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 sustaining the long-term effects of China's civil exams.

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1 Introduction

Innovation has long been recognized as a crucial driver of economic growth, with its significance dating back to 1776 (Smith, 1776). Building on this foundation, Solow (1957) and Romer (1990) incorporate innovation into their growth models, underscoring its pivotal role in advancing economies. In recognition of this, the Chinese government has made substantial investments in innovation, allocating over three trillion dollars toward scientific research and education in the past 20 years (Bureau, Science and Commission (2023)). Despite these efforts, innovation remains unevenly distributed across China's prefectures, as illustrated in Figure 1.[1]

Historical institutions can have lasting effects, and China, with its extensive history, has institutions that likely played a significant role in shaping its development. One such institution is the imperial civil examination system, commonly known as the *keju*. The *keju* exam was designed to recruit the most academically talented individuals to serve in government positions, focusing primarily on candidates' knowledge of Confucian classics. The highest scorers on the national exam, known as *jinshi*, were appointed as government officials. However, the exam's content, which centered on The Four Books and The Five Classics[2], had little relevance to mathematics or scientific subjects. Furthermore, the rigid format of the exam, known as the eight-legged essay[3], imposed significant constraints on creative expression. Due to these limitations, many scholars argue that *keju* culture hindered scientific and technological advancement (Lin, 1995; Wang, 1991). Consequently, it remains unclear whether the *keju* culture continues to pose barriers to scientific progress today or

[1]The map 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]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.

[3]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).

whether it may have had a positive influence on contemporary innovation.

In this paper, I utilize prefecture-level data on the number of *jinshi* per 10,000 people (*jinshi* density) from 1371 to 1905 (Ming-Qing dynasty), as sourced from Chen, Kung and Ma (2020).[4] This historical data is then paired with contemporary measures of innovation, including the number of Chinese Academy of Sciences members, Chinese Academy of Engineering members, and both the quantity and quality of patents. Patent data across prefectures provides a direct reflection of local innovation capabilities. In addition, data on the distribution of highly innovative individuals in science and engineering offer further insights. A key advantage of these alternative datasets over patent data is their ability to identify the birthplaces of the most innovative individuals, providing a more accurate reflection of the origin of innovation within a region. In contrast, patent data may include applications from both local residents and migrants, meaning it 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 more advanced prefectures produced more *jinshi* and 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.

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

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

link, I employ the average river distances to each prefecture's nearest pine and bamboo habitats as an instrumental variable, based on the work of Chen, Kung and Ma (2020). This approach hinges on the importance of books for *keju* exam preparation, the role of pine and bamboo in woodblock printing, and the reliance on water transport. A shorter river distance implies better access to books, which likely improved *keju* exam outcomes. The instrument variable satisfy two conditions. At first, the geographic distribution of pine and bamboo habitats were determined exogenously. Second, the instrument 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-Qing dynasty contributed to improved contemporary innovation outcomes, observable 40 to 100 years after the abolition of the *keju* system in 1905.

It is important to understand how *keju* culture may have influenced innovation, persisted through China's political transformations, and remains relevant today.[6] In this study, I investigate whether regions with higher historical *jinshi* density are associated with greater military investment during the late Qing dynasty, a larger number of contemporary officials with significant authority, and improved access to information during that period. Additionally, I assess whether these regions had a higher concentration of top-performing students in the late Qing dynasty and a greater number of leading contemporary universities. Drawing on Bo, Liu and Zhou (2023), which highlights how military investments during the

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

[6]Historically, China employed the *keju* examination system to assess candidates, focusing primarily on their knowledge of Confucian classics rather than scientific or technical expertise. This system represented a conservative cultural orientation that prioritized societal stability over innovation, reinforcing traditional values rather than fostering creativity or scientific progress.

Self-Strengthening Movement led to the emergence of private firms and enhanced human capital in the 1930s, I test whether a stronger *keju* culture is linked to higher military investment during this period. Both historical evidence and empirical analysis support this hypothesis. Officials with significant authority within their departments play a crucial role in shaping policy outcomes, particularly in fostering innovation.[7] Access to information is another critical factor, as regions with better access may have been more exposed to Western technology, thereby promoting innovation. To investigate this, I assess whether higher *jinshi* density correlates with improved access to key infrastructure developments in the late Qing Dynasty, such as telegraph and railway systems. The findings reveal that areas with higher *jinshi* density had better access to telegraph infrastructure, although no significant relationship was found with railways. Moreover, the presence of top students is essential for innovation, and I use the number of students studying in Japan and enrolling at Tsinghua University as indicators. However, the results show no statistically significant impact of *keju* culture on the number of overseas students in Japan or Tsinghua students, suggesting that *keju* culture had a limited role in this context.

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." This suggests a potential link between contemporary education and innovation, as higher education is often associated with increased innovation. However, the influence of culture on innovation remains unclear. Li and Wang (2022) presents contrasting findings, showing that regions with a higher historical concentration of *Jinshi* are less likely to foster small business entrepreneurship.[8] My paper contributes to this debate

[7]For example, when individuals from a particular prefecture hold influential positions in key government departments, such as the Ministry of Education, there may be a tendency towards "hometown favoritism," where resources and investments are directed towards their hometowns. This dynamic can be particularly relevant in educational investment, where an official's influence might result in greater resources being allocated to their home region.

[8]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.

by providing direct evidence on whether the number of *Jinshi* per 10,000 can influence innovation. Additionally, I propose and test several other channels, which can be regarded as supplements to Chen, Kung and Ma (2020).

My study contributes to three strands of literature. The first examines the factors impacting innovation. Previous research suggests that fundamental infrastructure, such as road construction (Agrawal, Galasso and Oettl, 2017), city layout (Roche, 2020), and subway expansion (Koh, Li and Xu, 2022) can affect innovation. 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). My paper examines historical Chinese civil exams and these institutions long-run effects on contemporary innovation. Regarding the *keju* exam, researchers find that more revolutions (Bai and Jia, 2016) and better financial development (Lin et al., 2021) emerged after the abolition of the *keju* in 1905. My paper contributes to this literature by offering new insights into the potential influence of *keju* culture. The third contribution of my paper is providing evidence on the factors that influence successful scientists and innovators in China. Previous studies primarily focus on the United States (Airoldi, Labs and Moser, 2024; Bell et al., 2018,0). My paper extends this body of research by examining innovation within a developing country, specifically China, which plays a crucial role as one of the world's leading developing nations.

In the next section, I provide historical background on the *keju* Exam during the Ming and Qing dynasties. Sections 3 and 4 describe my data and identification strategy. In Section 5, I report my baseline estimates. Section 6 explores the heterogeneous effects over decades and subjects. In Section 7, I examine the channels. Section 8 concludes.

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. A large segment 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 the best at this stage could be awarded the prestigious title of *jinshi*, opening the doors to high-ranking official positions and significant influence in the imperial bureaucracy.

The exam is 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 and *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. The graders could not recognize the examinee's handwriting since the test papers would be transcribed by someone else to ensure anonymity. There were eight examiners, and the entire process was conducted under strict supervision. Any attempt at corruption was met with severe punishment, including the possibility of a 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. 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. 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, but the opportunities for advancement were vast. 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.

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, likely to exert 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 the 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), 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 provide essential consultation for national decision-making, with the aim of being innovation-driven and 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.[9] 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 is 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.[10] 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.

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 interest in Western technology among the populace. Consequently, I am investigating whether regions with a higher density of *jinshi* scholars played a more significant role in this movement. Data on military factories established during the Self-Strengthening Movement is sourced from Fan (2003), which

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

[10] 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.

provides detailed information on the location and investment for each military factory.

Top officials often hold significant authority in resource allocation and can exert considerable influence at the national level. To explore this, I utilize data from the Chinese Political Elite Database (CPED). This 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.

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 measure access to information based on whether a prefecture was connected to the telegraph or railway in the late Qing dynasty. The data for this analysis 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.

Modern universities are expected to play a significant role in sustaining local innovation. To support this analysis, I enumerate the number of high-quality universities in each prefecture. I employ three different measures: 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 data for the top 100 universities is sourced from the Shanghai Ranking. 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.

Top students are likely to play a pivotal role in becoming leading scientists and promoting innovation. Therefore, I use different sources to measure top students in different periods. 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*.[11]

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, while the urbanization rate represents the average share 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 science and technology, both of which can influence contemporary innovation.

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

Terrain ruggedness may affect the frequency of natural disasters, potentially shaping people's understanding of nature and extending to 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 more 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 must make to interpret the correlation as causal effects is that the *jinshi* density must be 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; $jinshi_i$ means the number of *jinshi* per 10,000 people from 1371 to 1905; X_i are 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; μ_p represents province fixed effects; and ϵ_i is the error term. β is the coefficient of interest and it represents the estimated correlation between Ming-Qing *jinshi* density and contemporary local innovation level.

4.2 IV Approach

Given that the *jinshi* density in each prefecture cannot be regarded as 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, were 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. 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 in the exams.

For the instrumental variable to be valid, two key conditions must hold. First, the distribution of pine and bamboo habitats must be exogenous to the locations in question. 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 is used to see 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 I can utilize $RiverDistance_i$ 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 μ_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. ϵ_i^1 and ϵ_i^2 are error terms. The key coefficient is β_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 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. Therefore, I aim to 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 statistically significant. This implies that prefectures farther from pine and bamboo habitats historically had lower *jinshi* densities, which aligns with the rationale behind the instrumental variable. Additionally, the Kleibergen-Paap Wald F statistic is 63.264, well above the Stock-Yogo weak identification test 10

With historical *jinshi* density instrumented by the IV, I present the 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 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, and suggest 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 show 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 is causing 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 such 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 at the top end.

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, while others may be less influenced. 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 at first, and then show the results about scienctist.

As introduced in the Data section, there are three types of patents: invention patents, utility model patents, and design patents. Inventions 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, with the least influence on 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, with 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 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, 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, or 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 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 has persistent influence on the number of members of the Chinese Academy of Sciences born after 1912, though it is suggestive that the influence is fading over periods. Similarly, I did the analysis for the members of Chinese Academy of Engeneering members. In Table 9, I observe the estimates on column (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 on the other three columns are not significant, they are positive and I cannot reject that they are the same as the estimates on columns (2) and (5). I also consider that whether the major history events may influence per capita number of scientists and engineerings, 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, while the increase in railway access is 8%. 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 similarly significant role.

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 an innovative mindset 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 Top School Students

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 those enrolled at Tsinghua University as proxies. Subsequently, I assess whether regions influenced more 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 and 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.

References

Acemoglu, Daron, Simon Johnson, and James A. Robinson. 2001. "The Colonial Origins of Comparative Development: An Empirical Investigation." *American Economic Review*, 91(5): 1369–1401.

Agrawal, Ajay, Alberto Galasso, and Alexander Oettl. 2017. "Roads and Innovation." *The Review of Economics and Statistics*, 99(3): 417–434.

Airoldi, Edoardo M., Bruna Labs, and Petr Moser. 2024. "Inequality in Science: Who Becomes a Star."

Bairoch, P. 1988. *Cities and Economic Development: From the Dawn of History to the Present.* University of Chicago Press.

Bai, Ying, and Ruixue Jia. 2016. "Elite recruitment and political stability: the impact of the abolition of China's civil service exam." *Econometrica*, 84(2): 677–733.

Baskaran, Thushyanthan, and Mariana Lopes da Fonseca. 2021. "Appointed public officials and local favoritism: Evidence from the German states." *Journal of Urban Economics*, 124. Cited by: 14; All Open Access, Green Open Access.

Bell, Alex, Raj Chetty, Xavier Jaravel, Neviana Petkova, and John Van Reenen. 2018. "Who Becomes an Inventor in America? The Importance of Exposure to Innovation*." *The Quarterly Journal of Economics*, 134(2): 647–713.

Bell, Alex, Raj Chetty, Xavier Jaravel, Neviana Petkova, and John Van Reenen. 2019. "Joseph Schumpeter Lecture, EEA Annual Congress 2017: Do Tax Cuts Produce more Einsteins? The Impacts of Financial Incentives VerSus Exposure to Innovation on the Supply of Inventors." *Journal of the European Economic Association*, 17(3): 651–677.

Bo, Shiyu, Cong Liu, and Yan Zhou. 2023. "Military investment and the rise of industrial clusters: Evidence from China's self-strengthening movement." *Journal of Development Economics*, 161: 103015.

Bureau, State Statistical, State Science, and Technology Commission, ed. 2023. *China Statistical Yearbook on Science and Technology.* China Statistics Press. Colophon title also in pinyin: Zhongguo keji tongji nianjian. Chiefly tables. Table of contents also in English; In Chinese and English.

Cao, Shuju. 2000. *Zhongguo renkoushi, diwujuan (History of Population in China, Volume 5).* Shanghai: Fudan University Press.

Cao, Shuju. 2015. *Zhongguo renkoushi, Mingshiqi (History of Population in China, the Ming Period).* Manuscript.

Chang, C. 1962. *The Income of the Chinese Gentry. Far Eastern and Russian Institute* *publications on Asia*, University of Washington Press.

Chen, Ting, James Kai-sing Kung, and Chicheng Ma. 2020. "Long Live Keju! The Persistent Effects of China's Civil Examination System." *The Economic Journal*, 130(631): 2030–2064.

Chen, Yongmin, and Thitima Puttitanun. 2005. "Intellectual property rights and innovation in developing countries." *Journal of Development Economics*, 78(2): 474–493.

Dell, Melissa. 2010. "The Persistent Effects of Peru's Mining Mita." *Econometrica*, 78(6): 1863–1903.

Do, Quoc-Anh, Kieu-Trang Nguyen, and Anh N. Tran. 2017. "One Mandarin Benefits the Whole Clan: Hometown Favoritism in an Authoritarian Regime." *American Economic Journal: Applied Economics*, 9(4): 1–29.

Elman, Benjamin A. 2009. "Eight-Legged Essay." In *Berkshire Encyclopedia of China.* , ed. Linsun Cheng, 695–989. Berkshire Publishing Group.

Elvin, M. 2004. *The Retreat of the Elephants: An Environmental History of China.* Yale University Press.

Fairbank Center for Chinese Studies of Harvard University, and Center for Historical Geographical Studies at Fudan University. 2016. "CHGIS, Version: 6." (c) Fairbank Center for Chinese Studies of Harvard University and the Center for Historical Geographical Studies at Fudan University.

Fan, B. 2003. *Qingji de Yangwu Xinzheng (the Self-Strengthening Movement in the Qing Dynasty).* , Shanghai Shudian Chubanshe.

Feldman, Maryann P., and David B. Audretsch. 1999. "Innovation in cities:: Science-based diversity, specialization and localized competition." *European Economic Review*, 43(2): 409–429.

Galor, Oded, and Ömer Özak. 2016. "The Agricultural Origins of Time Preference." *American Economic Review*, 106(10): 3064–3103.

Gao, Pei, and Yu-Hsiang Lei. 2021. "Communication Infrastructure and Stabilizing Food Prices: Evidence from the Telegraph Network in China." *American Economic Journal: Applied Economics*, 13(3): 65–101.

Guiso, Luigi, Paola Sapienza, and Luigi Zingales. 2016. "Long-Term Persistence." *Journal of the European Economic Association*, 14(6): 1401–1436.

Koh, Yumi, Jing Li, and Jianhuan Xu. 2022. "Subway, Collaborative Matching, and Innovation." *The Review of Economics and Statistics*, 1–45.

Li, L. (Geng), and Z. Wang. 2022. "Understanding the Long-Term Effects of Keju: The Case of Entrepreneurship in China." *Economics of Transition & Institutional Change*, 30(4): 665–689.

Lin, Chen, Chicheng Ma, Yuchen Sun, and Yuchen Xu. 2021. "The allocation of talent and financial development, 1897 to 1936." *Available at SSRN 3861129.*

Lin, Justin Yifu. 1995. "The Needham Puzzle: Why the Industrial Revolution Did Not Originate in China." *Economic Development and Cultural Change*, 43(2): 269–292.

Ma, Chicheng. 2024. "Classicism and Modern Growth: The Shadow of the Sages." *The Journal of Economic History*, 84(2): 395–431.

Nunn, Nathan. 2008. "The Long-term Effects of Africa's Slave Trades*." *The Quarterly Journal of Economics*, 123(1): 139–176.

Qian, Mu. 2012. *Merits and Demerits of Political Systems in Dynastic China.* SDX Joint Publishing.

Roche, Maria P. 2020. "Taking Innovation to the Streets: Microgeography, Physical Structure, and Innovation." *The Review of Economics and Statistics*, 102(5): 912–928.

Romer, Paul M. 1990. "Endogenous Technological Change." *Journal of Political Economy*, 98(5): 71–102.

Shen, Yunlong, ed. 1978. *Qingmo Gesheng Guanfei Zifei Liurixuesheng Xingmingbiao(List of Names of Self-funded Students Studying in Japan by Province in the Late Qing Dynasty).* , Wenhai Chubanshe.

Smith, Adam. 1776. *The Wealth of Nations.* London:W. Strahan and T. Cadell.

Solow, Robert M. 1957. "Technical Change and the Aggregate Production Function." *The Review of Economics and Statistics*, 39(3): 312–320.

Su, Yun-Feng. 2004. *Tsinghua University Faculty and Student Directory Compilation, 1927-1949.* Taipei:Academia Sinica Institute of Modern History.

Wang, Kaifu. 1991. *Baguwen Gaishuo (An Overview of Eight-Legged Essay).* China Peace Publishing House.

Yin, H., and B. Chen. 2021. "Hometown Identity of Financial Officials, Financial Development and Promotion of Officials in China." *Australian Economic Papers*, 60(3): 520–543.

Zhang, X., and Q. Han. 2006. *Zhongguo Yinshua Shi (Chinese Printing History).* Hangzhou: Zhejiang Gu Ji Chu Ban She.

Zhu, Baojiong, and Peilin Xie. 1980. *Ming-Qing jinshi timing beilu suoyin (Official Directory of Ming-Qing Imperial Exam Graduates).* Shanghai: Shanghai guji chubanshe.

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

Dependent Variable:	The Number of Chinese Academy of Science Members born:				
	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.

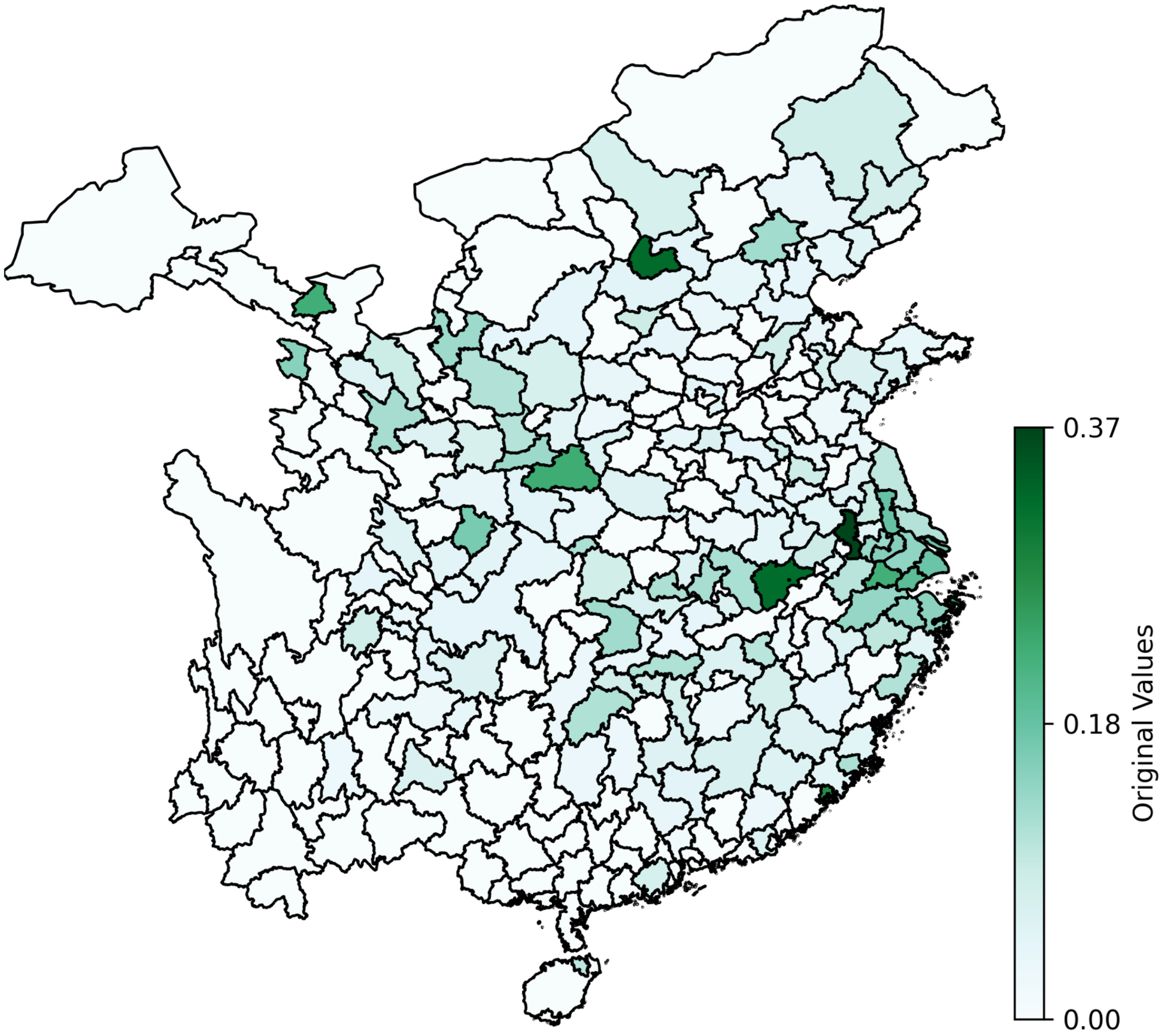
Table 16: OLS and 2SLS Estimates of the Effects of Historical Jinshi Density on the Number of Top Students (Channel Analysis)

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.

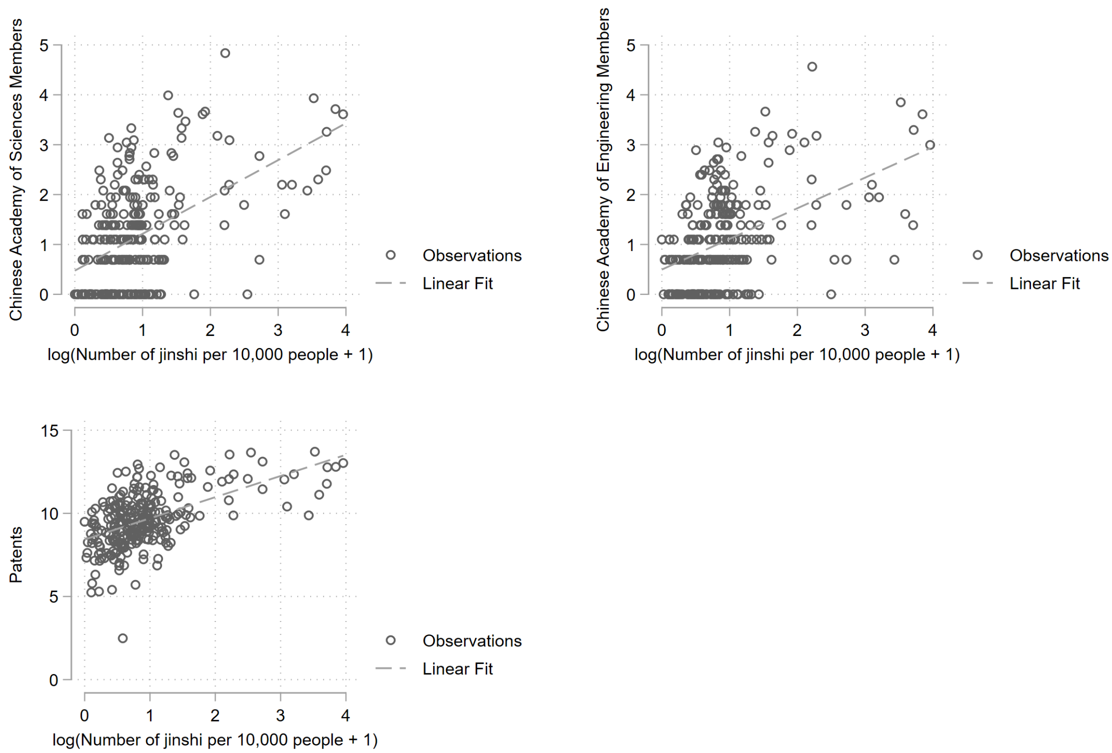
Figures

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



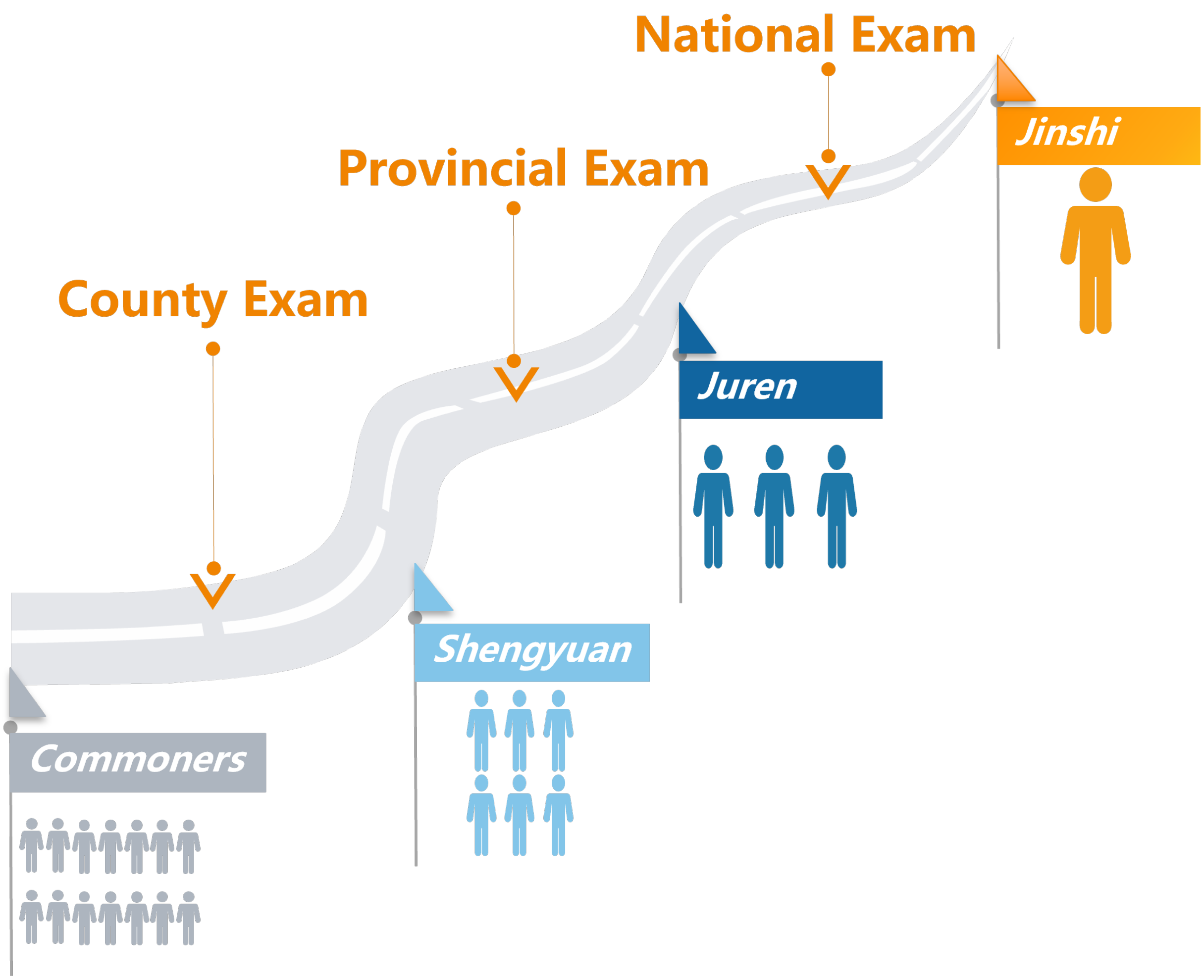
Notes. This map displays the uneven distribution of members per 100,000 in the Chinese Academy of Sciences. Regions with greener colors indicate a higher number of members from those areas.

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
	(1)	(2)	(3)	(4)	(5)
(6)					
			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.