

# Teaching to the Tests: An Economic Analysis of Traditional and Modern Education in Late Imperial and Republican China

Noam Yuchtman\*

October 2010

## Abstract

Reformers in late imperial China called for the modernization of educational institutions, seeing in Western education a method of acquiring the skills necessary to modernize China's economy and society. Their claims have not been evaluated using systematic data analysis. I combine historical evidence with more rigorous analysis of Tianjin-Pukou Railroad employee records, and find that these reformers were correct in believing that different educational institutions produced different skills and different economic outcomes. Specifically, modern, Western education in late imperial and republican China provided especially useful skills for a developing economy: many of republican China's most important men in modern industry were educated in the modern system; certain high-paying jobs at the Tianjin-Pukou railroad were practically reserved for individuals with a modern education; and, the Railroad rewarded university and engineering training especially well in order to gain access to scarce, modern human capital. Traditional education did earn a wage premium relative to unskilled workers, but it was not compensated as well as modern training in engineering or at university, and it was concentrated in clerical occupations. These findings suggest that variation in human capital contributed significantly to income inequality in republican China, and that educational modernization was important for China's ability to adopt new technologies and develop a modern economy.

---

\*UC-Berkeley, Haas School of Business. Contact: [yuchtman@haas.berkeley.edu](mailto:yuchtman@haas.berkeley.edu). I would like first to thank Professor Elisabeth Köll for providing me with the Tianjin-Pukou Railroad's employee records and for her encouragement and guidance. Excellent research assistance was provided by Xiaotong Dan. Ryan Bubb, Davide Cantoni, Claudia Goldin, Larry Katz, Peter Lindert, Debin Ma, Jim Robinson, Se Yan, and seminar participants at the Guanghua School of Management, Fudan University, and Harvard's Economic History Tea and Economic Development Lunch provided very helpful comments and encouragement.

# 1 Introduction

Two distinct educational tracks existed in China in the late 1800s and the early 1900s.<sup>1</sup> The *traditional* track was initially larger, far more prestigious, and was a pillar of imperial China's social structure, government, and economy.<sup>2</sup> It prepared students to take the imperial civil service exams with the goal of achieving gentry status or receiving a civil service position.<sup>3</sup> The traditional system focused on the memorization and mastery of the Confucian classics, and training in essay-writing to pass the exams; even when students were examined on policy questions or modern science, their answers were evaluated according to their literary and stylistic, rather than analytical, merit.<sup>4</sup>

By the late 19th century, a second, *modern* educational track existed that was strongly influenced by foreign (Western) methods of education. Modern schools were established by Westerners in China, or by Chinese as part of the Self-Strengthening movement. New subjects, such as mathematics, sciences, engineering, and foreign languages, appeared in the curriculum. Education was more applied, providing scientific training, and less focused on the training of civil service elites.<sup>5</sup>

Military defeats to Western countries (e.g., in the Opium Wars), as well as Japan (in the Sino-Japanese War of 1894-1895), indicated to many Chinese the need for change: reformers urged military changes, political changes, and many urged changes in the structure and content of education. The links among economic modernization, international competitiveness, and educational reform were explicit. Elman (2006, page 201) writes of a Qing official who felt that “the military successes of Meiji Japan were a model for China and that emulating the Japanese would require expanded education in the sciences and industry.” In 1898, the (Guangxu) Emperor wrote, “Our scholars are now without solid and practical education; our artisans are without scientific instructors; when compared with other countries we soon see how weak we are.”<sup>6</sup> Calls for educational and

---

<sup>1</sup>This period spans the end of the Qing Dynasty (1644-1912) and the establishment of the Republic of China (1912-1949 on the mainland).

<sup>2</sup>Elman (2000), page xvii, writes, “In China since medieval times, imperial dynasties, gentry-literati elites, and classical studies were tightly intertwined in the operation of the civil service examinations. All three were perpetuated during the late empire (1368-1911), and they stabilized for five hundred years because of their interdependence.”

<sup>3</sup>Chang (1955) describes the link between the passage of exams and the achievement of status in Qing China.

<sup>4</sup>Elman (2000) is a rich history of the examination system in late imperial China; Elman (2006) discusses the attempts made to incorporate Western subjects into the classical education system in the late 1800s.

<sup>5</sup>Elman (2006).

<sup>6</sup>Headland (no date), page 116.

examination reform – specifically, the introduction of Western subjects – briefly bore fruit, in the 1898 100-days reform.<sup>7</sup> But, as the name suggests, reform did not last, as conservatives re-asserted themselves.<sup>8</sup> Yet the control of conservatives was short-lived: the examination system was finally abolished in 1905, and the last Qing emperor abdicated the throne in 1912.<sup>9</sup> Thereafter, the modern education system grew rapidly, from around 4,000,000 students in the 1910s to over 12,000,000 in the 1930s.<sup>10</sup>

Given the social, economic and political importance of the traditional education system, and the passionate statements urging (and rejecting) the adoption of modern education in late imperial China, it is not surprising that the examination system has received the attention of historians of China (e.g., Elman (2000) and Chaffee (1995)). The surprise is the minimal discussion of *economic outcomes* associated with the traditional education system, or the modern system that replaced it. There are a few exceptions: Huff (2003) argues that traditional Chinese education was too closely linked to the structure of the imperial government and the official ideology. Thus, there was no insulated space for researchers to conduct creative, potentially norm-challenging scientific research, as there was in Europe. The lack of independent research centers doomed Chinese science eventually to reach a dead end, while Western science could be pursued indefinitely. Huff views differences in educational institutions (based on different religious philosophies and conceptions of law) as crucial in explaining the divergence of technological progress between China and the West. Justin Yifu Lin (1995) also argues that Chinese educational institutions prevented the rise of modern science, pointing to the incentives faced by Chinese elites to invest in human capital that would

---

<sup>7</sup>Karl and Zarrow (2002) discuss the educational and political reforms of 1898, as well as their legacy.

<sup>8</sup>There were impassioned defenses of Chinese education: rather than view Meiji Japan as a paragon, one individual argued that “For five thousand years the spirit of the sages has continued in China . . . [we] absolutely must not do as the Japanese, who had dispensed with their own learning in favor of Western learning.” (Weston (2002), page 108). Of course, such passion may have been due to a desire to maintain rents accruing to conservatives as much as it was due to a love of classical Chinese learning: Hon (2002, page 96) writes, “[C]onservatives had many reasons to object to reform, especially political reform. Some were antiquarians; others were by nature skeptical of change. But a large number were ‘corrupt bureaucrats’ (*suli*) who had a vested interest in preserving the political status quo. In other words, the conservatives were not as ignorant of China’s problems as many people assumed; nonetheless, they would do what they could to protect their interests.”

<sup>9</sup>Wright (1968) discusses revolutionary developments in China in the first decade of the 20th century.

<sup>10</sup>These numbers are taken from Yan (2007), Table 8. The number of traditionally-educated students is very difficult to pin down. Chang (1955) estimates that there were nearly 1,000,000 degree-holding members of the Chinese gentry in the late 19th century. As the exams were competitive (even at the lowest levels), there were surely many more than 1,000,000 individuals enrolled in schools that were loosely part of the traditional system. Rawski (1979) argues that perhaps 30 percent of Chinese had some ability to read – though what this ability meant in practice, and how to classify the schooling of those individuals who had extremely limited literacy, are difficult questions to answer.

produce examination success, rather than scientific discovery.<sup>11</sup> These works emphasize the role of traditional education in China's historical development, but they lack systematic empirical evidence with which to substantiate this link.

The absence of research on the economics of the traditional education system is even more puzzling in light of China's incipient modernization in the pre-World War II period. Thomas Rawski (1989, page 181) writes that "Beginning in the 1890s, new forms of transport and communication transformed commerce and accelerated the growth of commercial production in every sector of China's economy. Motorized water and rail traffic permanently altered China's economic landscape. At the same time, the spread of telegraphic and telephonic communication expanded information networks. New modes of transport and communication contributed to a rapid growth of domestic trade and caused a dramatic contraction of economic space." Modern economic activity arose beyond the transportation sector: "British observers recalled the 1920s as a period remarkable for 'the number of mills and factories of all kinds which were springing up all along the principal railway lines.'"<sup>12</sup> Although the extent of China's pre-War growth is the subject of debate, there is no doubt that significant economic modernization occurred in some industries and in some regions. Interestingly, while the traditional education system has often been cited as a source of Chinese economic backwardness, the rise of modern education (or the fall of the traditional one) has rarely been mentioned as an important factor in the timing of China's economic modernization.<sup>13</sup> There is no systematic evidence on the contribution of modern educational institutions to China's economic development in the republican era.

I hope to evaluate quantitatively the arguments made by reformers in the late Qing: was traditional Chinese education effectively useless for modern industry? Was modern education es-

---

<sup>11</sup>Debin Ma's (2004, 2006, 2008) work on Chinese economic development in the first half of the twentieth century is focused on the role of political and legal institutions in promoting growth. However, he alludes to the importance of educational institutions in China's performance in sericulture, writing, "[A]wareness of the on-going technological revolution in European sericulture could not be found in the Lower Yangzi before the twentieth century [in contrast to Japan]. Preparation for the grueling, pyramid-structured Civil Service Examination system based on the memorization of Confucian classics continued to engross the intellectual energies of the Chinese elites."

<sup>12</sup>Rawski (1989), page 225.

<sup>13</sup>For example, Chang (1993), pages 289-290, associates modern, Western education with the rise of railroads in early 20th century China, writing, "[After the Republic was founded] engineering students sent abroad to Europe, the U.S., and Japan were returning in increasing numbers. Those engineers trained in China for the most part graduated from Shanghai Specialized Industry School (later changed to Transportation University, Shanghai Campus)." Elman (2006) is the only source I have found that emphasizes the role of modern education in China's development.

pecially useful? If reformers were correct, one would expect the content of individuals' education to be reflected in their labor market outcomes. If modern education was highly complementary to the technology used in the modern sector, and if modern education was scarce, one would expect it to have been associated with large wage premiums, relative to traditional education.<sup>14</sup> If traditional and modern education provided very different skills, one would expect them to have been concentrated in very different occupations.

I take these implications – wage differences and occupational differences – to the data, and show two sets of associations that clarify the economics of the traditional and modern education systems. The first association is at a very broad level: I examine the educational backgrounds and vocations of elite Chinese profiled in *Who's Who* compilations in the imperial and republican periods.<sup>15</sup> These compilations show quite strikingly how much China changed in around 50 years: at the end of the imperial period, elites were almost never trained in the modern system, and they typically were involved in government or scholarship; in the early republican period, the most important men in China were more often in modern industry, railroads, and banking – and most of them had been educated in the modern system.

The second set of associations uses individual employee records from the Tianjin-Pukou (JinPu) Railroad (one of republican China's most important) to test for correlations between employees' educational backgrounds and their labor market outcomes with the railroad. I estimate a variety of regression models and find results that confirm reformers' views in part, and qualify them in part. At the broadest level, traditional and modern education are associated with *very similar* wage premiums (relative to unskilled workers) at the railroad. This suggests that reformers were perhaps too harsh in their criticism of traditional education. Upon closer analysis, however, one sees that reformers were essentially correct: when educational background is disaggregated by type and level, one sees enormous returns to modern university and engineering training, with traditional education earning far smaller (though positive) skill premiums. One also sees striking differences in

---

<sup>14</sup>Throughout the paper, I assume that differences in salaries represent differences in productivity, and generally well functioning, competitive labor markets. Rawski (1989) suggests that this is not a bad approximation by 1929, the year the records I analyze were compiled. Of course, there are many reasons why wage differences may not reflect productivity differences, ranging from monopsonistic labor markets, to differences in monitoring costs across jobs, to compensating differentials.

<sup>15</sup>The use of biographical compilations has precedence in the literature; see Nicholas (1999).

occupational outcomes: traditionally-educated workers worked disproportionately in clerical work, where their years of training in reading and writing could be put to good use. Those with modern education were more often in managerial roles, and in technical roles, where their training in advanced Western subjects was useful. I conclude from this analysis that traditional and modern education did produce different types of human capital which were differentially productive in modern industry; thus, modern education was a key input in China's modernizing economy in the early 20th century.

These results can contribute to several separate literatures. First, they can contribute to the body of work on Chinese educational institutions, by providing systematic, quantitative evidence of the economic consequences of traditional and modern Chinese education. By examining the microeconomic, labor market outcomes associated with each educational system, one can better understand the human capital generated in each system, and the role that modern educational institutions played in China's development.

Second, by providing an estimate of wage differences associated with different levels and types of education, this analysis contributes to a very sparse literature on inequality in the Chinese labor market in the late imperial and republican periods. Yan (2007) is a pioneering paper, providing the best estimates on wage inequality in late 19th and early 20th century China. However, he calculates wage inequality associated with occupation (or skill level) differences, but does not estimate the wage premium associated with any type or level of schooling. Measures of earnings inequality by education type and level for China in the early 20th century will make it easier to put modern Chinese inequality in proper perspective.<sup>16</sup>

Finally, by providing empirical evidence that the content of an individual's education is reflected in his labor market outcomes in the modern sector, I provide suggestive evidence that educational content and the choice of educational institutions matter for economic development. Jones (2008) and Murphy, Shleifer, and Vishny (1991) argue that quantity of education alone cannot capture the role played by human capital in economic development.<sup>17</sup> Chaney (2008), among

---

<sup>16</sup>Goldin and Katz (2001, 2008) examine earnings inequality, and specifically the link between inequality and education in the United States, in historical perspective, contributing greatly to our understanding of the sources of contemporary earnings inequality.

<sup>17</sup>Jones argues that the "depth" of training is crucial to economic growth – a specialist with deep training can

others, shows that ruling elites have not always and everywhere chosen efficient educational institutions; perhaps China's traditional education system was maintained in order to preserve the political economic status quo, at the expense of economic development.<sup>18</sup> In the second half of the nineteenth century, the adoption of Western industrial technology was crucial for economic success (e.g., in Meiji Japan). If modern education was highly complementary to Western technology, the late adoption of modern schooling in China (vis a vis Japan) may explain China's delayed economic modernization – while the rise of modern schooling in the early 1900s might explain part of China's economic success in the republican era.<sup>19</sup>

I will begin, in Section 2, by presenting the historical evidence on differences between traditional and modern education: I discuss the educational content of the two systems and the analysis of the *Who's Who* compilations that I have studied. In Section 3, I analyze the JinPu Railroad employee records, beginning with a discussion of the Railroad, then discussing the data, examining salary and occupational differences across educational backgrounds, and evaluating my empirical strategy. Finally, in Section 4, I summarize my arguments and conclude.

## 2 Historical Evidence of Modern Education's Importance to China's Development

### 2.1 Educational Content

Traditional and modern educational institutions were structured differently, with different objectives, and they produced very different forms of human capital. In this subsection, I provide an overview of the two systems' contents.

---

advance the technological frontier more effectively than a generalist with shallow training (even if the two are equally skilled, as measured by years of schooling). Murphy et al. consider the trade-off that skilled individuals face between rent-seeking and productive work, and show that countries producing entrepreneurial engineers grow more quickly than countries producing rent-seeking lawyers. Presumably, one type of education is better for development than the other, although it is clear that the choice of education will interact with many other political institutions.

<sup>18</sup>Acemoglu and Robinson (2008) show that inefficient institutions that benefit ruling elites can persist.

<sup>19</sup>Work considering China's development in the very long run includes Mokyr (1990, 2002, and 2005), Wong (1997), Pomeranz (2000), Allen (2006), and Broadberry and Gupta (2005). The importance of a modern, industrial sector in China's economic history is made clear in Rawski (1989); it is theoretically examined far more generally in Murphy, Shelifer, and Vishny (1989).

### 2.1.1 The Traditional Chinese Education System

The traditional Chinese education system provided training in the Confucian classics as preparation for a series of highly competitive exams that were used to select individuals for service in the imperial bureaucracy.<sup>20</sup> Students began their studies as young children, some as young as three years old, first learning basic Chinese characters, and as they progressed, memorizing the thousands of characters composing the Confucian classics.<sup>21</sup> After mastering the basic characters, students would study Tang dynasty (618–907 A.D.) poetry and begin working through the Four Books and the Five Classics (the classical texts on which they would be examined). Many years of diligent study were required to master and memorize these books; for example, Zhang Jian, a scholar in the second half of the 19th century, could recite the Four Books from memory at age 12, after nine years of study. Students would devote yet more time to practicing their composition skills—most importantly, the eight-legged essays they were forced to produce on their examinations—and reading commentaries and histories that would be useful for their exams.

Perhaps the most striking aspect of traditional training was its narrow focus: mastery of the Confucian classics and the ability to write the eight-legged essays were almost exclusively the skills that determined a candidate's success on the exams in the late Qing.<sup>22</sup> Importantly (and understandably), students responded to the incentives offered by the examination system and often did not seek broad educations that went beyond the material needed to succeed in the exams.<sup>23</sup>

The narrow focus of the exams was recognized as a problem by political reformers in the second half of the 19th century (as I will discuss in more detail below), and attempts were made to introduce new, Western subjects into the civil service exams and so into the traditional curriculum. Efforts

---

<sup>20</sup>It is important to note that the traditional education system served cultural and social functions beyond its usefulness in selecting bureaucrats and its provision of human capital. See Chaffee (1995) and Elman (2000).

<sup>21</sup>The description of training for the exams comes from Elman (2000), page 275, which is based on the education of scholar Zhang Jian in the second half of the 19th century.

<sup>22</sup>The metropolitan examination, which qualified individuals for civil service positions, contained a section on the Four Books and poetry, a section on the Five Classics, and a section on Policy. However, these policy questions were “typically overlooked” by graders (Elman (2000), page 523). At other times, other skills, like poetry were more important than the eight-legged essay; see Elman (2000). Note that deep knowledge, as discussed in Jones (2008), can thus have a downside, if that deep knowledge is in less productive domains.

<sup>23</sup>In 1896, Liang Qi-chao “pointed out the deleterious influence of the civil examinations on learning. Most candidates would master whatever curriculum was set on the examinations . . . Hence, curricular reform was mandatory to change the learning habits of literati who sought public office.” Quote taken from Elman (2000), page 589.

were made, for example, to include questions regarding Western science on the imperial exams. These efforts were badly needed: Elman (2006) writes, “By 1750, textbooks made the application of mechanical principles accessible to anyone literate in English or French, and artisans and engineers applied them. None were translated into Chinese, because the Jesuits [who controlled the transfer of Western science to China in the 18th century] never made the jump to the mathematicization of practical mechanics. . . . By the late eighteenth century, experimental physics and mechanics had surpassed the use of geometry in Europe. Meanwhile, however, the Chinese were still using as a basis for mathematical learning the Ten Mathematical Classics.”

Unfortunately, attempts to introduce Western subjects into the imperial exams in the second half of the 19th century were unsuccessful in encouraging serious study of modern science.<sup>24</sup> Exam prompts continued to be rather philosophical, such as “Much of European science originates from China; we need to stress what became a lost learning as the basis for wealth and power.”<sup>25</sup> Essays on Western science were judged according to their stylistic and literary merit, so traditionally-educated Chinese were not trained at all in the application of Western science, nor were they trained to understand it deeply. The exams required a traditional approach to the study of Western science: Elman writes, “The civil examinations were the last bastion of traditional Chinese science, where the ‘Chinese origins’ approach to Western learning remained obligatory.” To receive useful training in Western science, one needed to exit the traditional system and enter a modern school.

### **2.1.2 Modern, Western Education in Late Imperial and Republican China**

The Qing, beginning in the second half of the 19th century, began to see Western education as necessary for keeping up with Western imperialist powers, and later, Japan. But acceptance of Western education was to be sharply circumscribed: the goal was “Self-Strengthening,” which meant preserving the core of Chinese learning by studying only that Western learning which was useful to prevent being militarily defeated. While the Qing established military arsenals, developed small numbers of modern schools, and paid for Chinese students to study abroad, it continued to

---

<sup>24</sup>The lack of success was not due to a lack of effort by some Chinese, but due to the conservatism of some powerful officials. See Hon (2002) for a discussion of the acrimonious debates over the relative positions of Western and traditional learning.

<sup>25</sup>Taken from Elman (2006), page 145.

draw its officials from the traditional education system; while officials admired Japan for its military and economic success, one official argued, “[We] absolutely must not do as the Japanese, who had dispensed with their own learning in favor of Western learning.” Thus, the imperial Chinese state played a fundamental role in establishing modern educational institutions in imperial China, but it was also the key constraint to a larger modern education system.

Modern educational institutions in China took several forms in the second half of the 19th century. Missionary schools, some Jesuit, and many Protestant, taught foreign languages and Western math and science. Arsenal schools, first established in the 1860s by the Qing government, provided applied training that was aimed at producing militarily useful skills and knowledge, though this knowledge was also useful in nonmilitary fields. A modern educational hierarchy, including high schools and universities, taught Western subjects as well. Finally, Chinese students accessed Western knowledge through study abroad; Japan was the most important destination for Chinese scholars, while the United States also played an important role in training Chinese in Western subjects like medicine, engineering, and law.

Though small in number, the earliest modern educational institutions were likely important to developing a scientifically literate workforce: Elman (2006, page 144) writes that China saw “the growth of thousands of technicians, engineers, and skilled artisans in the empirewide arsenals, [beginning] in the 1880s and 1890s.” Modern schools were also the repositories of Western scientific knowledge. For example, at the Jiangnan arsenal, translations were made of Western books in fields such as engineering and navigation.<sup>26</sup> These sorts of translations both increased the stock of useful knowledge in China and provided useful training that should have increased graduates’ productivity in modern industry.

It is important to discuss the position of modern educational institutions in a larger education system dominated by the examination system and traditional learning. Modern schools were not focused on training individuals in the Confucian classics, and their students did not expect to succeed in the imperial exams; indeed, many schools were explicitly vocational, providing training in applied science and engineering. It is clear in the historical literature that the modern schools

---

<sup>26</sup>Elman (2006).

did not attract the very best away from the traditional system. The latter was far more prestigious, even after the Qing government began incorporating individuals with training in modern subjects into the bureaucracy. Elman (2006, page 195) writes, “The scientist was ‘one who investigated things,’ and he now coexisted with the orthodox classical scholar in the bureaucratic apparatus but at lower levels of political rank, cultural distinction, and social esteem.” Thus, there was an obvious distinction between traditional study of the classics and the study of modern science.

### **2.1.3 Summary: Comparing Traditional and Modern Education**

Traditional education and modern education were clearly producing different types of human capital for different purposes: in the former, one would master the Confucian classics, perfect one’s writing skills, and aim to pass civil service exams. In the latter, one would take courses on Western subjects, often with specific, applied knowledge being the goal of one’s education, in the hope of attaining a non-civil-service job. At first glance, the arguments of reformers seem reasonable: if one spends decades of one’s life practicing essay writing, one will be a talented essay writer, but likely not good at solving problems of mechanics or chemistry. And, if one pursued explicitly knowledge in chemistry and mechanics, one ought to be more productive in occupations that required that knowledge.

The actions taken by the British company John Swire and Sons in the early 20th century provide some substance to this view.<sup>27</sup> In 1909, the company granted £40,000 toward the establishment of the University of Hong Kong.<sup>28</sup> Of the first three academic chairs to be established, one was to be in “‘Applied Science,’ for the education of Railway, Mining and Electrical Engineers, Surveyors, etc. (of whom [China] stands greatly in need for the development of her resources).”<sup>29</sup> Swire makes explicit the link (from its perspective) between establishing a modern educational institution and receiving in return useful human capital: in a letter, a company official wrote,

“The project is neither purely Altruistic nor purely Utilitarian. I claim for it an em-

---

<sup>27</sup>Swire and Sons was the predecessor to the extant firm, Swire Group. In the early 20th century, its China business included, trade, shipping, refineries, dock management, and finance.

<sup>28</sup>Swire and Sons Archive, JSSI 4/3 Box 1171.

<sup>29</sup>JSSI 4/3 Box 1171.

inently practical basis benefitting China and ourselves equally. The benefits to China have already been summarized, and it is needless to dwell on the immense alleviation of human suffering which will result from a steady output of Chinese medical men working among their own people and of Chinese engineers who can assist in averting the constantly recurring famines and loss of life due to inundations of rivers and lack of irrigation, or the wealth and prosperity which would accrue to the teeming poverty-stricken population by the opening up of railways and mines, and improvements in agriculture and forestry.”<sup>30</sup>

These statements – and most importantly, the revealed preference of a profit maximizing firm spending a large sum of money – suggest that the distinctions in the two education systems’ human capital that we see today were apparent to individuals to whom those distinctions mattered in the early 1900s.

## 2.2 An Analysis of *Who’s Who* Compilations

Before delving into the analysis of the JinPu employee records, it is valuable to have a broader perspective on the changes in China’s economy and society around the turn of the twentieth century. By examining individuals profiled in *Who’s Who* compilations, one can see these broad changes, at least as they are reflected in the lives of the Chinese elite.

I begin by comparing individuals profiled in *Eminent Chinese of the Qing Period*, edited by Arthur Hummel, to individuals profiled in a series called *Who’s Who in China*, published by the Shanghai-based periodical *Millard’s Review* in 1919 and 1920.<sup>31</sup> I selected the 44 individuals in the Qing compilation who were born between 1830 and 1895, in order to match the 152 individuals from the republican sample, born between 1846 and 1895.<sup>32</sup>

---

<sup>30</sup>JSSI 4/3 Box 1171.

<sup>31</sup>*Eminent Chinese of the Qing Period* was published in Washington, D.C., in 1943-44 using biographical accounts from Qing China. There certainly could have been strong biases in the selection of individuals into both of these *Who’s Who* compilations, a point I take up below. The republican *Who’s Who* was compiled in Cavanaugh (1982).

<sup>32</sup>To address concerns that selecting from a relatively small (and turbulent) time-period within the Qing dynasty might distort my results, I also coded individuals born between 1730 and 1735, who would have come of age at the height of the Qianlong reign (15 individuals), and individuals born between 1655 and 1660, who would have come of age at the height of the Kangxi reign (10 individuals). The general results from the later sample are supported

In Figure 1, panels A and B, one can see indications of a remarkable change in the vocations of the Chinese elite between the imperial and republican periods. Panel A shows the distributions of the primary fields in which individuals made their marks in the two eras. There is a clear rise of private enterprise in the republican period: whereas there were no individuals in private business, the railroads, or banking in the the Qing compilation, over 20 percent of the individuals profiled in the republican *Who's Who* achieved their primary success in these fields.<sup>33</sup> These results are consistent with Rawski's (1989) and Ma's (2008) findings of modernization in republican China, especially in Shanghai.

Panel B shows individuals' educational backgrounds. One can clearly see a shift toward elites with modern education in the republican period – from around five percent in the Qing sample to over fifty in the republican.<sup>34</sup> Interestingly, traditionally-educated individuals still make up one-third of the elites in the republican *Who's Who*. This suggests traditionally-educated individuals were not excluded from success in the republican era by virtue of their training.

A natural question upon observing these results is whether the elites trained in the modern education system were, in fact, the elites involved in modern economic activities. Indeed, they disproportionately were, though traditionally-educated individuals were also successful in the modern sector in republican China. As can be seen in Figure 2, among elites in modern fields, over 60 percent were trained in the modern sector, while around one-quarter received traditional educations.<sup>35</sup>

The evidence taken from the *Who's Who* compilations is anecdotal and subject to concerns about selection bias. However, analysis of these compilations reveals interesting patterns: China's elites seem to have changed dramatically in their vocations and educational backgrounds. The broad association is what one would expect from reformers' critiques: the rise of modern industry

---

<sup>33</sup>Here the question of selection bias is pertinent. The compilers of the republican *Who's Who* may have desired to select specifically those individuals successful in modern industry; Hummel may have wanted to depict a Qing Dynasty that was composed entirely of scholars and officials. These selection issues suggest interpreting these findings with caution.

<sup>34</sup>Again, the selection caveat applies.

<sup>35</sup>The link between elites trained in the modern education system and success in modern industry can also be seen in other biographical compilations. For example, among Chinese students (born between 1859 and 1898) who had studied in America, one-fifth returned to work as engineers, and nearly ten percent worked as bankers, in business, or in manufacturing. Many of the others worked in education in these fields. See Tsinghua University (1917).

in China (reflected by elites' involvement in these activities) is associated with training in modern educational institutions.

### 3 Examining Labor Market Outcomes Using Tianjin-Pukou Railroad Employee Data

#### 3.1 A Brief History of the JinPu Railroad

The JinPu Railroad was a joint German-British venture, initiated in 1898, to link Northern China to the rich Shanghai-Nanjing region.<sup>36</sup> Initially, the railroad relied almost exclusively on non-Chinese for skilled labor.<sup>37</sup> The track was finally completed in 1912, though by this time the railroad was under the control of the recently-established Republic of China (yet still financed by foreign capital). The railroad was successful: Köll (2009) writes, “[T]he JinPu line soon became a serious competitor [against the Grand Canal] for goods transportation into Hebei, Shandong, and Anhui provinces and strengthened the commercial ties between Shanghai and eastern Shandong.” Though the railroad was surrounded by political uncertainty – the Germans in Shandong province were replaced by Japanese after World War I, then the Japanese replaced several years later by Chinese; finally, until 1928, China was fought over by warlords – it continued to function successfully. It was fortunate not to be the site of many conflicts between labor and management, as were other Chinese railroads in the 1920s.<sup>38</sup>

In 1928, the Nationalist Government’s Ministry of Railroads took control of the JinPu Railroad, and centralized aspects of hiring and pay, specifically for the skilled workers that are the focus of this study.<sup>39</sup> Shortly after taking control, the Ministry collected information on skilled workers, including salary and educational background, providing a rare source of early 20th century data on

---

<sup>36</sup>This section draws on Köll (2009).

<sup>37</sup>Köll (2009) writes, “Initially, Chinese played a negligible role as engineers and technical advisors in the construction process of the JinPu railroad and other lines as well. Railroad engineering in terms of academic training and as a profession did not emerge until the late 1910s when railroad engineering institutes were established and began to produce engineers with expertise in technology, geological sciences, bridge and tunnel construction.”

<sup>38</sup>Köll (2009).

<sup>39</sup>The Nationalist Government, based in Nanjing, took control of China in 1928 as well.

these two variables for a sample of Chinese workers.<sup>40</sup>

### 3.2 Description of the Dataset

My sample consists of 829 Railroad employees who were paid monthly salaries or were assigned paygrades.<sup>41</sup> These employees were relatively skilled; low-skilled, manual laborers, who comprised a majority of railroad workers, are not included. The workers in the sample were employed in a variety of occupations, from clerks to police officers, to managers, to engineers. For the vast majority of these employees, the Railroad's records contain information on age, home province, occupation title, department, monthly salary (or pay grade), tenure with the Railroad, level and type of schooling completed, and prior work experience.<sup>42</sup>

In Table 1, I present summary statistics for the sample of employees. Yearly salaries are high for republican China: Rawski (1989, page 310) cites miners in China in 1927 earning around \$100 per year, while the JinPu workers in the sample earn nearly \$1,000 per year.<sup>43</sup> Workers in the sample, on average, had worked for the JinPu Railroad for nearly six years when the records were compiled, and many of them had previously worked in the railroads (nearly 60 percent). To get a better sense of the salary variable, in Figure 3, I show the distribution of yearly salaries smoothed using the Epanechnikov kernel density estimator. The graph has the familiar log-normal shape.

In Table 2, I present summary statistics for a set of educational dummy variables that I constructed from the employee records. These variables equal 1 if an individual was trained in a given education system, or, in the case of *noeduc*, if the education field was blank in the employee records.<sup>44</sup> These broad categories do not use all of the available information on educational background (I

---

<sup>40</sup>Datasets containing information on individuals' education and wages in the early 1900s are difficult to find even in the United States; see Goldin and Katz (2000).

<sup>41</sup>The JinPu Railroad employee records from 1929 were kindly provided to me by Prof. Elisabeth Köll and translated by Xiaotong Dan. The records are not a random sample, but are a broad sample of the JinPu Railroad's more skilled workers.

<sup>42</sup>I convert pay grades into salaries using the conversion provided in the 1932 Railway Yearbook (*Tiedao Nianjian*), 1932.

<sup>43</sup>All monetary quantities are expressed in Chinese dollars. In 1929, the Chinese dollar steadily depreciated against the U.S. dollar, falling in value from 2.2 per U.S. dollar to 2.7. Numbers taken from the Global Financial Data database.

<sup>44</sup>In the empirical work that follows, I exclude those individuals without information on educational background, because this group includes both individuals with no formal education and individuals whose educational background was missing. The results are very similar when these individuals are included as a separate category.

exploit this information further, by disaggregating these categories, below), but they are a good first cut at the data. Although the majority of individuals in the sample come from the modern system (59 percent), traditionally-educated workers are a non-trivial minority, and one can see that, unconditionally, they are paid very well. One can also see substantial differences in average age, tenure, and prior work experience associated with different educational backgrounds. Controlling for these characteristics will be important to the empirical analysis below.<sup>45</sup>

### 3.3 Earnings Differences

#### 3.3.1 The Empirical Model

To associate differences in educational backgrounds with differences in salaries, I estimate the following linear model:

$$\log(\text{Salary})_i = \beta + \sum_t \delta_t \text{Educ}_{ti} + \gamma Z_i + \epsilon_i \quad (1)$$

The outcome variable is the log of the yearly salary of employee  $i$ ; the right-hand side has an intercept term, a set of educational background dummy variables (with education category indexed by  $t$ ), a vector of individual-specific controls ( $Z$ ), such as province of origin, age, tenure with the railroad, etc. (so  $\gamma$  is a vector), and an idiosyncratic error term.

If OLS estimates of  $\delta_t$  in model (1) are significantly different from zero, I would like to attribute differences in log salaries to differences in educational backgrounds; but unfortunately, educational attainment in my sample is not randomly assigned. And, because selection into educational attainment categories is likely correlated with unobservable characteristics of the individuals in my dataset, which in turn may be correlated with salaries, I cannot rule out some degree of omitted variables bias affecting my results. I discuss these issues in more depth below; for now, I will defend the model by pointing to the rich set of controls that I have for each employee. While these cannot eliminate concerns about omitted variables, they should re-assure the reader that many important variables are accounted for, reducing the risk that differences associated with education are due to

---

<sup>45</sup>Concerns about *unobserved* worker characteristics that are correlated with educational background and labor market outcomes will be a major challenge to the empirical analysis, and are discussed in more detail below.

some other factor.

### 3.3.2 Earnings Differences Across Broad Education Categories

I begin by estimating equation (1) using dummy variables for broad educational categories: *traditional*, *modern*, *military*, *apprenticeship*, and *police* (with *police* the omitted group). The results from estimating several specifications are presented in Table 3. In column (1), equation (1) is estimated without any controls – this simply yields results corresponding to what was seen in Table 2: it is interesting that in the raw correlations (without controls) traditional education is actually associated with *higher* salaries than modern education.<sup>46</sup> Of course, traditionally-educated individuals likely differ in many ways compared to the others. Thus, in columns (2) and (3) control variables are introduced into the estimation. In column (2), a quadratic function of employee age and a set of dummy variables for province of birth are included, and their inclusion sharply reduces the estimated coefficient on *traditional*. The coefficient on *traditional* is now smaller than the coefficient on *modern*, though the two are statistically indistinguishable, and both are significantly greater than zero, and large (indicating a skill premium for both modern and traditional education of around 30 percent, relative to the police academies).<sup>47</sup> In column (3), along with the controls included in column (2), I control for a 3rd-order polynomial in tenure with the JinPu Railroad, the number of jobs worked prior to the current job, and for prior experience with a railroad (using a dummy variable).<sup>48</sup> Adding these additional controls does not meaningfully change the results: the coefficients on *traditional* and *modern* are significantly different from zero, around 0.3 in magnitude, and statistically indistinguishable from each other.

The results in Table 3, columns (1) through (3) are somewhat surprising: traditional education is associated with a large salary premium, relative to the least-skilled group. Moreover, this premium is approximately as large as that received by individuals trained in the modern system. I next subject these results to a pair of robustness tests.

---

<sup>46</sup>For the sake of brevity, the discussion of results will focus on the comparison between modern and traditional education. The results in Table 3 indicate that military education was another valuable source of human capital, but its analysis is left for future work.

<sup>47</sup>All calculations of significance are based on heteroskedasticity-robust standard error estimates.

<sup>48</sup>All reported results are robust to other specification choices as well, for example higher-order polynomial terms in age or tenure.

First, one might be concerned that selection into systems of education changed across cohorts as the traditional education system was reformed and eventually replaced.<sup>49</sup> Thus, I estimate equation (1) using the full set of controls, but only for individuals at least 40 years old in the sample. The results are shown in Table 3, column (4). Though the coefficients on *traditional* and *modern* are both larger than in the other specifications including controls (now salary premiums are on the order of 50 percent), the results are qualitatively similar to the sample unrestricted by age.

The second robustness check is to control for employee characteristics less parametrically than was done above. To this end, I limit the sample to individuals trained in traditional or modern education, and estimate the average treatment effect of being in modern education using a nearest-neighbor matching estimator. I match observations on their province of origin, age, tenure with the JinPu Railroad, the number of jobs worked before coming to the JinPu Railroad, and whether one of these prior jobs was with another railroad.<sup>50</sup> In Table 3, column (5), we see that the matching estimate, too, shows no significant difference in log salaries between those educated in the traditional and in the modern system (in fact, the point estimate of modern education’s effect on salaries is actually negative).<sup>51</sup>

### 3.3.3 Earnings Differences Across Narrow Education Categories

The results found using broad educational categories suggest that the difference between traditional and modern human capital is not as simple as Chinese reformers might have led us to believe. But, the categories used above are crude: there is a big difference (presumably) between the human capital acquired studying in a teachers’ college and that acquired studying engineering at a university – but both of those educational paths were pooled in the *modern* variable above.

In this subsection, I disaggregate the broad categories above as follows:

---

<sup>49</sup>For example, individuals beginning their education after 1905 did so after the examination system was abolished, making education in the Confucian classics much less appealing.

<sup>50</sup>Results are robust to other specifications.

<sup>51</sup>The finding that traditionally-educated workers received a skill premium supports Rawski’s (1979) argument that traditional education produced a fairly literate Chinese society in the 19th century, and that of Baten et al. (2009), that 19th century Chinese were relatively numerate as well.

- Modern Education → primary/middle, secondary, teachers’ college, university, missionary school, vocational school.<sup>52</sup>
- Traditional Education → traditional education, traditional education with modern subjects.<sup>53</sup>
- Military Education → traditional military academy, modern military academy.<sup>54</sup>

I now estimate equation (1), but use dummy variables for the disaggregated education categories in place of the broader groups.<sup>55</sup>

The estimated coefficients on the education dummy variables, from a model including all control variables, are presented in Table 4, column (1), and plotted with 95% confidence intervals in Figure 4. Several striking results stand out: the coefficient on *university* is enormous, indicating a 100%-plus salary premium relative to unskilled workers. It is clear that within the modern education category, different levels of education are associated with very different salaries: modern primary/middle school completion is associated with a relatively small, 18% salary premium – tiny compared to the university premium.<sup>56</sup>

We also see large differences between traditional education (of either type) and modern, university training, suggesting that a qualified reformers’ argument may hold: modern human capital was highly productive (and rewarded), especially that which was provided at the highest level of modern education. Yet, years of schooling alone do not seem to be the most important factor: the difference between the coefficient on *teacherscol* and that on *university* is striking. The *content* of modern education could surely have affected salary premiums, with teachers’ colleges producing less valuable human capital than universities. I take up this point below, but first examine the robustness of the results.

As above, the first robustness check I run is to estimate equation (1), with the narrow education categories and all controls, but only for individuals aged 40 or older. These results are

---

<sup>52</sup>These are exhaustive, mutually exclusive sub-categories within the broad *modern* category.

<sup>53</sup>As was described above, toward the end of the Qing, there were attempts, albeit rather unsuccessful, to introduce Western subjects into the examination and traditional curriculum. These categories are mutually-exclusive, exhaustive sub-categories within the broad *traditional* education category.

<sup>54</sup>These categories are mutually-exclusive, exhaustive sub-categories within the broad *military* education category.

<sup>55</sup>The broad categories of apprenticeship and police education (which will be omitted) will continue to be used.

<sup>56</sup>The difference in coefficients is highly statistically significant (result not shown).

presented in Table 4, column 2, and they are similar to those in column (1). Finally, I limit the sample to those individuals with traditional or modern education, and estimate the sample average treatment effect of university education using a nearest-neighbor matching estimator. As above, I match on employees' province of origin, age, tenure with the JinPu Railroad, the number of jobs worked before coming to the JinPu Railroad, and whether one of these prior jobs was with another railroad. As in columns (1) and (2), a very large salary premium is associated with university education – over 70%.

The results in Table 4 reveal an enormous degree of earnings inequality across individuals with different educational backgrounds. University training was associated with far higher wages than the unskilled in the sample (and even the unskilled in the sample were not poor by the standards of the day); even more striking is the salary premium university graduates received compared to all of the other educational categories (in pairwise tests, not shown, p-values are all less than .02). I next look more closely at the role of educational content in generating salary differences.

In Table 5, column (1), I present estimates from equation (1), including all controls, using the narrow educational categories, but adding additional dummy variables indicating training in engineering and training abroad.<sup>57</sup> Note that these coefficients should be added to those of the relevant narrow educational category, typically, *university*.<sup>58</sup> For example, 30 individuals studied engineering at university, and 12 did so at university abroad. Thus, for 18 university-trained individuals, their salary premium (relative to the omitted *police* group) is the sum of the coefficient on *university* and the coefficient on *engineering*; for another 12 university-trained individuals, the premium is the sum of the coefficients on *university*, *engineering*, and *foreign*.

The estimates in Table 5, column (1) suggest that the JinPu Railroad was willing to pay a great deal for human capital that was especially useful to it: a large wage premium is associated with training in engineering (and in training abroad) in addition to the results already seen for university training. The coefficient on *university* falls when *engineering* and *foreign* are included

---

<sup>57</sup>These provided the cutting-edge modern knowledge that many Chinese around the turn of the century felt was vital for Chinese development. 44 individuals in the sample were trained in engineering and 30 studied abroad.

<sup>58</sup>Of the 44 individuals who studied engineering, 35 studied at university, 5 at vocational school, and 4 in primary/middle school. Of the 30 individuals who studied abroad, 24 did so at university and 6 did so in vocational school.

(compare to Table 4, column (1)), suggesting that part of the premium observed in Table 4 was due to the content of university training. But university training continues to be associated with a very large salary premium, suggesting that human capital produced in universities in fields other than engineering was also valuable.

In Table 5, column (2), I estimate the same model as in column (1), but only for employees 40 years old and older. The results support the conclusions reached for the sample unrestricted by age. Finally, in Table 5, column (3), I limit the sample to those educated in the modern or traditional system, and estimate the sample average treatment effect of being educated in engineering (matching on the variables used above). Again one sees the importance of educational content: relative to a group that includes university graduates (and some who studied abroad), those who studied engineering receive a very large salary premium.<sup>59</sup>

The results presented in Tables 3-5 suggest a more complex relationship between education type and success in the modern sector than reformers claimed. Traditionally-educated workers were compensated as skilled workers, and on average, they earned as much as those trained in the modern sector broadly defined. What reformers seem to have been quite right about is the important role of training in certain fields: training at university and training in engineering were, in fact, highly valued by the railroads – those individuals with these educational backgrounds earned massive salary premiums. An implication of these results is that earnings inequality across educational backgrounds was severe in China in the early 20th century, supporting the results of Yan (2007), who finds a high degree of earnings inequality across occupational classes.

### 3.4 Occupation Differences

Differences in salaries provide evidence of employees' value to the JinPu Railroad (and so the value of different types of human capital); differences in occupations provide evidence of the tasks employees were relatively good at (and so the skills generated by acquiring different types of human

---

<sup>59</sup>In work omitted for brevity, I limit the sample to those with university training, and estimate the treatment effect of engineering training using the nearest neighbor matching estimator: again, I find a very large, highly significant treatment effect.

capital).<sup>60</sup> To study differences in occupational outcomes across individuals with different educational backgrounds, I constructed a set of occupational categories based on railroad departments: *police*, *machine*, *road*, *clerical*, *train*, *hospital*, and *management*.<sup>61</sup> The exception to this simple assignment strategy (occupational category = department) is that I assign individuals whose occupation is “secretary” or “clerk” to the clerical department.<sup>62</sup> In Table 6, I present summary statistics on the occupational categories.

To associate differences in educational backgrounds with differences in occupational outcomes, I first estimate the following model, estimated using OLS:

$$Occupation\Gamma_i = \pi + \sum_t \psi_t Educ_{ti} + \phi Z_i + \eta_i \quad (2)$$

The outcome variable is simply a dummy variable equal to 1 if employee  $i$  is in occupational category  $\Gamma$  (where  $\Gamma$  is *police*, *machine*, *road*, *clerical*, *train*, or *management*). As in equation (1), the right-hand side has an intercept term, a set of educational background dummy variables (with education category indexed by  $t$ ), a vector of individual-specific controls ( $Z$ ), namely, a quadratic function of age, a cubic in tenure with the railroad, a set of province of origin dummies, a dummy variable indicating prior railroad experience, and the number of jobs worked prior to working for the JinPu Railroad (so  $\phi$  is a vector), and an idiosyncratic error term.<sup>63</sup> In the occupation regressions I omit the *traditional* education category to more closely focus on the comparison between modern and traditional education.

In Table 7, I present the results of estimating equation (2) for each occupational category, always using the full set of controls. In a comparison of modern with traditional education, it is immediately clear that traditionally-educated workers are disproportionately in the clerical de-

---

<sup>60</sup>As mentioned in the introduction, I am relying on the assumption that labor markets functioned well and were competitive. If these assumptions are not met, there will be a wedge between wage and productivity.

<sup>61</sup>The police department, unsurprisingly, policed the railroad lines, trains, stations, and property; the machine department managed and repaired the rolling stock of the railroad; the road department planned and managed the lines; the clerical department managed paperwork and correspondence; the train department staffed stations and manned switches, the hospital is self-explanatory, and the management department managed the affairs of the entire Railroad. In the analysis that follows I drop the hospital department from the analysis, due to its very small size.

<sup>62</sup>In general, I do not use the occupation variable to determine occupational category because it is often too vague: for example, “Assistant” is an extremely common occupation. Using the departments as given (without re-assigning secretaries and clerks) does not change the results.

<sup>63</sup>In this section I return to the analysis of the broad education categories; analysis of narrow educational categories does not yield new insights, as it did above.

partment.<sup>64</sup> This is consistent with their intense training in reading and writing. One also sees that modern education is significantly more prevalent in one of the more “technical” departments (*road*), but not the other (*machine*). One can view this as loosely supportive of modern education being applied in the technical occupations. Finally, we see that the white collar jobs that paid the most and likely demanded the most technical knowledge – in the management department – were disproportionately held by individuals with modern education.<sup>65</sup>

To test the robustness of the OLS results, I next estimate a multinomial logit model, which jointly estimates a set of regressions, one for each occupational outcome, other than an omitted, base occupation:

$$\log(\Pr(\text{Occupation}\Gamma_i = 1)/\Pr(\text{OccupationBase}_i = 1)) = \alpha + \sum_t \theta_t \text{Educ}_{ti} + \mu Z_i + \nu_i \quad (3)$$

The variable  $\Gamma$  can take the values it took above. The outcome, for each value of  $\Gamma$  (other than the Base), is the log ratio of the probability that an individual is in a given occupation, relative to the base occupation. The right-hand side of equation (3) is analogous to the right-hand side of equation (2). We can use maximum likelihood to estimate the effect of some educational category (relative to the omitted educational category) on the log ratio of probabilities (that is,  $\theta_t$ ).

I use the machine department as the base occupational category and choose traditional education to be the omitted educational category. Thus, the coefficient on *modern* in the *clerical* regression will tell us the effect of moving from traditional to modern education on the relative likelihood that an employee is in the clerical department, relative to the machine department. These coefficients are difficult to interpret intuitively, but their sign and significance are informative.

The estimated coefficients on *modern* from estimating equation (3), using all controls except province dummies, are presented in Table 8.<sup>66</sup> The results confirm the findings in Table 7: modern education is more strongly associated with work in the road department and the management department, but less strongly associated with work in the clerical department.

---

<sup>64</sup>I describe the coefficient as an excess of traditionally-educated workers because there are, in fact, many individuals in the clerical department trained in the modern system – just not nearly as many relative to the group’s size as for traditional workers.

<sup>65</sup>These conclusions are supported by results estimated using only employees aged 40 or older; those results are omitted for brevity.

<sup>66</sup>The model does not converge when province dummies are included.

The occupational differences by educational category strongly suggest that the JinPu Railroad hired individuals to work in occupations for which their human capital suited them: those trained in the traditional system disproportionately worked in the clerical department, and were almost never found in some departments, such as management. Those with modern educations were hired to run the railroad and were often found in the technical departments as well. These results complement those on salary differences, indicating that differences in educational content were reflected in labor market outcomes.

### 3.5 Evaluating Alternative Explanations

In this subsection, I consider several alternative stories that could explain the results presented above.

#### 3.5.1 Omitted Ability

A standard concern in regressions linking earnings to educational attainment is that educational attainment is correlated with unobserved ability, which itself helps to determine earnings. In comparing traditional and modern education, historical evidence suggests that *on average* selection into the traditional system was by the more able, due to its greater prestige.<sup>67</sup> This sort of selection would drive up the estimated return to traditional education; it may explain why the return looks as high as it does, but it does not explain the huge gap between traditional education and university or engineering training.

An alternative theory of selection is that the traditionally-educated were positively selected on average, but that those individuals with the highest levels of modern education had still better unobserved characteristics.<sup>68</sup> In particular, one might worry that individuals with university training earned more than traditionally-educated workers even *within* the clerical department. This

---

<sup>67</sup>Elman (2006), page 158, writes, “Although considered marginal because they usually had failed the more prestigious civil examinations, many Chinese literati saw in Western learning and the modern sciences an alternative route to fame and fortune.”

<sup>68</sup>This could be due to better unobserved ability at the highest levels of modern education, or simply the inability of the researcher to perfectly observe the quantity of traditional education.

would challenge the argument that cross-department earnings differences, based on differences in skills, drove the average differences in earnings between the traditionally-educated and those with high levels of modern education. Instead, finding large earnings differences within the clerical department would suggest that traditionally-educated workers were simply less productive than those with a university education, even at tasks in which the traditional education system should have provided useful training.

To test whether high levels of modern education were associated with large salary premiums even within the clerical department, I estimate equation (1) using the disaggregated education categories, but only for employees within the clerical department.<sup>69</sup> The results of this exercise are presented in Table 9, column 1 (compare to Table 4, column 1), and indicate that within the clerical department traditionally-educated workers earned salary premiums as great as those with the highest levels of modern education. The coefficient on traditional education is *greater* than that on university education, while the coefficient on traditional education with modern subjects is smaller than the university coefficient, but is not statistically significantly so (the p-value from a test of the coefficients' equality is .23). I next repeat this exercise, but limit the sample to individuals aged 40 and older (see Table 9, column 2 and compare to Table 4, column 2), and the results are similar. Finally, I limit the sample to those workers in the clerical department with traditional or university educations, and estimate the treatment effect of a university education among these clerical workers using a nearest-neighbor matching estimator (see Table 9, column 3).<sup>70</sup> Again, there is no large salary premium for the university-educated, relative to the traditionally-educated, in the clerical department. This is further evidence that the traditionally-educated earned less than those with high levels of modern education because the traditionally-educated had skills that limited them to certain jobs, not because they are generally less productive than those with advanced, modern educations.

---

<sup>69</sup>I do not include a dummy variable for engineering training, as only a single engineer worked in the clerical department (as one would expect if engineers' training was put to good use).

<sup>70</sup>This estimate is not exactly comparable to that in Table 4, column 3, as that estimate is of the treatment effect of a university education among all workers with any type of modern or traditional education. In the current exercise, the focus is on traditional education versus the highest level of modern education, so lower levels of modern education are not included in the analysis.

### 3.5.2 Sorting Across Industries

Another important concern is whether very few, or only certain types of, traditionally-educated individuals chose to work for the railroads. Historically, working in teaching or government was more closely associated with the traditionally-educated. Such preferences would have led individuals to work for the railroads only if they were not productive in other fields (negative selection), or if the railroads paid extremely high wages (compensating differentials). It is not clear, then, what sort of bias one would expect from such selection.

This becomes still more complicated once one considers the greater entry of gentry into the private sector in the 19th century (see Chang (1955 and 1962)), the difficulty for traditionally-educated individuals to find teaching positions in the modern education system (see Rawski (1979, page 164), and the fact that the JinPu Railroad was managed by the Chinese government. Admittedly, sorting across industries is a concern, and future work should attempt to provide more systematic evidence on the labor market outcomes of traditionally-educated individuals in republican China.

### 3.5.3 Sorting Within the Railroad

Regarding the occupational results, it is natural to ask about JinPu Railroad personnel policies: is it possible that we see traditionally-educated workers in the clerical department because concentrations of similarly-trained individuals might have certain positive productivity effects (they use the same jargon, etc.)? This seems unlikely to be true: the majority of employees in the clerical department in the JinPu Railroad were actually trained in the *modern* system; but, the traditionally-educated were disproportionately working there. Thus, it is not the case that traditionally-educated workers were, based on hiring policies at the railroad, concentrated in their own (low-wage) department. They worked alongside those trained in the modern system, but not in some of the highest paying departments.

### 3.5.4 Summary

Selection into different educational and occupational outcomes in China around the turn of the 20th century is an important issue in this analysis, and is an extremely interesting topic for further study. One cannot rule out that such selection may bias the estimates here, but it is clear that the selection effects would need to be quite complex to generate the observed labor market outcomes. On the other hand, a parsimonious theory that traditional and modern education produced different types of human capital, which were associated with different wages and occupations, can explain the results very well.

## 4 Conclusion

In this paper, I have presented a collage of historical and econometric evidence suggesting that China's traditional and modern educational institutions produced different types of human capital, and that this was reflected in labor market outcomes. Chinese reformers around the turn of the 20th century were correct in believing that modern, Western education provided especially useful skills for a developing economy that was adopting new technologies from abroad: many of early republican China's most important men in modern industry were educated in the modern system; the Tianjin-Pukou Railroad limited access to certain high-paying jobs to individuals trained in the modern system; and, the Railroad rewarded modern university and engineering training especially well, in order to gain access to scarce, modern human capital.

However, reformers' arguments were often too simplistic: traditional education did earn a wage premium relative to unskilled workers, indicating that it produced human capital that was valuable to modern industry (traditionally-educated individuals did not all end up like Lu Xun's Kong Yiji, penniless).<sup>71</sup> The problem with the human capital provided by traditional education was that it was extremely limited: it allowed one to be a clerk, but not much else – one could not plan the path of a rail-line and manage its development; one could not work as an engineer.

---

<sup>71</sup>Lu Xun, one of China's great modern writers, wrote the story *Kong Yiji* (the surname is that of Confucius) in 1919.

The limitations of traditional human capital can be seen both in the occupational outcomes of employees, and in the large salary differences between the traditionally-educated and those educated in engineering or at university. These findings are important at the individual level, indicating significant income inequality, even within a relatively skilled group of workers. The findings are also important at the macroeconomic level, suggesting that the delayed development of modern educational institutions may have played a role in China's delayed economic modernization; the growth of modern education around the turn of the 20th century may have contributed to China's pre-War economic development.

## References

**Acemoglu, Daron and James A. Robinson** (2008). "Persistence of Power, Elites and Institutions," *American Economic Review*, 98(1), pp. 267-293.

**Allen, Robert C.** (2006). "Agricultural Productivity and Rural Incomes in England and the Yangtze Delta, c. 1620- c. 1820," Nuffield College, mimeo.

**Broadberry, Stephen and Bishnupriya Gupta** (2005). "The Early Modern Great Divergence: Wages, Prices and Economic Development in Europe and Asia, 1500-1800," CEPR Discussion Paper No. 4947.

**Buck, John Lossing** (1937). *Land Utilization in China*. Chicago: University of Chicago Press.

**Cavanaugh, Jerome** (1982). *Who's Who in China, 1918-1950*. Hong Kong: Chinese Materials Center.

**Chaffee, John W.** (1995). *The Thorny Gates of Learning in Sung China: A Social History of Examinations*. Albany, NY: State University of New York Press.

**Chaney, Eric** (2008). "Tolerance, Religious Competition and the Rise and Fall of Muslim Science," Harvard University, mimeo.

**Chang, Chung-li** (1955). *The Chinese Gentry*. Seattle, WA: Washington University Press.

**Chang, Chung-li** (1962). *The Income of the Chinese Gentry*. Seattle, WA: University of Washington Press.

**Chang, Jui Te** (1993). "Technology Transfer in Modern China: The Case of Railway Enterprise (1876-1937)," *Modern Asian Studies*, 27(2), pp. 281-296.

**Elman, Benjamin A.** (2000). *A Cultural History of Civil Examinations in Late Imperial China*. Berkeley, CA: University of California Press.

**Elman, Benjamin A.** (2006). *A Cultural History of Modern Science in China*. Cambridge, MA: Harvard University Press.

**Goldin, Claudia and Lawrence F. Katz** (2000). "Education and Income in the Early 20th Century: Evidence from the Prairies," *Journal of Economic History*, 60, pp. 782-818.

**Goldin, Claudia and Lawrence F. Katz** (2001). "Decreasing (and Then Increasing) Inequality in America: A Tale of Two Half-Centuries," in F. Welch, ed., *The Causes and Consequences of Increasing Inequality*. Chicago, IL: University of Chicago Press.

**Goldin, Claudia and Lawrence F. Katz** (2008). *The Race Between Education and Technology*. Cambridge, MA: Harvard University Press.

**Headland, Isaac Taylor** (no date). *Court Life in China: The Capital, its Officials and People*. Champaign, IL: Project Gutenberg.

**Hon, Tze-ki** (2002). "Zhang Zhidong's Proposal for Reform: A New Reading of the Quanxue

pian,” in Karl, Rebecca E. and Peter Zarrow eds. (2002). *Rethinking the Reform Period. Political and Cultural Change in Late Qing China*. Cambridge, MA: Harvard University Press.

**Huff, Toby** (2003). *The Rise of Early Modern Science: Islam, China, and the West*. Cambridge, UK: Cambridge University Press.

**Hummel, Arthur W.** (1943-44). *Eminent Chinese of the Ch'ing Period*. Washington, DC: U.S. Government Printing Office.

**Jones, Benjamin F.** (2008). “The Knowledge Trap: Human Capital and Development Reconsidered,” Northwestern University, mimeo.

**Karl, Rebecca E. and Peter Zarrow** eds. (2002). *Rethinking the Reform Period. Political and Cultural Change in Late Qing China*. Cambridge, MA: Harvard University Press.

**Köll, Elisabeth** (2009). “Chinese Railroads, Local Society, and Foreign Presence: The Tianjin-Pukou Line in pre-1949 Shandong,” in Bruce A. Elleman and Stephen Kotkin eds., *Rivers of Steel: Manchurian Railways and Chinese Development, An International Perspective*. Armonk, NY: M.E. Sharpe.

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

**Ma, Debin** (2004). “Why Japan, not China, Was the First to Develop in East Asia, Lessons from Sericulture 1850-1937,” *Economic Development and Cultural Change*, 52(2), pp. 369-394.

**Ma, Debin** (2006). “Law and Commerce in Traditional China, an Institutional Perspective on the Great Divergence,” *Keizai-Shirin*, 73(4).

**Ma, Debin** (2008). “Economic Growth in the Lower Yangzi Region of China in 1911-1937: A Quantitative and Historical Analysis,” *Journal of Economic History*, 68, pp.355-392.

**Mokyr, Joel** (1990). *The Lever of Riches: Technological Creativity and Economic Progress*. New York, NY: Oxford University Press.

**Mokyr, Joel** (2002). *The Gifts of Athena: Historical Origins of the Knowledge Economy*. Princeton, NJ: Princeton University Press.

**Mokyr, Joel** (2005). “The Intellectual Origins of Modern Economic Growth,” *Journal of Economic History*, 65(2), 285-351.

**Murphy, Kevin M., Andrei Shleifer, and Robert W. Vishny** (1989). “Industrialization and the Big Push,” *Journal of Political Economy*, 97(5), pp. 1003-1026.

**Murphy, Kevin M., Andrei Shleifer, and Robert W. Vishny** (1991). “The Allocation of Talent: Implications for Growth,” *Quarterly Journal of Economics*, 106(2), pp. 503-530.

**Nicholas, Tom** (1999). “Clogs to Clogs in Three Generations? Explaining Entrepreneurial Performance in Britain Since 1850,” *Journal of Economic History*, 59(3), 688-713.

**Pomeranz, Kenneth** (2000). *The Great Divergence: China, Europe and the Making of the Modern*

*World*. Princeton, NJ: Princeton University Press.

**Rawski, Evelyn S.** (1979). *Education and Popular Literacy in Ch'ing China*. Ann Arbor, MI: University of Michigan Press.

**Rawski, Thomas** (1989). *Economic Growth in Prewar China*. Berkeley, CA: University of California Press.

**Shastry, Gauri Kartini** (2008). "Human Capital Response to Globalization: Education and Information Technology in India," Wellesley College, mimeo.

Swire and Sons Archives, accessed at the School of Oriental and African Studies, London, UK.

Tsinghua University (1917). *Who's Who of American Returned Students*.

*Tiedao Nianjian* (1932).

**Weston, Timothy B.** (2002). "The Founding of the Imperial University and the Emergence of Chinese Modernity," in Karl, Rebecca E. and Peter Zarrow eds. (2002). *Rethinking the Reform Period. Political and Cultural Change in Late Qing China*. Cambridge, MA: Harvard University Press.

**Wong, R. Bin** (1997). *China Transformed: Historical Change and the Limits of European Experience*. Ithaca, NY: Cornell University Press.

**Wright, Mary C.** ed. (1968). *China in Revolution*. New Haven: Yale University Press.

**Yan, Se** (2007). "Real Wages and Skill Premia in China, 1858-1936, Evidence from the China Maritime Customs Archives," UCLA, mimeo.

**Table 1: Summary Statistics**

<u>Variable</u>	<u>Obs.</u>	<u>Mean</u>	<u>Std. Dev.</u>	<u>Min</u>	<u>Max</u>
yearly salary	806	960.61	746.40	180	6600
age (years)	757	36.91	9.26	16	74
tenure (years)	802	5.99	7.08	0	24
prior jobs	715	2.90	1.86	1	11
railroad experience	829	0.59	0.49	0	1
industry experience	829	0.21	0.41	0	1
government experience	829	0.31	0.46	0	1
teaching experience	829	0.12	0.32	0	1
military experience	829	0.20	0.40	0	1
banking experience	829	0.03	0.16	0	1

Note: Salary denominated in Chinese dollars, which exchanged for American dollars at approximately 2.5 Chinese dollars per American dollar. "Prior jobs" is a count of jobs worked prior to his current position with the JinPu Railroad that are listed in the employee's record; the "experience" variables are dummy variables equal to 1 if an employee had experience in the relevant category listed in his record.

**Table 2: Summary Statistics by Broad Education Category**

<b><u>Category</u></b>	<b><u>Obs.</u></b>	<b><u>Mean</u></b>	<b><u>Number</u></b>	<b><u>Ave. Salary</u></b>	<b><u>Ave. Age</u></b>	<b><u>Ave. Tenure</u></b>	<b><u>Prior Railroad Experience</u></b>	<b><u>Num. Prior Jobs</u></b>
modern	829	0.585	485	1020.5	34.4	5.4	0.64	2.6
traditional	829	0.057	47	1174.2	43.6	8.3	0.57	2.9
military	829	0.082	68	969.6	36.7	3.8	0.41	3.3
police	829	0.082	68	600.7	39.1	6.6	0.74	3.0
apprent.	829	0.018	15	1042.4	46.3	9.9	0.80	3.0
no education	829	0.176	146	837.5	44.0	7.8	0.44	1.3

Note: "Obs." refers to the number of individuals in the sample; "Mean" is the average value of each educational category dummy variable in the entire sample; and "Number" refers to the number of individuals in the relevant educational category in the sample. Salary is denominated in Chinese dollars; age and tenure are in years; prior railroad experience is a dummy equal to 1 if an individual had experience with a railroad prior to his current position with the JinPu Railroad; the number of prior jobs is simply a count of prior jobs listed in the employee's record with the JinPu Railroad. Averages within an educational category are for the individuals with a 1 for the relevant educational category dummy variable, and non-missing information in the specific category.

**Table 3: Salary Differences Across Broad Education Categories**

	<i>Outcome variable: log(salary)</i>				MATCHING
	(1)	(2)	(3)	(4)	(5)
modern	0.28 [.075]***	0.315 [.075]***	0.333 [.078]***	0.451 [.151]***	-0.114 [.141]
traditional	0.482 [.123]***	0.255 [.118]**	0.31 [.115]***	0.367 [.177]**	
military	0.286 [.098]***	0.228 [.099]**	0.204 [.098]**	0.286 [.209]	
apprent	0.268 [.145]*	0.009 [.140]	0.099 [.158]	0.208 [.203]	
police	omitted	omitted	omitted	omitted	
p-value: modern=traditional	0.06	0.56	0.8	0.29	0.42
obs.	674	665	660	219	516
r-squared	0.02	0.31	0.38	0.53	
controls	none	age, age <sup>2</sup> , province dummies	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs
ages	all	all	all	40 and older	all

Note: Robust standard errors in brackets. Regressions have log salary as an outcome, a set of dummy variables for broad education categories, and a set of controls. Columns 1-4 use OLS; column 5 uses nearest-neighbor matching on the sample of individuals educated in the traditional or modern system. \* p<0.1, \*\* p<0.05, \*\*\* p<0.01

**Table 4: Salary Differences Across Disaggregated Educational Categories**

	<i>Outcome variable: log(salary)</i>		MATCHING
	(1)	(2)	(3)
missionschool	0.336 [.109]***	0.36 [.186]*	
primarymid	0.169 [.083]**	0.178 [.160]	
secondary	0.261 [.116]**	0.391 [.207]*	
teacherscol	0.127 [.125]	0.185 [.361]	
vocational	0.325 [.097]***	0.684 [.233]***	
university	0.761 [.098]***	1.022 [.197]***	0.528 [.100]***
tradmod	0.356 [.131]***	0.34 [.208]	
tradtrad	0.303 [.184]*	0.439 [.240]*	
modmil	0.449 [.128]***	0.912 [.270]***	
tradmil	0.193 [.105]*	0.302 [.217]	
apprent	0.099 [.150]	0.207 [.193]	
police	omitted	omitted	
obs.	660	219	516
r-squared	0.45	0.39	
controls	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs
ages	all	40 and older	all

**Note:** Robust standard errors in brackets. Regressions have log salary as an outcome, a set of dummy variables for narrow education categories, and a set of controls. Columns (1) and (2) use OLS, column (3) uses a matching estimator only on individuals trained in the traditional or modern system. \* p<0.1, \*\* p<0.05, \*\*\* p<0.01

**Table 5: Including Engineering and Foreign Education Dummy Variables**

	<i>Outcome variable: log(salary)</i>		MATCHING
	(1)	(2)	(3)
university	0.529 [.100]***	0.714 [.192]***	
foreign	0.505 [.114]***	0.422 [.166]**	
engineering	0.449 [.092]***	0.876 [.159]***	0.818 [.140]***
obs.	660	219	516
r-squared	0.49	0.45	
controls	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs
ages	all	40 and older	all

Note: Robust standard errors in brackets. Regressions have log salary as an outcome, a set of dummy variables for narrow education categories, dummies indicating specific training (at foreign institutions or in engineering), and a set of controls. Columns (1) and (2) use OLS, column (3) uses a matching estimator only on individuals trained in the traditional or modern system. \* p<0.1, \*\* p<0.05, \*\*\* p<0.01

**Table 6: Summary Statistics for Occupational Categories**

<u>Occupational Category</u>	<u>Obs.</u>	<u>Mean</u>	<u>Number</u>	<u>Ave. Salary</u>
police	829	0.27	227	640.1
machine	829	0.33	270	998.5
roads	829	0.11	95	1110.3
clerical	829	0.19	158	1127.3
train	829	0.04	32	681.1
hospital	829	0.01	5	1812.0
managerial	829	0.05	42	1377.2

Note: Salary denominated in Chinese dollars. Average salary is noted for the individuals with a 1 for the relevant dummy variable.

**Table 7: Occupational Outcomes Across Education Types**

	<i>Occupation Category</i>					
	<b>Police</b>	<b>Machine</b>	<b>Road</b>	<b>Clerical</b>	<b>Train</b>	<b>Management</b>
modern	0.031	0.006	0.193	-0.215	-0.015	0.072
	[.045]	[.067]	[.045]***	[.067]***	[.040]	[.018]***
police	0.706	-0.337	-0.007	-0.318	-0.036	0.011
	[.063]***	[.065]***	[.046]	[.075]***	[.040]	[.015]
military	0.622	-0.259	0.114	-0.457	-0.018	0.022
	[.067]***	[.067]***	[.052]**	[.072]***	[.047]	[.023]
apprent	0.014	0.519	-0.071	-0.392	-0.069	0.011
	[.083]	[.098]***	[.045]	[.069]***	[.040]	[.017]
traditional	omitted	omitted	omitted	omitted	omitted	omitted
obs.	663	663	663	663	663	663
r-squared	0.5	0.24	0.18	0.18	0.09	0.08

Note: Robust standard errors in brackets. Each column represents an independent OLS regression with a dummy variable indicating that an employee has an occupation in the relevant category as the outcome variable. The explanatory variables are dummies for broad educational categories (with traditional education as the omitted comparison group), and controls for age (a quadratic polynomial), tenure (a cubic polynomial), number of prior jobs, a dummy variable indicating prior railroad experience, and a set of province of origin dummy variables. \* p<0.1, \*\* p<0.05, \*\*\* p<0.01

**Table 8: Multinomial Logit Estimates**

	<i>Occupation Category</i>				
	<b>Police</b>	<b>Road</b>	<b>Clerical</b>	<b>Train</b>	<b>Management</b>
modern	-0.62	1.858	-1.05	-0.254	19.225
	[.637]	[.796]**	[.455]**	[.731]	[2.708]***
obs. 659			Pseudo R-squared: 0.25		

Note: Robust standard errors in brackets. Each column represents a model that was estimated jointly with the others. The reported coefficients indicate the change in the log probability of being in the relevant occupational category (relative to the omitted *machine* category), when moving from the omitted *traditional* education category to the *modern* education category. The models include controls for age (a quadratic polynomial), tenure (a cubic polynomial), number of prior jobs, and a dummy variable indicating prior railroad experience. \* p<0.1, \*\* p<0.05, \*\*\* p<0.01

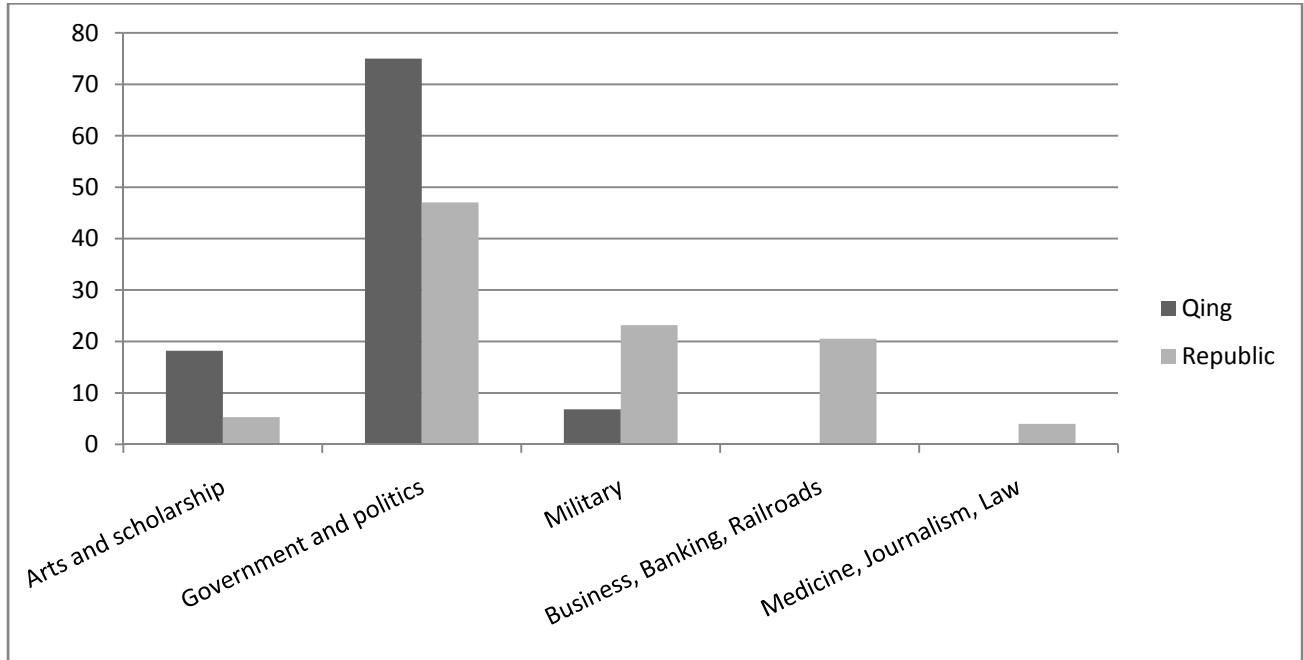
**Table 9: Salary Differences Across Disaggregated Educational Categories:  
Clerical Department Employees**

	<i>Outcome variable: log(salary)</i>		MATCHING
	(1)	(2)	(3)
missionschool	0.608 [0.288]**	0.263 [0.538]	
primarymid	0.060 [0.213]	0.059 [0.438]	
secondary	0.007 [0.225]	0.168 [0.280]	
teacherscol	-0.008 [0.279]	-0.242 [0.560]	
vocational	0.229 [0.207]	0.488 [0.447]	
university	0.468 [0.206]**	0.094 [0.360]	0.28 [0.193]
tradmod	0.195 [0.276]	0.058 [0.409]	
tradtrad	0.530 [0.342]	0.607 [0.446]	
modmil	-0.040 [0.189]	.	
tradmil	0.800 [0.279]***	.	
apprent	.	.	
police	omitted	omitted	
obs.	142	50	50
r-squared	0.47	0.63	
controls	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs	quadratic age, cubic tenure, province dummies, prior railroad exper, num. prior jobs
ages	all	40 and older	all
department	clerical	clerical	clerical

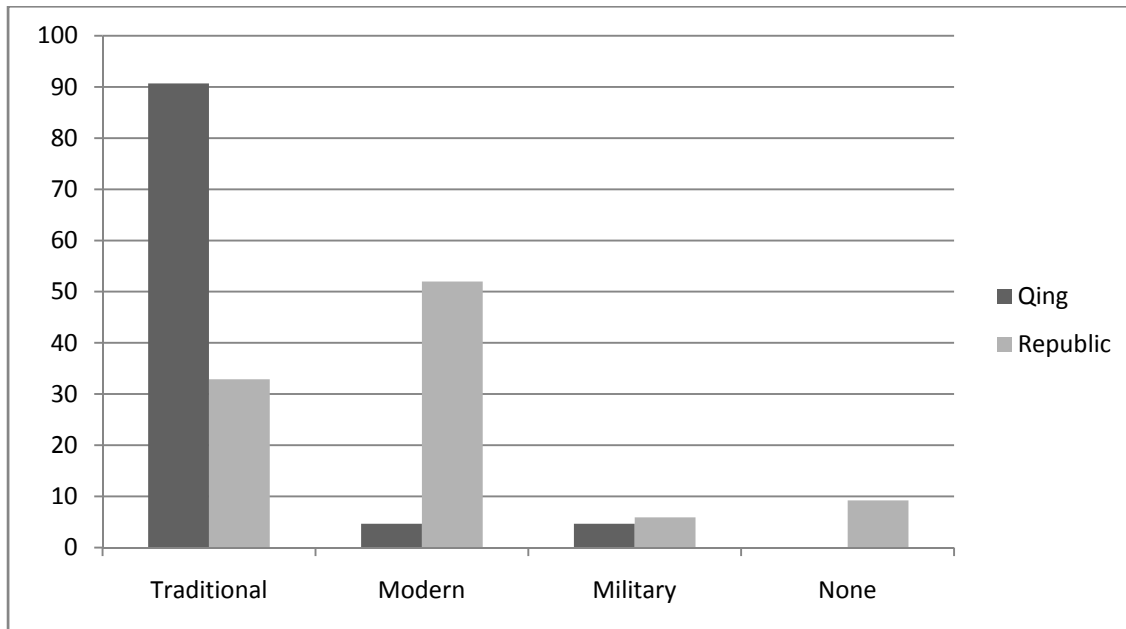
**Note:** Robust standard errors in brackets. Regressions have log salary as an outcome, a set of dummy variables for narrow education categories, and a set of controls. Columns (1) and (2) use OLS, column (3) uses a matching estimator only on individuals trained in the traditional system or through the university level in the modern system. \* p<0.1, \*\* p<0.05, \*\*\* p<0.01

**Figure 1:** Fields and Educational Backgrounds of Individuals Profiled in *Who's Who* Compilations for Imperial (Qing) and Republican China

**Panel A: Percentage of Individuals in Different Fields of Success**

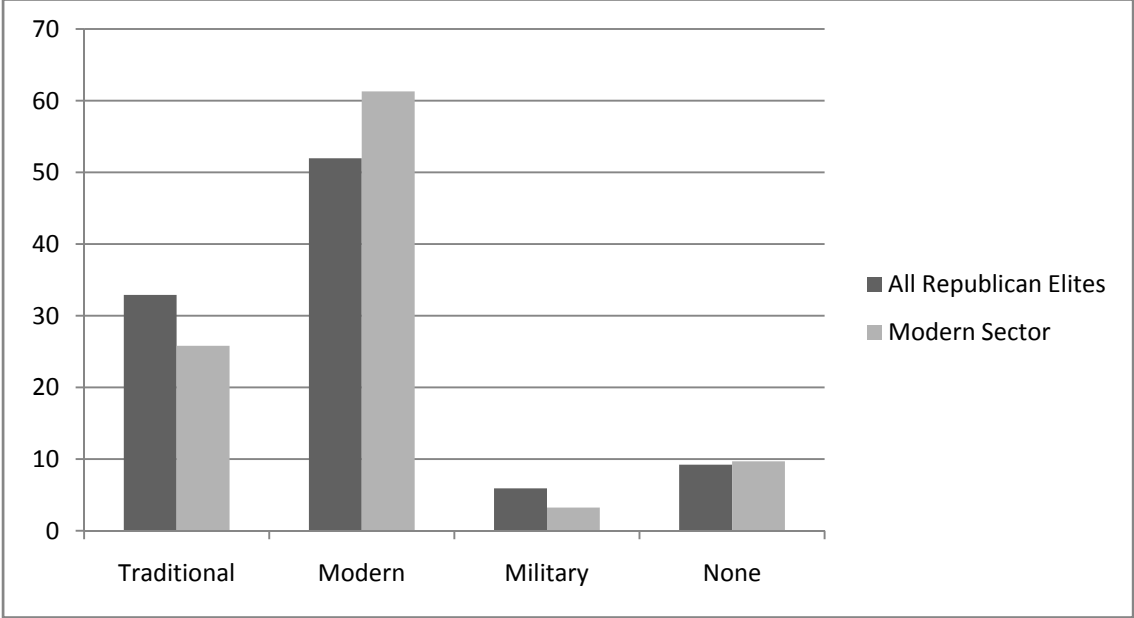


**Panel B: Percentage of Individuals from Different Educational Backgrounds**



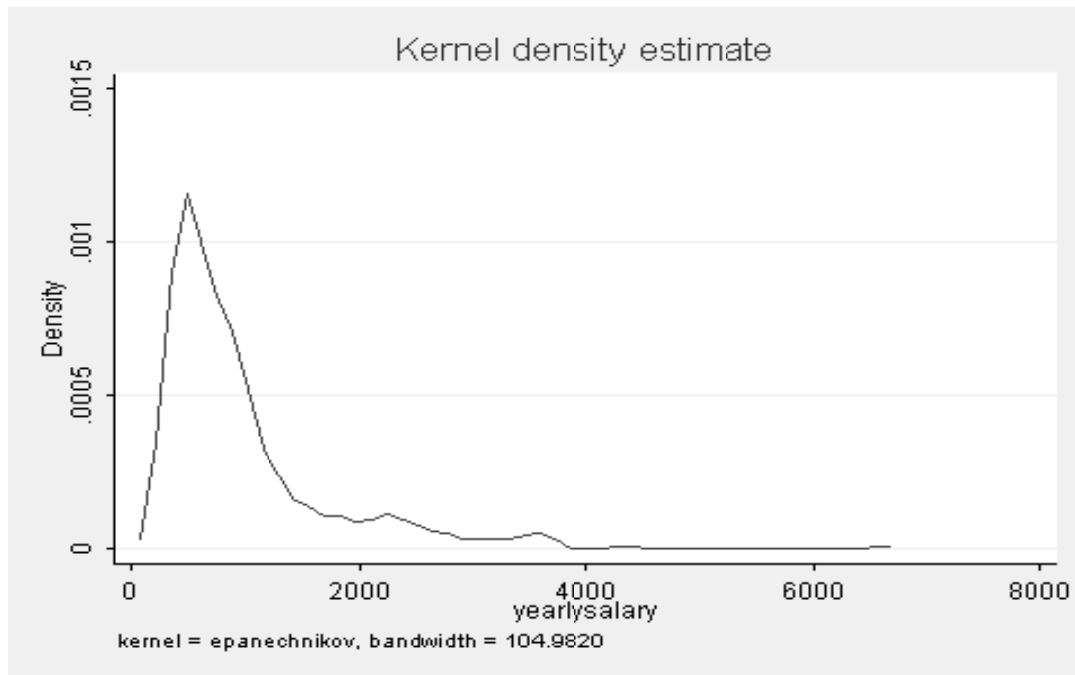
**Note:** Profiles analyzed come from *Eminent Chinese of the Qing Period*, edited by Arthur Hummel (44 individuals) and *Who's Who in China*, published by the *Millard's Review* (152 individuals).

**Figure 2:** Educational Background of Profiled Individuals Working in the Modern Sector in Republican China



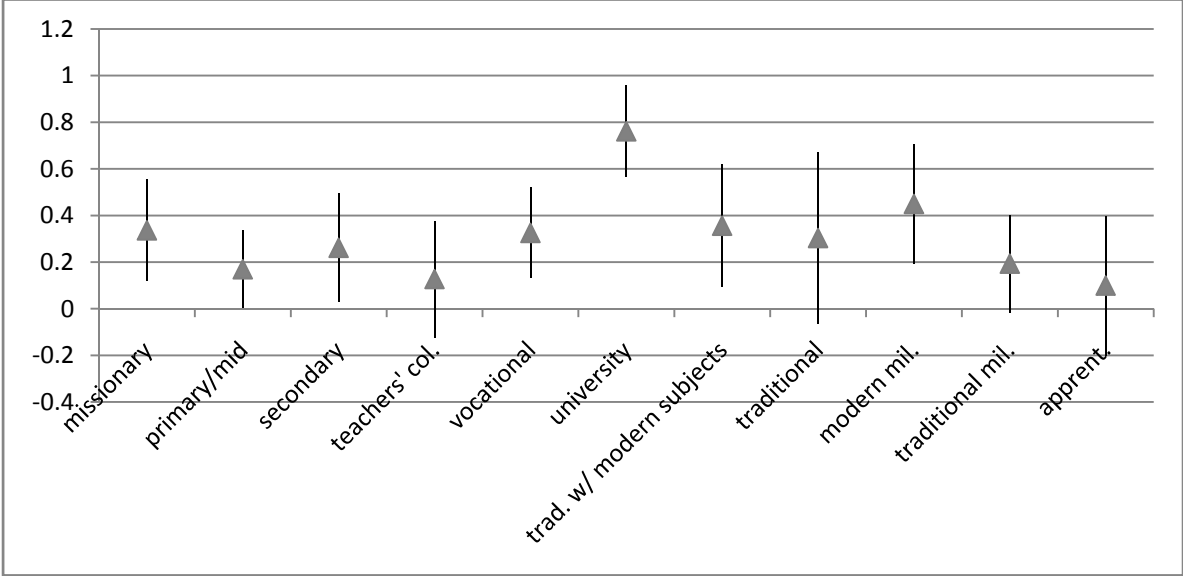
Note: Profiles analyzed come from *Who's Who in China*, published by the *Millard's Review*.

**Figure 3: Distribution of Yearly Salaries**



Note: Salaries come from 806 workers with information on salary or grade, with grades converted into salaries using conversion from the 1932 Railway Yearbook.

**Figure 4: Salary Differences Associated with Narrow Education Categories**



Note: Graph shows coefficient estimates and 95% confidence intervals for dummy variables indicating an educational background in the categories listed (with a police education the omitted group). Coefficients come from regressing log salary on dummy variables for narrow educational categories, control variables for age, tenure, prior work experience, and province of origin. Confidence intervals based on heteroskedasticity-robust standard errors.