiled data on research inputs and outputs of 2000 universities or colleges in China from 1993-2017 based on Kang and Liu (2021), and we selected teaching and research staff; total number of subjects; total number of science and technology projects; research expenditure; monographs; achievements; contracts signed; awards and other measures of research performance. These indicators can measure the research performance of Chinese universities comprehensively.

Secondly, in order to control the characteristics of universities or colleges, we collected information on the participation of universities in various Project using the public information released by the MOE, and we refer to Liu et al. (2018) to collate the information of universities merged. Finally, by searching policy documents or public reports issued by Chinese local governments, we collected information on the construction of UTs, including the geographical location, the time of UTs use, and the specific information of the schools in the UTs.

#### 3.2 Variables

(1) Dependent variable. In general, there are various ways to measure university research performance. Obtaining research projects commissioned by national ministries, local governments, enterprises and institutions is the most important way for Chinese universities to obtain research funds. The more the number of subjects, the more abundant the research funds available for expenditure, and the stronger the research strength of universities tends to be. Monographs, patents, and technology transfer are the final form of research products. Achievement awards are often a

further acknowledgement of the final output of a university, and such awards are honorary government accolades for existing university achievements, often signaling whether a university has cutting-edge research. Therefore, with reference to Kang and Liu (2021), seven scientific indicators were selected as explanatory variables in this study, including total number of science and technology subjects, research expenditures, monographs, identified results, contracts signed, technology transfer income and awards.

(2) Core explanatory variable. The dummy variable is whether the university has relocated to a UTs. Clustering is equal to one if the university has relocated to a UTs, and zero otherwise. The cluster type is further subdivided considering the heterogeneity of different types of universities. The number of all schools in the UTs where the university is located  $cluster\_n$  is assigned accordingly, while  $cluster^e$  and  $cluster^o$  are the core explanatory variables for the clusters of elite schools and ordinary schools, respectively.

(3) Control variables. By reference to Kang and Liu (2021), we have chosen whether the university participates in the "211 Project", "985 Project", "985 Project Innovation Platform", "National Basic Ability Construction Project of Western and Central China (mid-western)" and whether universities have been merged or not. In addition, we also controlled the number of teaching and research personnel, research staff as a percentage of total faculty. Table 1 shows the main variables and descriptive statistics.

### 3.3 Identification strategies

Our sample contains universities that have never been clustered (control group) and those that have been clustered (treatment group) during the sample period. A difference in the merger time of each university remains. Thus, we can use the time-varying DID framework to assess the consequences of university clusters. Data before and after the clusters are available for 411 universities, which thus make up our treatment group. The rest that has never been clustered constitutes the "control group". We constructed the following model in accordance with Beck et al. (2010).

$$Y_{it} = \beta_0 + \beta_1 cluster_{it} + \alpha X_{it} + \gamma_t + \mu_i + \varepsilon_{it} \quad (1)$$

where  $Y_{it}$  is the dependent variable of a series of scientific research indicators used to measure the university research performance;  $i$  and  $t$  represent the university and year, respectively;  $cluster_{it}$  is

core explanatory variable, which indicate whether university  $i$  is clustered in period  $t$ ;  $\gamma_t$  and  $\mu_i$  represent the time fix effects and the university fix effects, respectively. Which could measure the time trend and each university that do not change with time include geographical location and establishment date.  $X_{it}$  is the control variables, including 211 Project, 985 Project, 985 Project Innovation Platform, National Basic Ability Construction Project of Western and Central China, merged, the number of teaching and research personnel, research staff as a percentage of total faculty. The coefficient  $\beta_1$  is our main result of interest, which reflects the effect of university clustering on the university research performance. Then, we use equation (2) to test Hypothesis 2:

$$Y_{it} = \beta_0 + \beta_1 cluster\_N_{it} + \alpha X_{it} + \gamma_t + \mu_i + \varepsilon_{it} \quad (2)$$

The core explanatory variable  $cluster\_N_{it}$  is the number of schools in the UTs where the university is located, and other parameters are consistent with Eq. (1). Finally, we use equation (3) to test Hypothesis 3:

$$Y_{it} = \beta_0 + \beta_k \sum_{k=e,o} cluster_{it}^k + \alpha X_{it} + \gamma_t + \mu_i + \varepsilon_{it} \quad (3)$$

where  $E$  and  $O$  represent the elite and ordinary universities, respectively. The other parameters are consistent with Eq. (1).

## 4. Measurement results and robustness test

### 4.1 Basic regression

We test three hypotheses in Table 2. Clustering has a very weak and insignificant positive effect on the total number of science and technology subjects, but it has a negative correlation on other indicators, and five of them are significant in Panel A. These findings indicate that the growth rate of research performance decreases after the geographical clustering of universities. Instead of improving research performance, geographic cluster produces a “agglomeration uneconomical effect”. This confirms the first hypothesis of this paper. In panel B, we replace the core explanatory variable with the number of schools in the UTs where the university is located according to Eq. (2). The results show that five indicators have positive results and one of them is significant. The remaining two indicators have negative results but insignificant. Taking into account the significant negative results in Panel A, this result suggests that the “agglomeration uneconomical effect” will be weakened if there are more schools clustered around the university and confirms the second

hypothesis. In panel C, we regress according to Eq. (3). The first and second lines are the cluster performance of the elite and ordinary universities, respectively. We can clearly find that elite universities show a larger and more significant “agglomeration uneconomical effect” in all indicators except award, which shows that the indicates that elite universities have worse cluster effects than ordinary universities, thus verifying Hypothesis 3.

Among the control variables, the total number of teaching and research staff and research staff as a percentage of total faculty showed a significant positive effect on research performance overall, which indicates the importance of faculty on university’s research performance. Mergers and projects such as 211 Project, 985 Project all showing a significant negative relationship on scientific research performance. On the one hand, this result may be due to approach to university mergers by reference to Kang and Liu (2021). On the other hand, it may be due to the fact that ordinary universities that were not selected for Project 211 and Project 985 are the main target of the implementation of university expansion, a situation that reduces the gap between ordinary universities and the universities participating in each project.

Although the time-varying DID method can clearly identify the net effect of university clusters on scientific research performance, the treatment and control groups must meet the pre-parallel trend hypothesis. Specifically, the development trends before the university clusters must be consistent. We generated a dummy year variable (i.e., eight years before and eight years after, resulting in 16 years in total) as an explanatory variable to check whether such hypothesis is supported. The coefficients of the seven dependent variables of 16 years are separately plotted in Figs. 1–7 to visually present the pre-parallel trend test and the dynamic effects. The result shows that the policy dummy variables are all insignificantly before the cluster and all of them showed a significant downward trend after clustering.

## 4.2 Robustness tests

The above-mentioned data show the basic results of the university cluster and scientific research performance. To further validate the conclusions, we adopted a series of robustness tests.

### 4.2.1 Control the province–year joint fixed effects

In the basic regressions, we control for time fixed effects to capture time trends in changes in

research performance. Similarly, we control for university fixed effects to control for the effects of other factors that do not vary over time. In addition, we exclude the effect of time-varying factors of each university on its research performance through a series of control variables. However, in order to make the results more credible, we also need to exclude possible heterogeneity issues at the provincial level. This is mainly because: the construction of a UTs cannot be done by a single city in terms of both financial and policy support, but must be supported by the provincial government. Because of the strong heterogeneity in development levels among provinces, it is likely that provinces with high levels of economic development or rich higher education resources will be more supportive of the construction of UTs. Failure to control for this factor may bias our estimation results to an upward overestimate. Therefore, we include province-year fixed effects in our regressions and show the results in Table 3, where it can be found that the results are not significantly different compared to Table 2.

#### 4.2.2 Eliminate the effect of outliers

Given that this paper is based on panel data of 2000 universities in China from 1993 to 2017, the level gap between sample schools is large. In order to exclude possible confounding of our results by outliers generated by the top and bottom universities, the dependent variables were regressed again by applying a 1% winsorization, and the corresponding regression results are presented in Table 4. The regression results show that, our three hypotheses are still valid after winsorization.

#### 4.2.3 Remove samples from special areas

Chinese universities are very unbalanced in terms of geographical distribution. The eastern and coastal regions are home to almost all of China's top universities, especially in Beijing and Shanghai, which have the best higher education resources in China, both in quantity and in quality. Beijing, the capital of China, is undoubtedly the center of politics and culture, with Peking University and Tsinghua University, two of China's highest-ranking universities, all located in Beijing, and almost all of the other best specialized universities located in Beijing. Shanghai, one of the first cities in China to open up to the outside world, has gradually become the economic center of China, and a number of high-level universities, represented by Fudan University and Shanghai Jiao Tong University, have also gathered in Shanghai. These two cities were already geographically clustered

with universities before they were built UTs, in order to eliminate the specificity that these two cities bring to the UTs, we remove the sample from Beijing and Shanghai and then made a regression. Table 5 lists the regression results, which are still robust compared to the baseline regression results.

#### 4.2.4 Distinguish the types of university cluster

We distinguishing the UT types of university cluster, divide them into three types according to Wang and Tang (2020). All of the universities are divided into 4-year standard university education and 3-year vocational college education, 4-year universities tend to train academic personnel and focus on scientific research, while 3-year colleges generally train industrial workers and do not focus much on academic research. So, there are three combinations of models for schools in UTs, namely, college-college, college-university, university-university. We examine whether the cluster performance differs among the various types of clusters. The results showed that all three types showed a decline rather than a boost in scientific research performance. Further observation reveals that college-college and university-university types produce less of a downward effect on scientific research performance, compared to the college-university type. Moreover, the university-university type has the weakest negative correlation with scientific research performance. This finding suggests that the clustering of different types of schools does not lead to "agglomeration economic effect". The mismatch between technologies leads to university do not help college enhance the level of scientific research performance, and universities are negatively affected by college.

The above results suggest that the ineffectiveness of geographic clustering of universities from the perspective of improving research is considered a systematic conclusion. The results remain the same after differentiating between cluster types and objects, further supporting the logic of the previous section.

## 5. Discussion

In the past decades, geographic clustering of universities or research institutions has been considered by most policy makers as an important policy tool to increase the level of research output or innovation. Some countries, such as China, South Africa, Germany and France, have undertaken geographic clustering of universities or research institutions under government leadership. Government funds and support are very important for scientific research activities in universities



and research institutions. Compared with enterprises, government is more capable of intervening top-down approach in universities or research institutions. Thus, the problems discussed in this paper are likely to arise in their clusters. The present findings show that geographic clustering of universities is difficult to improve their scientific research performance.

If geographical clustering is necessary, then the first consideration should be whether there is a technological divide between the subjects involved in the clustering, and it is desirable that the subjects of the clustering have similar technologies and knowledge. Secondly, regarding the location of the cluster, we should try to avoid increasing the commuting cost of researchers by building subways or new housing and other facilities, so that researchers' lives and research work overlap spatially as much as possible. The problem of geographical clustering is not unique to China. Government-led geographically agglomerated areas of research institutions in France and Italy have also not shown satisfactory agglomeration economies (Bonaccorsi and Daraio, 2005). Therefore, the above-mentioned two points are worthy of attention in university or research institutions clusters in other countries.

Although our conclusion confirms several doubts on the performance of university clusters, the findings come from a sample in China, where the social system and the higher education system are unique in their own way. This means that the findings may not be fully generalizable to any country or region, raising the issue of external validity. For example, other countries may not cluster universities through government-led relocation, but instead use a voluntary clustering of universities with the government only providing services. The strong executive power of the Chinese government leaves little buffer for policy implementation, and the complex relationship between universities and the government often leads to a decline in the efficiency of communication. However, the issues identified in this paper are common and deserve the attention of all countries.

## **6. Conclusion**

Universities and public research institutions today play a fundamental role in the production of scientific knowledge (e.g., inventions) necessary for the development of a competitive economic system in an increasingly knowledge-based society (Etzkowitz and Leydesdorff, 2000). With this in mind, policy makers have increased investment and development in higher education. The geographical clustering of universities is a development tool that can improve university research

through agglomeration economies and will undoubtedly continue to happen in other countries.

This paper identifies the impact of university clustering with the help of the "university towns" project implemented throughout China in 1999. Panel data of 2000 colleges and universities from 1993 to 2017 and the DID method to test the scientific research performance after university clusters. The results show that university clustering has a significant negative impact on research performance due to technological dis-proximity and elevated commuting costs. Further tests show that research performance after clustering is lower when there are fewer participating schools. Moreover, the clustering effect of elite universities is lower than that of ordinary universities. After a series of robustness tests, the above findings remain valid. We hope that this study provides guidance for future clustering of universities or research institutions.

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**Table 1**

## Main variables and calculation methods

Source: According to The compilation of scientific and technical statistics of Chinese higher education, the digits retain three digits after the decimal point.

Variable meaning	Calculation methods	N	Mean	S.D.
Cluster	Cluster is equal to 1 if the university had relocated in UTs, and 0 if otherwise.	18002	0.106	0.308
985	985 is equal to 1 if the university is in 985project, and 0 if otherwise.	18002	0.029	0.168
211	211 is equal to 1 if the university is in 211project, and 0 if otherwise.	18002	0.095	0.294
985 platform	985 platform is equal to 1 if the university is in 985 platform, and 0 if otherwise.	18002	0.015	0.124
Merge	Merge is equal to 1 if the university had merged, and 0 if otherwise.	18002	0.086	0.281
Midwestern	Midwestern is equal to 1 if the university is in midwestern, and 0 if otherwise.	18002	0.036	0.187
Number of teaching personnel	Number of teaching staff is counted by logarithms	18002	5.947	1.154
Number of research personnel	Number of research staff is counted by logarithms	18002	4.465	1.899
Research personnel ratio	Research personnel / Total number of teaching and research staff	18002	0.229	0.137
Total number of science and technology subjects	Number of science and technology projects is counted by logarithms	18002	4.289	1.929
Research expenditures	The research expenditures are counted by logarithms	18002	7.308	3.223
Monographs	Number of monographs is counted by logarithms	18002	0.891	1.116
Identified results	Number of identified results is counted by logarithms	18002	1.112	1.373
Contracts signed	Number of contracts signed is counted by logarithms	18002	0.74	1.253
Technology transfer income	Total income by technology transfer is counted by logarithms	18002	2.138	3.234
Awards	Number of awards is counted by logarithms	18002	1.001	1.202

**Table 2**

## Basic results

Dependent variable	Total number of science and technology subjects	Research expenditures	Monographs	Identified results	Contracts signed	Technology transfer income	Awards
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A							
<i>Cluster</i>	0.002 (0.044)	-0.061 (0.069)	-0.235*** (0.070)	-0.282*** (0.076)	-0.219*** (0.076)	-0.566*** (0.183)	-0.105** (0.051)
R-squared	0.958	0.939	0.750	0.734	0.721	0.704	0.845
Panel B							
<i>cluster<sub>it</sub></i>	0.001 (0.010)	-0.017 (0.016)	0.015 (0.016)	0.006 (0.016)	0.008 (0.018)	0.065* (0.039)	-0.008 (0.012)
R-squared	0.958	0.939	0.750	0.734	0.721	0.704	0.845
Panel C							
<i>cluster<sup>e</sup></i>	-0.170*** (0.065)	-0.360*** (0.093)	-0.422*** (0.128)	-0.326** (0.144)	-0.447** (0.179)	-0.987*** (0.350)	-0.092 (0.096)
<i>cluster<sup>o</sup></i>	0.055 (0.052)	0.032 (0.083)	-0.177** (0.080)	-0.268*** (0.086)	-0.148* (0.079)	-0.434** (0.206)	-0.109* (0.060)
R-squared	0.959	0.939	0.750	0.734	0.721	0.704	0.845
Observations	17723	17723	17723	17723	17723	17723	17723
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) cluster-robust standard error at university level are presented in parentheses; (2) \*, \*\*, \*\*\* denote significance at the 10%, 5% and 1% levels, respectively.

**Table 3**

Added the province–year joint fixed effects

Dependent variable	Total number of science and technology subjects	Research expenditures	Monographs	Identified results	Contracts signed	Technology transfer income	Awards
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A							
<i>Cluster</i>	0.005 (0.044)	-0.059 (0.069)	-0.238*** (0.070)	-0.291*** (0.075)	-0.227*** (0.076)	-0.589*** (0.182)	-0.104** (0.051)
R-squared	0.959	0.939	0.750	0.735	0.722	0.705	0.845
Panel B							
<i>cluster<sub>lit</sub></i>	0.002 (0.010)	-0.017 (0.016)	0.014 (0.016)	0.002 (0.016)	0.005 (0.017)	0.057 (0.039)	-0.008 (0.012)
R-squared	0.959	0.939	0.750	0.735	0.722	0.705	0.845
Panel C							
<i>cluster<sup>e</sup></i>	-0.166** (0.065)	-0.359*** (0.093)	-0.425*** (0.129)	-0.340** (0.141)	-0.459** (0.179)	-1.022*** (0.347)	-0.090 (0.096)
<i>cluster<sup>o</sup></i>	0.058 (0.052)	0.034 (0.082)	-0.179** (0.080)	-0.276*** (0.085)	-0.155** (0.078)	-0.454** (0.204)	-0.108* (0.060)
R-squared	0.959	0.939	0.751	0.735	0.722	0.705	0.845
Observations	17663	17663	17663	17663	17663	17663	17663
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) cluster-robust standard error at university level are presented in parentheses; (2) \*, \*\*, \*\*\* denote significance at the 10%, 5% and 1% levels, respectively.



**Table 4**

## 1% Winsorization test

Dependent variable	Total number of science and technology subjects	Research expenditures	Monographs	Identified results	Contracts signed	Technology transfer income	Awards
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A							
<i>Cluster</i>	0.016 (0.053)	-0.041 (0.080)	-0.230*** (0.070)	-0.281*** (0.079)	-0.196*** (0.074)	-0.540*** (0.181)	-0.105** (0.052)
R-squared	0.947	0.928	0.748	0.730	0.723	0.703	0.842
Panel B							
<i>cluster<sub>N<sub>it</sub></sub></i>	-0.006 (0.012)	-0.025 (0.018)	0.012 (0.016)	0.003 (0.016)	0.007 (0.017)	0.063 (0.039)	-0.009 (0.012)
R-squared	0.947	0.928	0.748	0.730	0.723	0.703	0.842
Panel C							
<i>cluster<sup>e</sup></i>	-0.287*** (0.069)	-0.542*** (0.107)	-0.464*** (0.122)	-0.430*** (0.143)	-0.382** (0.167)	-0.919*** (0.340)	-0.126 (0.096)
<i>cluster<sup>o</sup></i>	0.110* (0.062)	0.115 (0.092)	-0.157** (0.079)	-0.234*** (0.089)	-0.138* (0.078)	-0.422** (0.205)	-0.098 (0.060)
R-squared	0.947	0.928	0.748	0.730	0.723	0.703	0.842
Observations	17723	17723	17723	17723	17723	17723	17723
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) cluster-robust standard error at university level are presented in parentheses; (2) \*, \*\*, \*\*\* denote significance at the 10%, 5% and 1% levels, respectively.

**Table 5**

Remove the sample of Beijing and Shanghai

Dependent variable	Total number of science and technology subjects	Research expenditures	Monographs	Identified results	Contracts signed	Technology transfer income	Awards
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A							
<i>Cluster</i>	0.015 (0.053)	-0.052 (0.082)	-0.216*** (0.073)	-0.318*** (0.081)	-0.188** (0.075)	-0.505*** (0.181)	-0.114** (0.054)
R-squared	0.946	0.925	0.733	0.736	0.717	0.700	0.840
Panel B							
<i>cluster<sub>it</sub></i>	-0.010 (0.012)	-0.039** (0.019)	0.010 (0.017)	-0.007 (0.017)	-0.000 (0.017)	0.047 (0.038)	-0.010 (0.013)
R-squared	0.946	0.925	0.733	0.736	0.717	0.700	0.840
Panel C							
<i>cluster<sup>e</sup></i>	-0.248*** (0.076)	-0.482*** (0.111)	-0.423*** (0.135)	-0.475*** (0.159)	-0.443** (0.173)	-0.870*** (0.310)	-0.158 (0.102)
<i>cluster<sup>o</sup></i>	0.085 (0.062)	0.063 (0.094)	-0.161** (0.082)	-0.275*** (0.090)	-0.120 (0.078)	-0.407** (0.206)	-0.103 (0.062)
R-squared	0.946	0.925	0.733	0.736	0.717	0.700	0.840
Observations	16545	16545	16545	16545	16545	16545	16545
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

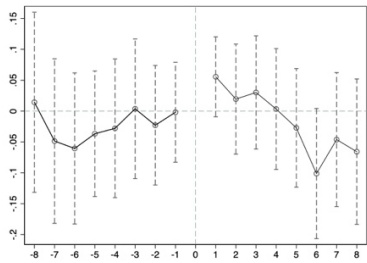
Notes: (1) cluster-robust standard error at university level are presented in parentheses; (2) \*, \*\*, \*\*\*denote significance at the 10%,5% and 1% levels, respectively.

**Table 6**

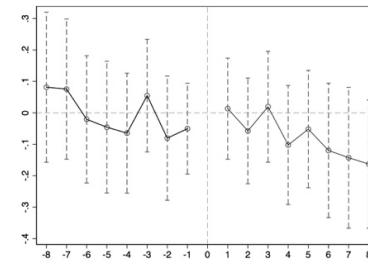
Distinguish the types of university cluster: further robustness test

Dependent variable	Total number of science and technology subjects	Research expenditures	Monographs	Identified results	Contracts signed	Technology transfer income	Awards
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
<i>cluster<sup>cc</sup></i>	-0.054 (0.189)	0.205 (0.333)	-0.246* (0.126)	0.063 (0.195)	-0.206* (0.109)	-0.748* (0.407)	-0.233 (0.181)
<i>cluster<sup>uu</sup></i>	0.154 (0.134)	0.010 (0.152)	-0.422** (0.186)	-0.459*** (0.167)	-0.085 (0.159)	-0.513 (0.361)	-0.017 (0.117)
<i>cluster<sup>uc</sup></i>	-0.017 (0.057)	-0.091 (0.088)	-0.183** (0.081)	-0.276*** (0.091)	-0.248*** (0.091)	-0.551** (0.218)	-0.112* (0.060)
R-squared	0.948	0.929	0.748	0.730	0.721	0.704	0.844
Observations	17723	17723	17723	17723	17723	17723	17723
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
University-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

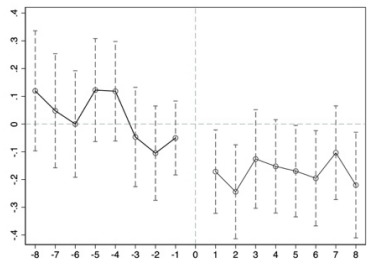
Notes: (1) cluster-robust standard error at university level are presented in parentheses; (2) \*, \*\*, \*\*\* denote significance at the 10%, 5% and 1% levels, respectively.



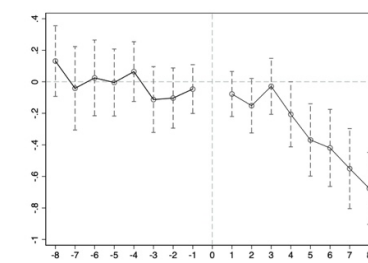
**Fig. 1.** Parallel trend test of logarithm of total number of science and technology subjects



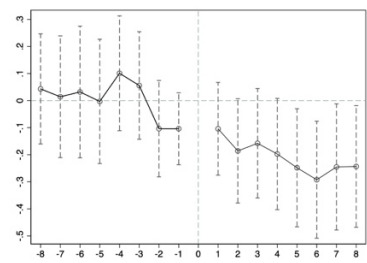
**Fig. 2.** Parallel trend test of logarithm of research expenditures



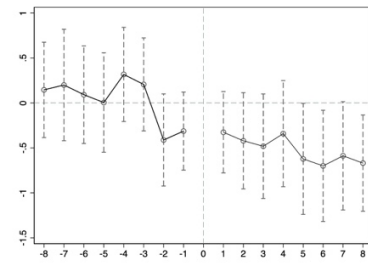
**Fig. 3.** Parallel trend test of logarithm of monographs



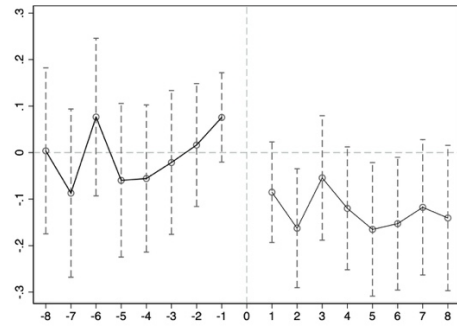
**Fig. 4.** Parallel trend test of logarithm of identified results



**Fig. 5.** Parallel trend test of logarithm of contracts signed



**Fig. 6.** Parallel trend test of logarithm of technology transfer income



**Fig. 7.** Parallel trend test of logarithm of awards