Journal of Development Economics 141 (2019) 102382

Contents lists available at ScienceDirect

Journal of Development Economics

journal homepage: www.elsevier.com/locate/devec

Farewell to confucianism: The modernizing effect of dismantling China's imperial examination system☆

Ying Bai

Department of Economics, The Chinese University of Hong Kong, NT, Hong Kong

ARTICLE INFO

JEL Codes:
O10
N95
O31

Keywords:
Imperial civil examination
Incentive
Modern firms
Overseas study

ABSTRACT

This study uses 1899–1908 prefecture-level panel data to assess how the likelihood of passing the civil service examination affected modernization before and after the examination system's abolition. Because higher quotas were assigned to prefectures with an agricultural tax of over 150,000 piculs, we use a regression discontinuity design to generate an instrument that resolves potential endogeneity and ensures robust results. We find that following abolition, prefectures with higher quotas of successful candidates tended to establish more modern firms and send more students for overseas study in Japan. A subsequent analysis using an individual dataset further shows that the skill level of these overseas students increased after abolition, especially in regions with higher per capita quotas. This finding implies that the examination system led to substantial misallocation of talents.

1. Introduction

In 2015, 91 out of 156 countries worldwide recruited public sector employees via competitive examinations designed to attract the most talented and brightest candidates. In India, for example, an average 900,000 to 1,000,000 candidates apply every year, 500,000 of whom sit the preliminary examination in the hope of filling one of only about 1000 vacancies (Leado, 2017).[1] This merit-based examination, however, although it may help the government improve the quality of bureaucracy and enhance state capacity, may be costly to economic growth in the case that a great deal of talent is wasted studying for the exam (e.g., Baumol, 1990). One historical example of such talent misallocation is the civil service examination system used by Imperial China to select a large proportion of its ruling class of scholar bureaucrats. The hope of passing this examination and becoming a government official gave Chinese elites a major incentive to invest in a traditional education based on Confucian classics but little motivation to learn other forms of *useful knowledge* (Kuznets, 1965; Mokyr, 2002) such as Western science and technology. The civil examination thus constituted an institutional obstacle to the country's rise in modern science and industry (Baumol, 1990; Clark and Feenstra, 2003; Huff, 2003; Lin, 1995).

To assess the extent to which this examination system negatively affected China's modernization, this paper explores the impact of the system's 1904–1905 abolition. A major empirical challenge in doing so, however, is the abolition's universality, which engendered no regional variations in policy implementation. Hence, to better understand the abolition's modernizing effect, we use a simple conceptual framework that incorporates two choices open to Chinese elites: learn from the West and pursue modernization activities (i.e., study modern science and technology) or invest in preparing for the civil examination (i.e., study Confucian classics). In this model, elites with a greater chance of passing the examination are less likely to pursue (Western) modernization activities pre abolition but more likely to do so post abolition. Accordingly, the regions with a higher likelihood of passing the exami-

☆ I thank Sascha Becker, Zhiwu Chen, Philip Hoffman, Ruixue Jia, James Kung, Travis Ng, Nathan Nunn, Albert Park, Liugang Sheng, Xinzheng Shi, Carol Shiue, Tuan Hwee Sng, Zheng Song, Nico Voigtländer, Noam Yutchman, Junsen Zhang, and seminar participants at the Chinese University of Hong Kong, National University of Singapore, National University of Taiwan, Singapore Management University, Shanghai University of Finance and Economics, Tsinghua University, China Economic Summer Institute 2014, the XVIIth World Economic History Congress, the "Economic Growth and Development" workshop (at Nanyang Technological University), and the EEA Annual Congress 2016 for helpful comments and suggestions. All remaining errors are mine.

E-mail address: ybai@cuhk.edu.hk.

[1] The QoG Expert Survey Dataset (Dahlström et al., 2015), administered to about eight respondents in each country, includes one question on whether public sector employees in that county are hired via a formal examination system. If the average response value (measured from 1 "hardly ever" to 7 "almost always") is larger than or equal to 4, we define the country as using a formal examination system to recruit civil servants.

https://doi.org/10.1016/j.jdeveco.2019.102382
Received 16 November 2018; Received in revised form 14 August 2019; Accepted 29 August 2019
Available online 9 September 2019

nation should be those with a larger increase in post-abolition modernization activities, allowing us to use a difference-in-differences (DID) method to identify the abolition's causal impact.

To control the regional composition of successful candidates, the central government of the Qing Dynasty (1644–1911) designated a quota for each prefecture, meaning that individuals' chances of passing the examination - measured by the ratio of quotas to the population - varied greatly by region (Chang, 1955). We exploit this variation by relating it to the regional level of modernization activities, measured by (1) the number of newly established private firms (per million inhabitants) above a designated size that employ steam engine technology or electricity (as a proxy for Western technology use) and (2) the number of Chinese students (per million inhabitants) newly arrived in Japan, the most important host country for Chinese overseas study. Although the two measures might capture other characteristics, such as entrepreneurship or human capital accumulation, both activities are intensely linked to modern science and technology, and thus serve as effective proxies for modernization.

Our empirical results, based on an 1899–1908 panel dataset covering 262 prefectures, indicate that once the decision to abolish the examination system was made, prefectures with higher quotas per capita tended to establish more modern enterprises and send more students to Japan. Evaluated at the sample mean, each one standard deviation increases in the logged quotas per capita (0.70) led to another 0.23 newly established modern firms and another 0.66 students traveling to Japan for overseas study per year. These empirical results are robust to controlling for geographic factors, population, level of urbanization, and Western penetration, as well as to the use of different model specifications. By estimating the yearly correlation between the logged quotas per capita and the density of modernization activities from 1899 to 1908, we also show that the pre-abolition correlation remains stable until it suddenly increases following the abolition decision.

These observations raise the question of why abolishing the examination system contributed to the rise of modernization activities. One possibility is that it encouraged the existing stock of educated talent to pursue different avenues (e.g., go into business rather than study for the examination) or switch their educational investment (e.g., study modern science and technology instead of Confucian classics). Our results allow for both possibilities, with those for the establishment of modern firms pointing to the former and those for more Chinese studying overseas in Japan suggesting the latter. At the same time, however, if there existed an unobserved metric, such as the reallocation of physical capital between the two sectors, our methodology would not be able to distinguish it. Yet if physical capital reallocation were a major channel driving our results, we would expect the effects to be larger in richer regions. To test this prediction, we use the 1893 urbanization level as a proxy for economic prosperity and apply a triple quota effect of post-abolition and urbanization. Our finding of no significant heterogeneous effect implies that physical capital is not a constraint for talent reallocation, albeit without necessarily signaling that physical capital reallocation is unimportant.

Another concern is whether the change in the quota effect is driven by other policy changes or government behavior. For instance, if the government had launched reforms to help new business startups or provides financial support for modern education, any increase in the quota effect would be much larger in regions whose local government had more political power or economic resources. In fact, by using a provincial capital dummy and the number of government-owned firms as pertinent proxies, we show that these factors do not strengthen the quota effect, implying that the role of government cannot explain our main findings. One pattern reflected in all our results is the tendency of regions with more quotas to learn and adopt more modern knowledge post abolition, which raises the question of whether the quota effect is conditional on the availability of such knowledge. Because treaty ports and Protestant missionaries greatly helped the diffusion of useful knowledge in the late Qing, we examine whether such Western penetration strengthened the quota effect. The results indicate that the presence of Protestant missionaries significantly increased the quota effect on overseas study, mainly because missionary schools provided some modicum of preliminary modern education for the talented and hence facilitated their study abroad. Nonetheless, we find no increase in the quota effect on the establishment of modern firms, possibly because knowledge accessibility was not an important constraint on entrepreneurs.

We also recognize, however, that the quotas may be correlated with other omitted variables such as political connectedness, the effects of which may also have changed after system abolition. Hence, to resolve potential endogeneity, we use a fuzzy regression discontinuity (RD) design that exploits the historical development of the quota system from its first use in 1644–1724 to divide prefectures based on a Ming Dynasty (1368–1643) proposal that designated those with agricultural taxes over 150,000 piculs as important (vs. unimportant) and assigned them higher quotas.[2] Since a new regional importance classification system was adopted in 1731, the rule discontinuity had no impact on a prefecture's importance during the late Qing. In fact, the quotas remained stable during the Qing Dynasty, which allows us to exploit the discontinuity in the quotas' assignment as an instrumental variable to identify their effect(s). These results still show a significant increase in the effect of logged quotas per capita following abolition.

At the same time, if the allocation of talent were affected by the civil service examination, there should be a substantial pool of talented individuals who were not pursuing modernization activities before its abolition. We test this hypothesis by assessing the effect of logged quotas per capita on the individual skill levels of Chinese studying in Japan, inversely measured as the duration of school application (the time between the year of arrival and entrance year). Whereas the average application duration before 1904 was 4.69 years, it decreased to 2.46 years after the abolition decision. This decrease (increase) in application duration (skill level) was much sharper in regions with higher per capita quotas because before abolition the more talented individuals in the traditional sector were allocated to regions offering a higher likelihood of civil service examination success. The reduced duration also implies that before 1904, only low skilled individuals in the traditional sector chose to pursue modernization activities. The resulting misallocation of talent may have negatively impacted economic growth in late Imperial China.

According to theoretical studies (Acemoglu, 1995; Baumol, 1990; Murphy et al., 1991, 1993), if a society specifies a higher payoff for rent seeking than for productive activities, more talent will be allocated in unproductive directions, making rent seeking (such as that by civil servants) costly to economic growth. This paper draws on this assumption to shed light on why China's economic leadership failed to spearhead an industrial revolution in the fourteenth or even the eighteenth century (Allen, 2009; Maddison, 1998, 2001; Pomeranz, 2000). Landes (2006), for example, argues that China missed the opportunity to either generate a self-sustaining process of technological advancement based on its own achievements or learn from European technology once foreigners had entered the country. This present study empirically identifies the effects of the second missed opportunity and supports the extant hypothesis that the civil examination constituted an institutional obstacle to the rise of modern science and industry (Huff, 2003; Lin, 1995).[3] Hence, the analytical findings, although based in historical fact, may have relevant implications for contemporary nations that continue to practice examination-based recruitment of civil servants.

In fact, this paper makes a useful contribution to a growing scholarly interest in the varied effects of civil service examination systems,

[2] "Picul" is the English word for a historic Chinese unit of mass whose Chinese character is pronounced Dan as a unit of measure.

[3] Prior studies provide several explanations for the great divergence between the West and the East by focusing on why the West (England) was able to generate a self-sustaining process of technological advancement and stimulate long-run economic growth (see, e.g., Voigtländer and Voth, 2006, 2013).

such as Yuchtman (2017)'s recent identification of differences in labor market outcomes associated with studying in traditional versus modern educational schemes. In similar vein, Chen et al. (2017) trace the persistent impact of success in higher level (rather than entry-level regional) examinations on today's education. This current study is most closely related, however, to Bai and Jia (2016)'s exploration of the impact of abolishing the civil service examination on revolutionary participation. The major difference between the two papers is that we focus on the economic consequences of the abolition, adopt a regression discontinuity approach to identify the causal impact, and use an individual dataset of Chinese students in Japan to provide micro-evidence on the allocation of talent.

Other relevant research demonstrates that in Europe also, economic development was closely correlated with the transformation of the education system, particularly the evolution of universities, which, once they replaced cathedral and monastic schools in the eleventh century (e.g., the University of Bologna), spread rapidly throughout the continent in subsequent centuries (Verger, 1992). These institutions provided students with a new curriculum comprising such subjects as philosophy (logic), grammar, arithmetic, geometry, astronomy, and many other practical disciplines credited with contributing to Europe's commercial revolution (Cantoni and Yuchtman, 2014; Mokyr, 2005). In contrast, education in Imperial China focused for centuries almost solely on Confucian classics and rote learning.[4] Hence, by identifying the negative effect of China's traditional education system on economic development, our study explores the role of educational content in the sharp differences between Europe's and China's economic trajectories.

More generally, our work enhances understanding of institutions' role in economic development and sheds light on the reasons for the great divergence in technological expertise and per capita income around the world in the last five centuries. It thus expands the already broad empirical evidence that good institutions - such as secure property rights (Acemoglu and Johnson, 2005; North and Thomas, 1973), efficient legal systems (La Porta et al., 1997), fewer barriers to entry, and the absence of oligarchies (Acemoglu, 2008; Acemoglu et al., 2011; Olson, 1982) - correlate positively with better economic performance. More particularly, our analysis empirically identifies the effects of the reward structures of two types of economic activities fully addressed in the theoretical literature (Acemoglu, 1995; Baumol, 1990; Murphy et al., 1991, 1993); namely, rent seeking and productivity.

The remainder of the paper is organized as follows. Section 2 briefly reviews the historical background and describes the dataset, after which Section 3 introduces the conceptual framework and empirical specifications. Sections 4 and 5, respectively, report the results of the baseline test and robustness checks, and the outcomes of the regression discontinuity approach used to resolve the potential endogeneity problem. Section 6 then outlines the change in the Western sector skill level as observed in the individual dataset of Chinese studying in Japan. Section 7 summarizes the findings and concludes the paper.

2. Historical background and data

2.1. A brief introduction of the civil examination system

The civil examination system was designed to select the best administrative officials for the state's bureaucracy through a test of educational merit, and to create a class of scholar bureaucrats independent of family status.[5] Established by Emperor Yang of the Sui Dynasty (581–618) in AD 605 (Keay, 2009)[6] and further developed during the Tang (618–907) and Song (960–1276) dynasties (Chaffee, 1995), the system became the primary channel for recruiting government officials during the Ming (1368–1644) and Qing (1644–1910) dynasties (Ebrey, 1999; Elman, 2000; Ho, 1962). During both these latter periods, its curriculum and structure remained extremely stable with its content dominated by the Confucian canon of the Four Books and Five Classics.[7] The system included three stages of testing: (1) the lowest level biennial licensing examination (*Yuankao*) held in the prefectural capital after primary testing in the county seat,[8] (2) the triennial qualifying examination (*Xiangshi*) administered in the provincial capital, and (3) the highest level academy examination (*Huikao*) held in the national capital with re-examination (*Dianshi*) at the imperial palace. Successful candidates received a new title at each level and became automatically eligible to sit the next level of examination. Candidates who passed the prefecture-level examination were called *Shengyuan* or *Xiucai* (literati), and those who passed the provincial and national-level tests were *Juren* (recommended man, provincial graduate) and *Jinshi* (presented scholar, palace examination graduate), respectively (see Appendix A).

Whereas candidates who passed at least the provincial-level examination qualified for appointment to government office, those who passed the higher level academy or palace examinations tended to be automatically appointed to a government position. This latter was the highest possible achievement under the civil examination system and brought great power and prestige. For instance, government officials such as district magistrates had great authority to carry out court orders, collect taxes, and implement central government policies, all of which provided "the greatest opportunity for the rapid accumulation of wealth" Chang (1962, p.7). In fact, Ni and Van (2006) estimate that circa 1873, officials' corruption income was 14–22 times greater than their regular income, resulting in combined earnings of about 5000 taels of silver per year (Chang, 1962) and placing about 22 percent of the agricultural output in the hands of around 0.4 percent of the population (Ni and Van, 2006).[9]

Even candidates who passed only the lowest level (district) examination became members of the lower gentry, which was associated with considerable privileges, prestige, and income (Chang, 1955, 1962; Elman, 1990, 2000; Glahn, 1996). The title of *Shengyuan* or *Xiucai* gave these individuals access to three important sources of income for this Chinese elite: the management of local affairs, secretarial assistantships to officials, and teaching (Chang, 1962). They were also exempt from corporal punishment and corvée (i.e., forced labor), and had the right to wear a scholar's robes. Although the gentry class comprised only about 2 percent of the population, they received about 24 percent of the national income (Chang, 1962).

[4] To the extent that the education system and its content represent an equilibrium outcome of private decisions and government policy choices, they are likely to be endogenous (Cantoni and Yuchtman, 2013).

[5] According to (Ho, 1962, p.56), given "the lack of effective legal barriers preventing the movement of individuals and families from one status to another," the civil examination system made upward mobility possible. However, Elman (2000, p.xxix) argues that rather than being "a system designed for increased social mobility," the examination "served as an institutionalized system of inclusion and exclusion that publicly legitimated the impartial selection of officials."

[6] The beginnings of this practice can be traced back to the Han Dynasty (206 BC-220 AD) (Chaffee, 1995).

[7] The examinations were bound by many regulations and presented within strict frameworks. For instance, candidates were required to write eight-legged Confucian essays, and form was even more important than content (Chang, 1955; Elman, 2000; Yuchtman, 2017).

[8] New candidates had to be chosen by magistrates and prefects for the county, and culled by prefectural tests before they qualified as "apprentice candidates". After they were screened in the primary test, successful candidates took a final licensing examination in the prefectural capital (Elman, 2000).

[9] According to Allen et al. (2011), the nominal wage of unskilled labor in Beijing at that time was about 33 taels of silver per year (0.09 of a tael per day).

2.2. Civil examination and modernization

The civil examination system served its purpose very well up until the mid-nineteenth century, helping the central government to capture and hold the loyalty of local elites (Man Cheong, 2004), select suitable and efficient managerial elites (Elman, 2000), create cultural uniformity and consensus on basic values (Elman, 1990, 1991), and maintain political, social, and cultural control (Elman, 2000, 2005). However, after China's serious defeats in the First (1839–1842) and Second (1856–1860) Opium Wars, the Qing government had to embrace Western military and industrial practices to modernize China and strengthen itself against the West. Nonetheless, these efforts, which became known as the Self-Strengthening Movement (1861–1894), were generally unsuccessful and failed to bolster Qing rule or military power.[10] In fact, according to Elman (2005, p.306), "[m]any thought efforts to achieve 'wealth and power' through 'self-strengthening' were insufficient because the overall education system undergirding the civil examinations had not been properly addressed." For instance, in 1871, Yung Wing (1828–1912), having convinced the Chinese court to send students to the United States, organized the Chinese Educational Mission, which provided government scholarships for 120 teenage boys to study for 15 years in the New England area. Although the government and Yung had high hopes for the program, the recruitment process proved very difficult because parents were reluctant to send their sons abroad. Yung had to return to his hometown in southern China and use his own networks to recruit students from families having more previous contact with Westerners (Bieler, 2004; Leibovitz and Miller, 2011).[11]

The difficulty of recruiting promising students was also the most serious impediment in other educational initiatives, such as government schools (Biggerstaff, 1961),[12] because "the route to personal and familial success in China still lay through the Confucian-based civil service examination system" (Rhoads, 2011, p.20). As a result, nobody with a good chance of examination success would "choose any other course" (Biggerstaff, 1961, p.78), and only those who failed the civil examination pursued nonofficial educational or career opportunities (Elman, 2005). For example, Yan Fu (1853–1921), a Chinese translator famous for introducing Western ideas to China in the late nineteenth century (Schwartz, 1964), was provided with the best tutor in childhood and encouraged to prepare for the civil examination. When his studies abruptly ended with the death of his father in 1866, however, Yan entered the School of Navigation of the Fuzhou shipping yard and then studied at the Royal Naval College, Greenwich, England, from 1877 to 1879. On his return to China, his Western education brought him no immediate success, so in an attempt to attain elite status and win respectability and influence, he took (and failed) the provincial examinations four times between 1885 and 1894.

After several voices blamed the civil examination as a root cause of China's backwardness in the late nineteenth century,[13] Chinese literati, even those who had passed this test, proposed reforming the selection process to introduce Western learning into the civil service curriculum. For instance, Feng Guifen (1809–1874), who had finished second in the 1840 palace examination and served as an imperially selected examiner on several occasions, put forward an 1861 proposal to incorporate mathematics, physics, and machinery into the system. Likewise, in 1867, Li Hongzhang (1823–1901), who had passed the palace examination in 1847 and was a vigorous leader of the Self-Strengthening Movement, proposed establishing eight examination categories, including mathematics and engineering as a single category. Although these proposals were never fully enacted, the reform ideas circulated and contributed to the Hundred Days' Reform of 1898, which temporarily abolished the imperial examination system.

2.3. The reform and abolition of the civil examination

According to Elman (2000, p.603), "[i]n the midst of crisis, many high officials now saw civil examinations as the fundamental problem in the way of further educational reform rather than the institutional means to control literati elites." Hence, after the Siege of the International Legations during the Boxer Uprising in 1900, the Empress Dowager Cixi was forced to reform the examination system (see Franke (1960) for a detailed outline), abolishing the eight-legged essay in 1901 while retaining the three-level examination structure. Yet in the first set of civil examinations the following year, the examiners failed to implement the new format, which mitigated the reform's final outcome (Elman, 2000).

Nevertheless, on January 13, 1904, the imperial court approved the Committee on Education's Memorandum Requesting the Gradual Reduction of the Examination System as an Experiment, which urged governments to "replace the examination with schools as the road to officialdom" (Elman, 2000, p.603). It was this imperial edict of 1904 that led to the decisive abolition of the examination system in favor of gradual replacement over the next decade by a modern school system, which was expected to encourage individuals to pursue modernization activities The edict also sanctioned the Regulation for Schools (*Xuetang Zhangcheng*)), which provided rules for all institutional types from kindergarten to university and made schools and school examinations a formal part of the examination system by granting civil degrees to their students.[14] By 1904, therefore the gradual transformation of the imperial civil examination system "into a system of school examinations …was irrevocable" (Elman, 2000, p.604).

The abolition process was further hastened by Japan's defeat of Russia in the Russo-Japanese War of 1904–1905, which was largely fought on Chinese soil in Manchuria. Japan's success was attributed to the Meiji Restoration and modernization, which set an example for China to emulate. On August 31, 1905, Zhang Zhidong and Yuan Shikai requested the immediate abolition of the imperial examination system, arguing that "if there is a further delay of ten years while the system is being gradually abolished and schools are slowly being opened, it will be more than twenty years before there will be men of talent available for use …. Our strong neighbors are pressing in upon us [so how] can we delay?" On September 2, 1905, the Empress Dowager Cixi endorsed this memorandum and ordered the discontinuance of the old examination system at all levels the following year. This abrupt change, which established no alternative system of elite recruitment, led to political instability and the collapse of the Qing Dynasty (Bai and Jia, 2016). Nonetheless, because this paper examines the economic rather than the political consequences of the abolition, we use January 13, 1904, as the timing of the policy shock, and the period from January 13, 1904, to September 2, 1905, as the transition period.

After abolishing the imperial civil examination, the dynastic government did not stop recruiting elites from commoners but rather attempted to switch to a modern education system by combining the government service examination with a specialty field examination as a means of awarding academic degrees and official positions to students

[10] China's defeat in the First Sino-Japanese War (1894-95) provided clear evidence that the movement had failed.

[11] Few students came from the scholarly/official elite.

[12] Government schools remained separate from the Translation Department in the hope that the graduates would go on to pass the more prestigious civil examinations. Hence, the school's foreign environment attracted the sons of Shanghai merchants and Christian converts.

[13] Some foreign observers asserted at the time that the civil examination was an obstacle to China's modernization. For instance, Young J. Allen, one of the leading Protestant missionaries in Beijing, traced Chinese underdevelopment to superstition, opium, and the civil examination (Elman, 2015).

[14] Passing the prefectural (provincial) examination was equivalent to graduating from higher elementary school (high school), while passing the metropolitan examination corresponded to university graduation (Franke, 1960, p.66).

trained abroad. According to Regulations Governing Examinations for Appointment to Office (Shouguan Kaoshi Zhangcheng), students who had trained abroad for at least three years could take the primary examination given by the Ministry of Education, receive a specialized field certificate on passing it, and become eligible for the palace examination administered jointly by the Imperial Commissioner and the Ministry of Education. During the 1905–1911 period, these examinations were administered six times, producing 1388 successful candidates that the government either appointed to such posts as county magistrate or assigned based on field of specialty to the Foreign Ministry, Finance Ministry, Ministry of Education, Ministry of War, Ministry of Justice, Ministry of Posts and Communications, Ministry of the Interior, or Ministry of Agriculture, Industry, and Commerce (Deng, 1995). The existing elites adapted easily to the new system (Wang, 1960) because it gave incumbents more influence over elite recruitment (Spence, 1990). More important for the validity of our identification strategy, although the policies encouraged Chinese to study abroad, under the new system, the likelihood of being selected was no longer related to regional quotas.[15]

2.4. Data

2.4.1. Regional quota system

The dynasties distributed opportunities to become rich based on provincial and prefectural quotas throughout the country, which served "as an institutional means to confine and regulate the power of elites" (Elman, 2000, p.140). The quota system allowed the government to control the size of the gentry class, which consisted exclusively of candidates who had passed the licensing examinations and which in the late empire comprised only 1.6–1.9 percent of the total population (Chang, 1955; Elman, 2000). However, using regional quotas also enabled the recruitment of imperial officials from rural areas, so control of the gentry's regional composition was inherent in the initial stages of the licensing examination system. By restricting the prefecture or county quotas, the dynasty could control the number and location of candidates entering the official selection process. The prefecture examination quotas were assigned during 1644–1724 and then remained very stable, with the only notable change occurring in an 1850 effort to quell the Taiping Rebellion (Chang, 1955). Likewise, throughout the Qing Dynasty, the number of successful candidates for the higher level examinations (*Juren* and *Jinshi*) were also regulated by regional quotas at the provincial level. Then, the regions thus offered very unequal opportunities for individual participants.

The empirical analysis in this study covers the 262 prefectures of the 18 provinces south of the Great Wall, the country's traditional agricultural area (see Fig. 1) which circa 1880 (during the Qing period) housed about 90 percent of the country's population (Ge, 2000). To exploit the cross-prefecture variation in the likelihood of passing the civil examination, we use the quotas for the licensing examination, the lowest (entry) level test, administered in the prefectural capitals and the threshold for attaining gentry status with its accompanying privileges and income. To compute the quota for each prefecture, we combine the quotas assigned each of its counties and the additional quota assigned the entire prefecture, which could be shared among the counties. Based on our data, taken from the *Imperially Established Institutes and Laws of the Great Qing Dynasty* (*Qing Hui Dian Shi Li*, Kun, 1899),[16] the sum of the quotas in the 262 sample prefectures was 29,808.[17] We depict the geographic distribution of the absolute values of the quotas for licensing examinations and quotas per capita (unit: per million inhabitants) in Fig. 1, which shows an average prefectural quota of 113.8 (SD = 75.6) and an average quota per capita of 135.8 (SD = 141.3). The prefecture with the highest (lowest) likelihood of a candidate passing the examination is Anxi Zhou in Gansu Province (Haimen Ting in Jiangsu Province) with a quota per million inhabitants of 1704.2 (8.7).

Before conducting the empirical analysis, we need to identify the possible determinants of quotas per capita (Appendix C), which we later employ as control variables. To do so, we first regress the quotas per capita on our provincial dummies, which reveals that provincial fixed effects can explain 30 percent of the per capita variation in quotas. Second, to control for size effects, we include the population density in 1880 and the size of the prefectures in the empirical estimates. Third, to control for geographic factors (i.e., differences in access to the coastline and navigable rivers), we include two dummy variables: Coast (whether a prefecture is situated on the seaboard) and Riverside (whether a prefecture is located along the Changjiang [Yangtze] River, China's most navigable river). Approximately 13.4 percent of the sampled prefectures are located on the coast, and 6.2 percent on the Changjiang River. Lastly, we control for the longitude and latitude of the prefecture's capital, as these might be correlated with climate and agricultural conditions. Together, these variables explain around 60 percent of the total variation in per capita quotas (see Table 1 for definitions, data sources, and summary statistics of the relevant variables).

2.4.2. Measuring modernization

We focus on two typical modernization activities related to Western science and technology in the late nineteenth and early twentieth centuries: the establishment of (private) modern firms and overseas study.

2.4.3. Modern firms

After its defeats in the First (1839–1842) and Second (1856–1860) Opium Wars, China began to adopt Western technologies and establish modern enterprises. With the exception of the Self-Strengthening Movement (1861–1895) initiated by Qing government officials to acquire military technology and armaments, this adoption was carried out primarily by private firms that emerged in the mid-nineteenth century. We thus use the number of mechanized industrial firms above a designated size as a proxy for the adoption of Western technology. We draw our data from Chang (1989)'s compilation of all modern enterprises (with their locations and establishment dates), none of which was established by the government. All firms meet the following five criteria: (1) organized as a company, (2) over 30 employees, (3) use mechanization, (4) over 10,000 silver yuan in capital, and (5) an output value over 50,000 silver yuan.

By plotting the number of private enterprises in our sampled prefectures by establishment year, Fig. 2 (the left graph) clearly shows establishment beginning in 1848 but with a negligible number of firms before 1878, followed by a gradual increase during the height of the Self-Strengthening Movement. When this movement failed after China's defeat in the First Sino-Japanese War (1894–1895), the number of new firms suddenly decreased from 18 in 1894 to 3 in 1895 and then 6 in 1896. However, after a period of slow growth from 1895 to 1903, private enterprises mushroomed at the end of the Qing Dynasty and dawn of the new republic, with 71 firms opening in 1906, the year following civil examination system abolition, and 125 firms established in 1912, the first year of the Republic of China.

2.4.4. Overseas study

In the late Qing period, an ever growing number of educated Chinese left home to study overseas, primarily in Japan, considered the most suitable country because of its geographic proximity and cultural similarity. In fact, between 1900 and 1911, 90 percent of the 20,000

[15] According to our estimations, the correlation between regional quotas (under the civil service examination system) and the probability of being selected in 1907 is insignificant (see Appendix C).

[16] See Appendix B for an example.

[17] Before the Taiping Rebellion, the number was 24,698, which differs from the 25,089 reported by Chang (1955) because we cannot include the quotas for Eight Banner and Fengtian (Manchu) or the special quota for merchants.

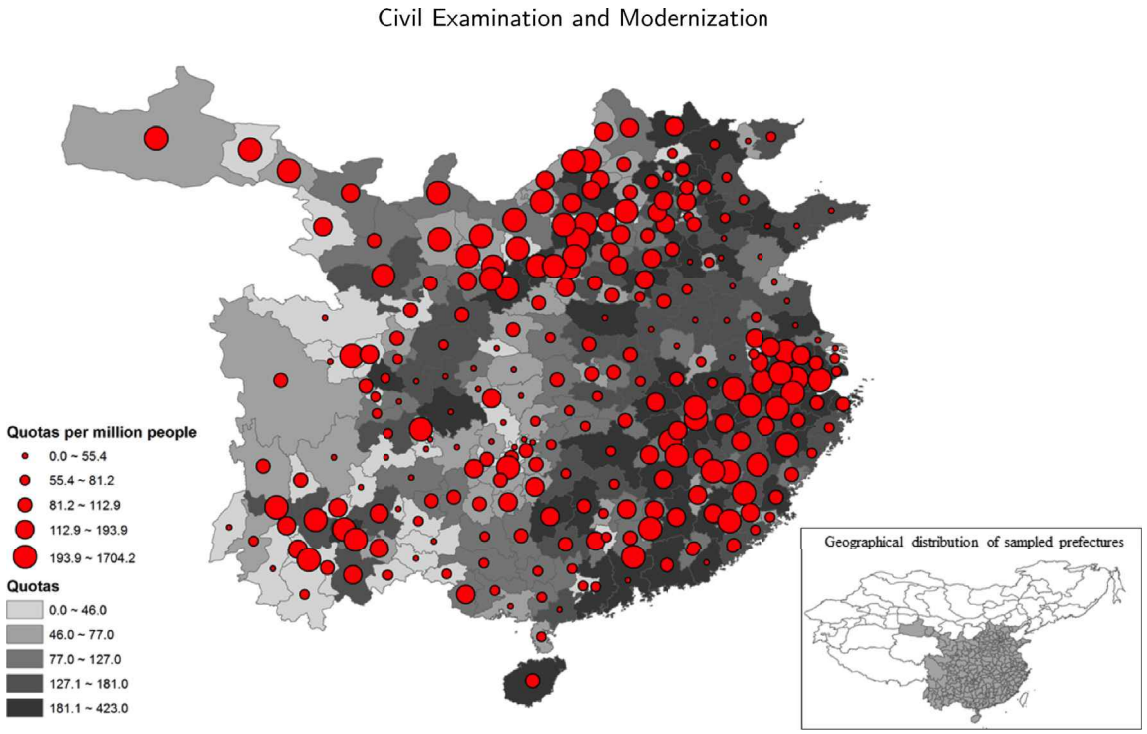

Fig. 1. Geographic distribution of quotas - Source: *CHGIS*, Version 4, Harvard Yenching Institute, and Fudan Center for Historical Geography, January 2007.

Table 1
Definition of variables and data sources.

Variables	Variable Definitions	Data Sources	Observation	Mean	S.D.
Domestic firms	Number of new erected firms, 1899–1908	A	262*10	0.109	(0.607)
	Number of new erected firms per million inhabitants	A, B	262*10	0.071	(0.696)
Foreign firms	Number of new erected firms, 1899–1908	A	262*10	0.033	(0.365)
	Number of new erected firms per million inhabitants	A, B	262*10	0.012	(0.132)
Chinese students in Japan	Number of new students, 1899–1908	C	262*10	0.615	(2.394)
	Number of new students per million population	C, B	262*10	0.440	(1.626)
Quota of imperial examination	Quota of imperial civil examination (hundred)	D	262	1.138	(0.756)
	Quota per million population	D, B	262	135.777	(141.272)
	ln(Quota per million inhabitants)	D, B	262	4.635	(0.702)
	ln(Quota per million inhabitants), pre-Rebellion	D, B	262	4.493	(0.742)
	Δ ln(Quota per million inhabitants), during Rebellion	D, B	262	0.144	(0.161)
Control variables	Changjiang (Yangtze) River (=1, if riverside)	E	262	0.062	(0.240)
	Coast (=1, if coastal)	E	262	0.134	(0.341)
	Longitude	E	262	111.561	(5.792)
	Latitude	E	262	30.687	(4.953)
	Population, 1880 (log-term)	B	262	13.620	(1.075)
	Size (log-term)	E	262	9.336	(0.770)
Initial economic conditions	ln(Urban population) (larger than 32,000), 1893	E	262	1.037	(1.235)
	ln(Number of bank branches in 1850s)	F	262	0.069	(0.255)
Role of government	Province capital	E	262	0.073	(0.260)
	ln(Cumulative number of government-owned firms, 1904)	A	262	0.087	(0.323)
Western economic penetration	Treaty ports dummy in 1904	F	262	0.122	(0.328)
	Duration of Protestantism presence	G	262	14.615	(15.691)
Taxation in late Ming Dynasty	Agricultural tax (10,000 piculs)	H	160	17.441	(33.352)
Importance of prefecture	Rank in late Qing Dynasty	I	262	2.607	(0.972)
	Abundant in late Qing Dynasty	I	262	0.760	(0.428)

Sources: A: Chang (1989); B: Ge (2000); C: Shen (1978); D: Kun (1899); E: CHGIS (2007); F: Yan (1955); G: Bai and Kung (2015); H: Liang (1980); I: Liu (1993).

Chinese studying overseas were doing so in Japan (Yao, 2004), about 4.4 percent of them (Sanetou, 1983) in Japanese universities and other institutions of higher learning, including institutes of technology (Shen, 1978). Because Shen (1978)'s compilation of these details gives each student's name, birthplace, and date of arrival in Japan, we are able to calculate the number of new students arriving in Japan from each prefecture each year with a focus on arrival dates and school application time.[18] As Fig. 2 (the right graph) shows, the number of arrivals increased after 1902 but decreased after 1905, perhaps because most

[18] Shen (1978)'s comprehensive list, which includes not only those sponsored by the government but also the self-sponsored, reveals that the students were enrolled in subjects ranging from the arts and humanities to science, technology, engineering, and medicine.

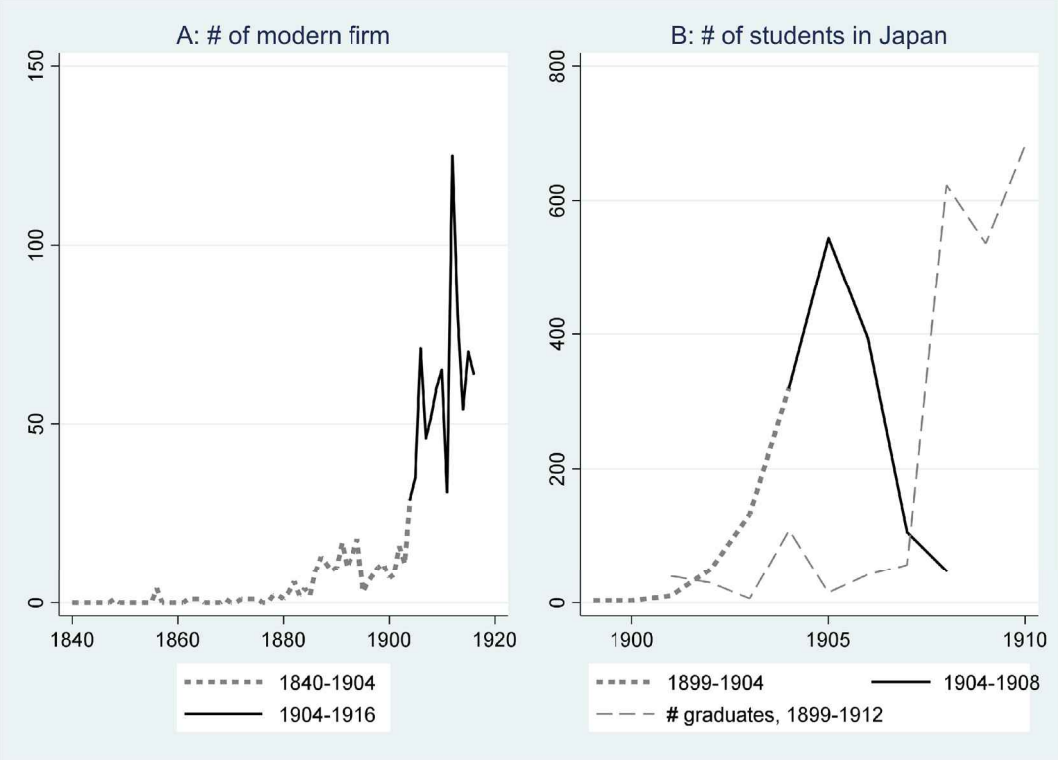

Fig. 2. Yearly trends of modernization activities.

students arriving after 1906 were less likely to have gained university entrance.[19] By plotting the number of Chinese graduates (Sanetou, 1983) in the same figure to check data reliability, we demonstrate that the number of students arriving in 1901–1906 is very similar to the number of graduates three or four years later (1904–1909), which implies that the data pre or during 1906 might be much more reliable than those after this year.

3. Conceptual framework and estimation strategy

3.1. Conceptual framework

We classify the types of learning as either traditional/Chinese learning (civil examination route, coded 0) or as modern/Western learning (for establishing a modern firm or overseas study, coded 1), with the relevant analytical question being occupational choice. Because each individual is likely to compare the expected wages for both types of occupations, we expect those with higher (lower) expected earnings under the traditional education system to participate in the civil examination system (modern learning).

Using a framework developed by Borjas (1987) and Roy (1951), we first take the log earnings from traditional education:

$$\ln w_0 = \kappa_0 + \eta_0,$$

where $\eta_0 \sim N(0, \sigma_0^2)$, with η_0 serving as the de-mean value of a skill in the traditional education sector. Regional mean log earnings (κ_0) are determined by the probability of success, which is regulated by the quota system. Then,

$$\kappa_0 = \rho \ln(\frac{Q}{\tau \cdot pop}) = \rho(\ln q - \ln \tau),$$

where $q = \ln(\frac{Q}{\tau \cdot pop})$ and τ denotes the share of talent in the population. The log earnings of adopting Western science and technology are assumed to be

$$\ln w_1 = \kappa_1 + \eta_1,$$

where $\eta_1 \sim N(0, \sigma_1^2)$, and η_1 serves as the de-mean value of a skill in the Western sector. η_0 and η_1 are correlated with correlation $\rho_{01} = \frac{\sigma_{01}}{\sigma_0 \sigma_1}$, where $\sigma_{01} = cov(\eta_0, \eta_1)$. An individual chooses the Western system if

$$\ln w_1 - \ln w_0 = (\kappa_1 - \kappa_0) + (\eta_1 - \eta_0) > 0,$$

so the probability of a randomly chosen individual deciding to adopt this system is

$$P = \tau \Pr[v = \eta_1 - \eta_0 > (\kappa_0 - \kappa_1)] = \tau \Phi(\frac{\kappa_1 - \kappa_0}{\sigma_v}), \quad (1)$$

where $\sigma_v = \sqrt{\sigma_0^2 + \sigma_1^2 - 2\sigma_{01}}$.

Before the abolition of the civil examination system, the effect of $\ln q$ on P is

$$\frac{\partial P}{\partial \ln q} = [\Phi(\frac{\kappa_1 - \kappa_0}{\sigma_v}) + \phi(\frac{\kappa_1 - \kappa_0}{\sigma_v})] \cdot \frac{\partial \tau}{\partial \ln q} - \frac{\rho \tau}{\sigma_v} \phi(\frac{\kappa_1 - \kappa_0}{\sigma_v}),$$

so the effect of the logged quotas per capita can be divided into two parts. The first stems from the correlation between the quota density ($\ln q$) and talent density in the population (τ),[20] which occurs for two possible reasons: (1) the allocation of a larger quota to regions with

[19] Since Shen (1978) bases on the universities' rosters around 1908–1909, the students arrived in Japan after 1906 may not have entered the universities given that the mean application time is about 2.74 years based on a sample of 1584 students. Another possible reason is that Chinese students began choosing to study in Western Europe or the United States.

[20] Since the talent density is unlikely to change immediately with the abolition, omitting τ in the conceptual framework will not affect our analysis. The only difference is that P will be interpreted as the probability of a randomly chosen talent deciding to choose the Western system.

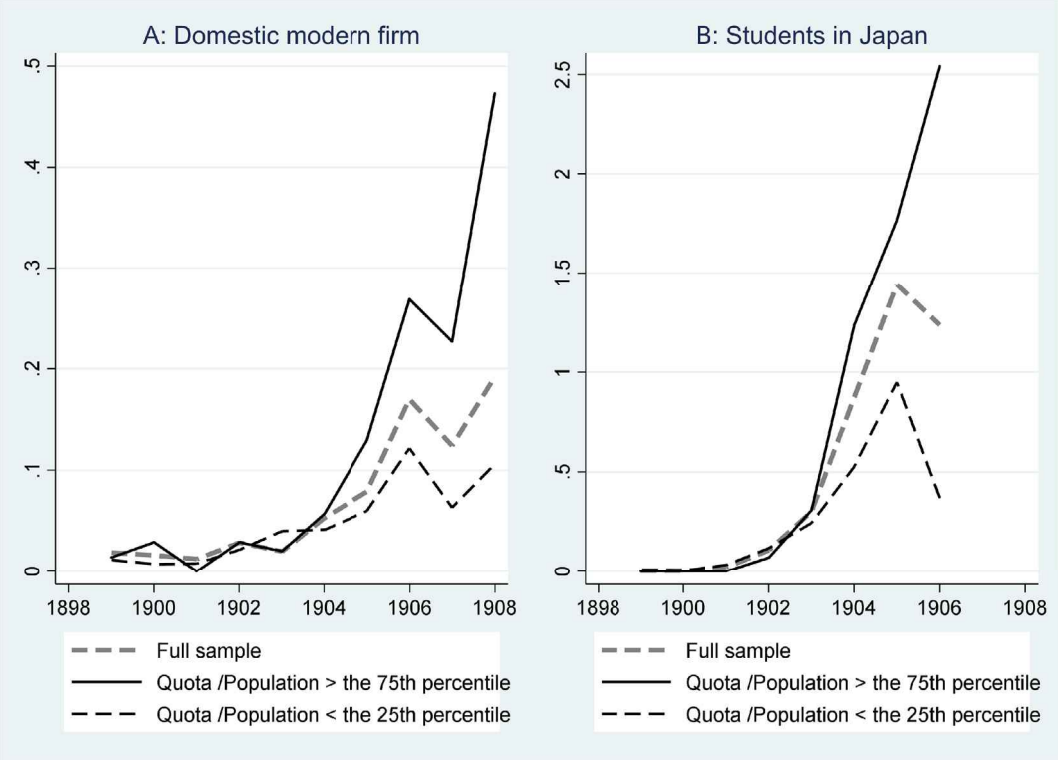

Fig. 3. Quotas per capita and modernization activities.

more talent or (2) greater investment in education by regions with a higher quota density, resulting in more high-quality laborers. This latter is illustrated by the male (female) literacy rates in late Imperial China being among the highest in the pre-modern world at 30–45 (2–10) percent (Rawski, 1979), possibly because of the traditional education system. The second part, $-\frac{\rho\tau}{\sigma_v}\phi$, measures the negative effect of the civil examination system, which, although able to nurture (or correlate with) a group of high-quality laborers, also channeled these talents into itself. Following its abolition, expected earnings in the public sector ((κ_0) were no longer determined by the quota system, so the effect of ln$q$ on P can be written as

$$\frac{\partial P'}{\partial \ln q} = [\Phi(\frac{\kappa_1 - \kappa_0}{\sigma_v}) + \phi(\frac{\kappa_1 - \kappa_0}{\sigma_v})] \cdot \frac{\partial \tau}{\partial \ln q}.$$

Then, assuming that the share of total talents was unlikely to change sharply just after abolition, comparing the effect of the logged quotas per capita pre and post abolition will identify the civil examination system's negative effect.

It is worth noting that although both the variables used to proxy modernization activities in the empirical analysis (i.e., new modern firms and new Chinese students to Japan) can be expected to increase notably in regions with larger post-abolition quotas, their implications for modernization might be different. That is, whereas the establishment of new firms implies that the abolition affected the existing stock of educated, talented people,[21] the presence of Chinese students in Japan implies that the abolition also led education age talent to change its educational investment. At the same time, it is difficult to neatly disentangle talent allocation from the diffusion of technically useful knowledge, because greater post-abolition acquisition of the latter by talented individuals may have reinforced knowledge diffusion to the common people. One possible difference in the predictions is that under the talent allocation hypothesis, the talented would be more affected, meaning a post-abolition increase in skill level in the modern sectors (those equipped with useful knowledge), whereas under the knowledge diffusion assumption, an effect would be observable for both talented and average individuals. We thus test the prediction in Section 6.

3.2. Estimation strategy

Our basic estimation strategy uses a DID method to identify the change in the effects of ln$q$ following abolition:

$$\frac{\partial P'}{\partial \ln q} - \frac{\partial P}{\partial \ln q} = \frac{\rho}{\sigma_v}\phi(\frac{\kappa_1 - \kappa_0}{\sigma_v}) = \beta > 0 \quad (2)$$

We then use the numbers of newly established modern firms (per million inhabitants) and new Chinese students to Japan (per million inhabitants), denoted by y_{it}, to proxy P and regress it on the interaction between lnq_t and the dummy indicator for the post-abolition period ($Post_t$). Thus,

$$y_{it} = \beta Post_t \times \ln q_i + \lambda_i + \eta_t + \varepsilon_{it} \quad (3)$$

where q_i denotes the quotas per capita (unit: quotas per million inhabitants), λ_i represents prefecture specific effects, η_t designates the year dummies controlling for year specific effects, and ε_{it} is the error term.

Before implementing our empirical tests, in Fig. 3, we present descriptive evidence of the increased effect of per capita quotas by comparing the density of the two modernization activities, new modern firms and new Chinese students to Japan, between the first quartile (highest quotas per capita) and fourth quartile (lowest quotas per capita). As the graph clearly shows, before 1904, the two groups differed little but the difference became larger after the decision to abolish the examination system. Because the data on Chinese students in Japan cover mainly the 1898–1908 period, our analysis of the effect on mod-

[21] Li (2005) examines the background of entrepreneurs during the late period of Qing dynasty and the early period of the Republic of China and finds that the traditional scholar gentry class was one of major sources of Chinese entrepreneurs, which implies reallocation of the existing stock of educated, talented people.

ern firms focuses on this same period (but with a longer observation window in the subsequent robustness tests). Another nontrivial reason to focus on the short window is that the central government's power structure at that time was relatively stable after the Empress Dowager Cixi's 1898 coup d'état forced the Guangxu emperor into seclusion and left her to govern as regent until both died later that year. Hence, despite a few political disturbances, including the Boxer Uprising, there was no ruler turnover.

4. Empirical testing

4.1. Difference in differences (DID)

We begin the empirical testing using a DID method that includes the interaction between the control variables and the post-abolition dummy ($Post_t$):

$$y_{it} = \beta Post_t \times \ln q_i + Post_t \times Z_i\gamma + \lambda_i + \eta_t + \delta_{prov} \cdot \eta_t + \varepsilon_{it} \quad (4)$$

where q_{it} represents the per capita quotas (unit: per million inhabitants). To rule out the possibility that any change in the quota effect results from changes in the effects of other variables, we include interaction terms between the various control variables (Z_i) and the post-1904 dummy ($Post_t$). Z_i represents a vector of prefecture-level characteristics: whether located along the Changjiang (Yangtze) River or on the coast, latitude and longitude, size (area in log-term), and total population in 1880 (log-term). λ_i denotes prefecture specific effects, η_t is the year dummies controlling for year specific effects, and $\delta_{prov} \cdot \eta_t$ represents the province-year specific effects.

The results using the number of new modern firms per million inhabitants as the dependent variable (Table 2, columns (1) and (2)) show about a 0.244 increase in the effect of the logged quotas per capita when only prefecture, year, and province-year specific effects are included. Even after the inclusion of all controls, however, the coefficient remains relatively stable. In terms of magnitude, when evaluated at the mean population of the sampled prefectures (1.315 million), a prefecture with one standard deviation higher logged quotas per capita (0.70) established 0.23 more modern firms each year. Comparing a prefecture in the 75th percentile (5.098 per million) with one in the 25th percentile (4.141 per million) of quotas per capita, a prefecture with the highest examination success likelihood (hereafter, higher opportunity prefecture) established 0.313 more firms per year (evaluated at the mean population of the sampled prefectures).

A subsequent analysis using the number of overseas students per million inhabitants as the dependent variable then indicates that higher opportunity prefectures sent more students to Japan after the examination was abolished (Table 2, columns (4) and (5)). Specifically, evaluated at the mean population of the sampled prefectures, a prefecture with a one standard deviation higher logged quota density (0.70) sent 0.66 more students to Japan per year. Likewise, comparing a prefecture in the 75th percentile (5.098 per million) with one in the 25th percentile (4.141 per million) of quotas per capita, the highest opportunity prefecture sent 0.901 more students to Japan per year.

We then assess whether the 1904 decision to gradually abolish the examination system led to changed expectations that affected the behavior of forward-looking agents or whether the effect of logged quotas per capita increased only after the abrupt September 1905 abolition of the system with no alternative plan for elite recruitment. To do so, we divide 1904–1908 into two subperiods, 1904–1905 and 1906–1908, and then interact these with logged quotas per capita and other control variables. The results (reported in Table 2, columns (3) and (6)) reveal that the effects of the logged quotas per capita increased beginning in January 1904 after the decision to gradually replace the civil examination system with a modern school system. The increase in the effects on modern firm establishment was much smaller, unsurprising given the time needed to implement such a venture.

Lastly to alleviate any concerns that the quotas might be related to omitted variables (e.g., Western penetration or forced openness), we conduct a placebo test in which we regress the number of new foreign enterprises on the logged quotas per capita and its interaction term with a post-abolition dummy. Our rationale is that if the quota effect does not capture the impact of the omitted variables, there should be no significant change in the effect on other economic activities not directly related to the examination. The establishment of foreign firms is clearly not directly related to quotas per capita because foreigners were not affected by the civil examination system. The results (reported in Table 2, columns (7)–(9)) show no significant change in the effect of quotas per capita.

The above analysis uses the ratio of new modern firms or new overseas students to population ($\frac{Y_i}{pop_i}$) as the dependent variable, and the logged quotas per capita ($ln(\frac{Q_i}{pop_i})$) as the explanatory variable. To check whether this specific form of the function is driving our results, we apply two alternative specifications, the first of which uses quotas per capita ($q_i = \frac{Q_i}{pop_i}$) directly as the explanatory variable:

$$y_{it} = \beta Post_t \times q_i + Post_t \times Z_i\gamma + \lambda_i + \eta_t + \delta_{prov} \cdot \eta_t + \varepsilon_{it} \quad (5)$$

The results (reported in Table 3, column (1)) show a significant increase in the effect of quotas per capita following the abolition decision. The second alternative specification then uses a dummy for the presence of new firms or overseas students as the dependent variable, with quotas per capita and logged quotas per capita as the explanatory variables:

$$I(Y_{it} > 0) = \beta Post_t \times q_i + Post_t \times Z_i\gamma + \lambda_i + \eta_t + \delta_{prov} \cdot \eta_t + \varepsilon_{it} \quad (6)$$

The outcomes (shown in columns (2) and (3), respectively) still support the hypothesis, so we replace the dependent variable with the absolute number of new firms or students (see columns (4) and (5)) or the logged number (see columns 6 and 7). These results reveal a significant increase in the quota effect post abolition.

4.2. Yearly impacts of quotas per capita

Although the previous analysis indicates that the effect of quotas increased significantly post abolition, if this effect was gradually increasing before abolition, our estimator could be compounded with the pre-abolition trend. We thus test for this possibility by implementing an alternative specification:

$$y_{it} = \sum_{\rho=1899}^{1908} \beta^{\rho}(\ln q_i \times Year\ dummy_{\rho=t}) + \sum_{\rho=1899}^{1908} (Z_i \times Year\ dummy_{\rho=t})\gamma^{\rho} + \lambda_i + \eta_t + \delta_{prov} \cdot \eta_t + \varepsilon_{it},$$

where $Year\ dummy_{\rho=t}$ equals 1 if $\rho = t$, and 0 otherwise. Because the effects of these variables (Z_i) may have changed over time - for instance, the Coast effect on economic prosperity may have increased as China became more open - in the regression, we interact these variables with the full set of year dummies ($Year\ dummy_{\rho=t}$). Then represents the yearly correlation between the logged quotas per capita and the density of modernization activities relative to the year 1903, which we use as a reference. Fig. 4, which plots the yearly correlation with upper and lower bounds for the 95 percent confidence intervals, reveal two notable points. First, the effect of per capita quotas on modernization shows no clear trend in any of the five years prior to abolition: none of the five coefficients for modern firms/overseas study is significant. We cannot therefore reject the null hypothesis that all pre-abolition effects

Table 2
Baseline results.

	(1) Domestic firms/population			(2) Oversea students/population			(3) Foreign firms/population		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Post × ln(Quotas per capita)	0.242**	0.249**		0.667**	0.716**		−0.004	0.002	
	(0.120)	(0.107)		(0.286)	(0.300)		(0.004)	(0.004)	
1904–05 × ln(Quotas per capita)			0.051*			1.118**			−0.002
			(0.030)			(0.435)			(0.003)
1906–08 × ln(Quotas per capita)			0.382**			0.447*			0.005
			(0.176)			(0.231)			(0.008)
Post × ln(Pop.)	Yes			Yes			Yes		
Post × Controls		Yes			Yes			Yes	
1904–05 × Controls			Yes			Yes			Yes
1906–08 × Controls			Yes			Yes			Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province * Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2620	2620	2620	2620	2620	2620	2620	2620	2620
R-squared	0.097	0.102	0.122	0.440	0.444	0.452	0.093	0.101	0.104

Note: The results are for a two-way fixed effects model; standard errors clustered at the prefecture level are in parentheses. Controls represent a vector of prefecture-level characteristics: whether located along the Changjiang (Yangtze) River or on the coast, latitude and longitude, size (area in log-term), and total population in 1880 (log-term). *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 3
Model specifications.

	Panel A: Establishment of Modern Firms						
	Firms/population	Firm (0/1)		# of Firms		Ln (# of Firms+1)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post * Quotas per capita *10^{-3}	2.682***	0.248***		0.645***		0.280***	
	(0.784)	(0.054)		(0.177)		(0.065)	
Post * ln(Quotas per capita)			0.047***		0.144***		0.057***
			(0.017)		(0.053)		(0.017)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province * Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2620	2620	2620	2620	2620	2620	2620
R-squared	0.138	0.151	0.150	0.197	0.197	0.183	0.182

	Panel B: New Overseas Students in Japan						
	Students/population	Student (0/1)		# of Students		Ln (# of Students+1)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post * Quotas per capita *10^{-3}	2.944*	0.369***		1.818**		0.523***	
	(1.755)	(0.128)		(0.714)		(0.173)	
Post * ln(Quotas per capita)			0.090***		0.411***		0.127***
			(0.026)		(0.133)		(0.035)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province * Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2620	2620	2620	2620	2620	2620	2620
R-squared	0.442	0.434	0.435	0.380	0.380	0.550	0.550

Note: The results are for a two-way fixed effects model; standard errors clustered at the prefecture level are in parentheses. Controls represent a vector of prefecture-level characteristics: whether located along the Changjiang (Yangtze) River or on the coast, latitude and longitude, size (area in log-term), and total population in 1880 (log-term). *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

are equal to zero. Second, the effect increased immediately following abolition. As a placebo test, we replace the dependent variable with the number of new foreign enterprises per million inhabitants and repeat the exercise, plotting the yearly correlation and confidence intervals in Fig. 4. We find not only that the quota effect on foreign firm establishment shows no clear pattern during the 11 years studied but that the effect on the number of new foreign firms differs greatly from that of new domestic modern firms.

Because our firm data cover a longer period, we are able to perform a robustness check on these findings by assessing the yearly effects of the logged quotas per capita on the establishment of domestic modern firms during 1896–1916. This check not only allows us to determine whether the effect fades out, stays constant, or even increases over time but also helps us to understand the intertwining relation between talent allocation and knowledge diffusion. In an extreme case, if all the existing talent were reallocated to modern sectors, the quota effect should disappear. Then, assuming that the feedback of talent allocation on knowledge diffusion is not sufficiently meaningful, we would predict a decline in the quota effect over time. The results (see Fig. 5) support this prediction: the effect gradually increases up to 1908 and then becomes relatively volatile but with a slight average decrease over time, which is far more consistent with the talent allocation explana-

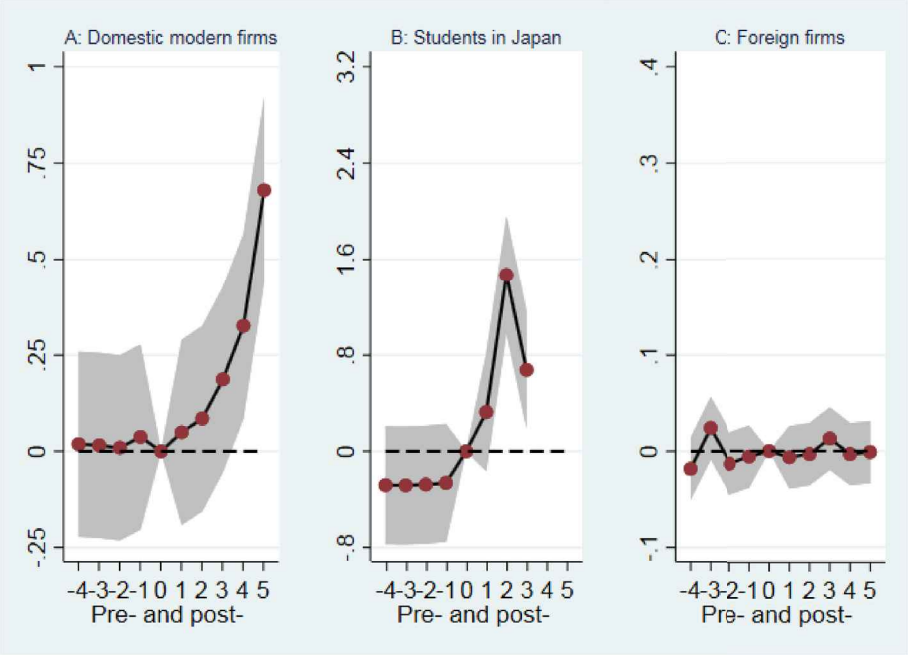

Fig. 4. Yearly effect of logged quotas per capita, 1899–1908; The black line represents the yearly correlation between the logged quotas per capita and the density of modernization activities relative to the year 1903, together with the upper and lower bounds for the 95% confidence intervals.

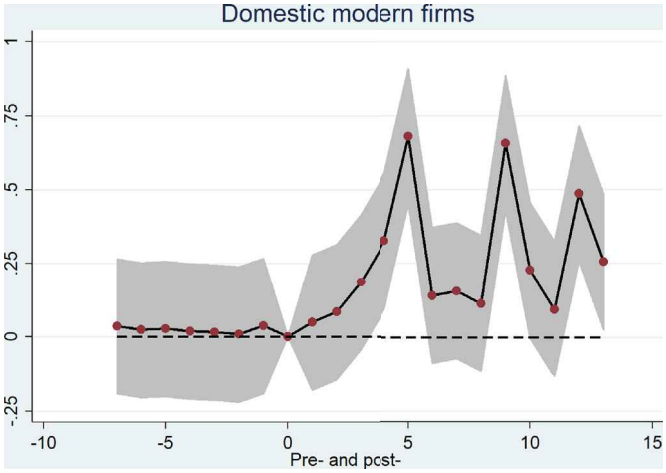

Fig. 5. Yearly effect of logged quotas per capita, 1896–1916; The black line represents the yearly correlation between the logged quotas per capita and the density of modernization activities relative to the year 1903, together with the upper and lower bounds for the 95% confidence intervals.

tion. Unfortunately, a lack of data prevents us from repeating the exercise for overseas study.

4.3. Robustness checks

4.3.1. Controlling for various success ratios

In the baseline analysis, we proxy the examination's influence by quotas per capita at the prefecture level (i.e., at the first of the three examination levels). To check robustness, we use as our proxy the success ratio at the higher examination level, calculated as the ratio of the total number of presented scholars during the Qing Dynasty to the total number of quotas per capita. At the same time, because becoming a government official is the highest achievement under the civil examination system, we calculate the ratio of total senior officials (provincial level and above) to total presented scholars to measure the probability of success in the prefecture's bureaucratic system.[22]

Interacting the two success ratios with the post-abolition dummy (see Table 4) reveals that the effect of the presented-scholars-to-quotas ratio significantly increased post abolition (columns (4) and (8)), possibly because quotas for passing the lowest level examination were regulated at the prefecture level, while those for the higher level examinations were assigned at the provincial level. As a result, successful lowest level candidates from a prefecture competed with those from other prefectures in the same province, making their likelihood of success highly dependent on the level of human capital within the province. Hence, once provincial dummies are controlled for, the ratio of successful candidates in the highest level examination (presented scholars) to entry-level quotas is probably a reliable measure of human capital. In fact, we do find that post abolition, regions with higher human capital levels tended to form more modern firms and send more students to Japan. The effect of the second ratio (i.e., senior officials to presented scholars) on the number of new students in Japan also marginally increased significantly (columns (4) and (8)), possibly because it measures the density of political connections in each region, which may be exploited to gain government support for overseas study. More important, when we control for the two success ratios at the higher level, the effect of quotas per capita remains robust, which alleviates any concerns that the impact of quotas per capita captures the effect of human capital and political connections.

4.3.2. Controlling for relevant political and economic activities

The abolition-engendered outlets for talent, however, were not limited to the establishment of modern firms and overseas study: removal of the traditional career path also encouraged would-be elites to participate in revolution (Bai and Jia, 2016). Yet why did some of these latter choose to rebel while others pursued a new educational path or started

[22] We count the total number of presented scholars and the total number of senior government officials born in each prefecture from 1644 to 1904, and then calculate the ratios of presented scholars to quotas, and of senior officials to presented scholars.

Table 4
The impact of the success ratio under the civil examination system.

	(1) Firms per million population				(2) Students per million population			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post × Quotas per capita × 10^{-3}	2.682***			2.587***	2.944*			2.759*
	(0.784)			(0.749)	(1.755)			(1.650)
Post × Presented		0.231***		0.158***		0.622***		0.535***
scholars/Quotas		(0.066)		(0.051)		(0.180)		(0.176)
Post × Senior			−0.375	−0.163			0.291	0.484*
officials/Presented scholars			(0.355)	(0.125)			(0.220)	(0.286)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2620	2620	2540	2540	2620	2620	2540	2540
R-squared	0.138	0.102	0.105	0.152	0.442	0.443	0.436	0.454

Note: The results are for a two-way fixed effects model; standard errors clustered at the prefecture level are in parentheses. The baseline controls include all variables in column (8) of Table 2. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

up modern businesses? Historical narratives like the diary of Liu Dapeng (Liu, 1990) - which records post-abolition changes in his home village of Chiqiao, Shanxi province - provide some clues to this mystery. According to Dapeng, whereas many whose pre-abolition income would have come primarily from teaching (mainly those with lower level degrees) switched successfully to the new education system (May 26, 1905) or went to study in Japan (March 20, 1906), those who could not adapt lost their positions and fell into poverty (June 29, 1908). Among those who attempted the transition, the most talented tended to move into the business sector (September 3, 1907), while the less talented preferred to enter the new school system and were more likely to become radical revolutionaries (August 30, 1907). Although this pattern may have arisen because Shanxi merchants dominated Chinese commerce at that time, providing more business opportunities in Shanxi province, these anecdotes suggest that post abolition, individuals tended to choose the activity that could maximize their expected returns conditional on their own characteristics (e.g., ability or social status) and regional factors (e.g., business environment).

To formalize this idea and explore the choices between all three activities, we extend the two-sector Roy model used in the previous analysis to a multisector version. Specifically we assume a model with 1 traditional sector ($i = 1$) and $N - 1$ modern sectors ($i = 2, 3, \ldots, N$), denoting the log earnings to choose the ith sector as $\ln w_i = \kappa_i + \eta_i$, with η_i representing the de-mean value of a skill in the ith sector, and $(\eta_1, \eta_2, \ldots, \eta_N)$ being jointly multivariate and normally distributed. The jth sector is then chosen if and only if $\ln w_j \geq \ln w_k$ for all $j \neq k$. The probability of choosing the jth sector can thus be written as

$$\Pr_j = \Pr[\eta_1 - \eta_j < \kappa_j - \kappa_1, \ldots, \eta_i - \eta_j < \kappa_j - \kappa_i, \ldots, \eta_N - \eta_j < \kappa_j - \kappa_N].$$

Before abolition, κ_1 is an increasing function of logged quotas per capita ($\ln q$), so $\partial \Pr_j / \partial \ln q < 0$. After abolition, κ_1 is unrelated to quotas, so $\partial \Pr_j / \partial \ln q = 0$. Even using this multisector framework, a DID approach can still identify the negative incentive effect of the civil service examination.

Within this extended framework, changes in the quota effect vary between modern sectors, so we compare the magnitude of the quota effect on the three activities. Because the data on revolutionaries is limited, we focus on the 1900–1906 period (Table 5, columns (1), (2), and (5)) and use the logged term as the dependent variable so that the coefficient can be interpreted as elasticity. We find that a 1 percent increase in quotas post abolition led to a 0.118 percent increase in revolutionary participation, a 0.041 percent increase in modern firm establishment, and a 0.171 percent increase in overseas study in Japan.[23] During the short period immediately after abolition, the effects on overseas study in Japan and revolutionary participation, particularly, are much larger than the effect on the establishment of modern firms.

Because these alternative choices might be correlated with each other, we next examine what types of relations exist among the political and economic activities and whether these relations affect our estimations. First, we are interested in informally exploring Huntington (1968)'s notion that modern human capital and revolution might be complementary. To do so, we investigate correlation between revolutionary participation and modernization activities and find that the former is positively related to establishing modern firms and studying overseas (Table 5, columns (3) and (6)). Next, we estimate the relation between the two modernization activities and do in fact find them to be positively correlated (columns (4) and (7)). Nonetheless, since our data do not cover all activities related to modernization, this finding, although interesting, cannot empirically support the complementarity of all modernization activities. In theory, some activities might be negatively correlated (substituted). As our data only include forming modern firms and studying overseas, and not all activities related to modernization can be enumerated, we are unable to observe this notion empirically.

It is particularly worth noting that our estimates remain stable even when the inclusion of alternative activities (Table 5, column (2) vs. columns (3) and (4); column (5) vs. columns (6) and (7)), thereby somewhat mitigating any concern over omitted variables. Since these activities are positively correlated, implying that they might be related with some common unobservables. If the interaction between the logged quotas per capita and the post-abolition dummy were capturing the effects of these unobserved variables, then the inclusion of alternative activities would change the coefficient of the interaction term, which in our results is not the case.

4.4. Heterogeneous effects

4.4.1. The role of initial economic conditions

While hypothesizing that talented individuals tended to be reallocated to the modern sector after examination system abolition, we also recognize that some unobserved metric like physical capital may also have been reallocated between the two sectors. Although we cannot distinguish between these cases, if physical capital reallocation is a major channel driving our results, there should be a larger increase in the

[23] When evaluated at the mean, a one standard deviation increase in logged quotas per capita leads to a 0.146 standard deviation increase in logged revolutionary participation, a 0.117 standard deviation increase in logged modern firm establishment, and a 0.223 standard deviation increase in logged overseas study in Japan.

Table 5
Controlling for various political and economic activities.

	ln (Revolutionaries+1)	ln (Firms+1)			ln (Students+1)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post × ln(Quotas per capita)	0.118**	0.041**	0.038**	0.036**	0.171***	0.152***	0.165***
	(0.050)	(0.017)	(0.017)	(0.017)	(0.048)	(0.045)	(0.048)
ln (Revolutionaries+1)			0.030*			0.160***	
			(0.018)			(0.035)	
ln (Students+1)				0.032*			
				(0.017)			
ln (Firms+1)							0.136**
							(0.068)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1834	1834	1834	1834	1834	1834	1834
R-squared	0.443	0.215	0.219	0.219	0.591	0.604	0.592

Note: The results are for a two-way fixed effects model; standard errors clustered at the prefecture level are in parentheses. The baseline controls include all variables in column (8) of Table 2. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

quota effect in richer regions. To test this prediction, we investigate the heterogeneous effect of quotas using the logged urban population in 1893 to proxy for initial economic conditions (denoted by W_i). We then interact this proxy with the post-abolition dummy and the logged quotas per capita (for a triple interaction term):

$$y_{it} = \beta Post_t \times \ln q_i + Post_t \times W_i\theta_1 + Post_t \times W_i \times \ln q_i\theta_2 + Post_t \times Z_i\gamma + \lambda_i + \eta_t + \delta_{prov} \cdot \eta_t + \varepsilon_{it}.$$

In the triple term, we de-mean both the logged city population from 1893 and the logged quotas per capita, allowing the coefficient of $Post_t \times \ln q_i$ to be interpreted as the change in the effects of logged quotas per capita when evaluated at the average initial economic condition. Comparing the estimates in Table 6, columns (1) and (6), with the baseline results in Table 2, columns (1) and (4), reveals that the coefficient of $Post_t \times \ln q_i$ changes only trivially when we control for the role of the city. Hence, although we find a significant increase in the effects of the initial economic condition, the effect of the triple term is not significant, suggesting that even in poor regions, local elites may still have had sufficient resources to establish modern firms or send individuals to study in Japan.

4.4.2. The role of government

Another challenge in our identification strategy is that the civil examination might have been abolished at the same time as the government adopted other policy changes, such as the various reforms launched to reduce startup costs and stimulate economic growth. In fact, even before abolition (i.e., during the Self-Strengthening Movement and Reform Movement of 1898), the Qing government had invested resources in modern educational infrastructure and government-owned firms. Following abolition, it was able to reallocate even more resources to modern education and the economic sector. If such government behaviors or other policy shocks could explain our findings, the impact of the quotas post abolition should be much larger in prefectures in which the government had more political power or economic resources. We thus hypothesize that the quota effect could be increased by two factors: the government's rank in the political hierarchy, proxied by a provincial capital dummy, and the economic resources under government control, represented by the number of government-owned firms before 1904.

To test these possibilities, we interact the provincial capital dummy and the logged number of government-owned firms (G_i) with the post-abolition dummy and the logged quotas per capita (the triple interaction term):

$$y_{it} = \beta Post_t \times \ln q_i + Post_t \times G_i\theta_1 + Post_t \times G_i \times \ln q_i\theta_2 + Post_t \times Z_i\gamma + \lambda_i + \eta_t + \delta_{prov} \cdot \eta_t + \varepsilon_{it}.$$

Focusing first on the role of the provincial capital (Table 6, columns (2) and (7)), our inclusion of the triple term allows the coefficient on $Post_t \times \ln q_i$ to be interpreted as the change in the logged quotas per capita effect in noncapital prefectures, which remains significantly positive. More important, the triple term is not significant, implying no systemic differences between capital and noncapital prefectures in the change in quota effect. When we shift the focus to the accumulated number of government-owned firms in 1904 (columns (3) and (8)), the triple term is again not significant, which, when combined with previous results, strongly suggests that the role of government cannot explain our main findings.

4.4.3. The role of Western penetration

Given our main empirical finding that regions with larger quotas tended to learn and adopt more modern knowledge, we need to check whether the quota effect is conditional on modern knowledge availability (i.e., the supply of *useful knowledge*). To do so, we focus on the most important source of Western knowledge in the late Qing, treaty ports, whose presence in 1904 we denote by a treaty ports dummy (K_i) whose triple term we check against the logged quotas per capita and the post-abolition dummy:

$$y_{it} = \beta Post_t \times \ln q_i + Post_t \times K_i\theta_1 + Post_t \times K_i \times \ln q_i\theta_2 + Post_t \times Z_i\gamma + \lambda_i + \eta_t + \delta_{prov} \cdot \eta_t + \varepsilon_{it}.$$

As before, the inclusion of the triple term allows the coefficient on $Post_t \times \ln q_i$ to be interpreted as the change in the logged quotas per capita effect in prefectures without treaty ports, whose coefficient remains significantly positive (Table 6, columns (4) and (9)). Yet again, the triple term is not significant, implying no systemic differences between treaty ports and nontreaty ports in the change in quota effect.

Yet treaty ports affect not only access to modern knowledge but also many other aspects, such as trade opportunities and institutions. Hence, as another proxy for knowledge diffusion, we use the 1904 extent of Protestantism, which significantly affected China's economic development between 1840 and 1920, with over 90 percent of the effect coming via the diffusion of useful knowledge (Bai and Kung, 2015). We find that although most missionaries came not from Japan but from Western countries, Protestantism strengthened the impact of quotas following abolition, possibly because missionary schools provided preliminary education for talented students and thus helped them to study abroad. We find no such effect, however, on the establishment of modern firms, perhaps because when the examination was abolished, access to knowledge related to modern firms was not an important constraint on entrepreneurs. Lastly, in the presence of these controls, $Post_t \times \ln q_i$ remains significantly positive, implying that Western penetration is also unable to explain our main findings.

Table 6
Triple effects.

	Firms/population					Students/population				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Post × ln (Quotas per capita)	0.199**	0.231**	0.222**	0.263**	0.175**	0.670**	0.597**	0.638**	0.699**	0.712**
	(0.091)	(0.111)	(0.107)	(0.116)	(0.084)	(0.319)	(0.302)	(0.307)	(0.305)	(0.300)
Post × ln (City pop in 1893 + 1)* ln (Q/P)	−0.033					0.256				
	(0.067)					(0.165)				
Post × ln(City pop in 1893 + 1)	0.064**					0.320***				
	(0.028)					(0.080)				
Post × Provincial capital* ln (Q/P)		0.202					0.231			
		(0.220)					(0.609)			
Post × Provincial capital		0.106					1.003***			
		(0.082)					(0.322)			
Post × ln (Govt. owned firms+1)* ln (Q/P)			0.033					0.433		
			(0.183)					(0.514)		
Post × ln (Govt. owned firms+1)			0.217**					0.757**		
			(0.094)					(0.300)		
Post × Treaty port* ln (Q/P)				−0.235					0.305	
				(0.326)					(0.331)	
Post × Treaty port				0.146					0.607**	
				(0.159)					(0.236)	
Post × ln (Prot. dur+1)* ln (Q/P)					−0.009					0.024***
					(0.007)					(0.007)
Post × ln (Prot. dur+1)					0.003					0.024***
					(0.002)					(0.006)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2620	2620	2620	2620	2620	2620	2620	2620	2620	2620
R-squared	0.104	0.103	0.104	0.104	0.106	0.458	0.451	0.450	0.447	0.454

Note: The results are for a two-way fixed effects model; standard errors clustered at the prefecture level are in parentheses. The baseline controls include all variables in column (8) of Table 2. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

5. RD design

A further concern, however, is that our estimations might be biased by some unobserved time-invariant factors related to quotas, which a DID approach can only rule out when their effects do not change before or after the civil examination system abolition. On the other hand, a change is possible in the effects of omitted variables, some of which (F_i) are correlated with logged quotas per capita. For instance, after the abolition, elite recruitment may rely more on such omitted variables as political connectedness. If the quotas are indeed positively related to omitted variables (e.g., political connectedness) and the effect of omitted variables on the return to the public sector increases post abolition, a DID estimation might underestimate the change in the quota effect.

5.1. Fuzzy RD design: discontinuous rule in quota assignment

As previously mentioned, when the Manchu conquered China and established the Qing Dynasty, their central government adopted a dichotomous classification of prefectures proposed (but never implemented) by the Ming Dynasty (Liu, 1993), which categorized them as either important (administratively "troublesome", $I = 1$) or unimportant (administratively "simple", $I = 0$). One criterion was whether the agricultural tax (x) passed the threshold of 150,000 piculs, in which case ($x \geq 150$, unit: 1,000 piculs), the prefecture was classified as important (Zhang, 1987). We therefore hypothesize a discontinuity rule in quota assignment whereby prefectures with an agricultural tax over or equal to 150,000 piculs are more likely to have larger quotas.

In doing so, we recognize that since the quotas assigned between 1644 and 1724 remained relatively stable during the Qing Dynasty (except for the approximately 10 percent increase at the start of the Taiping Rebellion), the discontinuity rule during the early Qing Dynasty could have had a persistent effect on the quotas during the late Qing period. In addition, because a new 4-point ranking of administrative units was introduced in 1731, seven years after original quota assignment, the discontinuity rule had no impact on a prefecture's importance during the late Qing.[24]

This historical background and the fuzzy RD design applied to address the endogeneity are illustrated in Fig. 6, which shows a clear demarcation between the important ($I = 1$) and unimportant prefectures ($I = 0$). More quotas were assigned to the important prefectures during 1644–1724, and remained relatively stable up until abolition. At the same time, replacement of the discontinuity rule by the new rule of importance in 1731 implies that the former had no direct effect on prefecture importance in the late Qing Dynasty. It is also worth noting that although an agricultural tax of 150,000 piculs is a sufficient condition for importance, it is not a necessary one. Prefectures could also be deemed important if they held a prince's mansion, were the seat of a provincial government (a city with all three departments in it), had stationed troops, had vital postal routes, or provided for armed forces (Zhang, 1987). These additional conditions relax the concern that the central government might have manipulated the agricultural tax to assign an importance ranking to a specific prefecture (e.g., the seat of a provincial government).

To identify the important prefectures empirically, we use Ming tax (x) data compiled by (Liang, 1980, see Fig. A3 of Appendix D) and differ the log terms with the cutoff value ($c = 150{,}000$ piculs) denoted by $\widetilde{x} = \ln(x/c)$. As shown in Fig. A4 of Appendix D (left graph), 72 prefectures around the cutoff value are within the one standard deviation bandwidth, 36 of which have an agricultural tax larger than the cutoff value. We also test for whether the running variable (agricultural

[24] Under the new system, every administrative unit (prefecture) was characterized based on the presence or absence of four administrative dimensions - economy, transportation, difficulty of governance, and security. Specifically, the four attributes are (1) having a center of communication (Chong, "thoroughfare"), (2) engaging in a great deal of official business (Fan, "troublesome, abundant"), (3) difficult to collect taxes from (Pi, "fatigue"), and (4) having a crime-prone populace (Nan, "difficulty"). They yield 16 (4×4) possible post designations. The central government's Board of Personnel used this classification system to designate four post levels - most important, important, medium, and simple - whose use continued until the end of the Qing Dynasty.

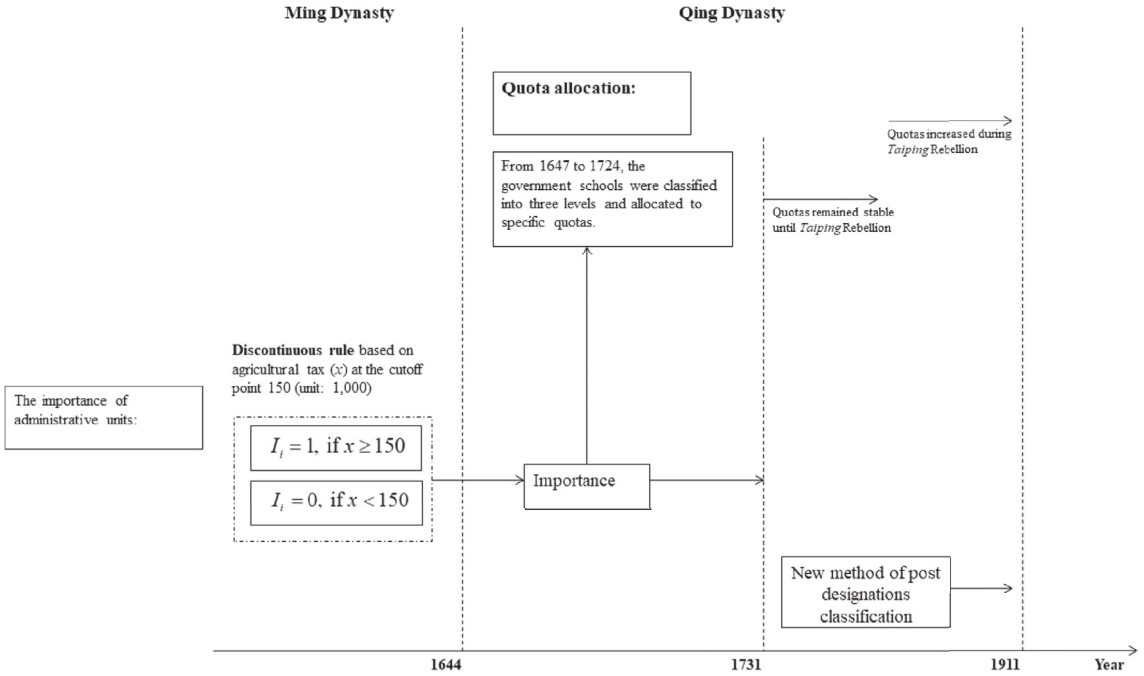

Fig. 6. Historical background of the regression discontinuity design.

tax during the Ming Dynasty) was subject to manipulation by adopting McCrary (2008)'s method of examining the continuity of the running variable density function around the cutoff point. The results, reported in Appendix D, show no significant change in this continuity, indicating no substantive problem of Ming tax manipulation.

5.2. Model specifications

5.2.1. Nonparametric method

We use fuzzy RD to exploit the discontinuity in the expected value of treatment I_i, conditional on agricultural tax (x). There is a jump in the expected value of $\ln q_i$ at $c = 150$ (unit: 1000 piculs), so that:

$$E[\ln q_i \mid \widetilde{x}_i, Z_i] = \begin{cases} f_1(\widetilde{x}_i, Z_i) & \text{if } \widetilde{x}_i \geq 0 \\ f_0(\widetilde{x}_i, Z_i) & \text{if } \widetilde{x}_i < 0. \end{cases} \tag{7}$$

The nonparametric version of the fuzzy RD can then be represented by

$$E[\ln q_i | 0 < \widetilde{x}_i < \delta, Z_i] - E[\ln q_i | -\delta < \widetilde{x}_i < 0, Z_i] \simeq \psi^*. \tag{8}$$

To derive the fitted values from the nonparametric regressions, we use Cleveland (1979)'s tricube weighting function and a bandwidth of 1, estimated separately for prefectures on either side of the cutoff value, meaning that they represent a moving average of quotas across this value. The nonparametric results (see Fig. 7) - especially the discontinuous increase when taxes are just above the 150,000 picul cutoff value - provide strong evidence that the important prefectures were indeed assigned larger quotas.

We then perform the same exercise as above but with the logged quotas per capita replaced by the change in the average numbers of private firms (per million inhabitants) established each year pre and post abolition (left graph) and then replacing the dependent variable with the density of new students. To do so, we use the reduced-form conditional expectation of modernization activities expressed in Equation (9):

$$E[\Delta y_i | 0 < \widetilde{x}_i < \delta, Z_i] - E[\Delta y_i | -\delta < \widetilde{x}_i < 0, Z_i] \simeq \beta\psi^*. \tag{9}$$

The outcomes for both analyses (see left and right graph, respectively, of Fig. 8) show a similar jump at the cutoff value. β can be estimated by dividing Equation (9) by (8) and taking a limit as δ tends to zero. Although we cannot provide a convincing non-parametric estimation since it requires a large number of observations near the treatment threshold (Imbens and Lemieux, 2008), these graphs (Figs. 7 and 8) could provide visual evidence that prefectures with larger quotas tended to establish more firms and send more students to Japan after the abolition of the imperial civil examination.

5.2.2. Parametric method: controlling for the polynomials

Although nonparametric techniques have the advantage of not relying on the assumption of functional form, we use a parametric method here because of the small sample size, rewriting Equation (7) as

$$E[\ln q_i \mid \widetilde{x}_i, Z_i] = f_0(\widetilde{x}_i, Z_i) + I_i \cdot [f_1(\widetilde{x}_i, Z_i) - f_0(\widetilde{x}_i, Z_i)]. \tag{10}$$

Assuming that $f_1(x_i, Z_i)$ and $f_0(x_i, Z_i)$ are describable by pth-order polynomials, then Equation (10) can be rewritten as

$$\ln q_i = \psi_0^* I_i + \sum_{j=1}^{P} (\psi_{00} + \psi_{0p}\widetilde{x}_i^j + \psi_j^* \widetilde{x}_i^j I_i) + Z_i\psi + \nu_i, \tag{11}$$

where $\widetilde{x}_i^j$ is the jth polynomial and $\widetilde{x}_i^j I_i$ is the interaction between the jth polynomial and the importance indicator. In this case, I_i can be regarded as an instrument of the logged quotas per capita.

5.2.3. Polynomial order and bandwidth selection

In the case of polynomial regressions, the key question is the choice of polynomial order, which we decide here based on the Akaike information criterion (*AIC*) of model selection. In a regression discontinuity context, the *AIC* is given by $n\ln(\hat{\sigma}^2) + 2(P+1)$, where $\hat{\sigma}$ is the mean squared error of the regression (Lee and Lemieux, 2010), so we can choose P to minimize the *AIC*. Another key issue is the choice of an appropriate bandwidth (δ) around the regression cutoff point given that a large bandwidth is generally more precise (i.e., more available observations), but the polynomial function provides a closer approximation within a small bandwidth. Hence, to illustrate the robustness of our results, we select several bandwidths, beginning with a small $\delta = 0.5$ ($-0.5\,\text{SD} \leq \widetilde{x} \leq 0.5\,\text{SD}$), and then increase it step by step as follows: $\delta = 0.6, 0.7, 0.8, 0.9, 1.0$. By adhering closely

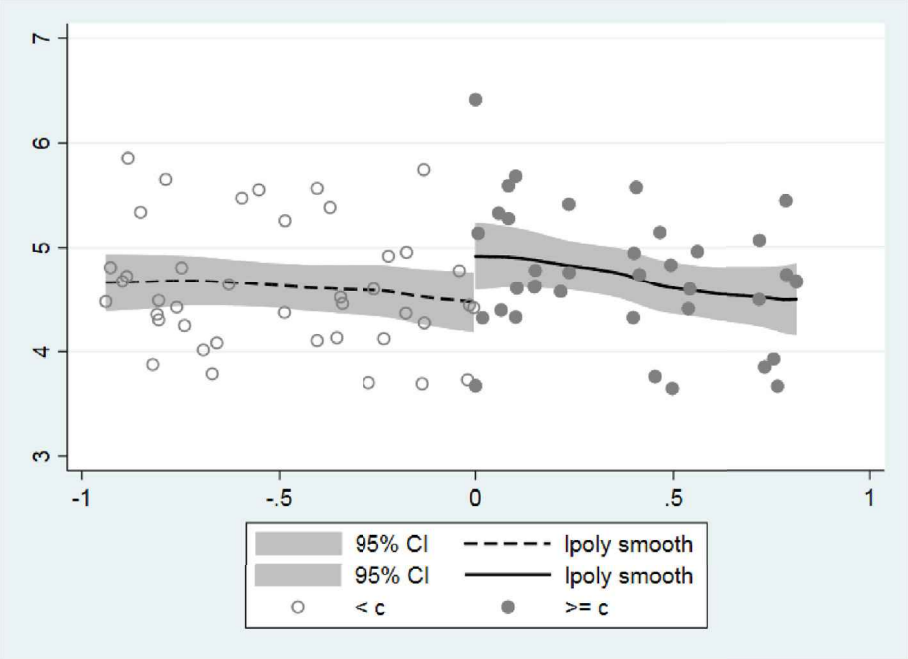

Fig. 7. Nonparametric estimation of RD on the logged quotas per capita.

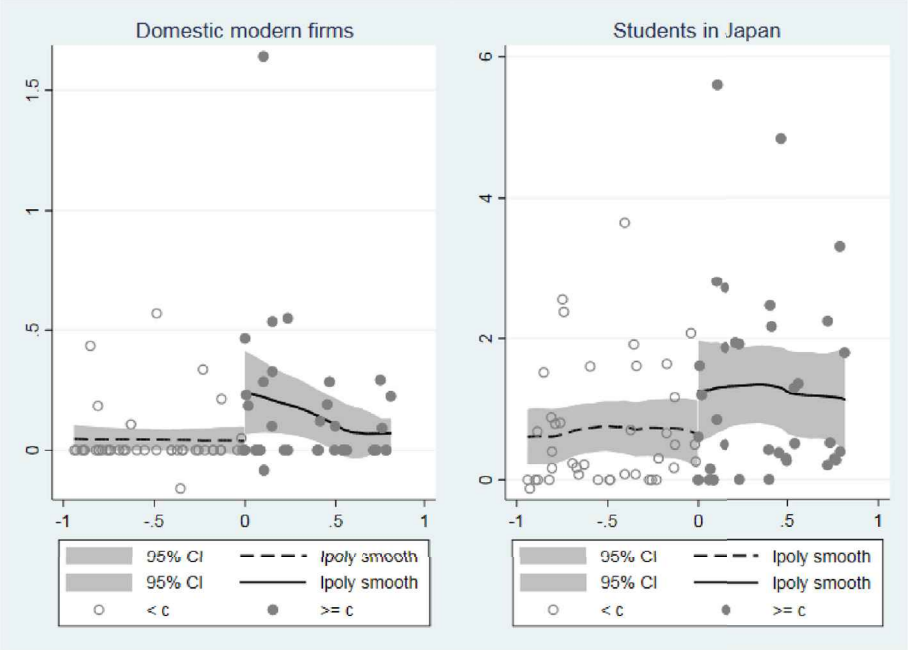

Fig. 8. Nonparametric estimation of RD on the change in modernization activities.

to Imbens and Lemieux's (2008) suggestions for selecting the optimal bandwidth, we determine it to be $-0.55\text{SD} \leq \widetilde{x} \leq 0.55\text{SD}$.

We then test the robustness of the following five specifications of the polynomial of $\widetilde{x}$ in the given bandwidths, each with the following inclusions: I_i alone without any polynomial of $\widetilde{x}$ (polynomial order $P = 0$), the first-order polynomial of $\widetilde{x}$ and its interaction with I_i (polynomial order $P = 1$), the quadratic polynomials ($P = 2$) and their interactions with I_i, the cubic polynomials ($P = 3$), and their interactions with I_i, and the quartic polynomials ($P = 4$), and their interactions with I_i (see Table 7, rows (1) through 5, respectively). In all these specifications and in all bandwidths, the significance of I_i shows the results to be insensitive to polynomial order.

Table 7 also reports the *AIC* statistics for each specification, which allows the optimal polynomial order to be decided based on AIC minimization. For instance, for $\widetilde{x} \in [-0.5, 0.5]$, the optimal polynomial order is 1, implying that only linear polynomials and their interaction with I_i are controlled for. The optimal polynomial order, reported in the penultimate row, indicates that when the bandwidth is enlarged, it is unnecessary to include the higher order polynomial. The table further indicates that the effects of I_i range from 0.168 to 0.603, meaning that any prefecture with Ming agricultural taxes exceeding 150,000 piculs would have had an 18.3 ($e^{0.168} - 1$) to 82.7 ($e^{0.603} - 1$) percent higher quota per capita.

Table 7
Model specifications for the RD design: Bandwidth and polynomials.

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Optimal Bandwidth
Bandwidth	(−0.5, 0.5)	(−0.6, 0.6)	(−0.7, 0.7)	(−0.8, 0.8)	(−0.9, 0.9)	(−1.0, 1.0)	(−0.55, 0.55)
A: No polynomial	0.290***	0.273***	0.282***	0.290***	0.303***	0.314***	0.287***
	(0.068)	(0.066)	(0.058)	(0.055)	(0.055)	(0.054)	(0.067)
R-squared	0.913	0.902	0.894	0.892	0.884	0.880	0.913
B: Linear polynomial	0.336***	0.313***	0.282***	0.222**	0.168*	0.167*	0.328***
	(0.110)	(0.102)	(0.094)	(0.094)	(0.094)	(0.085)	(0.104)
R-squared	0.914	0.903	0.894	0.893	0.888	0.888	0.914
AIC:	−166.979	−186.5	−219.473	−250.571	−261.306	−293.238	−185.301
C: Quadratic polynomial	0.469***	0.457***	0.415***	0.356***	0.338***	0.329***	0.494***
	(0.155)	(0.138)	(0.125)	(0.118)	(0.109)	(0.107)	(0.145)
R-squared	0.917	0.908	0.898	0.896	0.893	0.893	0.917
AIC:	−162.066	−184.191	−216.279	−246.839	−259.196	−292.345	−181.596
D: Cubic polynomial	0.434**	0.448**	0.462***	0.410***	0.355**	0.393***	0.411**
	(0.177)	(0.174)	(0.156)	(0.137)	(0.138)	(0.124)	(0.162)
R-squared	0.925	0.909	0.899	0.900	0.895	0.896	0.924
AIC:	−161.938	−177.462	−209.881	−243.673	−254.385	−289.154	−180.432
E: Quartic polynomial	0.603***	0.481***	0.410**	0.382**	0.358**	0.359**	0.588***
	(0.200)	(0.177)	(0.183)	(0.156)	(0.152)	(0.146)	(0.185)
R-squared	0.932	0.924	0.900	0.900	0.895	0.897	0.931
AIC:	−161.468	−184.843	−203.963	−237.239	−247.741	−283.031	−180.898
Optimal specification:							
Order of polynomial	1	1	1	1	1	1	1
Number of observations	72	81	92	101	107	116	77
$\widetilde{x} \geq 0$	36	43	50	56	60	66	41
$\widetilde{x} < 0$	36	38	42	45	47	50	36

Note: Although not reported, control variables (whether located along the Changjiang (Yangtze) River or on the coast, latitude and longitude, size (area in log-term), and total population in 1880 (log-term)), polynomials, the interaction terms between polynomials and "Important" entitlement, province dummies, and constant terms are included in the regressions. Robust standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

5.3. Instrument validity

The only notable change that followed quota assignment during the early Qing period occurred at the onset of the Taiping Rebellion, and the old system of ranking administrative units had by then already been abolished. Hence, a natural placebo test of instrument validity is to test that the importance indicator I_i is correlated only with the logged quotas per capita and not with this rebellion era change. As Table 8 shows, the importance indicator I_i is indeed strongly correlated with the pre-Taiping rebellion logged quotas per capita but not significantly correlated with its change during the Taiping Rebellion (rows (1) and (2) of Table 8).

One assumption of the instrument is that the classification system of administrative units (based on post designation) changed greatly in 1731, which is not related with I_i. However, if I_i still influenced the importance of prefectures in the late Qing period, then our instrument might affect firm establishment via other channels. For instance, the Qing government could have paid more attention to the important prefectures, leading to the construction of more state enterprises in these locations. To test the validity of this assumption, we employ two variables: a binary variable for whether the prefecture is problematic for tax collection (i.e., "troublesome" or not) and a category variable for prefecture importance, ranked based on the 1731 amended ranking of simple, medium, important, and most important. We then regress these variables on I_i using the following specification:

$$W_i = \psi_0^* I_i + \sum_{j=1}^{P} (\psi_{00} + \psi_{0p}\widetilde{x}_i^j + \psi_j^*\widetilde{x}_i^j I_i) + Z_i\psi + \nu_i. \quad (12)$$

The results, reported in Table 8, rows (3) and (4), respectively, show no significant relation.

The RD approach also requires another identifying assumption: that all outcomes except quota size must vary smoothly at the cutoff point. Thus, supposing that W^1 and W^0 are potential outcomes in the two groups with $I_i = 1$ and $I_i = 0$, then $E(W^1 \mid x, Z)$, and $E(W^0 \mid x, Z)$ should be continuous at the threshold.[25] To evaluate the plausibility of this assumption, we draw on Equation (12) and use two dummies to signify economic prosperity (W_i): the city population in 1893 (log term) and the number of open bank branches in the 1850s. We find that the effect of the importance indicator (I_i) is insignificant, suggesting that I_i is not correlated with other variables related to economic prosperity, a key factor that might affect enterprise establishment. An additional analysis of two factors of Western penetration - the duration of treaty ports in 1904 and the total number of foreign firms - confirms that all these variables vary smoothly at the cutoff point.

5.4. Instrumental evidence

To instrument the logged quotas per capita and estimate its effect on modernization, we use a two-stage least squares method:

$$y_{it} = \rho Post_t \times \ln q_i + Post_t \times Z_i\gamma + \sum_{j=1}^{P} Post_t \times (\kappa_{00} + \kappa_{0j}\widetilde{x}_i^j + \kappa_j^*\widetilde{x}_i^j) + \lambda_i + \eta_t + \delta_{prov} \cdot \eta_t + \varepsilon_{it}$$

$$Post_t \times \ln q_i = \psi_0^* Post_t \times I_i + \sum_{j=1}^{P} Post_t \times (\psi_{00} + \psi_{0p}\widetilde{x}_i^j + \psi_j^*\widetilde{x}_i^j I_i) + Post_t \times Z_i\psi + \lambda_i + \eta_t + \delta_{prov} \cdot \eta_t + \nu_{it}$$

[25] In Appendix D, we show that for most variables, the differences in baseline controls and political and economic outcomes between prefectures below and above the cutoff is not significant (Table A3 of Appendix D) except for the importance indicator in the late Qing Dynasty. The significance of this variable also disappears, however, when we include the running variable (see Table 8, row 3).

Table 8
Effect of being ranked "important" on other economic factors: RD estimates.

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Optimal Bandwidth
Bandwidth	(−0.5, 0.5)	(−0.6, 0.6)	(−0.7, 0.7)	(−0.8, 0.8)	(−0.9, 0.9)	(−1.0, 1.0)	(−0.55, 0.55)
(1) ln (Quotas per capita),	0.304***	0.287***	0.257***	0.209**	0.151*	0.136*	0.302***
Pre-Taiping rebellion	(0.113)	(0.098)	(0.092)	(0.090)	(0.090)	(0.081)	(0.100)
R-squared	0.921	0.918	0.910	0.911	0.905	0.903	0.921
(2) Δ ln (Quotas per capita),	0.032	0.026	0.025	0.014	0.017	0.031	0.026
During Taiping rebellion	(0.052)	(0.045)	(0.041)	(0.039)	(0.035)	(0.034)	(0.048)
R-squared	0.750	0.765	0.772	0.777	0.782	0.789	0.770
(3) On an "important"	−0.336	−0.228	−0.283	−0.074	−0.074	−0.030	−0.190
ranking	(0.425)	(0.396)	(0.353)	(0.313)	(0.296)	(0.275)	(0.398)
R-squared	0.496	0.413	0.427	0.427	0.365	0.359	0.437
(4) On a "troublesome"	−0.025	0.049	0.018	−0.008	0.036	0.061	0.059
ranking	(0.165)	(0.158)	(0.143)	(0.139)	(0.129)	(0.129)	(0.162)
R-squared	0.435	0.393	0.358	0.352	0.288	0.280	0.419
(5) ln (City pop in 1893 + 1)	0.644	0.668	0.453	0.212	0.166	0.136	0.507
	(0.615)	(0.537)	(0.480)	(0.446)	(0.398)	(0.406)	(0.552)
R-squared	0.585	0.551	0.516	0.488	0.490	0.434	0.578
(6) ln(Bank in 1850 + 1)	0.153	0.095	0.072	0.045	0.030	−0.023	0.107
	(0.209)	(0.174)	(0.154)	(0.122)	(0.116)	(0.125)	
							(0.181)
R-squared	0.326	0.310	0.277	0.288	0.274	0.214	0.303
(7) Duration of treaty ports	5.774	5.851	5.861	4.250	5.159	4.886	7.167
	(10.052)	(8.776)	(7.340)	(6.167)	(5.929)	(5.548)	(9.387)
R-squared	0.443	0.421	0.373	0.367	0.348	0.317	0.439
(8) ln(Cum. foreign firms+1)	−0.003	0.020	0.035	0.060	0.061	0.111	0.027
	(0.252)	(0.220)	(0.182)	(0.149)	(0.142)	(0.155)	(0.230)
R-squared	0.535	0.525	0.470	0.462	0.420	0.339	0.534
Number of observations	72	81	92	101	107	116	77

Note: Although not reported, control variables (whether located along the Changjiang (Yangtze) River or on the coast, latitude and longitude, size (area in log-term), and total population in 1880 (log-term)), polynomials, the interaction terms between polynomials and "Important" entitlement, province dummies, and constant terms are included in the regressions. Robust standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

where $Post_t \times I_i$ instruments $Post_t \times \ln q_i$ while controlling for the interaction of the polynomial of $\widetilde{x}_i$, importance indicator I_i, and post-1904 dummy $Post_t$ (Angrist and Pischke, 2009). Polynomial order is determined by the AIC statistics given in Table 7. The main results using the optimal bandwidth of $-0.55\text{SD} \le \widetilde{x} \le 0.55\text{SD}$ (see Table 9) support the hypothesis that post abolition, the effect of the logged quotas per capita increased by about 0.697, significant at a 1 percent probability. We also find that the instrumented effect of the quota is much larger than the baseline results.[26] To test whether these results are sensitive to polynomial order, we further estimate them with the inclusion of the quadratic, cubic, and quartic polynomials. The effect of $Post_t \times \ln q_i$ ranges from 0.582 to 0.608 and remains significant. When we repeat the exercise with different bandwidths to check for bandwidth sensitivity, the results remain robust and stable across bandwidth choices, with highly significant coefficients between 0.677 and 1.218 (see columns (2)–(7)).

We then rerun the analysis using number of new Chinese students in Japan (rather than new firms) as the dependent variable, showing a significant 3.771 increase in the effect post abolition (Table 10, column (1)). Then, by comparing the instrumental evidence for different polynomial orders and different bandwidths with the baseline results (last row), we show a 0.788 to 1.193 increase in the effects of the logged quotas per capita post abolition, which, once the instrument corrects for potential bias, increases to between 2.470 and 3.711, much larger than the baseline.

6. Talent allocation: the effect on individual skill levels

Having already demonstrated a greater number of modernization activities after civil examination system abolition, especially in the regions with higher quotas per capita, we now test whether a substantial pool of talented people was allocated to the traditional sector who did not pursue modernization activities before abolition. If the civil examination did indeed lead to such talent misallocation, then the average skill level of laborers in the modern sector should have increased post abolition as more talented individuals began pursuing these activities. This prediction could enhance our understanding of the interrelation between talent allocation and knowledge diffusion, since the knowledge diffusion may not necessarily have such prediction.

To derive a testable hypothesis, we begin by calculating the expected return based on our conceptual framework:

$$E(\ln w_0 \mid M=1) = \kappa_0 + E(\eta_0 \mid M=1)$$
$$= \kappa_0 + \frac{\sigma_0\sigma_1}{\sigma_v}(\rho_{01} - \frac{\sigma_0}{\sigma_1})\lambda(\frac{\kappa_0-\kappa_1}{\sigma_v})$$
$$E(\ln w_1 \mid M=1) = \kappa_1 + E(\eta_1 \mid M=1)$$
$$= \kappa_1 + \frac{\sigma_0\sigma_1}{\sigma_v}(\frac{\sigma_1}{\sigma_0} - \rho_{01})\lambda(\frac{\kappa_0-\kappa_1}{\sigma_v}),$$

where $M = 1$ represents individuals who pursue the modern system, and $E(\ln w_0 \mid M = 1)$ and $E(\ln w_1 \mid M = 1)$ denote the expected returns in the traditional and modern sectors, respectively. Based on these two equations, we can write the expected skill levels in the two sectors of individuals who pursue the modern system as

$$E(\eta_0 \mid M=1) = \frac{\sigma_0\sigma_1}{\sigma_v}(\rho_{01} - \frac{\sigma_0}{\sigma_1})\lambda(\frac{\kappa_0-\kappa_1}{\sigma_v})$$
$$E(\eta_1 \mid M=1) = \frac{\sigma_0\sigma_1}{\sigma_v}(\frac{\sigma_1}{\sigma_0} - \rho_{01})\lambda(\frac{\kappa_0-\kappa_1}{\sigma_v})$$

where ρ_{01} represents the correlation between the skills in the two sectors. The question remains, however, of whether the skill level of individuals who pursue the Western system ($M = 1$) is high or low. Deter-

[26] We report the baseline results for the corresponding subsample at the bottom of Table 9.

Table 9
Effect on the establishment of modern firms.

Bandwidth	(1.1)	(1.2)	(1.3)	(1.4)	(2)	(3)	(4)	(5)	(6)	(7)
	Optimal bandwidth				(−0.5, 0.5)	(−0.6, 0.6)	(−0.7, 0.7)	(−0.8, 0.8)	(−0.9, 0.9)	(−1.0, 1.0)
	(−0.55, 0.55)									
Second Stage										
Post × ln(Quotas per capita)	0.697***	0.582***	0.608**	0.582***	0.731***	0.677***	0.961***	0.904***	1.218***	0.956**
	(0.211)	(0.194)	(0.280)	(0.218)	(0.222)	(0.213)	(0.283)	(0.323)	(0.417)	(0.391)
First Stage										
Post × Importance	0.328***	0.494***	0.411***	0.588***	0.336***	0.313***	0.282***	0.222***	0.168***	0.167***
	(0.036)	(0.049)	(0.057)	(0.060)	(0.038)	(0.037)	(0.035)	(0.031)	(0.030)	(0.028)
Post × Linear polynomial	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Post × Quadratic polynomial		Yes	Yes	Yes						
Post × Cubic polynomial			Yes	Yes						
Post × Quartic polynomial				Yes						
Post × Polynomials × Importance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	770	770	770	770	720	810	920	1010	1070	1160
F-Stat (weak IV)	83.9	101.4	52.4	95.0	78.7	71.3	65.9	50.8	31.0	36.9
Baseline Results										
Post × ln(Quotas per capita)	0.306***	(0.080)			0.310***	0.269***	0.164**	0.156**	0.121*	0.127*
					(0.084)	(0.072)	(0.080)	(0.075)	(0.068)	(0.068)
Observations	770				720	810	920	1010	1070	1160
R-squared	0.291				0.295	0.278	0.208	0.196	0.206	0.223

Note: Although not reported, all baseline controls, namely all variables in column (8) of Table 2, are included in the regressions. Standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 10
Effect on overseas study.

Bandwidth	(1.1)	(1.2)	(1.3)	(1.4)	(2)	(3)	(4)	(5)	(6)	(7)
	Optimal bandwidth				(−0.5, 0.5)	(−0.6, 0.6)	(−0.7, 0.7)	(−0.8, 0.8)	(−0.9, 0.9)	(−1.0, 1.0)
	(−0.55, 0.55)									
Second Stage										
Post × ln(Quotas per capita)	3.711***	2.973***	2.382**	1.650*	3.647***	3.612***	3.000***	2.470**	3.328**	2.816**
	(0.870)	(0.788)	(1.120)	(0.860)	(0.905)	(0.871)	(0.925)	(1.056)	(1.337)	(1.221)
First Stage										
Post × Importance	0.328***	0.494***	0.411***	0.588***	0.336***	0.313***	0.282***	0.222***	0.168***	0.167***
	(0.036)	(0.049)	(0.057)	(0.060)	(0.038)	(0.037)	(0.035)	(0.031)	(0.030)	(0.028)
Post × Linear polynomial	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Post × Quadratic polynomial		Yes	Yes	Yes						
Post × Cubic polynomial			Yes	Yes						
Post × Quartic polynomial				Yes						
Post × Polynomials × Importance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	770	770	770	770	720	810	920	1010	1070	1160
F-Stat (weak IV)	83.9	101.4	52.4	95.0	78.7	71.3	65.9	50.8	31.0	36.9
Baseline Results										
Post × ln(Quotas per capita)	1.193***	(0.317)			1.122***	1.149***	0.992***	0.996***	0.788***	0.834***
					(0.334)	(0.289)	(0.270)	(0.253)	(0.232)	(0.219)
Observations	770				720	810	920	1010	1070	1160
R-squared	0.760				0.764	0.755	0.770	0.760	0.757	0.750

Note: Although not reported, all baseline controls, namely all variables in column (8) of Table 2, are included in the regressions. Standard errors are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

mining the answer depends on three parameters, σ_0, σ_1, and ρ_{01}, which we apply to three cases:

Case 1: $1 > \rho_{01} > \frac{\sigma_0}{\sigma_1}$, then $E(\eta_0 \mid M = 1) > 0$ and $E(\eta_1 \mid M = 1) > 0$. Because the skills valued in the traditional system are also valued in the modern (Western) system (ρ_{01} is large) and the return on skills from the modern (Western) sector is larger than that in the traditional sector ($\sigma_0 < \sigma_1$), highly skilled individuals in the traditional sector will choose to pursue the modern system.

Case 2: $1 > \rho_{01} > \frac{\sigma_1}{\sigma_0}$, then $E(\eta_0 \mid M = 1) < 0$ and $E(\eta_1 \mid M = 1) < 0$. Because high wage dispersion ($\sigma_1 < \sigma_0$) makes the traditional education system unattractive to low-skilled individuals, they will choose to enter the modern sector.

Case 3: $\rho_{01} < min(\frac{\sigma_0}{\sigma_1}, \frac{\sigma_1}{\sigma_0})$, then $E(\eta_0 \mid M = 1) < 0$ and $E(\eta_1 \mid M = 1) > 0$. Although individuals who pursue the modern system are selected from the lower tail of the distribution under the traditional system, they become the upper tail under the modern system, because the correlation between the skill levels in the two sectors is sufficiently small.

To determine which is the case for late Imperial China, we examine the effect of the logged quotas per capita on the skill level under the modern system; that is, $E(\eta_1 \mid M = 1)$. Pre abolition, the effect is

$$\frac{\partial E(\eta_1 \mid M=1)}{\partial \ln q} = \frac{\sigma_0\sigma_1}{\sigma_v}\frac{\rho_{01}}{\sigma_v}(\frac{\sigma_1}{\sigma_0} - \rho_{01})\lambda',$$

where $\lambda' > 0$, but post abolition,

$$\frac{\partial E(\eta_1 \mid M=1)}{\partial \ln q} = 0.$$

Hence, the change in the effect of the logged quotas per capita on the skill level in the modern system before and after abolition is

$$\frac{\partial E(\eta_1 \mid M=1)}{\partial \ln q}\Big|_{post-abolition} - \frac{\partial E(\eta_1 \mid M=1)}{\partial \ln q}\Big|_{pre-abolition} = -\frac{\sigma_0\sigma_1}{\sigma_v}\frac{\rho_{01}}{\sigma_v}(\frac{\sigma_1}{\sigma_0} - \rho_{01})\lambda'.$$

As shown in Table 11 (Panel A), only in Case 2 does the civil examination system have a negative impact on talent allocation because only the individuals in the lower tail of the distribution choose to pursue the modern system. That is, a higher probability of passing the civil examination encourages less able individuals to choose the modern track. In Cases 1 and 3, on the other hand, the higher quota density may lead to an increase in individual skill levels within the modern system.

To empirically examine the effect of the logged quotas per capita on skill level, we use the individual dataset of Chinese students in Japan who on their arrival must apply for school or university entrance. In addition to passing an entrance examination, they must study the language and adapt to the educational system, making the more (less) able students more likely to spend a shorter (longer) period in preparation. We therefore use the duration of the school application process (i.e., time between year of arrival in Japan and entrance year) as an inverse measure of skill level. With a mean application duration of about 2.74 years (1584 students), the average duration pre abolition is 4.69 years (203 students) compared to 2.45 years post abolition (1381 students).

This decrease in application duration, however, may not solely result from the examination system abolition: the Japanese government or society may have made changes that affected Chinese student admission (Sanetou, 1983). In fact, in 1905, the Japanese government responded to the massive inflow of Chinese students by enacting the Regulation on the Admission of Chinese Students (*Guanyu Zhunxu Qingguoren Ruxue Zhi Gongsili Xuexiao Guicheng*), which led Chinese students in Japan to boycott classes in protest, suggesting that the changes were not in their favor. At the same time, however, Japanese society invested great effort in facilitating the Chinese students' overseas education in three particular aspects: First, after 1900, they published numerous textbooks for learning the Japanese language, increasing their number from only 2 in 1900 to 58 in 1908 (see Fig. A5 of Appendix E). Second, they established many specialized schools (e.g., the Kobun Institute) to provide Chinese students with Japanese language and general courses. Hence, although our dataset includes only students in formal universities, the existence of such schools could have helped Chinese students pass their entrance examinations. Third, in 1904–1905, three universities (Waseda University, Meiji University, and Hosei University) established college preparatory schools designed to prepare Chinese students for higher education. However, dropping all students affected by these college preparatory schools from our analysis will not change our main findings (see Appendix E: Tables A4 and A5).

To examine the effect of the logged quotas per capita using within-year regional variation, we employ the following specification, which includes the arrival year fixed effect:

$$d_{it} = \beta_0 \ln q_i + \beta_1 Post_t \times \ln q_i + Z_i\gamma_0 + Post_t \times Z_i\gamma_1 + \eta_t + \delta_{prov} \cdot \eta_t + \varepsilon_{it},$$

Table 11
Predicted and estimated effects on overseas student ability.

Panel A: Predicted effects of the logged quotas per capita			
Effects on the skill level of Chinese students in Japan			
	Case 1	Case 2	Case 3
Pre abolition	>0	<0	>0
Post abolition	= 0	= 0	= 0
Change in effects	<0	>0	<0
Effects on the duration of school application			
	Case 1	Case 2	Case 3
Pre abolition	<0	>0	<0
Post abolition	= 0	= 0	= 0
Change in effects	>0	<0	>0
Panel B: Effect on the Duration of School Application			
	(1)	(2)	(3)
(1) ln(Quotas per capita)	0.730**	0.573*	0.578
	(0.325)	(0.321)	(0.381)
(2) Post × ln(Quotas per capita)	−0.730**	−0.686**	−0.700*
	(0.330)	(0.325)	(0.393)
Control variables		Yes	Yes
Post × Control variables			Yes
Arrival year FE	Yes	Yes	Yes
Province × Arrival year FE	Yes	Yes	Yes
Observations	1584	1584	1584
R-squared	0.589	0.591	0.595
ln(Quotas per capita): Post (1)+(2):	0.000	−0.113	−0.122
	(0.083)	(0.109)	(0.108)

Note: Standard errors clustered at the prefecture level are in parentheses. Controls represent a vector of prefecture-level characteristics: whether located along the Changjiang (Yangtze) River or on the coast, latitude and longitude, size (area in log-term), and total population in 1880 (log-term). *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

where d_{it} is the application duration of student j born in prefecture i, who arrives in Japan in year t. The main explanatory variable is the logged quotas per capita ($\ln q_i$) and its interaction term with a dummy for whether the student arrived in Japan after or during 1904. η_t is a set of dummies indicating year of arrival, and $\delta_{prov} \cdot \eta_t$ represents the province specific arrival year effect.

As shown in Table 11 (Panel B), the effect of logged quotas per capita significantly decreases with the abolition of the civil examination, which supports the prediction of Case 2: $\frac{\sigma_1}{\sigma_0} - \rho_{01} < 0$. Likewise, the return on skills in the modern sector is less than that in the traditional sector, and only low-skilled individuals in this latter pursue this system before abolition, reflecting the adverse pre-abolition selection. That is, in late Imperial China, the return from a traditional education under the civil examination was unstable: a candidate who passed the civil examination and became a government official would earn a higher income, but the return for those who failed was very low. The return from a modern Western education, in contrast, was relatively less dispersed during this period.

7. Conclusions

In late imperial China, political power was much more diffused and the political system, less oligarchic. Rather than being hereditary, the ruling elites were selected via the imperial civil examination. Yet although this institution helped the dynasty maintain political stability, it also provided Chinese talent with more incentives to invest in traditional Chinese education and fewer incentives to seek our other types of knowledge, such as science and technology. This focus may be one reason that China's economic leadership failed to spearhead an industrial revolution not only in the fourteenth century but even in the eighteenth.

By examining the abolition of the imperial civil service examination system, we show that after abolition, prefectures with higher quotas tended to establish more modern private enterprises and send more individuals to study overseas. In addition, using an individual dataset of Chinese students in Japan, we demonstrate that the skill level of students in the modern (Western) education system increased following system abolition, especially in regions with higher quotas. Not only does this latter imply that the civil service examination negatively affected talent allocation, but the findings overall support the hypothesis that China's civil examination served as an institutional obstacle to the rise of modern science and industry.

On a more general level, this study expands our understanding of the role of institutions in economic development. More specifically, we empirically confirm that, as proposed in theoretical models (Acemoglu, 1995; Baumol, 1990; Murphy et al., 1991, 1993), a higher payoff for rent seeking results in more unproductive allocation of talent, which is costly to economic growth. Hence, given the popularity of examination-based recruitment of civil servants even today, this historical study may have practical implications for many contemporary societies.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jdeveco.2019.102382.

References

Acemoglu, D., 1995. Reward structures and the allocation of talent. Eur. Econ. Rev. 39, 17–33.
Acemoglu, D., 2008. Oligarchic versus democratic societies. J. Eur. Econ. Assoc. 6, 1–44.
Acemoglu, D., Cantoni, D., Johnson, S., Robinson, J.A., 2011. The consequences of radical reform: the French revolution. Am. Econ. Rev. 101, 3286–3307.
Acemoglu, D., Johnson, S., 2005. Unbundling institutions. J. Political Econ. 113, 949–995.
Allen, R.C., 2009. The British Industrial Revolution in Global Perspective. Cambridge University Press, Cambridge.
Allen, R.C., Bassino, J.P., Ma, D., Moll-Murata, C., Van Zanden, J.L., 2011. Wages, prices, and living standards in China, 1738-1925: in comparison with Europe, Japan, and India. Econ. Hist. Rev. 64, 8–38.
Angrist, J., Pischke, J., 2009. Mostly Harmless Econometrics: An Empiricist's Companion. Princeton University Press, Princeton, NJ.
Bai, Y., Jia, R., 2016. Elite recruitment and political stability: the impact of the abolition of China's civil service exam. Econometrica 84, 677–733.
Bai, Y., Kung, J.K.S., 2015. Diffusing knowledge while spreading god's message: Protestantism and economic prosperity in China, 1840-1920. J. Eur. Econ. Assoc. 13, 669–698.
Baumol, W.J., 1990. Entrepreneurship: productive, unproductive, and destructive. J. Political Econ. 98, 893–921.
Bieler, S., 2004. Patriots or Traitors: A History of American Educated Chinese Students. M.E. Sharpe, Armonk, NY.
Biggerstaff, K., 1961. The Earliest Modern Government Schools in China. Cornell University Press, Ithaca, NY.
Borjas, G.J., 1987. Self-selection and the earnings of immigrants. Am. Econ. Rev. 77, 531–553.
Cantoni, D., Yuchtman, N., 2013. The political economy of educational content and development: lessons from history. J. Dev. Econ. 104, 233–244.
Cantoni, D., Yuchtman, N., 2014. Medieval universities, legal institutions, and the commercial revolution. Q. J. Econ. 129, 823–887.
Chaffee, J.W., 1995. The Thorny Gates of Learning in Sung China. State University of New York Press, Albany, NY.
Chang, C.L., 1955. The Chinese Gentry: Studies on Their Role in Nineteenth-Century Chinese Society. University of Washington Press, Seattle, WA.
Chang, C.l., 1962. The Income of the Chinese Gentry. University of Washington Press, Seattle, WA.
Chang, Y., 1989. Private Industries in the Late Ching and the Early Republic of China, 1860-1916. Bulletin of the Institute of Modern History, Academia Sinica, pp. 315–561. 18.
Chen, T., Kung, J.K.S., Ma, C., 2017. Long Live Keju! the Persistent Effects of China's Imperial Examination System. (Working Paper). .
CHGIS, 2007. Version 4. Harvard Yenching Institute, Cambridge.
Clark, G., Feenstra, R., 2003. Technology in the great divergence. In: Bordo, M.D., Taylor, A.M., Williamson, J.G. (Eds.), Globalization in Historical Perspective. University of Chicago Press, Chicago.
Cleveland, W.S., 1979. Robust locally weighted regression and smoothing scatterplots. J. Am. Stat. Assoc. 74, 829–836.
Dahlstrm, C., Teorell, J., Dahlberg, S., Hartman, F., Lindberg, A., Nistotskaya, M., 2015. The Quality of Government Expert Survey II - A Report. University of Gothenburg: The Quality of Government Institute.
Deng, S., 1995. Government awards to students trained abroad, 1871-1911. Chin. Stud. Hist. 28, 35–46.
Ebrey, P.B., 1999. The Cambridge Illustrated History of China. Cambridge University Press, Cambridge.
Elman, B.A., 1990. Classicism, Politics, and Kinship: the Ch'ang-Chou School of New Text Confucianism in Late Imperial China. University of California Press, Berkeley.
Elman, B.A., 1991. Political, social, and cultural reproduction via civil service examinations in late imperial China. J. Asian Stud. 50, 7–28.
Elman, B.A., 2000. A Cultural History of Civil Examinations in Late Imperial China. University of California Press, Berkeley.
Elman, B.A., 2005. On Their Own Terms: Science in China, 1550-1900. Harvard University Press, Cambridge.
Elman, B.A., 2015. Science in China, 1600-1900: Essays by Benjamin a Elman. World Century, Hackensack, NJ.
Franke, W., 1960. The Reform and Abolition of the Traditional Chinese Examination System. Center for East Asian Studies, Harvard University, Cambridge.
Ge, J., 2000. Zhongguo Renkou Shi (China Population History). Fudan University Press, Shanghai.
Glahn, R.v., 1996. Fountain of Fortune: Money and Monetary Policy in China, 1000-1700. University of California Press, Berkeley.
Ho, P.T., 1962. The Ladder of Success in Imperial China: Aspects of Social Mobility, 1368-1911. Columbia University Press, New York.
Huff, T.E., 2003. The Rise of Early Modern Science: Islam, China and the West. Cambridge University Press, Cambridge.
Huntington, S., 1968. Political Order in Changing Societies. Yale University Press, New Haven and London.
Imbens, G.W., Lemieux, T., 2008. Regression discontinuity designs: a guide to practice. J. Econom. 142, 615–635.
Keay, J., 2009. China: A History. Basic Books, New York.
Kun, G., 1899. Qing Hui Dian Shi Li (Imperially Established Institutes and Laws of the Great Qing Dynasty). Zhonghua shu ju. Reprinted in 1991., Beijing. .
Kuznets, S., 1965. Economic Growth and Structure: Selected Essays. Norton, New York.
La Porta, R., Lopez-de Silanes, F., Shleifer, A., Vishny, R.W., 1997. Trust in large organizations. Am. Econ. Rev. 87, 333–338.
Landes, D.S., 2006. Why Europe and the West? Why not China? J. Econ. Perspect. 20, 3–22.
Leado, B., 2017. How Many Candidates Appeared in UPSC2017? Byju's Free IAS Preparation. https://byjus.com/free-ias-prep/candidates-appeared-in-upsc-2017.
Lee, D.S., Lemieux, T., 2010. Regression discontinuity designs in economics. J. Econ. Lit. 48, 281–355.

Leibovitz, L., Miller, M., 2011. Fortunate Sons: the 120 Chinese Boys Who Came to America, Went to School, and Revolutionized an Ancient Civilization. W. W. Norton & Company, New York.
Li, M., 2005. Qingmo Minchu Zhongguo Chengshi Jieceng Yanjiu, 1897-1927 (Urban Social Stratification in the Late Qing and the Early Republic of China, 1897-1927). Social Sciences Academic Press [Shehui Kexue Wenxian Chubanshe], Beijing.
Liang, F., 1980. Zhongguo Lidai Hukou, Tiandi, Tianfu Tongji (Historical Statistics on Hukou, Land and Land Tax of China). Shanghai renmin chubanshe, Shanghai.
Lin, J.Y., 1995. The Needham puzzle: why the industrial revolution did not originate in China. Econ. Dev. Cult. Change 43, 269–292.
Liu, C.y., 1993. Chung Fan Pi Nan: a preliminary study of post designations during the Ch'ing. Bull. Inst. Modern History, Acad. Sinica 64, 175–204.
Liu, D., 1990. Tuixiangzhai Riji (Diary from the Chamber to Which One Retires to Ponder). Shanxi Renmin Press, Taiyuan.
Maddison, A., 1998. Chinese Economic Performance in the Long Run. OECD Development Centre, Paris.
Maddison, A., 2001. The World Economy: A Millennia Perspective. OECD Development Centre, Paris.
Man Cheong, I.D., 2004. The Class of 1761: Examinations, State and Elite in Eighteenth Century China. Stanford University Press, Stanford, CA.
McCrary, J., 2008. Manipulation of the running variable in the regression discontinuity design: a density test. J. Econom. 142, 698–714.
Mokyr, J., 2002. The Gifts of Athena: Historical Origins of the Knowledge Economy. Princeton University Press, Princeton, NJ.
Mokyr, J., 2005. The intellectual origins of modern economic growth. J. Econ. Hist. 65, 285–351.
Murphy, K.M., Shleifer, A., Vishny, R.W., 1991. The allocation of talent: implications for growth. Q. J. Econ. 106, 503–530.
Murphy, K.M., Shleifer, A., Vishny, R.W., 1993. Why is rent-seeking so costly to growth? Am. Econ. Rev. 83, 409–414.
Ni, S., Van, P.H., 2006. High corruption income in ming and qing China. J. Dev. Econ. 81, 316–336.
North, D.C., Thomas, R.P., 1973. The Rise of the Western World: A New Economic History. Cambridge University Press, Cambridge.
Olson, M., 1982. The Rise and Decline of Nations: Economic Growth, Stagflation, and Social Rigidities. Yale University Press, New Haven.
Pomeranz, K., 2000. The Great Divergence: China, Europe, and the Making of the Modern World Economy. Princeton University Press, Princeton, NJ.
Rawski, E.S., 1979. Education and Popular Literacy in Ch'ing China. University of Michigan Press, Ann Arbor.
Rhoads, E.J.M., 2011. Stepping Forth into the World: the Chinese Educational Mission to the United States, 1872-81. Hong Kong University Press, Hong Kong.
Roy, A.D., 1951. Some thoughts on the distribution of earnings. Oxf. Econ. Pap. 3, 135–146.
Sanetou, K., 1983. Zhongguoren Liuxue Riben Shi (The History of Chinese Students in Japan). Shenghuo dushu xinzhi sanlianshudian, Beijing.
Schwartz, B.I., 1964. In Search of Wealth and Power: Yen Fu and the West. Harvard University Press, Cambridge.
Shen, Y. (Ed.), 1978. Qingmo Gesheng Guanfei Zifei Liuri Xuesheng Xingmingbiao [The Lists of Oversea Students in Japan in the Late Qing Period]. Wenhai chubanshe, Taipei.
Spence, J., 1990. The Search for Modern China. WW Norton & Company, New York.
Verger, J., 1992. Teachers. In: Ridder-Symoens, H.d (Ed.), A History of the University in Europe: Volume 1, Universities in the Middle Ages, Cambridge University Press, Cambridge, pp. 144–168.
Voigtlnder, N., Voth, H.J., 2006. Why England? Demographic factors, structural change and physical capital accumulation during the Industrial Revolution. J. Econ. Growth 11, 319–361.
Voigtlnder, N., Voth, H.J., 2013. The three horsemen of riches: Plague, war, and urbanization in early modern Europe. Rev. Econ. Stud. 80, 774–811.
Wang, Y., 1960. Western impact and social mobility in China. Am. Sociol. Rev. 25.
Yan, Z., 1955. Zhongguo Jindai Jingjishi Tongji Ziliao Xuanji (Selected Statistic Materials of Modern China Economy). Kexue chubanshe, Beijing.
Yao, L., 2004. The Chinese overseas students: an overview of the flows change. In: 12th Biennial Conference of the Australian Population Association, pp. 15–17.
Yuchtman, N., 2017. Teaching to the tests: an economic analysis of traditional and modern education in late imperial and republican China. Explor. Econ. Hist. 63, 70–90.
Zhang, T., 1987. Ming Shi (The History of Ming). Shanghai guji chubanshe, Shanghai.