# The Long-run Impacts of Ancient Chinese Civil Exams on Contemporary Local Innovation *

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**Abstract**

China was historically heavily influenced by civil exams (*keju*), with the exams focused on recruiting the best academic individuals to serve in government. This paper explores the relationship between prefectures with historically more top scorers on the national exam (*jinshi*) between 1371 and 1905 and contemporary innovation, measured as the number of top scientists and engineers and the number of patents and their quality, finding a strong positive relationship. Results are robust to using an instrumental variable strategy that measures the minimum river distance from each prefecture to the nearest pine and bamboo forest. A doubling of the number of historically top scorers on the national exam leads to a 33% increase in the number of top scientists and engineers and a 92% increase in the number of patents. Investments in military equipment and telegraph construction play crucial roles in sustaining the long-term effects of China's civil exams.

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# 1 Introduction

For centuries, innovation has been recognized as a crucial driver of economic growth (Smith, 1776). Modern-day growth models that incorporate innovation (Romer, 1990; Solow, 1957) underscore the pivotal role it plays in advancing economies. In recognition of this, the Chinese government has made substantial investments in innovation, allocating more than $3 trillion toward scientific research and education over the past 20 years (Bureau, Science and Commission, 2023). However, innovation is known to be very unevenly distributed geographically both across and within countries.[1] This uneven distribution prompts critical questions about the underlying determinants of such disparities.

Historical institutions can have long-lasting effects on innovation and development trajectories (Acemoglu, Johnson and Robinson, 2001; Donges, Meier and Silva, 2023). The imperial civil service examination system that was used for centuries in China to select the top achievers to work in government is an institution that almost certainly shaped its development. The *keju* exam, fully institutionalized from 1371 to 1905, underpinned a system that was intended to recruit the most academically proficient individuals to serve in government. The highest scorers, *jinshi*, were appointed to roles in government. The exam largely tested knowledge of Confucian classics rather than scientific or technical expertise, which imposed constraints on creativity (Lin, 1995; Wang, 1991). Consequently, the system is believed to have reflected a conservative cultural orientation, prioritizing societal stability over innovation. Li and Wang (2022) shows that regions with a higher historical concentration of *jinshi* are less likely to foster small business entrepreneurship.[2] In contrast, Chen, Kung and Ma (2020) investigates how *keju* culture has contributed to human capital in 2010. This evidence points to a potential link between contemporary education

[1]Figure 1 illustrates the uneven distribution of Contemporary Chinese Academy of Sciences members across prefectures, who I regard as among the most innovative individuals in China. In certain prefectures, particularly in the western and southwestern regions, the number of top scientists per 100,000 people is significantly lower compared to other areas.

[2]Moreover, Ma (2024) suggests that the focus on classical worship deterred intellectuals from engaging with modern education, thereby stalling industrialization during the period from 1858 to 1927.

and innovation, as higher education is often associated with increased innovation. My paper contributes to the debate between Chen, Kung and Ma (2020) and Li and Wang (2022) on the long-term impacts of the *keju* system.

In this paper, I utilize prefecture-level data on the number of *jinshi* per 10,000 people (*jinshi* density) from 1371 to 1905.[3] Data on *jinshi* density from 1371 to 1905 are sourced from Chen, Kung and Ma (2020).[4] I pair these historical data with contemporary, prefecture-level measures of innovation: the number of Chinese Academy of Sciences members, Chinese Academy of Engineering members, and both the quantity and quality of patents. In addition, I use data on the distribution of highly innovative individuals in science and engineering to identify the birthplaces of the most innovative individuals. This provides a more accurate reflection of the origin of innovation within a region than is possible from using patent data alone, which may include applications from both local residents and migrants and, thus, could capture the attractiveness of a location rather than purely its innovation capacity.

I find a strong positive relationship between historical *jinshi* density and present-day innovation outcomes. However, these associations alone do not prove that *keju* culture directly influenced China's subsequent innovation development. It is plausible that historically *jinshi*-rich prefectures were simply more advanced and that this could be a reason that they continue to excel in modern times. To address this, I use a fixed-effects model with covariates to compare innovation levels across prefecture cities with varying *jinshi* densities within the same province, while controlling for economic and geographical factors such as agricultural suitability, population density, urbanization rate, terrain ruggedness, distance to the coast, and proximity to major rivers. By including these covariates, I aim to enhance comparability and better isolate the influence of *keju* culture on contemporary innovation. The regression results suggest that a doubling of *jinshi* density is associated with

[3]There were two main dynasties during this period, from 1371 to 1905: the Ming and the Qing. The Ming dynasty ruled from 1368 to 1644, followed by the Qing dynasty, which lasted from 1644 to 1912. For simplicity, I sometimes refer to the entire span as the Ming-Qing era.

[4]A prefecture is an administrative division situated between a county and a province.

39.5% increase in contemporary Chinese Academy of Science Members, 28.7% increase in contemporary Chinese Academy of Engineering members and 69.4% increase in the number of patents.

Despite these efforts, the fixed-effects model may still suffer from omitted variable bias, as not all factors influencing historical *jinshi* density and modern innovation outcomes can be accounted for. Therefore, to address this potential bias and establish a more robust causal link, I employ an instrumental variable using the average distance along the course of rivers to each prefecture's nearest pine and bamboo habitats. This approach, based on the work of Chen, Kung and Ma (2020), hinges on the long-standing reliance on water transport, the role of pine and bamboo in woodblock printing, and the importance of books for *keju* exam preparation. Thus, the river route-based distance that a given prefecture likely would have used to transport printing resources from such habitats implies that the people living in those prefectures with shorter routes would have had better access to books, which in turn likely would have improved *keju* exam outcomes. The instrumental variable satisfies two conditions. First, the geographic distribution of pine and bamboo habitats were determined exogenously, and second, the instrumental variable can only influence contemporary innovation through *jinshi* density.[5] My instrumental variable analysis yields positive and statistically significant results. A doubling of the number of historically top scorers on the national exam leads to a 33% increase in the number of Chinese Academy of Sciences members, a 44% increase in the number of Chinese Academy of Engineering members, and a 92% increase in the number of patents. This suggests that higher *jinshi* density during the Ming and Qing dynasties contributed to improved contemporary innovation outcomes; the impacts are observable 40 to 100 years after the abolition of the *keju* system in 1905.

[5] I present two pieces of evidence to support the premise. First, historical printing centers were gradually abandoned after the early 19th century due to advancements in printing technology, suggesting that these centers do not have a direct impact on contemporary innovation levels. Second, when I examined the correlations between the instrumental variable and several covariates that could potentially influence current innovation, none was statistically significant. This evidence gives me confidence that the exclusion restriction is unlikely to be violated.

It is important to understand how *keju* culture may have influenced innovation, persisted through China's political transformations, and remains relevant today. I explore the channels by investigating whether regions with higher historical *jinshi* density are associated with indicators that suggest greater levels of investments and a greater presence of highly educated individuals in two distinct time frames: the late Qing dynasty and Republic of China period (1861 to 1949), chosen because these years mark significant periods of modernization and reform in China, and contemporary times (1995 to 2015). I examine whether *jinshi*-dense areas in the late Qing dynasty received greater investments in key areas: spending on the military and on important infrastructure (telegraph and railway) and whether, in contemporary times, these areas have a larger number of government officials with significant authority. I also assess whether the regions that had a higher concentration of top-performing scorers in the *keju* exam system produced more top students in modern universities teaching western knowledge during the late Qing dynasty and Republic of China period and whether these areas now host a greater number of leading universities. My findings reveal that a stronger *keju* culture is linked to higher military investment between 1861 and 1894 and is associated with more extensive telegraph infrastructure, although no significant relationship was found with railway development. Furthermore, I find no statistically significant impact of *keju* culture on the number of overseas students in Japan or Tsinghua University students. However, regions with a legacy of *keju* culture are associated with a greater number of leading contemporary universities.

My study contributes to three strands of literature. The first examines the factors impacting innovation. Previous research suggests the impacts on innovation from fundamental infrastructure, such as road construction (Agrawal, Galasso and Oettl, 2017), city layout (Roche, 2020), and subway expansion (Koh, Li and Xu, 2022). Additionally, two other papers emphasize the importance of protecting intellectual property (Chen and Puttitanun, 2005) and the role of economic specialization in promoting innovation (Feldman and Audretsch, 1999). My research aims to explore culture as a potential factor influencing innovation, introducing a new dimension to this body of literature.

The second strand of literature investigates the persistent effects of historical institutions (Acemoglu, Johnson and Robinson, 2001; Dell, 2010; Guiso, Sapienza and Zingales, 2016; Nunn, 2008). Regarding Chinese civil exams system, specifically, researchers have found that after the system was abolished in 1905, more revolutions (Bai and Jia, 2016) and better financial development (Lin et al., 2021) ensued. The closest study to mine is Chen, Kung and Ma (2020), which investigates how *keju* culture has contributed to human capital in 2010. They examine metrics such as the average years of schooling and the percentage of people with education at various levels, such as "high school" or "university and above." However, the influence of *keju* culture on innovation remains unclear. My paper examines this historical institution and contributes to the literature by demonstrating its long-term effects on contemporary innovation. Additionally, I propose and test several other channels, which can be regarded as supplements to Chen, Kung and Ma (2020).

The third contribution of my paper is providing evidence on the factors that influence successful scientists and innovators in China. Previous studies have primarily focused on the United States (Airoldi, Labs and Moser, 2024; Bell et al., 2019). My paper extends this body of research by examining innovation within the developing-country context.

This paper is organized as follows. Section 2 provides historical background on the *keju* exam during the Ming and Qing dynasties. Section 3 the describes the data used. Section 4 outlines the identification strategy employed. Section 5 reports the baseline estimates. Section 6 explores the heterogeneous effects over decades and subjects. Section 7 examines the channels through which the effects may operate. Section 8 presents conclusions.

## 2 Background

The Chinese civil examination, also known as the *keju*, was first introduced during the Song dynasty (c. 960–1279) as a means to select government officials based on merit rather than birthright. However, it was not until the Ming dynasty (c. 1368–1644) that the civil examination system reached its full institutionalization, becoming a central pillar of the Chinese bureaucratic system. In 1905, after realizing the exam's obstructive role in cultivating talent in different fields and responding to the pressures of modernization and the need for a more diverse set of skills in the bureaucratic workforce, the Qing government decided to abolish the civil service exam, marking the end of an era that had lasted for over a millennium.

The civil exam consisted of three levels: the county level, the provincial level, and the national level. A large portion of the male population, regardless of social status, could take the exam at the county level, which was the first step in the long and arduous journey of becoming a government official as shown in Figure 3. If they performed well at the county level, they could be awarded the title of *shengyuan*, granting them certain privileges such as exemption from labor and taxes, and the opportunity to wear distinctive clothing. All *shengyuan* were eligible to take the exam at the provincial level, where competition was fierce. A portion of the top-performing candidates at this level could earn the title of *juren*, which elevated their status and provided greater opportunities for government service. All *juren* could then travel to the capital to take the national exam, the highest level of the civil service examination system. Those who performed best at this stage could be awarded the prestigious title of *jinshi*, opening the doors to high-ranking official positions and giving them significant influence in the imperial bureaucracy.

The exam was extremely competitive. According to the calculation in Chen, Kung and Ma (2020), the chances for people who took the county exam to become a juren or a *jinshi* were around 0.09% and 0.016%, respectively. Despite the very low ratio of *jinshi*, the exam was renowned for its integrity and resistance to corruption. There were eight examiners, and the entire process was conducted under strict supervision. The graders, as well, were held to high standards and were kept from recognizing examinees' handwriting through the use of a transcribe copy of the test takers' answers to ensure anonymity. Any attempt at fraudulence during this process was met with severe punishment, including the possibility of the death penalty, reflecting the exam's critical role in maintaining a meritocratic bureaucracy.

To prepare for the exam, it was crucial for students to have a deep understanding of the Four Books and the Five Classics, which formed the core of the Confucian curriculum.[6] Preparation could take various forms, including self-study, hiring private tutors, or attending official schools. Many students began their studies at a young age, dedicating years to mastering the required texts and honing their ability to write essays that adhered to the rigid structure of the eight-legged essay format.[7] The rigorous preparation process often meant sacrificing personal and family life in pursuit of scholarly excellence.

The benefits of attaining *jinshi* status were substantial and far-reaching. Individuals who achieved this status could attain elevated social standing and significant political influence. Typically, they began in positions comparable to the leader of a county. However, the opportunities for advancement were vast, as it was commonly accepted that gaining access to the center of power required exceptional performance in the exam as mentioned by Qian (2012). *jinshi* recipients also received a generous salary, which allowed them to live comfortably and support their families. According to Chang (1962), civil exam scholars held 24% of the nation's wealth, despite making up only 2% of the total population. Their accomplishments were celebrated and commemorated by their communities, often through having their names recorded in local gazetteers, erecting honorific arches, or even composing poems and songs in their honor. This recognition extended beyond their lifetime, ensuring their legacy endured for generations.

[6] The Four Books include the Doctrine of the Mean, The Great Learning, Mencius, and The Analects. The Five Classics are the Book of Odes, Book of Documents, Book of Changes, Book of Rites, and Spring and Autumn Annals. More information can be found here: Four Books and Five Classics.

[7] The eight "legs" refer to the distinct sections that form the essay's structure: introducing the topic (*pò tí*), developing the topic (*chéng tí*), beginning the discussion (*qǐ jiǎng*), first argument (*qǐ gǔ*), middle argument (*zhōng gǔ*), later argument (*hòu gǔ*), final argument (*shù gǔ*), and conclusion (*dà jié*). (Elman, 2009).

# 3 Data

## 3.1 The Civil Exam (*keju*)

As outlined in Section 2, individuals' achievements in the *keju* examination system are categorized into three tiers: *jinshi*, *juren*, and *shengyuan*. I select *jinshi* as the primary proxy for measuring the influence of the *keju*, as it represents the highest level of qualification and is therefore, likely to have the most significant impact on local innovation and scholarly achievement.

The data on *jinshi* scholars are derived from Chen, Kung and Ma (2020), who sourced the information from Zhu and Xie (1980). This dataset contains comprehensive information, including the names, birthplaces, and examination years of *jinshi* scholars. The directory records a total of 46,908 *jinshi* scholars who participated in the civil examinations between 1371 and 1904, a period spanning over 500 years. These examinations were conducted across 278 historical prefectures in China, which correspond to 272 contemporary prefectures.

Given that some prefectures had larger populations than others, the number of *jinshi* scholars is normalized by the prefecture population, using data from Cao (2000) and Cao (2015). This normalized measure, referred to as *jinshi* density, allows for meaningful comparisons across regions. To address skewness and account for zero values, the *jinshi* density is incremented by 1 and then transformed using a natural logarithm. This transformation ensures a more symmetric distribution, facilitating more accurate statistical analysis in the following sections.

## 3.2 Measures for Local Innovation Level

I use three outcome variables to measure local innovation levels: the number of members in the Chinese Academy of Sciences (CAS) and in the Chinese Academy of Engineering (CAE) and the number of Chinese patent applications at the prefecture level.

The Chinese Academy of Sciences (CAS) plays a central role in advancing China's progress in high technology and natural sciences, while the Chinese Academy of Engineering (CAE) is the leading institution in engineering sciences and technology in the country. Both CAS and CAE are consulted in national decision-making and are innovation-driven, internationally renowned think tanks. Membership in CAS and CAE is widely recognized as the pinnacle of achievement in science and engineering, representing the highest academic honors in these fields. Information on members of both CAS and CAE was collected from their respective official websites.[8] These websites provide detailed descriptions of each member, including their birth year, birthplace, and field of expertise. CAS members have been elected from 1955 to 2023, while CAE members have been elected from 1994 to 2023. Using the birthplace information, I calculate the number of CAS and CAE members for each prefecture.

Data on Chinese patent applications are sourced from the China National Intellectual Property Administration. Patents are categorized into invention patents, utility model patents, and design patents, with data spanning from 1992 to 2016.[9] I calculate the number of patent applications for each prefecture based on the addresses provided in the applications.

## 3.3 Data for Channel Analysis

To discuss the channels through which the historical *jinshi* density may influence the local innovation level today, I explore several data sources to provide a comprehensive analysis.

First, I use data on military factories sourced from Fan (2003), which provides detailed information on the location and investment for military factories established during the Self-Strengthening Movement. The Self-Strengthening Movement in the late Qing dynasty was a crucial initiative for China's transition into the modern era. During this movement, the government endeavored to establish military factories, which may have cultivated an

[8]The websites are www.cas.cn and www.cae.cn.

[9]Invention (*faming*) patents refer to a new technical solution proposed for a product, method, or its improvement. Utility model (*shiyong xinxing*) patents refer to a new technical solution suitable for practical use, proposed for the shape, structure, or their combination of a product. Design (*waiguan sheji*) patents refer to a new design that is aesthetically pleasing and suitable for industrial application, made for the shape, pattern, or their combination of a product, as well as the combination of color and shape or pattern.

interest in Western technology among the populace. Due to the movements connection with increased interest in technology, I investigate whether regions with a higher density of *jinshi* scholars played a more significant role in this movement.

Additionally, I utilize data from the Chinese Political Elite Database (CPED) to examine top officials in China. Top officials often have control over resource allocation and can exert considerable influence at the national level. The CPED dataset provides information on the birthplace and rank of officials from 1995 to 2015, enabling me to calculate the number of officials at the ministerial and premier levels based on their place of birth.

The third data set is sourced from Gao and Lei (2021), which includes connection data for 93 prefectures, trimmed based on the availability of food price data during their period of interest. I use this data to measure access to information based on whether a prefecture was connected to the telegraph or railway in the late Qing dynasty. Access to information may play a critical role in making local regions more receptive to Western technology, thereby enabling individuals to achieve more in fields introduced by Western countries.

I also use data for the top 100 universities sourced from the Shanghai Ranking. I employ three different measures using this data: the number of top 100 universities in 2015, the number of universities in the 985 Project, and the number of universities in the 211 Project. The 985 Project, initiated in 1998, is a government initiative aimed at establishing world-class universities in China, initially including nine universities, and expanding to 39 universities by 2004. The 211 Project, launched in 1995, focuses on strengthening approximately 100 institutions of higher education and key disciplines as a national priority. There are currently 112 universities in the 211 Project.Modern universities are expected to play a significant role in sustaining local innovation.

Finally, I use several different sources to measure top students in different periods since top students are likely to play a pivotal role in becoming leading scientists and promoting innovation. To assess the number of Japanese overseas students across prefectures, I digitize data from Shen (1978), which provides a comprehensive list of students who studied in Japan during the late Qing dynasty (1902–1909) and their places of birth. Additionally, I measure the number of top students by digitizing Su (2004), which records the number of Tsinghua University students from 1927 to 1949. Using data from Fairbank Center for Chinese Studies of Harvard University and Center for Historical Geographical Studies at Fudan University (2016), I assign the number of students to contemporary prefectures based on the centroid of each *fu*.[10]

### 3.4 Control Variables

Following Chen, Kung and Ma (2020), I select the following control variables for my analysis, as they may be correlated with both historical *jinshi* density and contemporary local innovation levels.

Wealthier areas are likely to have produced more *jinshi*, and such historical wealth may persist, leading to greater innovation today. While data on historical prefecture-level GDP is unavailable, I use population density and urbanization rate as proxies, as suggested by Bairoch (1988). Population density is calculated as the average population density from 1393 to 1910, and the urbanization rate represents the average ratio of the urban population between 1393 and 1920. This period aligns with the construction of the *jinshi* density variable. Additionally, given the agrarian nature of China's traditional economy, agricultural productivity is a useful measure of economic conditions. Therefore, I include potential agricultural productivity, calculated using the Caloric Suitability Indices developed by Galor and Özak (2016), as a control variable. Additionally, the distance to major navigable rivers is included as a control variable, as waterways were historically a key mode of transportation and could significantly impact the economic prosperity of local areas.

Geography also plays a critical role in a prefecture's development. Two geographical control variables are included: distance to the coast and terrain ruggedness. Distance to the coast serves as a proxy for access to trade with foreign countries and exposure to Western

[10] *Fu* was the second administrative level during the historical period of interest, and a prefecture is the equivalent administrative level in contemporary China.

science and technology, both of which can influence contemporary innovation. Terrain ruggedness, on the other hand, may affect the frequency of natural disasters, potentially shaping people's understanding of nature and scientific knowledge. The distance to the coast is measured as the distance from the centroid of a prefecture to the nearest point on the coastline, while terrain ruggedness is calculated by assessing elevation changes between neighboring grid cells, using data from the United States Geological Survey (USGS).

These control variables are designed to account for historical wealth, economic conditions, and geographical factors, ensuring that the prefectures compared are similar along these dimensions when assessing the influence of *keju* on contemporary innovation.

# 4 Empirical Strategy

In this section, I will begin by examining the correlation between today's innovation outcomes and historical *jinshi* density using a fixed-effects model while controlling for other prefecture-level characteristics. One important assumption I make to interpret the correlation as causal effects is that the *jinshi* density is randomly assigned to prefectures after controlling for the covariates. However, it is easy to recognize that the covariates cannot be exhaustive. Acknowledging the inherent limitations of the fixed-effects model in addressing omitted variable bias, I will also present an alternative model using instrumental variable (IV) methods to estimate the persistent effects of *jinshi* density on contemporary innovation levels. Both of these models have been derived from Chen, Kung and Ma (2020).

## 4.1 Fixed Effects Model

At first, I show the fixed effects used to estimate the correlation between contemporary innovation metrics and historical *jinshi* density. The model's specification is outlined below:

$$Y_i = \beta jinshi_i + \gamma X_i + \mu_p + \epsilon_i \tag{1}$$

where $Y_i$ indicates outcome variables measuring innovation in prefecture i in modern China; $jinshi_i$ signifies the number of *jinshi* per 10,000 people from 1371 to 1905; $X_i$ represents the control variables including distance to coast, terrain ruggedness, agricultural suitability, log of Ming-Qing population density, Ming-Qing urbanization rates, and log of the shortest distance to major navigable rivers; $\mu_p$ represents province fixed effects; and $\epsilon_i$ is the error term. $\beta$ is the coefficient of interest, and it represents the estimated correlation between Ming-Qing *jinshi* density and the contemporary local innovation level.

## 4.2 IV Approach

Given that the *jinshi* density in each prefecture cannot be assumed to be randomly assigned, even with the inclusion of various covariates, I present the regression used to generate the IV estimates.

The *keju* exam sought to identify candidates with a deep understanding of the Four Books and Five Classics. Books, including textbooks and reference materials. Therefore, access to these materials was essential for exam preparation. Beginning in the 14th century, China's dominant printing technology heavily depended on pine and bamboo for the production of both ink and paper (Zhang and Han, 2006). Given the high transportation costs at the time, water transport became the primary means of moving these printing materials. Thus, the instrumental variable is based on the premise that prefectures closer to pine and bamboo habitats had better access to books, resulting in stronger performance on the exams.

For the instrumental variable to be valid, two key conditions must be present. First, the distribution of pine and bamboo habitats must be exogenous to the locations. These habitats were naturally determined, and there is no evidence of deliberate planting efforts by businessmen (Elvin, 2004). Second, a prefecture's river distance should impact local innovation today solely through its historical *jinshi* density. While this condition cannot be directly tested, I examine numerous variables and find no significant correlation between river distance and other covariates, as shown in Table A1, providing some confidence that the exclusion restriction is unlikely to be violated.

Equation (3) below shows the correlation between river distance to pine and bamboo and historical *jinshi* density. Should the validity of river distance as an instrument in equation (3) be established, then $RiverDistance_i$ can be utilized as an instrumental variable for $\hat{jinshi}_i$ in equation (2).

$$Y_i = \beta_1 \hat{jinshi}_i + \gamma X_i + \mu_p + \epsilon_i^1 \tag{2}$$

$$jinshi_i = \alpha RiverDistance_i + \delta X_i + \mu_p + \epsilon_i^2 \tag{3}$$

where $jinshi_i$, $X_i$, and $\mu_p$ have the same meanings as in equation (1). $RiverDistance_i$ denotes the river distance of prefecture i to its nearest pine and bamboo habitats. $\epsilon_i^1$ and $\epsilon_i^2$ are error terms. The key coefficient is $\beta_1$, which indicates the persistent effects of *keju* on contemporary innovation level. The clustering level for all the following regressions is at the province level.

# 5 Estimates

In this section, I begin by demonstrating the correlation between historical *jinshi* density and contemporary innovation levels. Recognizing the potential for omitted variable bias in the fixed effects model, I then present the results using the instrumental variable (IV) approach to address this concern. Before introducing the main IV results, I establish the validity of the instrumental variable through a series of statistical tests.

## 5.1 OLS Estimates

As depicted in Figure 2, a higher log number of *jinshi* per 10,000 is associated with a higher number of members in the Chinese Academy of Sciences, the Chinese Academy of Engineering, and patents. This figure visually demonstrates the positive correlation between historical *jinshi* density and contemporary measures of innovation.

It is important to consider that higher historical *jinshi* density may be closely correlated with other factors, such as economic prosperity. More developed regions in the past likely had superior educational systems, which could lead to a higher number of top scholars. Additionally, historical prosperity may have had a lasting impact on contemporary innovation levels. To account for this, I include several control variables in the analysis, such as distance to the coast, terrain ruggedness, agricultural suitability, log of Ming-Qing population density, Ming-Qing urbanization rates, and log of the shortest distance to major navigable rivers. These controls allow for a more accurate comparison between prefectures with similar historical characteristics but different *jinshi* densities, providing a clearer estimate of the *keju* exam's impact on contemporary innovation.

Moreover, comparisons are restricted to prefectures within the same province for two key reasons. First, each province had a fixed quota for the number of *jinshi*, meaning individuals competed for *jinshi* within their own province. Second, the national exam was held in the capital, and proximity to the capital may have facilitated easier access to the exam. Restricting comparisons within provinces limits the variation in distance to the capital, allowing for a more focused analysis. After applying the fixed effects model, the results show that a doubling of *jinshi* density is associated with a 39.5% increase in the number of Chinese Academy of Sciences members, a 28.7% increase in the number of Chinese Academy of Engineering members, and a 69.4% increase in patent numbers, as shown in Table 2.

## 5.2 IV Estimates

In Table 2, I show the estimated effects of the persistent influence of the *keju* culture on today's innovation level. However, these estimates may still be subject to omitted variable bias. To address this, I use the average river distances from each prefecture city to its nearest pine and bamboo habitats as an instrumental variable.

Before presenting the IV estimates, it is important to note that a prefecture's average river distance to its nearest pine and bamboo habitats is negatively correlated with its *jinshi* density, as discussed in Section 4.2. As shown in Panel D of Table 3, the coefficient is -0.09 and is statistically significant. This suggests that, historically, prefectures farther from pine and bamboo habitats had lower *jinshi* densities, which aligns with the rationale behind the selection of the instrumental variable. Additionally, the Kleibergen-Paap Wald F statistic is 63.264, well above the Stock-Yogo weak identification test 10% threshold of 16.38, ruling out concerns of weak instruments.

With historical *jinshi* density instrumented by the IV, I present IV estimates to demonstrate the persistent influence of *keju* on contemporary innovation. In Panel B of Table 3, Column (1) shows a 44.3% increase in the number of Chinese Academy of Sciences members is associated with a doubling of historical *jinshi* density. Column (2) indicates a 33.2% increase in the number of Chinese Academy of Engineering members with the same doubling. Column (3) demonstrates a 91.7% increase in the number of patents. These results are not only statistically significant but also economically meaningful. Furthermore, the IV estimates are larger than the corresponding OLS estimates in Panel A of Table 3, consistent with the typical measurement error problem, which suggests that the IV estimates support the results from the fixed-effects model in assessing *keju*'s persistent influence. Across all measures of contemporary local innovation, the results indicate that *keju* culture has a positive and lasting impact.

It is possible that the higher numbers of top scientists and patents are driven by larger populations. For instance, if we assume a fixed ratio of individuals becoming top scientists based on population, one could imagine that an additional 100 people in a region might lead to one more top scientist. To address this, I calculate the innovation metrics on a per capita basis. Measuring innovation per capita also helps to assess the broader innovation activity within a prefecture. A higher innovation-per-capita figure suggests that more individuals in the region are engaged in innovative efforts. As shown in Columns (1) to (3) of Table 4, the estimates remain statistically significant for both OLS and IV models. In Panel B, Column (1) indicates a 7.2% increase in the number of Chinese Academy of Sciences members per 100,000 people associated with a doubling of historical *jinshi* density. Column (2) reflects a 6.1% increase in the number of Chinese Academy of Engineering members per 100,000, and Column (3) shows a 93.7% increase in the number of patents per 100,000. Furthermore, I directly check whether *keju* culture leads to a higher population. The estimates for CAS and CAE members per capita are slightly lower compared to those without adjusting for population, which raises the question of whether population differences are driving the results. To further examine whether *keju* culture influenced population growth, I directly test whether regions with higher historical *jinshi* density have larger populations today. As shown in Column (4), the estimates are statistically insignificant, suggesting that I cannot conclusively show that *keju* culture has led to higher populations in the present day. Thus, the influence of historical *keju* success appears to extend not only to innovation levels but also to the breadth of innovation across the population.

The quality of innovation is a crucial aspect that warrants significant attention. Major inventions such as the steam engine, electric light, computer, and mobile phone have profoundly transformed human life, enhancing productivity and altering lifestyles. It is essential to investigate whether *keju* culture influences the quality of contemporary innovation. As shown in Column (1) of Panel B in Table 5, a doubling of historical *jinshi* density leads to a 113.4% increase in the total number of citations. However, because the number of citations may be influenced by the sheer volume of patents, I calculate the average number of citations per patent. This analysis does not reveal a statistically significant relationship between historical *jinshi* density and contemporary innovation quality. Nonetheless, when focusing on patents with substantial influence—measured as those ranked in the top 10% within each subject area—I observe that a doubling of historical *jinshi* density leads to a 120.4% increase in the number of highly influential patents, as shown in Column (3). Therefore, while *keju* culture does not appear to elevate the average quality of innovation, it does seem to contribute to the production of highly impactful innovations.

# 6 Heterogeneous Effects

The previous section has demonstrated that the *keju* exam exerts a lasting influence on contemporary innovation. In this section, I explore whether certain fields are more affected by *keju* culture. Additionally, I examine whether the impact of the *keju* exam on innovation remains consistent across different decades or diminishes due to significant historical events. I will show the analysis for patents first, and then show the results about scientists.

As introduced in the Data section, there are three types of patents: invention patents, utility model patents, and design patents. Invention patents require more innovative ideas and are the most difficult type of patent to obtain. Using these patent categories, I calculate the number of patents in each category for every prefecture and conduct a separate analysis for each type. As shown in Table 6, the influence of *keju* is strongest on the number of invention patents. A doubling of historical *jinshi* density results in a 135% increase in invention patents, a 97.3% increase in utility model patents, and a 75.6% increase in design patents. Clearly, the impact of the *keju* exam is greatest on invention patents, followed by utility model patents, and then design patents. These findings suggest that *keju* culture encourages innovation across different levels of difficulty, but its influence is more pronounced when the level of innovation required is higher. Moreover, I assess whether *keju* culture influences per capita innovation across these categories. The results are consistent with the absolute values and has a similar decreasing trend across the patent types, as shown in

Table A2. This indicates that the effect of *keju* culture on innovation per capita mirrors its influence on patent numbers, with *keju* culture having a greater effect on more complex innovations.

It is not only important to consider the difficulty of innovation but also to examine whether *keju* culture primarily drives innovation in specialized, advanced fields requiring higher education, or whether it fosters innovation across a variety of subjects. To explore this, I analyze the influence of *keju* culture on the number of patents across different fields as shown in Table 7. In the table, all estimates in columns (1) through (9) are positive and statistically significant. Among these, *keju* culture has the largest effect on patents in Physics and Electricity. This is understandable, as patents in these fields likely require a strong educational background, such as a Ph.D. degree. The results suggest that *keju* culture encourages individuals to pursue higher education, leading to more patents in highly specialized fields. However, people in other fields also display a spirit of innovation, even if they may not possess the same level of formal education.

While the transmission of *keju* culture's influence on contemporary innovation is evident, it remains unclear whether this transmission was interrupted by historical events or continued uninterrupted until the present day. To address this, I categorize members of the Chinese Academy of Sciences and the Chinese Academy of Engineering into different groups based on their birth years. The first group consists of individuals born no later than the end of the Qing dynasty (1911), a period when *keju* still existed, but there was uncertainty about its future. The second group includes those born between 1912 and 1936, spanning the time between the fall of the Qing dynasty and the onset of the Second Sino-Japanese War, a period when *keju* had clearly ended and Western technology was gaining recognition. The third group includes those born between 1937 and 1948, covering the time period of the Second Sino-Japanese War and China's Civil War, times of significant political instability. The fourth group consists of individuals born between 1949 and 1960, whose formative years were heavily influenced by the Cultural Revolution—a period when scientific research and education were severely disrupted, and intellectuals were often targeted as bourgeois reactionary academic authorities. The final group comprises individuals born between 1961 and 1979, after the Cultural Revolution.

In Table 8, I observe statistically significant IV estimates at a 95% confidence interval in columns (2) to (5), which means the *keju* culture had a persistent influence on the number of members of the Chinese Academy of Sciences born after 1912, though it is suggestive that the influence was fading. Similarly, I did an analysis of the members of the Chinese Academy of Engineering members. In Table 9, the estimates in columns (2) and (5) are significant, which means that *keju* culture significantly increased the number of members of the Chinese Academy of Engineering born between 1912 and 1936, as well as those born between 1961 and 1979. Even though the coefficients in the other three columns are not significant, they are positive and I cannot reject the possibility that they are the same as the estimates in columns (2) and (5). I also consider the possible influence of major history events on the per capita number of scientists and engineers, and the results are consistent, the population-adjusted results in the appendix, as shown in Tables A3 and A4. Therefore, despite political instability, wars, and the Cultural Revolution, the persistent influence of the *keju* exam remains evident.

I categorize the members of the Chinese Academy of Sciences (CAS) and the Chinese Academy of Engineering (CAE) into distinct groups based on their fields of work. CAS members specialize in six major subject areas: information technical sciences, chemistry, life sciences and medical sciences, earth sciences, technological sciences, and mathematics and physics. CAE members, on the other hand, work across nine fields: mechanical and vehicle engineering; agriculture; chemical, metallurgical, and material engineering; engineering management; information and electronic engineering; civil and hydraulic engineering; medicine and health engineering; light industry and environmental engineering; and energy and mining engineering.

As shown in Table 10, the *keju* exam has a positive impact on the number of CAS members in the fields of technological sciences, earth sciences, and mathematics and physics. However, the influence is not statistically significant for other subjects, although the estimates remain positive. In Table 11, the IV estimates are statistically significant from columns (4) to (9), which include subjects such as civil and hydraulic engineering, agriculture, mechanical and vehicle engineering, chemical, metallurgical, and material engineering, engineering management, and information and electronic engineering. These fields are closely related to national security and are heavily supported by the government, suggesting that the *keju* culture has contributed to the production of top scientists and engineers in these critical areas. This may indicate the *keju* system's lasting influence on fostering loyalty to the state and supporting the development of top scholars in fields with strong government backing. I adjust the dependent variable based on the population in each prefecture, and the results are presented in Tables A6 and A7.

# 7 Mechanism

Given the persistent effects of *keju* culture from 1371 to 1904 on contemporary innovation levels, I propose several mechanisms through which *jinshi* density may have a lasting impact on local innovation. These channels include increased investment during the Self-Strengthening Movement, the rise of top officials from 2000 to 2015, enhanced access to telegraph services during the late Qing Dynasty, and the establishment of more top universities after 1990.

## 7.1 Increased Military Investment during the Self-Strengthening Movement

The Self-Strengthening Movement (SSM) emerged in response to a series of military challenges faced by Imperial China in the mid-nineteenth century. Its primary objectives were to adopt Western technology and strengthen the nation's military capabilities. Between

1861 and 1894, 34 munitions factories were established, predominantly under government control, with varying scales of investment. Bo, Liu and Zhou (2023) highlights that this program contributed to the accumulation of human capital.

As shown in Table 12, a doubling in *jinshi* density corresponds to an 18.4% increase in the number of military firms and an 84.7% increase in total military investment. Both results are statistically significant at the 99% confidence level. These findings support the hypothesis that regions with higher historical *jinshi* densities received greater military investment from the central government during the late Qing period, and these investments may have had long-term effects on contemporary innovation.

## 7.2 Increased Presence of Top Officials

Hometown favoritism is a well-documented phenomenon across various contexts. In Germany, Baskaran and Lopes da Fonseca (2021) finds that municipalities hosting a minister experience faster growth in state government employment, especially when the minister serves multiple legislative terms. Similarly, Do, Nguyen and Tran (2017) highlights that the promotion of native officials in Vietnam often results in significant improvements in local infrastructure. In China, Yin and Chen (2021) identifies a positive relationship between financial officials' hometown affiliations and regional financial development. High-ranking officials with considerable influence tend to channel more resources to their hometowns, thereby fostering local development and potentially boosting innovation. This suggests that *keju* culture may influence contemporary innovation by increasing the number of high-level officials emerging from historically successful regions.

As shown in Panel B of Table 13, a doubling of *jinshi* density is linked to a 28.3% increase in the number of Chinese officials at the ministerial level and a 7.1% increase at the premier level. These findings indicate that higher historical *jinshi* density leads to a greater number of contemporary top officials, which may contribute to regional innovation development.

## 7.3 Improved Access to Information

Infrastructure development plays a crucial role in promoting innovation by facilitating knowledge exchange. In the late Qing Dynasty, China initiated the construction of telegraph lines and railways across the country. The telegraph significantly reduced long-distance communication costs, while railways shortened travel times between distant regions. These infrastructures serve as proxies for evaluating a prefecture's access to information during the late Qing period.

As shown in Table 14, a doubling in *jinshi* density is associated with a 33.4% increase in access to telegraph services and an 8%increase in railway access. However, the railway estimate is not statistically significant due to large standard errors. These results suggest that telegraph construction may have been an important channel supporting later innovation, while railway access may not have played a significant role in promoting later innovation.

## 7.4 Increase in the Number of Top Universities

Universities play a critical role in promoting innovation by cultivating a culture of discovery and providing resources for research. This influence manifests in two primary ways: fostering innovative mindsets and offering facilities and equipment for invention and research. To assess whether *keju* culture has led to the establishment of more modern top universities, I conduct regressions on the number of top universities in various regions.

As shown in Panel B of Table 15, columns (1) to (3) display the relationship between historical *jinshi* density and three different measures of top universities in China. Column (1) shows that a doubling of *jinshi* density leads to a 45.4% increase in universities ranked in the top 100. Columns (2) and (3) show increases of 29.2% and 23.2% in 211 Project universities and 985 Project universities, respectively—both heavily supported by central government policies.

### 7.5 Increase in Students in Top Schools

Based on the educational backgrounds of some members of the Chinese Academy of Sciences (CAS), it is evident that many either graduated from prestigious universities or had overseas study experiences. If regions more heavily influenced by *keju* culture produced a greater number of students receiving top-tier education during the late Qing Dynasty, these students would be more likely to become members of the CAS or the Chinese Academy of Engineering (CAE). To measure the number of top students in the late Qing period and the early Republic of China era, I use the number of overseas students in Japan and the number of students enrolled at Tsinghua University as proxies. Subsequently, I assess whether regions more heavily influenced by *keju* culture produced a higher number of top students.

However, as indicated in Table 16, the estimated coefficients in Panel B, columns (1) and (2), are both positive but not statistically significant. This suggests that I cannot conclude that *keju* culture directly influenced contemporary innovation levels by increasing the number of students studying in Japan or attending Tsinghua University.

## 8 Conclusion

In this study, I construct a dataset quantifying historical top scorers on the national exam at the prefecture-city level in China and innovation levels in contemporary China. My Ordinary Least Squares (OLS) analysis reveals a positive association between historically higher numbers of top scorers on the national exam (*jinshi*) from 1371 to 1905 and greater levels of and higher quality of innovation across modern Chinese prefectures. To explore the potential causal relationship, I build on insights from Chen, Kung and Ma (2020), which suggest that improved access to books contributed to the success of the *keju* examination. In line with Chen, Kung and Ma (2020), I use the shortest average river distances to each prefecture's nearest pine and bamboo sources—materials commonly used for printing—as an instrumental variable for historical *jinshi* density. The Instrumental Variables (IV) analysis not only corroborates but also strengthens the findings of the OLS analysis.

I then investigate the mechanisms through which the enduring influence of *keju* culture has shaped historical trajectories. While the civil examination system (*keju*) identified academic talent from various regions, the *keju* culture played pivotal roles in increasing military investment by the central government during the Self-Strengthening Movement, facilitating the rise of contemporary officials with significant authority, advancing telegraph infrastructure in the late Qing dynasty, and contributing to a higher concentration of leading contemporary universities. These efforts were instrumental in driving the modernization of local regions and likely played a crucial role in cultivating exceptional talent throughout the last century in China.

My paper contributes to three key areas of literature: the determinants of innovation, the persistent effects of historical institutions, and the factors influencing the success of scientists and innovators in China. My research suggests that a substantial part of China's innovation stems not only from abrupt institutional changes but also from values cultivated over an extended historical period.

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# Tables

**Table 1: Summary Statistics**

| | Mean (1) | Std (2) |
|---|---|---|
| **Panel A: Variables from Chen et al. (2020)** | | |
| log(*jinshi* density) | 0.917 | (0.702) |
| log(distance to coast) | 12.605 | (1.173) |
| Terrain ruggedness | 0.207 | (0.175) |
| Agricultural suitability | 3.014 | (0.715) |
| log(Ming-Qing population density) | 2.188 | (0.994) |
| Ming-Qing urbanization rates | 0.052 | (0.035) |
| log(Shortest distance to major navigable rivers) | 2.939 | (2.667) |
| log(Shortest river distance to pine/bamboo) | 9.965 | (5.574) |
| **Panel B: Measurement of Innovation** | | |
| No. Chinese Academy of Science members | 5.096 | (10.927) |
| No. Chinese Academy of Engineering members | 4.088 | (8.325) |
| No. Patents | 55462.743 | (1.24e+05) |
| No. Chinese Academy of Science members per 100,000 | 0.114 | (0.173) |
| No. Chinese Academy of Engineering members per 100,000 | 0.096 | (0.139) |
| No. Patents per 100,000 | 1490.108 | (4580.581) |

Notes. There are 272 observations for each variable, corresponding to 272 prefectures. Panel A presents variables sourced from Chen, Kung and Ma (2020). The primary independent variable, log(*jinshi* density), represents the logarithm of the number of *jinshi* per 10,000 people from 1371 to 1904, a period often referred to as the Ming-Qing era. The instrumental variable, log(Shortest river distance to pine/bamboo), captures the average river distance from each prefecture to the nearest pine and bamboo habitats. To account for omitted variable bias, Panel A also includes control variables that may be correlated with both historical *jinshi* density and contemporary innovation levels. Panel B reports metrics of local innovation, which are the dependent variables, independently compiled by the author.

**Table 2: Correlation between Jinshi Density and Contemporary Innovation**

| | Number of Chinese Academy of Science Members | Number of Chinese Academy of Engineering Members | Number of Patents |
|---|---|---|---|
| | (1) | (2) | (3) |
| log(jinshi density) | 0.395*** | 0.287*** | 0.694*** |
| | (0.074) | (0.088) | (0.126) |
| Baseline Control | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 |

Notes. All dependent variables are logged, and the results are based on OLS estimates. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Log(*jinshi* density) represents the number of *jinshi* per 10,000 people between 1371 and 1904, reflecting the success of the *keju* system in the past. The table estimates Equation (1), and it shows the correlation between historical jinshi density and contemporary innovation.

**Table 3: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on Contemporary Innovation**

| Dependent Variable: | Number of Chinese Academy of Science Members | Number of Chinese Academy of Engineering Members | Number of Patents |
|---|---|---|---|
| | (1) | (2) | (3) |
| | | Panel A: OLS Estimates | |
| log(jinshi density) | 0.395*** | 0.287*** | 0.694*** |
| | (0.074) | (0.088) | (0.126) |
| | | Panel B: IV Estimates | |
| log(jinshi density) | 0.443** | 0.332** | 0.917*** |
| | (0.180) | (0.153) | (0.136) |
| | | Panel C: Reduced Form | |
| Log(river dist to bamboo/pine) | -0.037* | -0.028 | -0.081*** |
| | (0.020) | (0.017) | (0.015) |
| | | Panel D: First-stage | |
| Log(river dist to bamboo/pine) | -.090*** | -.090*** | -.090*** |
| | (0.011) | (0.011) | (0.011) |
| Baseline Control | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. All dependent variables measure innovation levels in prefectures and are logged. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Panel A reports OLS estimates, following equation (1), which shows the association between historical *jinshi* density and contemporary innovation. Panel B presents IV estimates, based on equation (2), which provides the causal impact of historical *jinshi* density on contemporary innovation. Panel C presents the reduced-form results, estimating the effect of the instrument variable—average river distance to each prefecture's nearest pine and bamboo habitats—on contemporary innovation. Panel D shows the first-stage results, based on equation (3), estimating the relationship between the instrument and the number of *jinshi* per 10,000 people between 1371 and 1904.

**Table 4: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on Contemporary Innovation**

| Dependent Variable: | Number of Chinese Academy of Science Members per 100,000 | Number of Chinese Academy of Engineering Members per 100,000 | Number of Patents per 100,000 | Population |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | | Panel A: OLS Estimates | | |
| log(jinshi density) | 0.066*** | 0.049*** | 0.706*** | -0.014 |
| | (0.015) | (0.016) | (0.115) | (0.037) |
| | | Panel B: IV Estimates | | |
| log(jinshi density) | 0.072** | 0.061** | 0.937*** | -0.021 |
| | (0.033) | (0.029) | (0.097) | (0.078) |
| | | Panel C: Reduced Form | | |
| Log(river dist to bamboo/pine) | -0.006* | -0.005* | -0.083*** | 0.003 |
| | (0.003) | (0.003) | (0.013) | (0.008) |
| Baseline Control | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. The dependent variables in Columns (1) to (3) measure per capita innovation levels in prefectures and are logged, while the dependent variable in Column (4) measures the population in prefectures and is also logged. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Panel A reports OLS estimates, following equation (1), which shows the association between historical *jinshi* density and per capita contemporary innovation or population. Panel B presents IV estimates, based on equation (2), which provides the causal impact of historical *jinshi* density on per capita contemporary innovation or population. Panel C presents the reduced-form results, estimating the effect of the instrument variable—average river distance to each prefecture's nearest pine and bamboo habitats—on contemporary innovation or population.

**Table 5: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on Contemporary Innovation Quality**

| Dependent Variable: | Number of Total Citations | Number of Average Citations | Number of Patents with top 10% Citations |
|---|---|---|---|
| | (1) | (2) | (3) |
| | | Panel A: OLS Estimates | |
| log(jinshi density) | 0.575*** | -0.092** | 0.690*** |
| | (0.165) | (0.040) | (0.159) |
| | | Panel B: IV Estimates | |
| log(jinshi density) | 1.135*** | -0.004 | 1.204*** |
| | (0.232) | (0.111) | (0.266) |
| | | Panel C: Reduced Form | |
| Log(river dist to bamboo/pine) | -0.091*** | 0.000 | -0.099*** |
| | (0.019) | (0.011) | (0.022) |
| Baseline Control | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. All dependent variables measure innovation quality in prefectures and are logged. 'Number of Total Citations' refers to the total number of citations received by all patents in the prefecture. 'Number of Average Citations' indicates the average number of citations per patent, calculated by dividing the total Number of citations by the total number of patents. 'Number of Patents with Top 10% Citations' refers to the number of patents receiving the most citations, ranked in the top 10 percent among all patents in the same subject based on citations. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Panel A reports OLS estimates, following equation (1), which shows the association between historical *jinshi* density and contemporary innovation quality. Panel B presents IV estimates, based on equation (2), which provides the causal impact of historical *jinshi* density on contemporary innovation quality. Panel C presents the reduced-form results, estimating the effect of the instrument variable—average river distance to each prefecture's nearest pine and bamboo habitats—on contemporary innovation quality.

**Table 6: OLS and 2SLS Estimates of the Effects of Historical Jinshi Density on the Number of Patents, By Type**

| Dependent Variable: | Invention | Utility Model Patent | Design Patent |
|---|---|---|---|
| | (1) | (2) | (3) |
| | | Panel A: OLS Estimates | |
| log(*jinshi* density) | 1.030*** | 0.737*** | 0.492*** |
| | (0.162) | (0.135) | (0.107) |
| | | Panel B: IV Estimates | |
| log(*jinshi* density) | 1.350*** | 0.973*** | 0.756*** |
| | (0.192) | (0.144) | (0.140) |
| Baseline Control | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. All dependent variables measure the number of patents across different types and are logged. A detailed description of the types of patents can be found in Section 3.2. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Panel A reports OLS estimates, following equation (1), which shows the association between historical *jinshi* density and the number of patents in different types. Panel B presents IV estimates, based on equation (2), which provides the causal impact of historical *jinshi* density on the number of patents in different types.

**Table 7: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on the Number of Patents, By Subjects**

| Dependent Variable: | Human necessities | Performing operations; transporting | Chemistry; metallurgy | Textiles; paper | Fixed constructions | Mechanical engineering; lighting; heating; weapons; blasting engines or pumps | Physics | Electricity | Other |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| | | | | | Panel A: 2SLS Estimates | | | | |
| log(jinshi density) | 1.162*** | 1.062*** | 1.098*** | 0.471*** | 0.864*** | 0.988*** | 1.637*** | 1.448*** | 0.835*** |
| | (0.203) | (0.266) | (0.296) | (0.171) | (0.237) | (0.237) | (0.299) | (0.339) | (0.242) |
| | | | | | Panel B: Reduced Form | | | | |
| Log(river dist to bamboo/pine) | -0.105*** | -0.096*** | -0.099*** | -0.043** | -0.078*** | -0.089*** | -0.148*** | -0.131*** | -0.076*** |
| | (0.022) | (0.028) | (0.030) | (0.017) | (0.024) | (0.024) | (0.030) | (0.033) | (0.024) |
| Baseline Control | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 |

Notes. The unit of observation is a prefecture city. All dependent variables measure the number of patents across different subjects and are logged. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Panel A reports IV estimates, following equation (2), which shows the causal effects of historical *jinshi* density on the number of patents in different subjects. Panel B presents estimates from reduced form, which provides the association between the average river distances to each prefecture's nearest pine and bamboo habitats on the number of patents in different subjects.

**Table 8: OLS and 2SLS Estimates of the Effects of Historical Jinshi Density on the Number of Chinese Academy of Science Members, By Periods**

| | The Number of Chinese Academy of Science Members born: | | | | |
|---|---|---|---|---|---|
| Dependent Variable: | before 1911 | between 1912 and 1936 | between 1937 and 1948 | between 1949 and 1960 | between 1961 and 1979 |
| | (1) | (2) | (3) | (4) | (5) |
| | Panel A: OLS Estimates | | | | |
| log(jinshi density) | 0.147** | 0.332*** | 0.172*** | 0.208*** | 0.072 |
| | (0.058) | (0.085) | (0.062) | (0.047) | (0.054) |
| | Panel B: IV Estimates | | | | |
| log(jinshi density) | 0.117 | 0.375** | 0.217** | 0.192** | 0.172*** |
| | (0.125) | (0.146) | (0.111) | (0.098) | (0.063) |
| Baseline Control | ✓ | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. All dependent variables measure the number of Chinese Academy of Science members and are logged. A detailed description of the division of periods can be found in the Heterogeneous Effects part. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Panel A reports OLS estimates, following equation (1), which shows the association between historical *jinshi* density and the number of Chinese Academy of Science members in different periods. Panel B presents IV estimates, based on equation (2), which provides the causal impact of historical *jinshi* density on the number of Chinese Academy of Science members in different periods.

**Table 9: OLS and 2SLS Estimates of the Effects of Historical Jinshi Density on the Number of Chinese Academy of Engineering Members, By Periods**

| | The Number of Chinese Academy of Engineering Members born: | | | | |
|---|---|---|---|---|---|
| Dependent Variable: | before 1911 | between 1912 and 1936 | between 1937 and 1948 | between 1949 and 1960 | between 1961 and 1979 |
| | (1) | (2) | (3) | (4) | (5) |
| | Panel A: OLS Estimates | | | | |
| log(jinshi density) | 0.024 | 0.294*** | 0.160** | 0.023 | 0.147** |
| | (0.024) | (0.084) | (0.074) | (0.054) | (0.063) |
| | Panel B: IV Estimates | | | | |
| log(jinshi density)) | 0.010 | 0.286* | 0.139 | 0.124 | 0.304*** |
| | (0.010) | (0.169) | (0.112) | (0.081) | (0.084) |
| Baseline Control | ✓ | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. All dependent variables measure the number of Chinese Academy of Engineering members and are logged. A detailed description of the division of periods can be found in the Heterogeneous Effects part. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Panel A reports OLS estimates, following equation (1), which shows the association between historical *jinshi* density and the number of Chinese Academy of Engineering members in different periods. Panel B presents IV estimates, based on equation (2), which provides the causal impact of historical *jinshi* density on the number of Chinese Academy of Engineering members in different periods.

**Table 10: OLS and 2SLS Estimates of the Effects of Historical Jinshi Density on the Number of Chinese Academy of Science Members, By Research Fields**

| | The Number of Chinese Academy of Science Members Work in: | | | | | |
|---|---|---|---|---|---|---|
| Dependent Variable: | Information Technical Sciences | Chemistry | Life Sciences and Medical Sciences | Earth Sciences | Technological Sciences | Mathematics and Physics |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | Panel A: OLS Estimates | | | |
| log(jinshi density) | 0.117** | 0.019 | 0.088 | 0.163*** | 0.143*** | 0.180*** |
| | (0.044) | (0.055) | (0.062) | (0.049) | (0.039) | (0.033) |
| | | | Panel B: IV Estimates | | | |
| log(jinshi density) | 0.086 | 0.075 | 0.094 | 0.165* | 0.230*** | 0.265*** |
| | (0.061) | (0.079) | (0.089) | (0.091) | (0.076) | (0.058) |
| Baseline Control | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. All dependent variables measure the number of Chinese Academy of Science members in different research fields and are logged. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Panel A reports OLS estimates, following equation (1), which shows the association between historical *jinshi* density and the number of Chinese Academy of Science members in different fields. Panel B presents IV estimates, based on equation (2), which provides the causal impact of historical *jinshi* density on the number of Chinese Academy of Science members in different fields.

**Table 11: OLS and 2SLS Estimates of the Effects of Historical Jinshi Density on the Number of Chinese Academy of Engineering Members, By Research Fields**

| | The Number of Chinese Academy of Engineering Members Work in: | | | | | |
|---|---|---|---|---|---|---|
| Dependent Variable: | Energy and Mining Engineering | Light Industry and Environmental Engineering | Medicine and Health Engineering | Civil and Hydraulic Engineering | Agriculture | Mechanical and Vehicle Engineering |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Panel A: OLS Estimates | | | | | | |
| log(jinshi density) | 0.088 | -0.004 | 0.078 | 0.103** | 0.080** | 0.180*** |
| | (0.053) | (0.028) | (0.061) | (0.046) | (0.036) | (0.044) |
| Panel B: IV Estimates | | | | | | |
| log(jinshi density | 0.124 | 0.011 | 0.065 | 0.142*** | 0.112** | 0.213** |
| | (0.098) | (0.061) | (0.097) | (0.047) | (0.052) | (0.086) |
| Dependent Variable: | Chemical, Metallurgical, and Material Engineering | Engineering Management | Information and Electronic Engineering | | | |
| | (7) | (8) | (9) | | | |
| Panel A: OLS Estimates | | | | | | |
| log(jinshi density) | 0.056 | 0.091** | 0.084** | | | |
| | (0.043) | (0.035) | (0.038) | | | |
| Panel B: IV Estimates | | | | | | |
| log(jinshi density) | 0.157** | 0.141*** | 0.117* | | | |
| | (0.067) | (0.052) | (0.060) | | | |
| Baseline Control | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. All dependent variables measure the number of Chinese Academy of Engineering members (CAE) in different research fields and are logged. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes the same control variables as the baseline regression. Panel A reports OLS estimates, following equation (1), which shows the association between historical *jinshi* density and the number of CAE members in different fields. Panel B presents IV estimates, based on equation (2), which provides the causal impact of historical *jinshi* density on the number of CAE members in different fields.

**Table 12: OLS and 2SLS Estimates of the Effects of Historical Jinshi Density on the Military Investment in Late Qing (Channel Analysis)**

| Dependent Variable: | Number of Military Firms | Total Military Investment |
|---|---|---|
| | (1) | (2) |
| | Panel A: OLS Estimates | |
| log(jinshi density) | 0.167*** | 0.665*** |
| | (0.049) | (0.190) |
| | Panel B: IV Estimates | |
| log(jinshi density) | 0.184*** | 0.847*** |
| | (0.056) | (0.229) |
| Baseline Control | ✓ | ✓ |
| Prov FE | ✓ | ✓ |
| Observations | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. Two dependent variables are measuring military investment between 1861 and 1894 in prefectures and are logged. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Panel A reports OLS estimates, following equation (1), which shows the association between historical *jinshi* density and the military investment in the late Qing dynasty. Panel B presents IV estimates, based on equation (2), which provides the causal impact of historical *jinshi* density on the military investment in the late Qing dynasty.

**Table 13: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on the Number of Contemporary Top Officials (Channel Analysis)**

| | The Number of Chinese Officials at Hierarchy: | | | |
|---|---|---|---|---|
| Dependent Variable: | Deputy Minister (Fubu) | Minister (Zhengbu) | Vice Premier (Fuguo) | Premier (Zhengguo) |
| | (1) | (2) | (3) | (4) |
| | Panel A: OLS Estimates | | | |
| log(jinshi density) | 0.103 | 0.092 | -0.001 | 0.019 |
| | (0.102) | (0.063) | (0.071) | (0.034) |
| | Panel B: IV Estimates | | | |
| log(jinshi density) | 0.154 | 0.283** | 0.069 | 0.071* |
| | (0.139) | (0.116) | (0.082) | (0.039) |
| | Panel C: Reduced Form | | | |
| Log(river dist to bamboo/pine) | -0.014 | -0.026** | -0.006 | -0.006* |
| | (0.013) | (0.011) | (0.007) | (0.004) |
| Baseline Control | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. Two dependent variables are measuring from the number of top officials from 1995 to 2015 born in prefectures and are logged. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See summary statistics notes for variable definitions. Panel A reports OLS estimates based on equation (1), which shows the association between historical jinshi density and the number of top officials in contemporary China. Panel B presents IV estimates, based on equation (2), which provides the causal impact of historical *jinshi* density on the number of top officials in contemporary China.

**Table 14: OLS Estimates of the Effects of Historical Jinshi Density on Local Information Access in Late Qing (Channel Analysis)**

| Dependent Variable: | Access to Telegraph | Access to Railway |
|---|---|---|
| | (1) | (2) |
| log(jinshi density) | 0.334*** | 0.081 |
| | (0.090) | (0.088) |
| Mean of Dep. Var. | 0.548 | 0.054 |
| Baseline Control | ✓ | ✓ |
| Prov FE | ✓ | ✓ |
| Observations | 93 | 93 |

Notes. The unit of observation is a prefecture city. The number of observations in this table is lower than that in other tables due to data limitations. Two dependent variables indicate whether the prefecture had access to telegraph services in 1904. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See the summary statistics notes for variable definitions. The table reports OLS estimates based on equation (1), which shows the association between historical jinshi density and information access in the late Qing dynasty.

**Table 15: OLS and 2SLS Estimates of the Effects of Historical Jinshi Density on the Number of Top Universities in Contemporary China (Channel Analysis)**

| Dependent Variable: | Number of Top 100 Universities | Number of 211 Project Universities | Number of 985 Project Universities |
|---|---|---|---|
| | (1) | (2) | (3) |
| | Panel A: OLS Estimates | | |
| log(jinshi density) | 0.326*** | 0.225*** | 0.172*** |
| | (0.052) | (0.056) | (0.039) |
| | Panel B: IV Estimates | | |
| log(jinshi density) | 0.454*** | 0.292*** | 0.231*** |
| | (0.072) | (0.064) | (0.043) |
| | Panel C: Reduced Form | | |
| Log(river dist to bamboo/pine) | -0.041*** | -0.026*** | -0.021*** |
| | (0.008) | (0.006) | (0.004) |
| Baseline Control | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. Three dependent variables measure the number of top contemporary universities in prefectures and are logged. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See the summary statistics notes for variable definitions. Panel A reports OLS estimates based on equation (1), which shows the association between historical jinshi density and the number of top universities in contemporary China. Panel B presents IV estimates based on equation (2), which provide the causal impact of historical jinshi density on the number of top universities in contemporary China. Panel C presents the reduced-form results, estimating the effect of the instrumental variable—average river distance to each prefecture's nearest pine and bamboo habitats—on contemporary top universities.

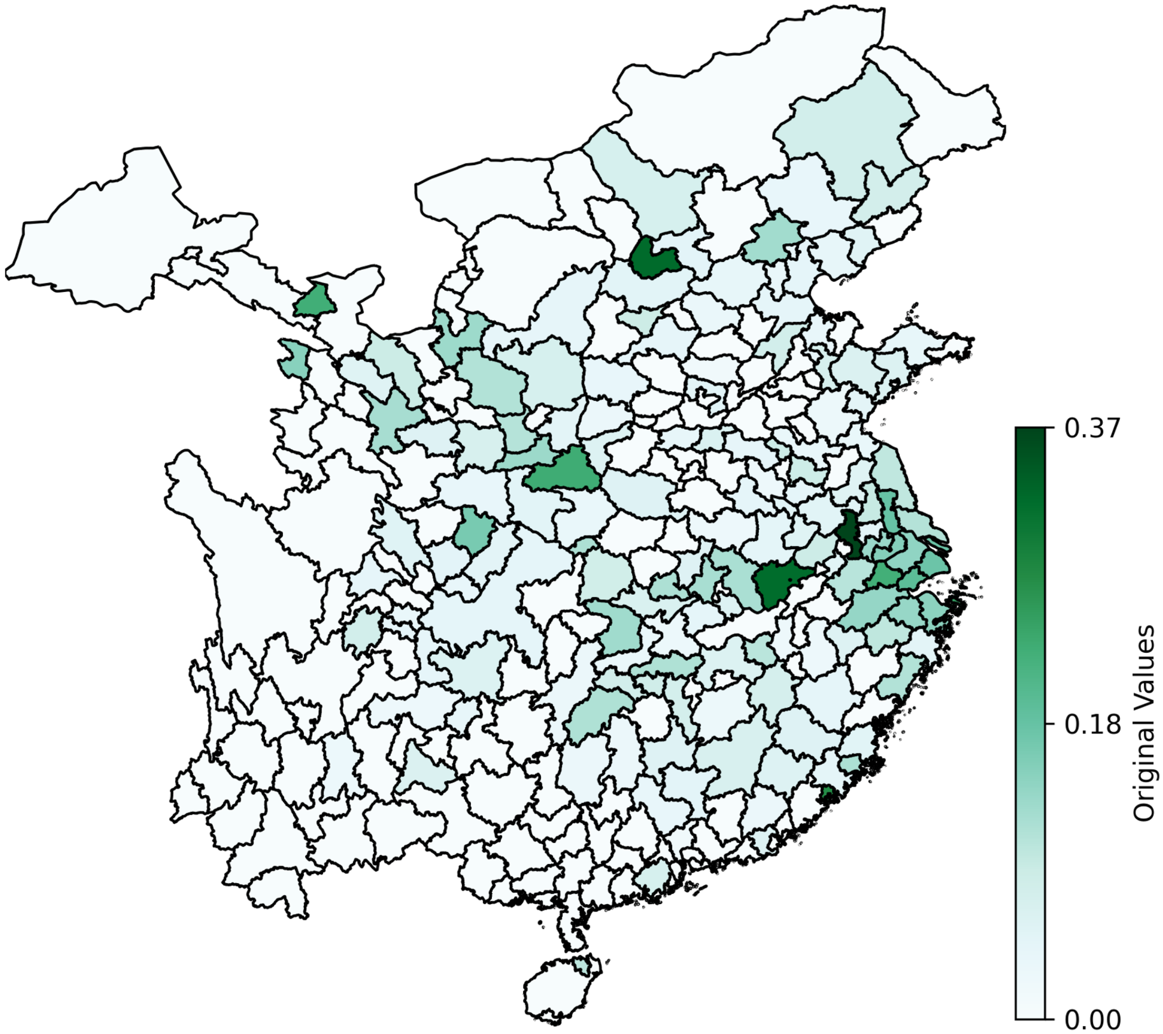
**Table 16: OLS and 2SLS Estimates of the Effects of Historical Jinshi Density on the Number of Top Students (Channel Analysis)**

| Dependent Variable: | Number of Students in Japan | Number of Students in Tsinghua University |
|---|---|---|
| | (1) | (2) |
| | Panel A: OLS Estimates | |
| log(jinshi density) | 0.143* | 0.240** |
| | (0.075) | (0.113) |
| | Panel B: IV Estimates | |
| log(jinshi density) | 0.112 | 0.125 |
| | (0.149) | (0.220) |
| | Panel C: Reduced Form | |
| Log(river dist to bamboo/pine) | -0.009 | -0.011 |
| | (0.015) | (0.022) |
| Baseline Control | ✓ | ✓ |
| Prov FE | ✓ | ✓ |
| Observations | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 |

Notes. The unit of observation is a prefecture city. Two dependent variables measure the number of top students in prefectures and are logged. The dependent variable in column (1) is the number of students who studied in Japan from 1902 to 1909, while the dependent variable in column (2) is the number of Tsinghua University students from 1927 to 1949. Robust standard errors, clustered at the provincial level, are reported in parentheses. Statistical significance is denoted by ***, **, and *, corresponding to the 1%, 5%, and 10% levels, respectively. Each regression includes province fixed effects and controls for distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. See the summary statistics notes for variable definitions. Panel A reports OLS estimates based on equation (1), which shows the association between historical jinshi density and the number of top students. Panel B presents IV estimates based on equation (2), which provide the causal impact of historical jinshi density on the number of top students. Panel C presents the reduced-form results, estimating the effect of the instrumental variable—average river distance to each prefecture's nearest pine and bamboo habitats—on top students.

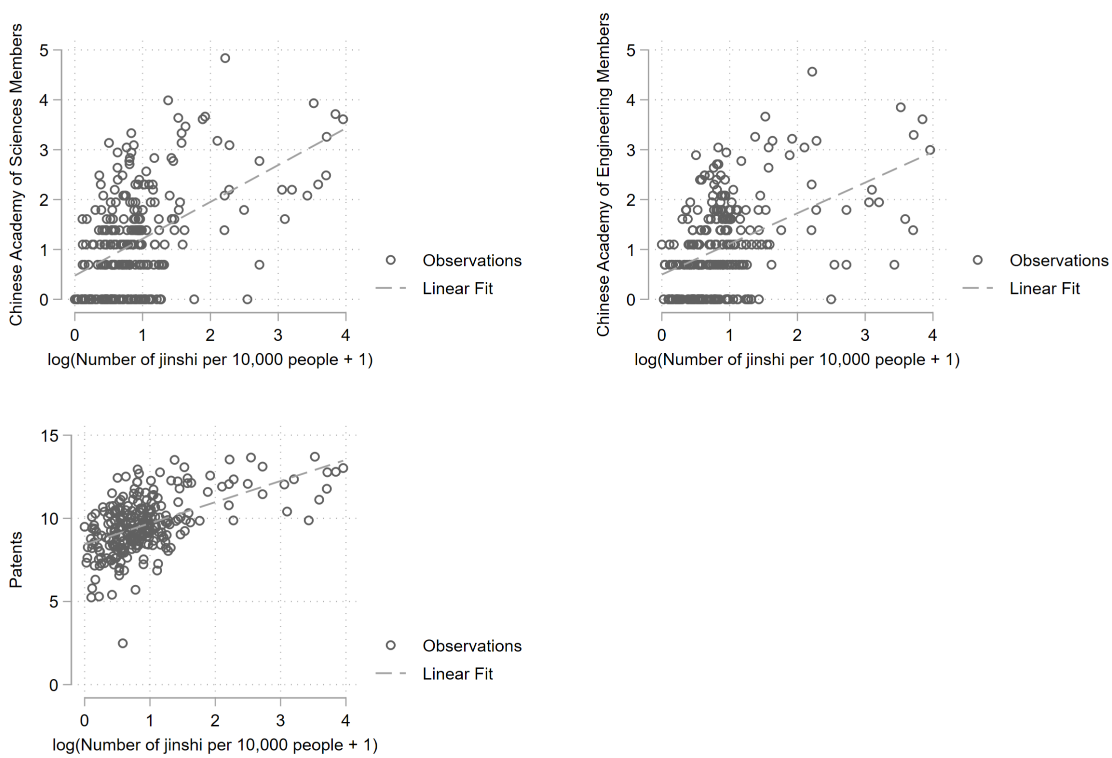
# Figures

**Figure 1:** Per Capita Number of Members in the Chinese Academy of Sciences



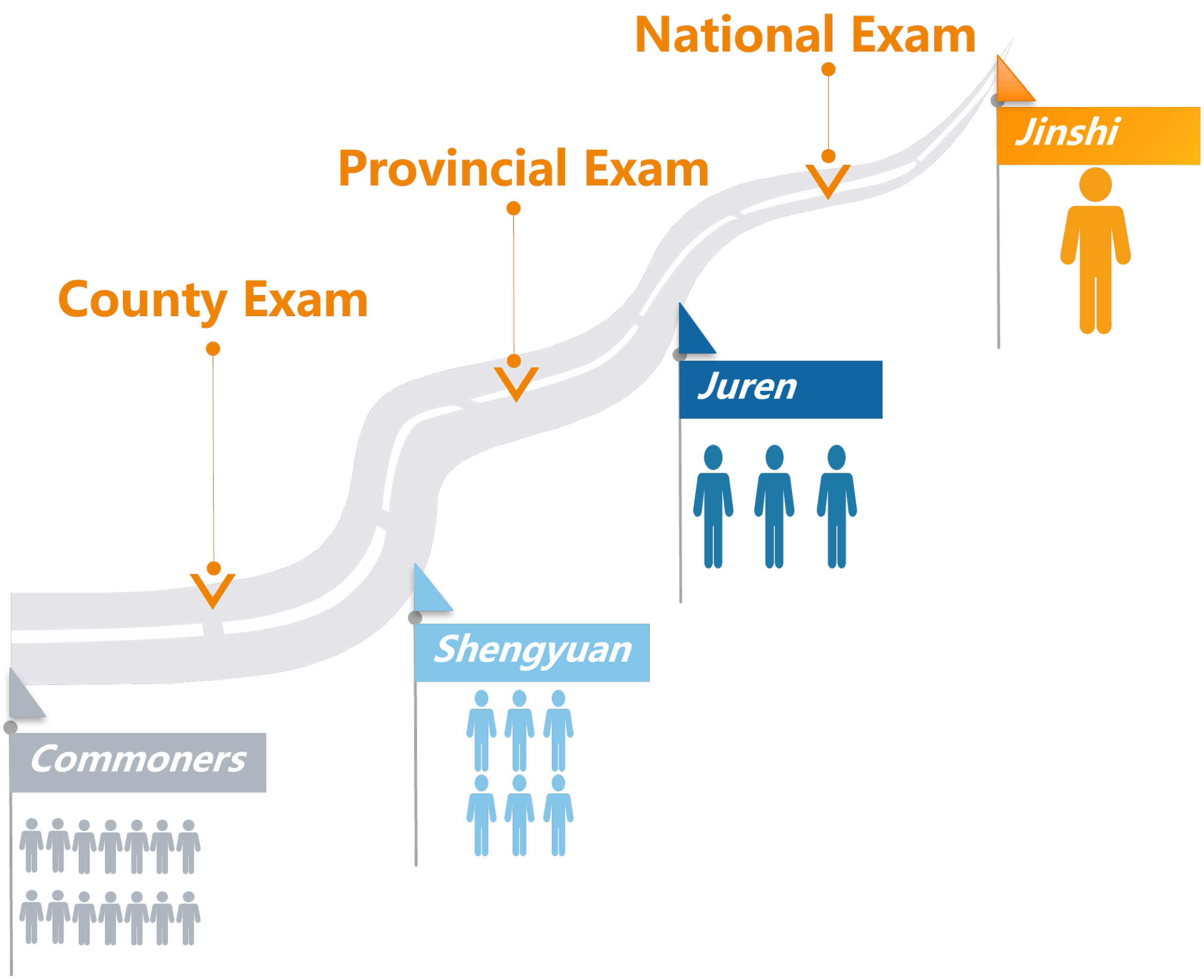

Notes. This map displays the uneven distribution of members per 100,000 in the Chinese Academy of Sciences. Regions with greener colors indicate a higher number of members from those areas.

**Figure 2:** *Jinshi* density (1371-1905) and contemporary innovation measures




Notes. This figure presents the raw observations of 272 prefectures. The x-axes are consistent across the four subfigures and represent the logarithm of the number of jinshi per 10,000 plus 1 from 1371 to 1905. The y-axes represent different metrics for local innovation levels. "Chinese Academy of Sciences Members" indicates the logarithm of the number of members in the Chinese Academy of Sciences plus 1. "Chinese Academy of Engineering Members" represents the logarithm of the number of members in the Chinese Academy of Engineering plus 1. "Patents" signifies the logarithm of the number of patents. Each circle represents one prefecture with its corresponding historical number of jinshi and contemporary innovation level. Each dashed line represents a linear fit to the circles in the same subfigure.

**Figure 3:** *Keju* Path




Notes. This figure illustrates a typical path for an individual taking the *keju exam*. It depicts a road connecting different titles: "*Commoners*," "*Shengyuan*," "*Juren*," and "*Jinshi*." Along the road, there are three barriers: "County Exam," "Provincial Exam," and "National Exam." Commoners can attain a title after successfully passing each barrier.

# Appendix A.

**Table A1: Exclusion Restriction**

| | Commercial Centers in Ming-Qing | Tea Centers in Ming-Qing | Silk Centers in Ming-Qing | Population Density in Ming | Population Density in Qing | Population Density in 1953 | Urbanization Rate in Ming-Qing | Urbanization Rate in 1920 |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| log(river dist to pine/bamboo) | -0.006 | -0.007 | -0.008 | 0.006 | -0.020 | -0.021 | -0.001 | -0.022 |
| | (0.005) | (0.005) | (0.007) | (0.045) | (0.019) | (0.017) | (0.001) | (0.024) |
| Observations | 272 | 272 | 272 | 272 | 272 | 267 | 272 | 272 |
| | Suitability (Rice) | Suitability (Wheat) | Suitability (Economic Crops) | Suitability (Maize) | Suitability (Sweet Potato) | Terrain Ruggedness | Droughts | Floods |
| | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| log(river dist to pine/bamboo) | -0.335 | -0.102 | -0.017 | -0.117 | 0.004 | 0.003 | -0.001 | -0.001 |
| | (0.217) | (0.134) | (0.041) | (0.097) | (0.064) | (0.002) | (0.001) | (0.001) |
| Observations | 272 | 272 | 272 | 272 | 272 | 272 | 272 | 272 |
| | Distance to Commercial Centers in Ming-Qing (logged) | Distance to Silk Centers in Ming-Qing (logged) | Distance to Tea Centers in Ming-Qing (logged) | Distance to Large Cities 1920 (logged) | Distance to National Capital (logged) | Distance to Provincial Capital (logged) | | |
| | (17) | (18) | (19) | (20) | (21) | (22) | | |
| log(river dist to pine/bamboo) | 0.094 | 0.110 | 0.093 | 0.028 | 0.002 | 0.021 | | |
| | (0.057) | (0.086) | (0.066) | (0.018) | (0.003) | (0.015) | | |
| Observations | 272 | 272 | 272 | 272 | 272 | 272 | | |

Notes. All results are OLS estimates. Robust standard errors, adjusted for clustering at the province level, are presented in parentheses. Statistical significance levels are denoted by ***, **, and *, indicating significance at the 1%, 5%, and 10% levels, respectively.

**Table A2: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on the Number of Patents per 100,000 in Different Types (Heterogeneous Effects)**

| Dependent Variable: | Invention per 100,000 | Utility Model Patent per 100,000 | Design Patent per 100,000 |
|---|---|---|---|
| | (1) | (2) | (3) |
| | | Panel A: OLS Estimates | |
| log(*jinshi* density) | 1.025*** | 0.748*** | 0.502*** |
| | (0.151) | (0.126) | (0.097) |
| | | Panel B: IV Estimates | |
| log(*jinshi* density) | 1.349*** | 0.992*** | 0.771*** |
| | (0.177) | (0.114) | (0.094) |
| Baseline Control | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 |

Notes. An observation is a prefecture city. All dependent variables are logged. Control variables consist of distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. Robust standard errors, adjusted for clustering at the province level, are presented in parentheses. Statistical significance levels are denoted by ***, **, and *, indicating significance at the 1%, 5%, and 10% levels, respectively.

**Table A3: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on the Number of Chinese Academy of Engineering Members per 100,000 over periods (Heterogeneous Effects)**

| | The Number of Chinese Academy of Science Members per 100,000 born: | | | |
|---|---|---|---|---|
| Dependent Variable: | between 1912 and 1936 | between 1937 and 1948 | between 1949 and 1960 | between 1961 and 1979 |
| | (1) | (2) | (3) | (4) |
| | Panel A: OLS Estimates | | | |
| log(jinshi density) | 0.198*** | 0.061** | 0.046*** | 0.007 |
| | (0.048) | (0.022) | (0.014) | (0.006) |
| | Panel B: IV Estimates | | | |
| log(jinshi density) | 0.220*** | 0.067* | 0.034 | 0.017** |
| | (0.085) | (0.039) | (0.022) | (0.008) |
| Baseline Control | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. An observation is a prefecture city. All dependent variables are logged. Panel A reports OLS estimates and Panel B reports 2SLS estimates. Control variables consist of distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. Robust standard errors, adjusted for clustering at the province level, are presented in parentheses. Statistical significance levels are denoted by ***, **, and *, indicating significance at the 1%, 5%, and 10% levels, respectively.

**Table A4: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on the Number of Chinese Academy of Engineering Members per 100,000 over periods (Heterogeneous Effects)**

| | The Number of Chinese Academy of Engineering Members per 100,000 born: | | | |
|---|---|---|---|---|
| Dependent Variable: | between 1912 and 1936 | between 1937 and 1948 | between 1949 and 1960 | between 1961 and 1979 |
| | (1) | (2) | (3) | (4) |
| Panel A: OLS Estimates | | | | |
| log(jinshi density) | 0.150*** | 0.060* | 0.004 | 0.017** |
| | (0.044) | (0.030) | (0.012) | (0.007) |
| Panel B: IV Estimates | | | | |
| log(jinshi density) | 0.160* | 0.063 | 0.017 | 0.033*** |
| | (0.088) | (0.053) | (0.023) | (0.009) |
| Baseline Control | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. An observation is a prefecture city. All dependent variables are logged. Panel A reports OLS estimates and Panel B reports 2SLS estimates. Control variables consist of distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. Robust standard errors, adjusted for clustering at the province level, are presented in parentheses. Statistical significance levels are denoted by ***, **, and *, indicating significance at the 1%, 5%, and 10% levels, respectively.

**Table A5: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on the Number of China Writers Association Members per 100,000 over periods (Heterogeneous Effects)**

| | The Number of Chinese Academy of Science Members per 100,000 born: | | | | |
|---|---|---|---|---|---|
| Dependent Variable: | between 1912 and 1936 | between 1937 and 1948 | between 1949 and 1960 | between 1961 and 1979 | after 1979 |
| (6) | (1) | (2) | (3) | (4) | (5) |
| | | | Panel A: OLS Estimates | | |
| log(jinshi density) | 0.186** | 0.122*** | 0.126*** | 0.013 | 0.002 |
| | (0.069) | (0.044) | (0.025) | (0.018) | (0.007) |
| | | | Panel B: IV Estimates | | |
| log(jinshi density) | 0.209 | 0.101 | 0.177*** | 0.045* | 0.008 |
| | (0.151) | (0.067) | (0.045) | (0.024) | (0.013) |
| Baseline Control | ✓ | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. An observation is a prefecture city. All dependent variables are logged. Panel A reports OLS estimates and Panel B reports 2SLS estimates. Control variables consist of distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. Robust standard errors, adjusted for clustering at the province level, are presented in parentheses. Statistical significance levels are denoted by ***, **, and *, indicating significance at the 1%, 5%, and 10% levels, respectively.

**Table A6: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on the Number of Chinese Academy of Science Members per 100,000 across Research Fields (Heterogeneous Effects)**

| | The Number of Chinese Academy of Science Members per 100,000 Work in: | | | | | |
|---|---|---|---|---|---|---|
| Dependent Variable: | Information Technical Sciences | Chemistry | Life Sciences and Medical Sciences | Earth Sciences | Technological Sciences | Mathematics and Physics |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | Panel A: OLS Estimates | | | |
| log(jinshi density) | 0.004** | 0.003 | 0.004 | 0.009** | 0.006*** | 0.009*** |
| | (0.002) | (0.003) | (0.004) | (0.004) | (0.002) | (0.002) |
| | | | Panel B: IV Estimates | | | |
| log(jinshi density) | 0.003 | 0.001 | 0.007 | 0.008 | 0.011*** | 0.012*** |
| | (0.003) | (0.003) | (0.007) | (0.006) | (0.004) | (0.004) |
| Baseline Control | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. An observation is a prefecture city. All dependent variables are logged. Panel A reports OLS estimates and Panel B reports 2SLS estimates. Control variables consist of distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. Robust standard errors, adjusted for clustering at the province level, are presented in parentheses. Statistical significance levels are denoted by ***, **, and *, indicating significance at the 1%, 5%, and 10% levels, respectively.

**Table A7: OLS and 2SLS Estimates of the Effects of Historical Jishi Density on the Number of Chinese Academy of Engineering Members per 100,000 across Research Fields (Heterogeneous Effects)**

| | The Number of Chinese Academy of Science Members per 100,000 Work in: | | | | | |
|---|---|---|---|---|---|---|
| Dependent Variable: | Energy and Mining Engineering | Light Industry and Environmental Engineering | Medicine and Health Engineering | Civil and Hydraulic Engineering | Agriculture | Mechanical and Vehicle Engineering |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | Panel A: OLS Estimates | | | |
| log(jinshi density) | 0.004 | -0.000 | 0.005 | 0.004 | 0.003** | 0.009*** |
| | (0.003) | (0.001) | (0.004) | (0.003) | (0.001) | (0.003) |
| | | | Panel B: IV Estimates | | | |
| log(jinshi density) | 0.007 | 0.000 | 0.007 | 0.006** | 0.006** | 0.007 |
| | (0.008) | (0.003) | (0.006) | (0.003) | (0.003) | (0.005) |
| Dependent Variable: | Chemical, Metallurgical, and Material Engineering | Engineering Management | Information and Electronic Engineering | | | |
| | (7) | (8) | (9) | | | |
| | | | Panel A: OLS Estimates | | | |
| log(jinshi density) | 0.0037 | 0.0029* | 0.0031* | | | |
| | (0.0028) | (0.0016) | (0.0015) | | | |
| | | | Panel B: IV Estimates | | | |
| log(jinshi density) | 0.009** | 0.005** | 0.003 | | | |
| | (0.004) | (0.002) | (0.004) | | | |
| Baseline Control | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Prov FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Observations | 272 | 272 | 272 | 272 | 272 | 272 |
| Kleibergen-Paap rk Wald F statistic | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 | 63.264 |

Notes. An observation is a prefecture city. All dependent variables are logged. Panel A reports OLS estimates and Panel B reports 2SLS estimates. Control variables consist of distance to the coast, terrain ruggedness, agricultural suitability, the logarithm of Ming-Qing population density, Ming-Qing urbanization rates, and the logarithm of the shortest distance to major navigable rivers. Robust standard errors, adjusted for clustering at the province level, are presented in parentheses. Statistical significance levels are denoted by ***, **, and *, indicating significance at the 1%, 5%, and 10% levels, respectively.