Military Investment and the Rise of Industrial Clusters: Evidence from China's Self-Strengthening Movement*

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Abstract

This paper studies the short- and long-term impact of large-scale military investment on civilian industrial growth by focusing on China's first attempt to modernize its military sector between 1861 and 1894. Panel data from 1858 to 1937 suggest that the program generated positive effects on civilian firm entry, but these effects appeared only after the government relaxed constraints on the entry of private firms. Long-term analysis shows that counties that received more military investment through the program, driven by plausibly exogenous *ex ante* political connections, had greater output in civilian industries in the 1930s. Analysis of the mechanisms suggest that the program boosted local economies through input-output linkages, human capital accumulation, and the rise of modern banks.

Keywords: Industrialization; military investment; industrial policy; industrial clusters; input-output linkages

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1 Introduction

Military threats haunt every nation and are key determinants of the allocation of state resources. From the fifteenth to the mid-twentieth century, the growing intensity and scale of warfare pushed many countries to increase their investment in military technology. An unintentional consequence of such state-led capital accumulation and technological progress in the defense sector was the spillover to other sectors. If the spillover effect was large enough, such as in Meiji Japan and the Russian empire, investment in the defense sector may triggered the transition toward a modern economy.

This paper studies the economic consequences of Imperial China's efforts to westernize its national defense sector in response to a series of military failures. Having experienced internal and external military challenges from the 1850s onward, a group of officials started the "Self-Strengthening Movement" (hereafter referred to as SSM) in 1861 to strengthen the nation's military power using Western technology. The program ran for over 30 years and resulted in the investment of 3.5% of the national income in the defense sector. Although the movement's primary aim was to boost national defense, it also involved activities that generated spillover effects on other industrial sectors: through the program, technicians were hired and translating schools were established, thereby introducing modern science and technology to the Chinese population; the program purchased machines from overseas, thus cementing long-distance trade networks. Some historians believe that "[f]rom 1860 to 1895 the face of urban China was changed by the opening of a significant number of mechanized factories" (Rowe, 2010, page 435), and the movement is "a harbinger of the Chinese industrial revolution to come" (Elman, 2004, page 326).

However, unlike the situations in Meiji Japan and the Russian empire, the movement failed to industrialize pre-modern China. In 1933, nearly 40 years after the movement, the contribution of industrial output to the national income was only about 3% (Rawski, 1989). Based on case studies, some economic historians find that the movement "produced virtually no spillover for the private sector" before 1895 (Brandt, Ma, and Rawski, 2017, page 6), partially because the government acted as an "obstacle", with limited efforts in promoting capital accumulation and technological progress that were essential to long-term industrial growth (Perkins, 1967, page 478).

We compile new data on industrial sectors from 1858 to 1937 to quantitatively evaluate the impact of the SSM on industrial growth and understand the spillover of military investments to other industries. Using panel data on civilian industrial firm entry, we first apply a difference-in-differences (DID) strategy to show that, after the establishment of munition factories, counties experienced a 33.4% increase in civilian firm entry. A Goodman-Bacon decomposition suggests that most of the effects arise from the comparison between the treated and untreated counties. To improve comparability, we adopt the coarsened exact matching (CEM) approach and obtain similar results.

The panel structure of the data allows us to validate the parallel pre-trend and control for county-level, time-invariant unobservable characteristics. In addition, we find the treatment effect to be small at first but salient after the 1890s, when the government lifted its entry restrictions on foreign and private firms. This echoes the importance of removing entry barriers to foreign and private firms for industrialization, as emphasized in other studies (Cheremukhin, Golosov, Guriev, and Tsyvinski, 2017; Brandt, Kambourov, and Storesletten, 2020).

The second part of our analysis evaluates the long-term impacts of the movement on civilian industrial output in 1933 using data digitized from the only industrial census conducted in China before the Second World War (WWII). The ordinary least squares (OLS) result, obtained after controlling for a rich set of socioeconomic characteristics, shows that a 1% increase in military investment was associated with a 0.597% increase in industrial output values in 1933. The results obtained using the CEM approach are very similar. Closer examination shows that the effect was localized without geographic spillover and had little impact on total factor productivity.

To further validate the causal relationship of the cross-section regression, we exploit the fact that the political connections of local governors largely determined the creation of munition factories. By collecting correspondence between the program's central advocate and local governors prior to the program and applying textual analysis to identify all of the letters discussing Western technology, we use the number of related letters as an instrument. The two-stage least squares (2SLS) estimator is close to the OLS estimator and remains statistically significant.

After establishing the causal relationship between military investment and later industrial development, we examine how investment in the military sector, which presumably introduced military-specific technology, facilitated growth in civilian industries. Using an input-output table derived from the 1929 U.S. census, we show that industries with stronger backward links to the military industry were more likely to develop. Further analysis suggests that the munition factories possibly required intermediate goods from the local economy, consistent with the high transportation costs of the examined period. We also consider other mechanisms for persistent growth commonly discussed in the literature, such as human capital accumulation of technical expertise and the creation of institutions facilitating business with foreigners. Our results show that military investment encouraged the accumulation of science-related human capital and entry of local banks.

This study is related to an emerging body of literature that uses temporary industrial shocks in history to examine the long-term effects of government programs (Kline and Moretti, 2013; Juhász, 2018; Giorcelli, 2019; Dell and Olken, 2020; Hanlon, 2020). In recent related studies on China, Fan and Zou (2021), Giorcelli and Li (2021) and Heblich, Seror, Xu, and Zylberberg (2021) examine the effect of the place-based policies of socialist China during the 1950s and 1960s on today's industrial output by identifying input-output linkages and other long-term agglomeration forces. Our study focuses on a much earlier period, when few modern industries existed before the program and investments were concentrated in the military sector. This historical event provides a relatively clean setting in which to identify the sole effect of investment in the defense sector and bypass the concerns of heterogeneous agglomeration across industries raised by Faggio, Silva, and Strange (2017). In addition, the continuous annual records available on firm entry enable us to conduct detailed analysis on the dynamics of the treatment effect before and after the program, which we use to reveal the key role of the deregulation of private firms.

This study also provides new empirical evidence on external economies of scale, a main theoretical rationale for industrial policies (Hirschman, 1958; Bartelme, Costinot, Donaldson, and Rodríguez-Clare, 2019).Although the nature of this movement differs from that of a modern industrial policy, studying how investment in the defense sector has spillover effects on other sectors can provide useful evidence for the external economies of scale. In a recent study, Gross and Sampat (2020) show that government-sponsored research investments have a large effect on technology clusters in the long run. Lane (2021) shows that the Heavy-Chemical Industry Drive in South Korea from 1973 to 1979, as a sector-specific industrial policy, promoted the expansion of targeted and downstream industries in the long run. Our study differs from these studies by focusing on the *unintentional* consequences of sector-specific investment in an economy without a pre-existing industrial base. The finding that external economies of scale manifest mostly through input-output linkages is consistent with the findings of several recent studies (Ellison, Glaeser, and Kerr, 2010; Blonigen, 2016; Liu, 2019; Lane, 2021).

As the first paper that quantitatively evaluates the SSM, this study continues the long-standing investigation of pre-modern China's transformation after its exposure to the Western industrialized world (Brandt, Ma, and Rawski, 2014; Kung, 2022). The economic history literature emphasizes the importance of trade openness (Jia, 2014a), knowledge diffusion brought by Protestantism (Bai and Kung, 2014), and the disruption of the original elite recruitment structure (Bai and Jia, 2016; Bai, 2019). Studies that focus on the industrial sector consider the role of the government in this transformation to be passive (Feuerwerker, 1958; Perkins, 1967; Rawski, 1989), consistent with its weak fiscal capacity (Sng, 2014; Sng and Moriguchi, 2014). However, Halsey (2014) questions this dismal traditional picture by comparing late nineteenth-century China's changes in fiscal and military sector to the state-building efforts of early modern Europe. This paper shows that, despite its weak state capacity and inefficient management, public investments made in the late nineteenth century shaped the geographic distribution of industrial sectors over time through multiple mechanisms.

The rest of the paper is organized as follows. Section 2 presents the historical context of our analysis. Section 3 discusses the data sources and defines the variables. Section 4 presents the main empirical results on the short- and long-term impacts of the program. Section 5 analyzes a number of potential mechanisms. Finally, Section 6 concludes the study.

2 Background

The SSM was Imperial China's response to a series of military crises in the mid-nineteenth century. The main goals of this movement were to master Western technology and strengthen the country's military power. Between 1861 and 1894, 34 munition factories were established. Most of these firms were under government control and had low efficiency. However, as Imperial China's first group of modern industries, they may have affected the local economy through multiple channels.

The key to identifying the effects of this program on other industries is to understand the location choices of the munition factories. Archival information suggests that, among all of the drivers, the attitude and support of local governors played the most prominent role.

2.1 The Self-Strengthening Movement

The SSM originated from the reactions of politicians and elites to a series of military threats from the 1850s onward. Imperial China was defeated during the Second Opium War (1856-1860), when British and French troops easily advanced toward the capital and forced the emperor to escape from the Forbidden City. Meanwhile, the Taiping Rebellion, which started in southern China, occupied the Lower Yangtze region for several years. These external and internal threats led to calls for an urgent reform of the military sector.

In 1861, a group of officials began to discuss, through official documents, the need to master Western technology and produce steamships and weapons with which to fight rebellion and strengthen the Chinese army.[1] In the same year, Marquis Zeng Guofan established the first Western-style munition factory in the province he governed. From 1861 to 1894, 30 similar factories and 4 shipyards were established across the country to produce military equipment and Western-style weapons and ships. This movement later spread to civilian industries such as textiles and mining in a limited scale, but often encountered opposition.[2]

Imperial China's defeat in the First Sino-Japanese War in 1895 marked the end of the SSM and forced the government to sign the Treaty of Shimonoseki, officially allowing foreign firms to enter China. This failure also led to a loss of trust in government-led industrialization and a conclusion that the SSM had been ineffective. In response to this atmosphere of distrust, the government relaxed its restrictions on private industrial firms. The following decade saw the creation of the Commerce Department in 1903, alongside a series of policies intended to encourage Chinese entrepreneurs to enter the industrial sector. The number of private industrial firms gradually increased and eventually overtook the number of public firms. The government quickly gave up ownership of the very few civilian firms but still controlled most of the munition factories.

2.2 The Birth of Modern Industries

Before 1860, Imperial China was essentially an agrarian economy, complemented by small-scale handicraft industries (Brandt, Ma, and Rawski, 2014). It had lively local and regional

[1]See Kuo and Liu (1978) for an overview. Examples of efforts to promote modernization include Yixin, Guiliang, and Wenxiang's memorials to the emperor on July 7, 1861 (Jia, 1979, page 2913) and Zeng Guofan's memorial to the emperor on July 18, 1861 (Bao, 2008, page 20)

[2]Some officials strongly opposed the idea of learning from the West in civilian industries throughout the movement. In addition, scholars believe that the movement was limited to the military sector (Cantoni and Yuchtman, 2013).

markets (Myers and Wang, 2002), but a limited scale of international trade despite the opening of five treaty ports after 1842. Most regions had virtually no contact with the Western world.

The SSM and newly established munition factories changed this picture. Aiming to produce advanced weapons, these factories were mechanized and equipped with imported machines, raw materials and technicians. As an example, the largest munition factory in the SSM, the Jiangnan Arsenal (*Jiangnan Zhizaoju*), reported in 1868 that it had built several manufacturing houses, including a gas furnace house, machinery house, wrought iron house, Western-style weapon house, carpentry, copper and iron factory, warehouse, storehouse, coal house, office, and dorms for technicians.[3] These technological advances allowed the factory to take a leading position in nineteenth-century Asia (Yue, 1999). The outputs of such factories were exclusively munitions, steamships, and accessories in the defense sector. In 1868, the Jiangnan Arsenal produced 12 French light cannons, 12 gun carriages, 1000 cannonball, 100 guns, 100 rifles, 200 carbines, 100 rockets, and 200 rocket carriages. Although other factories were not as well-funded as the Jiangnan Arsenal, they took a similar approach. For example, the much smaller the Fujian Arsenal (*Fujian Jiqiju*) also produced 2 breech-loading swivel guns and 10 wrought iron rifles in 1870, which were " comparable to the foreign ones."[4] The products of the munition factories were not sold on the market but directly distributed to the military.

The imports of physical and human capital occurred throughout the movement. According to a summary by Yue (1999), the movement leaders viewed manufacturing machines, machine workers, and the translation of scientific and technical texts as the three basic ingredients for constructing new industries. Therefore, in the early period, almost all of the physical inputs, including machinery and raw materials, were imported. As the movement progressed, some officials sought local resources, especially coal and iron, to reduce production costs. Meanwhile, the factories always hired foreign technicians, with some of the well-funded factories even translating books to learn science and engineering. The largest translation house was affiliated with the Jiangnan Arsenal, and it hired missionaries to translate more than 100 books from the West, first for practical purposes; the focus later shifted to books on basic science, social science, law, and Western history.

[3]See *Zhongguo jindai bingqi gongye dang'an shiliao*, vol. 1 pages 56 (The Second Historical Archives of China, 1993).

[4]See *Zhongguo jindai bingqi gongye dang'an shiliao*, vol. 1 pages 118 (The Second Historical Archives of China, 1993).

The estimated total investment in munition factories, such as expenditures for imports, hiring technicians, and translating books, was at least 55 million taels, which accounted for about 3.5% of the Qing government's total fiscal expenditure in this period.[5] The factories and investments likely affected the local economy through different channels. First, the production of firearms created demand for coal, iron, steel, and other intermediate goods, which would have encouraged the industries producing or sharing these intermediates or inputs. Second, the factories with affiliated schools or translating houses might have facilitated the accumulation of knowledge and local technicians. Third, by importing machinery, the munition factories could have also fostered business-friendly institutions. We will discuss each mechanism in detail and empirically test them.

2.3 Geographic Determinants of the Locations of Factories

As the movement lacked central planning or a clear guideline for the location choices of munition factories, we collect historical archives, which largely consist of official memorials to the throne that discussed setting up munition factories, to understand how locations were chosen. Archives show that officials considered closeness to coastlines, waterways and coal and iron mines, presence in provincial capitals, and accessibility to foreign enclaves when planning for munitions factories.

The national defense concern for naval warfare was essential to the decision to initiate the movement. Therefore, there were intense discussions about whether to set up factories in coastal areas or inland. Early proposals preferred the former as the products could be provided in a timely manner during a naval battle.[6] Most factories were therefore located along the coast. Later, however, after the Sino-French War in 1883 destroyed the Fuzhou Shipyard along the coastline, officials suggested that factories be established inland. A few factories in the later period of the movement were therefore built inland.[7] A few factories in the later period of the movement were therefore built inland.

[5]The fiscal expenditure data come from Shen (2006), with 11.4 million from 1861 to 1874, 18 million from 1875 to 1884, and 27.54 million from 1885 to 1894. The investment data come from Fan (2003), including investments in munition factories and shipyards. The total investment was 57 million for the whole country and 55 million for the sampled provinces.

[6]For example, a suggestion by Zhou Jiamei, later forwarded by the Office for the General Management (*Zongli Yamen*) to the emperor, the department in charge of the SSM, mentions that "to use the ships at any times, we need to set up factories everywhere...The factories should be set up by the Fuzhou Shipyard, the munition factories in Tianjin and Shanghai, as well as other places along the coastline"; see *Zhongguo jindai bingqi gongye dang'an shiliao*, vol. 1 page 10 (The Second Historical Archives of China, 1993).

[7]An example is the memorial to the throne by Zhu Yixin, see *Zhongguo jindai bingqi gongye dang'an shiliao*, vol. 1 page 27 (The Second Historical Archives of China, 1993).

In terms of other geographic determinants, the advantage of being close to waterways is that it lowers the transportation costs for machines and products, especially when the factories are located inland. The availability of local mines significantly reduced production costs and accessibility to foreign enclaves and firms, which helped further lower the cost of purchasing machines in that early period.[8] In addition, it was natural for factories to be built in provincial capitals as this facilitated easier supervision. Appendix A provides examples of the documents that discuss location choice.

2.4 The Role of Political Attitude

Closer examination suggests that, compared with other factors, provincial governors' attitudes played a key role in determining where to build these factories due to the conflicting political attitudes and decentralized fiscal system in the late nineteenth century. After the humiliating defeat in the Second Opium War, most politicians believed that the Qing dynasty was facing a major crisis but did not agree on how to deal with Westerners (Hao and Wang, 1980). As the central government remained neutral instead of clearly supporting Westernization, local officials who supported learning from the West (known as the "pro-reform faction", or *yangwu pai*), led the construction of the modernized munition factories.

The decentralized fiscal structure of this period enabled local governments to flexibly allocate their resources and fund munition factories. Although local governments had always been responsible for collecting taxes in the Qing dynasty, before the mid-nineteenth century, the central government used extra income to fund large public projects such as arsenals. This fiscal structure was transformed when the Taiping Rebellion destroyed the traditional tax base and forced the central government to grant provincial governments substantial autonomy in the collection, use, and distribution of local public funds.[9] Therefore, during our examined period, provincial governors only handed over a small fixed contribution to the central government and gained flexibility in expending their surplus income; provincial governors used these funds to set up munition factories. Halsey (2014) views these efforts to reform the fiscal

[8] In an extreme example, Li Hongzhang proposed to acquire a small foreign munition factories in the foreign enclave in Shanghai and expand it to the Jiangnan Arsenal in later years.

[9] Before the mid-nineteenth century, about 70% of the central government's fiscal revenue came from land taxes. The Taiping Rebellion largely hampered agricultural production in more than half of the provinces and drastically reduced fiscal revenue from traditional sources. In response, provincial governments developed new sources of taxes, such as the transit tax ("*likin*"), to overcome financial difficulties.

structure and fund munition factories as being in a similar spirit to that of state-building in early modern Europe.

Historical evidence suggests that provincial governors swayed the decision to establish munition factories. For example, the proposal to establish munition factories was frequently put forward by provincial officials rather than by the court. For a factory under construction, funding was mostly obtained from the province.[10] In other words, the decision to establish a factory depended less on the permission of the central government and more on the support of local governors. This feature became more evident when a provincial governor "carried the munition factory" upon being transferred to another province. For instance, the founder of the first munition factory, Zeng Guofan, took the factory with him from Anhui to Jiangsu. When Zuo Zongtang marched West during the civil war in the 1870s, he set up at least two munition factories on his way (Wang, 2009). In another example, Ding Baozhen, as an enthusiastic advocate of Western technology, set up two munition factories when he served as provincial governor for two distant provinces.[11] In these cases, the governors' personal attitudes toward Western technologies, and not the indigenous advantages of these places, determined whether and when munition factories were built.

The relocation of a munition factory from Guangdong to Hubei along with its provincial governor illustrates the relative importance of different factors. When Zhang Zhidong governed Guangdong, he initiated a factory there that took 3 years to collect sufficient funding. Later, when he was transferred to Hubei before the funding was fully collected, his successor in Guangdong wrote to the central government to complain of the difficulties in operating the factory and request to transfer the machines to other places. Zhang Zhidong then proposed to relocate the factory to Hubei, his current territory, stating formal reasons such as Hubei being "easier to access by waterways" and "full of coal." The central government then agreed to his proposal.[12] In this example, the provincial governor was the essential factor in establishing the factory, whereas other factors were used to justify the location choice. As the political at-

[10] For example, as the leading factories during the movement, the Jiangnan Arsenal and Fuzhou Shipyard relied on maritime customs tariffs for their daily operations. This was at the request of several governors, made years after the factories had been established. See *Zhongguo jindai bingqi gongye dang'an shiliao*, vol. 1, pages 575-578 (The Second Historical Archives of China, 1993). Other factories had similar situations.

[11] Ding Baozhen first established a factory in Shandong, a coastal province in the North, and then another in Sichuan, an inland province in the South, when he was transferred there. Both factories relied on local funding. His transfer was sanctioned to investigate corrupt officials in Sichuan and not related to the factories.

[12] See *Zhongguo jindai bingqi gongye dang'an shiliao*, vol. 1, pages 210-216 (The Second Historical Archives of China, 1993) for the details.

titude was particularly important in determining the locations of firms, we use this feature to construct an instrument for analysis.

3 Data and Descriptive Statistics

To investigate the effect of military investment during the late nineteenth century on subsequent industrial development, we collect county-level data from various sources. The main independent variable is a measure of military investment during the SSM. We also collect factors that may have affected the locations of munition factories and socioeconomic factors that influenced the performance of industrial sectors.

3.1 Outcome Variable: Measures on Industrial Development

We use two measures for the performance of civilian industries. We first collect annual data from 1858 to 1937 on the entry of new industrial firms at the county level. Information on firm entry is obtained from Du (1991, 2019) that reports the date of establishment, location, initial investment of each firm, and whether the firm was government-supervised or privately owned. These are by far the most comprehensive secondary sources of industrial firms in pre-war China. Appendix B.1 provides additional details about the sources and construction of firm entry data. Using this dataset, we construct a panel dataset to check the pre-trends and examine the dynamics of firm entry and heterogeneous responses of government-supervised and private firms.

We also digitize county-level information on industrial output and input in 1933, such as labor, capital stock, and raw materials, from the only industrial census conducted in China before WWII. The industrial census was conducted by the Institute of Economic Statistics in 1933 and published in 1937 (Liu, 1937). The data are regarded as being of high quality and are frequently used in studies of China's pre-war industrial sector.[13] Data Appendix B.1.2 provides more details. As the independent variables are data from the late nineteenth century, we match all of the information with counties in 1911 based on county records from the China Historical Geographic Information System v6 (hereafter referred to as CHGIS) (Harvard Yenching Institute, 2016). The matched dataset consists of 1,432 counties in 15 core provinces covering the

[13] Scholarly works based on this data include Liu and Yeh (1965); Chang (1969) and Rawski (1989).

major industrial regions in China.[14] We use this dataset to conduct a cross-sectional regression and evaluate the long-term effect of military investment on industrial growth.

3.2 Military Investment

Our key explanatory variable is the establishment of munition factories and shipyards during the SSM between 1861 and 1894, as derived from Fan (2003). For each munition factory established during the SSM, Fan (2003) provides comprehensive secondary information by recording its name, location, investment, and brief history obtained from official memorials to the throne and other archives. We use these data to construct a county-level panel on the establishment of munition factories and cross-sectional variation on the total investment. Data Appendix B.2 provides further details on the construction of variables. As shown in Appendix Table A1, most factories were established in the 1870s and 1880s; their total investment varied from 3,000 to 13.37 million taels.

Figure 1 shows the output value of civilian industrial production in 1933 and total investment in munition factories from 1861 to 1894 by county, with the darker areas indicating higher civilian industrial output and larger circles indicating more military investment. The locations of the munition factories built in the late nineteenth century coincide with the geographic distribution of civilian industries in 1933, implying that the program might have generated positive and persistent spillover effects on industries outside the military sector. We also plot the simple inter-temporal correlation in Appendix Figure A2.

3.3 Selection Criteria for Locations

We quantify the geographic factors that influenced the location choice of munition factories as introduced in Section 2.3, such as national defense concerns, access to waterways and coal mines, and accessibility to foreign firms and enclaves. For simplicity, we use "selection criteria" to denote these variables, which should be distinct between the treated and untreated groups (Li, Lu, and Wang, 2016).

[14]The original dataset consists of 17 provinces located in North (Hebei, Suiyuan, Chahar, Shandong, Shanxi, Henan), Northwest (Shaanxi), East (Jiangsu, Zhejiang, Anhui), Central (Jiangxi, Hubei, Hunan), southeast (Sichuan), and Southwest China (Fujian, Guangdong, Guangxi). We match them with the 15 provinces in 1911. The provinces not covered in the industrial census were all distant and had few industries.

National Defense Concerns National defense, especially naval warfare, was a key factor in the decision to build munition factories. To explicitly address the concern of naval attacks, we collect distance to the coastline, as constructed from the CHGIS.

Provincial or Prefectural Capital We use a dummy variable to capture whether a county is a provincial or prefectural capital, as local officials may have preferred to build munition factories in capitals for ease of supervision.

Distance to Waterways The archives suggest that rivers provided a convenient way to carry machines and products for munition factories. In addition, waterways were a useful source of power for manufacturing industries. We compute the shortest distance to rivers using CHGIS data and control for this variable.

Access to Natural Resources As natural resources are essential for manufacturing machinery, the munition factories might have been set up close to mines. We control for the distance to locations of coal and iron mines using data from Lai (1912).

Foreign Firms and Enclaves Foreign firms and enclaves may have affected the location choices of military investments, as they would have facilitated the import of machinery and technologies. The list of foreign firms is obtained from Chang (1987), and that of foreign enclaves is obtained from Yan (2012).[15]. We use dummy variables to indicate the locations of foreign enclaves and foreign firms established before 1860.

3.4 Confounding Factors

We also collect other variables that may have influenced industrial development in the early twentieth century, as suggested by the literature.

Official Ratings of Counties We collect the official ratings of counties drafted in the Qing dynasty and use a set of dummy variables to capture the level of importance.[16]

Longitude and Latitude We also control for the longitude and latitude of each county. The geographic locations of counties are obtained from the CHGIS.

[15]Only a few firms were established before 1860; they were limited in scale and specialized in very few sectors, such as export processing, ship repair, and public utilities in foreign enclaves.

[16]These official ratings are based on a county's accessibility by transport ("*chong*"), amount of administrative work ("*fan*"), taxation difficulty ("*pi*"), and frequency of crime ("*nan*"). For each county, the official system assigned 0-4 features by which to describe a county, with higher number of features indicating greater importance. Therefore, counties are divided into four types: the most important ("*zui yao que*"), with four features; the second most important ("*yao que*", or "important level"), with three features; the third most important ("*zhong que*", or "general level"), with two features; and the least important ("*jian que*"), with one or no feature. Controlling for official ratings is a common strategy used in the literature on Chinese economic history. See, for example, Bai and Jia (2016).

Historical Textile Centers One advantage of our setting is that there were few modern industries at the time. Nevertheless, handicraft industries also might have influenced the locations of modern industries. To address this concern, we collect the locations of handicraft textile production centers in the nineteenth century from Guo (1990).

Distance to Railways The construction of railways began around the same time as the establishment of munition factories. Railways are shown to be essential for modernization in other countries.[17] We formally address this concern by controlling for distance to the railway network using data compiled by Liu (2020).[18]

Distance to Roads Access to roads may also affect industrial development through transportation. We calculate the distance to courier roads using the maps in Skinner, Yue, and Henderson (2008).

Distance to Treaty Ports Easy access to ports may facilitate the growth of industries by easing transportation. Jia (2014a) shows that treaty ports were likely to experience faster population growth and higher urbanization rates. We collect the list of treaty ports in 1895 from Yan (2012) and extract their locations from the CHGIS to calculate the distance.

Distance to Copper Mines Copper is an important material required for munition and civil industries. Because nineteenth-century officials only considered access to coal and iron mines when determining the locations of munition factories, we do not include access to copper mines as a selection criteria but view it as a confounding factor. We use data from Lai (1912) for the location of copper mines.

Distance to Historical Battlefields The concern of foreign attacks is another factor that may have affected the locations of munition factories and industries. Therefore, we calculate distance to the locations of historical battlefields against Europeans.[19]

[17] A large body of literature documents the effect of railways on economic and population growth. To understand its impact on industrialization in historical settings, see Tang (2014), Hornung (2015), and Hornbeck and Rotemberg (2019).

[18] The role of railways in China is unlikely to be as significant as in the case of Japan or India, as the total length of railway lines is quite small. The total length of railway lines was China is 8,517.5 km in 1912 and 21,440.8 km in 1937, calculated from Ma, Lu, Wang, and Wang (1983). In comparison, British India constructed 67,247 km of railroad between 1853 and 1930, and Japan constructed 7,152 km of railroad between 1872 and 1907 (Donaldson, 2018; Tang, 2014). Both countries had much denser railway networks and higher railway mileage per capita than contemporary China.

[19] We only consider warfare between the Chinese and the Europeans taking place in the examined provinces before 1895, which leaves the First Opium War, the Second Opium War, and the Sino-French War. We then collect the battle fields of these wars from *Zhongguo lidai zhanzheng nianbiao* (A Chronology of Warfare in Dynastic China) (China's Military History Editorial Committee, 2003). Previous studies that use this source include Bai and Kung (2011) and Jia (2014b).

Suitability for Crop Production Counties with favorable agricultural conditions may have been able to supply additional labor for industrial production. We measure agricultural conditions using a county's suitability for common crops in Imperial China, such as cotton, tea, soy, wheat, and yam, as obtained from the Global Agro-Ecological Zones project (Food and Agriculture Organization, 2012).[20] We aggregate original cell-level data for each county by calculating the average suitability for each crop.

Taiping Rebellion and Political Instability The Taiping Rebellion, which lasted from 1851 to 1872, caused serious damage to the economy and at least 30 million casualties.[21] This shock destroyed agricultural production in many regions and might have affected the industrial sector. We record the regions affected by the Rebellion from the National Defense University (2013). The study period also witnessed several major political events that might have affected industrial development, such as domestic rebellions and civil wars among warlords. We collect the distribution of these civil conflicts from Jiang (2009).

Protestants in 1920 Bai and Kung (2014) show that counties with higher population densities of Protestants experienced faster economic growth at later time periods. We collect the number of Protestants per 10,000 people from Stauffer (1922).

As most of the control variables are derived from cross-sectional records, we directly include them in our cross-sectional regression and add the interaction terms between these variables and decade dummies to the panel regression.

3.5 Descriptive Statistics and Balance Check

Table 1 presents summary statistics for the variables used in the baseline analysis. We first show the data on firm entry from 1858 to 1937 used for our panel analysis. The mean value for new firms is 0.0431, suggesting that 4,938 firms were established in the sample provinces during this period. Around 26.4% of the sampled counties witnessed the entry of new firms. We then report cross-sectional information from multiple sources, such as industrial outcomes from the 1933 census and control variables.

To examine whether counties with and without munition factories (treated and untreated counties) are comparable, we conduct balance checks on various socio-economic character-

[20] For applications of the suitability data, see Nunn and Qian (2011); Kung and Ma (2014); Chen and Kung (2016), and Chen, Kung, and Ma (2020).

[21] The 30 million casualties is a widely cited number (see, for example, Rowe (2010), page 198). Ho (1959) argues that this number seriously underestimates the actual loss of population. Other estimates suggest that the loss of population ranges from 50 to 100 million (see Li and Lin (2015)).

istics. Panel A in Table 2 shows the difference in selection criteria between the treated and untreated counties. As counties may have been chosen for treatment based on these criteria, we expect their mean values to be different. Column (3) reports the unconditional differences in their mean values. The results are consistent with the patterns described in the archives, with counties located in provincial or prefectural capitals, which contain foreign enclaves and foreign firms established before 1860, having a higher probability of being treated. The remaining variables, such as distance to coastline, waterways, and natural resources, also show large but not statistically significant differences in the expected direction; this is probably because these variables are not universal criteria that apply to all cases.

We then compare the unconditional and conditional differences in the mean values of other socioeconomic characteristics for counties with and without munition factories, as shown in Panel B of Table 2. Column (3) shows the unconditional differences, and Column (4) presents the conditional differences calculated after controlling for the selection criteria. If counties were selected solely based on these factors, then their other characteristics should be comparable after controlling for the selection criteria (Satyanath, Voigtländer, and Voth, 2017). The results shown in Panel B confirm our expectations. None of the geographic characteristics are significantly different between the treated and untreated counties; the conditional differences in Column (4) are of smaller magnitude than those in Column (3). The conditional differences in political importance, Protestantism, suitability for tea cultivation, political instability, and historical textile centers between the two types of counties remain statistically significant. This suggests that the treated counties were politically more important and enjoyed better agricultural production conditions than the untreated counties, which is consistent with the hypothesis of the factories having been set up in regions of greater importance and with better transportation conditions. These counties likely attracted Protestants probably because the munition factories and their affiliated schools hired foreigners and missionaries. The fact that these counties were more likely to experience political instability and less likely to be historical textile centers than other counties suggest that they did not harbor political environments favorable for economic growth and were not selected based on the prosperity of handicraft industries.

To ensure that the treated and untreated counties are comparable, we adopt CEM to refine the control group. CEM, originally developed by Iacus, King, and Porro (2012) and has been gradually adopted in the recent economics studies (Ager, Bursztyn, Leucht, and Voth, 2021; Aneja and Xu, 2021; Voth and Xu, 2022; Xu, forthcoming). Compared with other matching algorithms, such as propensity score, CEM does not match based on precise values but on the coarsened joint distribution of observable characteristics (in our context, selection criteria). Thus, CEM retains a relatively large number of matched observations and reduces imbalance in the covariates (in our context, confounding factors) between the treated and untreated groups. Column (5) of Table 2 shows the mean difference in confounding factors between the treated and untreated counties after implementing CEM, which allows us to match around two thirds of the observations. We observe that the imbalance in the confounding factors is further reduced, implying that the treated and untreated counties are more comparable in the matched sample.

Panel C reports the mean difference in industrial output in 1933, which is our main outcome variable, between the treated and untreated counties. After controlling for the selection criteria, the conditional difference remains and statistically significant. Using the CEM sample barely changes this gap, suggesting that the treated and untreated counties followed different patterns of industrial development in 1933.

4 Effect of Military Investment on Industrial Development

In this section, we empirically examine the relationship between military investment in the late nineteenth century and industrial growth in subsequent years. We first construct a panel dataset for firm entry from 1858 to 1937 and use a DID approach. To examine the long-term effect, we use industrial output from the 1933 census as the outcome variable and run a cross-sectional regression. To address potentially endogenous location choices, we adopt an instrumental variable approach by exploiting plausibly exogenous variations in the attitudes of local governors toward Western military technology, which may have been influenced by the formation of their political factions before the movement.

4.1 Panel Data Analysis on Firm Entry from 1858 to 1937

We first apply a DID approach to investigate whether the establishment of the munition factories caused subsequent entry of civilian industrial firms by constructing a panel dataset from individual firm entry records from 1858 to 1937. The panel structure can control for time-invariant unobservable characteristics at the county level. In addition, by covering the period before and after the program, the data can answer the following questions: Did counties with military investment have a similar growth pattern in the number of industrial firms before the movement? When exactly did industrial firms enter the market after a county established a munition factory?

4.1.1 Difference-in-Differences Analysis

We examine the patterns of new firm entry using the following DID specification for county i in prefecture p in year t:

$$Entry_{ipt} = \alpha + \beta I(MF_{ipt} \geq 0) + \lambda_i + \delta_{pt} + \gamma Controls_{ip} \times D_t + \varepsilon_{ipt} \tag{4.1}$$

where $Entry_{ipt}$ is the number of newly established industrial firms plus 1, raised to the natural log form. $I(MF_{ipt} > 0)$ is an indicator function equal to 1 if county i in prefecture p had munition factories by year t and 0 otherwise.[22] The variable λ_i is county fixed effects that capture time-invariant characteristics at the county level. We use prefecture-by-year fixed effects, δ_{pt}, to capture prefecture-specific shocks. $Controls_{ip}$ is a vector of county-level control variables, as specified below, interacted with the decade dummies D_t.[23] ε_{ipt} is the error term. The standard errors are clustered at the prefecture level.

We control for the time-variant effects of a rich set of socioeconomic characteristics and geographic conditions generally associated with industrial development. The first group consists of the selection criteria defined in Section 3.3, such as distance to waterways and natural resources, province or prefecture capitals, and Western influence. The other controls addressing confounding factors are the variables defined in Section 3.4, such as political importance, numbers of Protestants, geographic and agricultural conditions, political instability, the Taiping Rebellion, distances to the historical battlefields with European countries, transportation networks and copper mines, and historical textile centers.

Table 3 presents the regression results. In Column (1), we only control for county, year, and prefecture-by-year fixed effects. The coefficient is 0.496 and statistically significant, indicating that the number of newly established industrial firms is positively associated with the

[22]We use this dummy rather than the actual amount of investments because the latter is only available every ten years (Fan, 2003).

[23]As the control variables are time-invariant, we add the interaction terms between them and the decade dummies to allow the influence of these variables to vary over time. We do not use year dummies because the entry of industrial firms was quite scattered in the nineteenth century, but the estimation would remain very similar.

establishment of munition factories. In Column (2), when we control for all of the selection criteria, the estimate reduces to 0.355 and remains statistically significant at the 1% level. As various measures of confounding factors, such as political importance, Western influence, and geographic conditions, are added to the regressions from Columns (3) to (5), the estimated coefficient for munition factories gradually decreases but remains statistically significant. When we include more control variables such as agricultural conditions, the Taiping Rebellion, political instability, access to copper mines, historical textile centers, and access to the transportation network, the estimates of the relevant coefficients remain quite stable, as shown in Columns (6)-(11). The size of this coefficient in Column (11), our preferred specification suggests that after including all of the control variables, following the establishment of munition factories in treated counties, the subsequent entry of civilian industrial firms increased by 33.4% over the counties without any munition factories. The estimate is statistically significant at the 1% level.

The primary challenge to the identification of the baseline regression is comparability between the treated and untreated counties. To address this issue, we restrict our regression to several subsamples. We first consider the subsample that only includes the 16 treated counties. Presumably, the counties selected for treatment are more comparable to each other than to those that were never treated. The estimation from this subsample regression result, shown in Column (1) of Table 4, shrinks to 0. This "no-effect" finding suggests that our baseline result is primarily driven by our comparison of the treated and untreated counties, instead of the early- and late-treated counties.[24] The rationale behind this result possibly lies in the strict regulations on private firm entry before 1895, which implies that all of the munition factories, both early and late, were constructed in the regulated period. This further implies that the comparison of the early- and late-treated counties yields no significant effect. In addition, the huge amounts of investment required for munition factories imply that the decision to construct factories at all is more important than determining whether to construct them earlier or later.

As the effect mainly arises from the presence or absence of treatment and not the timing of treatment, the comparison of treated and untreated counties is important for us to under-

[24] The decomposition of the staggered DID proposed by Goodman-Bacon (2021) confirms that the weight of the comparison of treated and untreated counties exceeds 99% in the baseline estimation, whereas the comparisons of the early- versus the late-treated counties and the late- versus the early-treated counties contribute 0.1% and 0.3% respectively. The decomposition result is visualized in Appendix Figure A3.

stand the effect. To refine the control group, we adopt CEM to improve comparability when untreated counties are included in the sample. Column (5) of Table 2 shows a reduction in imbalance in the confounding factors between the treated and untreated counties after implementing CEM. We then use the matched sample to perform the baseline DID regression and present the results in Column (2) of Table 4. The estimated treatment effect on firm entry rises from 0.334 in the baseline to 0.352 when we restrict the analysis to the matched sample. This result adds confidence in the selection issue not being a major concern.

Column (3) limits the sample to counties located in provincial capitals, where munition factories were more likely to be located. We already control for dummies indicating capitals, but these capitals might have been systematically different from other counties, which could affect our main results. The regression results in Column (3) show that the sample size decreases dramatically, but the coefficient remains similar and statistically significant. This suggests that our results are not driven solely by systematic differences in provincial capitals. Column (4) considers provinces in the southern part of Imperial China, which were located far away from the central government and whose provincial officials were subjected to fewer controls. The results remain statistically significant, and the sizes of the coefficients remain similar.[25]

We then conduct multiple robustness checks to ensure that the above results are not sensitive to alternative measures of the outcome variables and are not driven by outliers. Column (5) excludes Jiangsu, as this province had multiple treaty ports and contributed to more than half of pre-war China's industrial production in the early twentieth century. The estimated coefficient increases, suggesting that the munition factories played a more important role in the other provinces.

In Column (6), we add the quadratic term of all of the control variables to address the misspecification concern that these variables may not enter the regression in a linear form. The estimated result is quite similar to the baseline. As many observations of the number of new entry firms equal 0, we add 1 and raise it to the natural logarithm to obtain the outcome variable in the baseline regression. To examine the sensitivity of the estimates to this transformation, we adopt the inverse hyperbolic sine transformation and construct an alternative outcome. Column (7) of Table 4 shows that our estimate is robust to the alternative transformation of the number of new firms.

[25]The southern provinces are Jiangsu, Anhui, Zhejiang, Jiangxi, Hunan, Hubei, Fujian, Guangdong, Guangxi, Yunnan, Sichuan, and Guizhou. We exclude provinces that lack industrial data for 1933.

We next examine patterns based on whether a firm was government-supervised or privately owned. The estimated coefficient for private firms in Column (8) is slightly smaller than that of the full sample, whereas the coefficient for government-supervised firms in Column (9) is 0.050. As government-supervised firms were usually larger than private firms, we alternatively use total capital instead of the number of new-entry firms as the outcome variable. The results in Table A2 show that the coefficient of private firms remains much larger than that of government-supervised firms, confirming that private firms were the drivers of industrial growth.

We also perform our analysis at the prefecture level to address the potential geographic spillover of munition factories, following the classic strategy proposed by Miguel and Kremer (2004). Column (10) of Table 4 shows that the treatment effect is also present at the prefecture level, thereby alleviating geographic spillover concerns.

4.1.2 Event-Study Approach

We use the panel structure to verify the identification assumption of the DID approach, namely, in the absence of military investment, the treated and untreated counties should show the same growth pattern in terms of the number of new firms. To formally test this assumption, we adopt an event-study approach by running the following regression:

$$Entry_{ipt} = \sum_{\tau \geq -5, \tau \neq -1}^{12} \beta_\tau I(MF_{ipt}^{\tau} \geq 0) + \lambda_i + \delta_{pt} + \gamma Controls_{ip} \times D_t + \varepsilon_{ipt} \tag{4.2}$$

where the variables are the same as before, but each period lasts 5 years.[26] The reference category is one period prior to the military investment. We expect the coefficient β_τ to be positive when $\tau \geq 0$ and to be close to 0 when $\tau < 0$, indicating that the entry of industrial firms would not happen until a munition factory is established. In addition, as industrial agglomeration reinforces the initial effect, β_τ should increase over time.

Figure 2 plots the coefficients over the years relative to the establishment of a munition factory and the associated 95% confidence intervals. As shown in the figure, there were no significant differences in the growth patterns of new industrial firms before the introduction of munition factories. None of the estimated coefficients before the establishment of munition

[26]The choice of 5 years is for better visibility of the graph due to the long sample period of this study. The pattern is similar when we use annual data.

factories are significant, and all of them are close to 0. This result suggests that the increase in industrial firm entry probably occurred due to the establishment of munition factories rather than to systematic indigenous differences between counties. Therefore, we are more confident in our interpretation of the positive effect of the baseline DID regression in Table 3 as a causal effect.[27]

The event-study results also reveal that new firms emerged around 20 years after the establishment of local munition factories, probably due to strict regulations placed on private firm entry before 1895. To clearly link firm entry with the market environment, we adjust the event study approach by the calendar year and plot the estimated coefficients for different decades in Figure A5. The effect was very small between the 1860s and the 1880s; it began to be significantly greater than 0 in the 1890s, suggesting that only a small number of firms entered the market before 1895, probably due to restrictions imposed on private firms in the late nineteenth century (Brandt, Ma, and Rawski, 2014). After the 1900s, the effect became salient, consistent with the historical fact that the New Policies facilitated the entry of private industrial firms at the time. Our result highlights the key roles of deregulation and favorable business environments for private firms when implementing industrial policies (Aghion, Cai, Dewatripont, Du, Harrison, and Legros, 2015; Cheremukhin, Golosov, Guriev, and Tsyvinski, 2017). In addition, the fact that the treatment effects only emerged after deregulation in 1895 supports the explanation of agglomeration effects rather than of indigenous advantages such as natural resources.

4.2 The Long-Run Impact Using the 1933 Industrial Census

4.2.1 OLS Estimates

The limitation of the panel analysis is that data on firm entry cannot provide information on firm production or exit. To complement the panel analysis, in this subsection, we use cross-sectional information on the value of industrial output in 1933 as the outcome variable and examine whether military investment during the movement had any persistent effects on long-term industrial production. We define the independent variable using the amount of investment to replace the establishment of munition factories. As shown in Appendix Figure A6, the early factories generally received more investment than the later ones, suggesting that using variations in the establishment time and investment yields consistent implications.

[27]Figure A4 shows the event study results for the sample only containing the 16-treated counties.

For county i in prefecture p, we run the following regression:

$$IndustrialOutput_{ip} = \alpha + \beta MilitaryInvest_{ip} + \gamma Controls_{ip} + \delta_p + \varepsilon_{ip} \tag{4.3}$$

where $IndustrialOutput_{ip}$ is the output value of civilian industries in 1933 and $MilitaryInvest_{ip}$ is county-level investment on munition factories during the 1861-1894 period. We add 1 to both variables and raise them to their natural logarithmic form. $Controls_{ip}$ is the same as in the panel regression. We also include prefecture fixed effects, δ_p, to capture prefecture-level unobservable characteristics.

Column (1) of Table 5 reports the OLS regression results obtained using cross-sectional variations with all of the control variables. The results show that a 1% increase in military investment during the movement is associated with a 0.597% increase in the value of industrial output in 1933.

We also examine the spillover effect by restricting our sample to counties without military investment. This allows us to test whether their industrial output was affected by neighboring military investments. The estimates are reported in Appendix Table A3 and confirm the lack of a positive spillover effect. These results suggest that the long-term effect of the military investment was localized and had no geographic spillover, consistent with the fact that the movement failed to industrialize the whole country.

4.2.2 Instrumental Variable Estimates

A limitation of cross-sectional analysis is that it cannot take into account unobservable county-level confounders. Although we control for a large set of observable characteristics, it is challenging to fully address the unobservable factors that might have affected both the establishment of munition factories and local economic growth, such as an inclination toward Western technology that can bias the results upward. In addition, measurement errors in military investment can bias our results downward.

We construct an instrumental variable to address the weakness of cross-sectional analysis, taking advantage of the fact that the decision to establish munition factories was largely determined by provincial governors' political attitudes. To capture political attitude, we construct a political network measure involving the leader at the early stage of the program, Marquis Zeng Guofan, and other officials. Zeng Guofan was a traditional Chinese official who displayed military talents during the Taiping Rebellion and became the general who saved the Qing dynasty from this internal military crisis. His military experience made him an influential official until his death in 1872 and a strong advocate for Western military technology: he established the first modernized munition factory in Imperial China. [28]

Zeng Guofan formed his political coalition at an early stage, for which he recruited a large group of staff; many of his staff later became officials and supporters of the "pro-reform faction."[29] We use his *ex ante* political connections with provincial governors to determine the attitudes of these governors toward the construction of munitions factories.[30]

We collect all of Zeng Guofan's correspondences with his colleagues, apply textual analysis to extract related information, and identify the politicians who exchanged this information with him before 1861. Appendix C provides the details of the process. Zeng Guofan's correspondences reflect his closeness with other officials because he is known for frequently writing to politician colleagues and expressing his opinions, in particular on Western technology (Fairbank and Teng, 1979). This practice is consistent with the latest studies that use social networks, especially connections with a central figure, to identify possibly endogenous historical events (Xu, 2018; Becker, Hsiao, Pfaff, and Rubin, 2020; Voth and Xu, 2020).

Using the political network, we construct an instrumental variable in three steps. First, for each provincial governor, we use his correspondences with Zeng Guofan to measure political connections. Second, we calculate the distance between county i and the official residence of its provincial governor. Finally, we sum up the political connections for all of the governors of county i in the examined period and divide by the distance to provincial officials' residence. The instrumental variable takes the following form:

$$IV_i = \frac{\sum_j \text{PoliticialConnection}_j}{\text{Distance}_i + 1} \tag{4.4}$$

[28] Yung Wing, famous for being the first overseas Chinese student, who later helped the Qing government buy machinery abroad, praises Zeng Guofan as "literally and practically the supreme power of China at the time. But true to his innate greatness, he was never known to abuse the almost unlimited power that was placed in his hands…" (Yung, 1909).

[29] For example, two figures who later became leaders of the SSM, Li Hongzhang and Zuo Zongtang, were former members of Zeng Guofan's staff. In a recent article, Bai, Jia, and Yang (2021) study how Zeng Guofan and other elites in Hunan province used their own network for war mobilization.

[30] We only consider Zeng Guofan because he was the central figure of the "pro-reform faction" and the movement in its early stages. Li Hongzhang, a later leader of the movement, was Zeng Guofan's staff member in 1860. We check Li Hongzhang's correspondences (Dai and Gu, 2008) and find that correspondence between him and other politicians was rare before 1860, but that half of this correspondence was with Zeng Guofan.

where $PoliticalConnection_j$ is the closeness of governor j with Zeng Guofan, measured by the number of letters; $Distance_i$ represents the shortest distance between county i and the official county of residence of the provincial governor. We use distance as a weight for our measure of political connections; the intuition is that a governor should have been more influential in the counties closer to his place of residence than in those farther away.[31] This weight may raise the concern that the distance itself might have affected each county's industrial development. We address this concern by explicitly adding the distance measure to the regression as a control variable.

The key to ensure the externality of our instrument is that where these politicians to become provincial governors after 1861 were independent of Zeng Guofan's influence. This likely applies to our setting because of institutional arrangements in the assignment of provincial governors in the Qing dynasty. As provincial governors were the highest-ranking officials in each province, the central government retained its rights to appoint these governors and required them to be constantly rotated (Chan, 1980, page 448). In addition, Zeng Guofan was a cautious official and afraid of overstepping his boundaries (Liu, 1978, page 435). We use the fact that Zeng Guofan passed away in 1872, when the movement was still at its early stages and only about one quarter of the munition factories were established, to perform a balance test. Appendix Table A5 shows a comparison of counties treated before and after 1872; we find that both types of counties have similar characteristics, suggesting that Zeng Guofan did not affect the location choice of the factories. In the robustness test, we also present the results obtained after only considering factories built after his death.

Another concern is the exclusion restriction. If Zeng Guofan's political connections affected industrial growth through mechanisms other than military investment, then the exclusion restriction would be violated. In history, Zeng Guofan is famous for being an "activist, yet deeply conservative" (Kuhn, 1978, page 283). While making efforts to learn Western technology, he rejected foreign demands on modern infrastructure, such as railroads and telegraphs, as he was concerned about potential harm to the livelihoods of people (Hsu, 1980, page 73). To provide suggestive evidence on the validity of the exclusion restriction, we explore whether political connections might have affected industrial growth through other mechanisms, conditional upon the control variables. As very few county-level socioeconomic characteristics

[31] The official county of residence was usually the provincial capital. One exception was Jiangsu Province, where the two provincial leaders were located in different counties (*Zongdu* resided in Jiangning and *Xunfu* in Suzhou). The results would be very similar if we use the distance to provincial capitals.

are available aside from these factors, we perform the test at the prefecture level. Following the literature, we use population density and population growth rate as proxies for the level of economic development, the number of newspapers as a proxy for access to information, and the number of key officials as a proxy for local elites; we regress these measures on our instrument.[32] The results in Appendix Table A4 show that the instrument is not correlated with these socioeconomic characteristics; this increases our confidence in interpreting that the instrument is unlikely to have an effect on industrial development through mechanisms other than military investment.

4.2.3 IV Results

Column (2) of Table 5 reports the results of the first-stage regression. The estimated coefficient of the instrument is positive and statistically significant, suggesting that closer ties between provincial governors and Zeng Guofan increased military investment during the movement. Column (3) presents the results of the 2SLS regression. The estimated coefficient is 0.578, which is very close to the OLS results shown in the first column, and remains positive and statistically significant. The first-stage excluded F-statistics are greater than 30, indicating that our estimates do not suffer from the weak instrument problem (Stock and Yogo, 2005).

As done for the baseline DID regression, we repeat our regression using subsamples of the 16 treated and CEM-matched counties to further address the selection issue. When we only consider the 16 treated counties for the DID regression, we exploit the variations in the entry timings of the munition factories. In the cross-sectional regression, we rely on the variations in total investments. In Appendix Figure A6, we graph the average investment in munition factories and the factories' entry timings, divided into five stages. We find a clear correlation between the entry timings and investments, with the munition factories constructed earlier receiving more total investment. The cross-sectional 2SLS result obtained using the subsamples of the 16 treated counties is similar to its counterpart in the DID regression.[33] The result in Column (4) of Table 5 shows a mild positive effect, but is not significant. Due to the huge investments required for munition factories, it is not surprising that the magnitude of the estimate using only the 16 treated counties is smaller than the one using the full sample. The small sample size also reduces the precision of the estimate.

[32] The variables are obtained from Bai and Jia (2016).

[33] Due to the very small sample, we only include a small portion of the control variables (in practice, the selection criteria) and perform a bootstrap estimation of the standard error.

We perform the 2SLS regression using the CEM-matched subsample, which increases the comparability of the treated and untreated counties, and present the result in Column (5). The estimated effect using the matched sample is similar to that using the full sample. Columns (4) and (5) together suggest that the long-term effect is also driven by the comparison between the treated and untreated counties rather than by variations within the treated counties; this confirms our findings from the panel analysis.

We also conduct multiple robustness checks to ensure that the 2SLS results are robust to alternative variable choices and are not driven by outliers. In Column (6), we address the concern that the transformation to our outcome variable (plus 1 and raised to the natural logarithm) may be sensitive to the choice of unit for the industrial output value. We present the results obtained after using the inverse hyperbolic sine transformation of the outcome variable, as in the panel regression; we find that the estimated results barely change.

In Column (7), we add the quadratic term of the control variables to address the concern about the variables not entering the regression in a linear form. In Column (8), we control for the distance between a county and the official residence of its provincial officials. As we use this variable as the weight when constructing the instrument, this regression addresses the possibility of the distance to provincial officials' residences directly driving the instrumental variable results. The regression results suggest that being close to provincial officials had no direct impact on industrial growth.

We next perform two regressions to justify the validity of our instrument. First, we examine the presumption that the locations of munition factories were independent of Zeng Guofan's will by only considering factories established after his death in 1872. Column (9) shows a 2SLS regression conducted after excluding treated counties with munition factories established before 1872. The estimate is even larger than that obtained using the full sample, indicating that our instrument is not affected by Zeng Guofan's personal influence on the appointment of local officials.

Second, we show that the instrument works through the political network related to Western technology,. We conduct a placebo test by constructing an alternative measure of political connection based on Zeng Guofan's correspondences that are not related to the movement or industrial development, i.e., correspondences on Chinese philosophy. In addition to being a powerful politician, Zeng Guofan was a well-known Chinese philosopher whose correspondences covered Confucianism. We use four keywords, "Neo-Confucianism " (*lixue*), "Cheng Yi and Zhu Xi" (*Cheng Zhu*), "the Four Books" (*sishu*), and "the Five Classics" (*wujing*), which are the philosophical school Zeng believed in and its representative philosophers, respectively, and count the number of correspondences with these keywords. We believe that the correspondences that measure political connection based on Chinese philosophy are unrelated to the movement or industrial development. In Column (10), we rerun the 2SLS regression using the instrument constructed from the placebo political connection. The estimate is small and not significantly different from 0.

In the last column, as done for the baseline regression, we run the 2SLS at the prefecture level to address the spillover concerns. This estimate is also positive and significant.

The above results may arise either due to an expansion in the scale of production or an increase in productivity. We explicitly investigate whether military investment increased productivity by controlling for labor and capital inputs in 1933. As shown in Appendix Table A6, military investment had little effect on productivity, suggesting that most of the positive effect was due to an increase in inputs and in the scale of production and not due to technological progress. Compared with previous studies on China's industrial programs implemented after 1949 (the "156 Million-Rouble Plants" and the "Construction of the Third Front" programs), our estimated size of the spillover effect on other industries is smaller and we find a negligible effect on productivity.[34] We compare these industrial programs in Appendix D.

5 Mechanisms

The above analyses show that military investment in the nineteenth century influenced the locations of later industrial firms; these locations, which initially housed munition factories, gradually developed into densely varied industrial clusters over the following 70 years. Because industrial data in the following years do not include the military sector, the estimated effect likely arises due to a spillover from military to civilian industries rather than due to the direct legacy of military investment. It remains unclear how the military industry, which used specialized technologies and did not aim for profit maximization, contributed to the subsequent development of other industrial sectors. In this section, we provide the missing piece of this story by discussing several possible explanations. Based on the literature on indus-

[34] Heblich, Seror, Xu, and Zylberberg (2021) find that the effect of the "156 Million-Rouble Plants" on the employment share in industry in 1982 has an elasticity of 0.237. Fan and Zou (2021) find that the spillover effect on private industries in the Third Front program exceeds 2 percentage points. Both studies find a positive impact on productivity.

trial agglomeration (Marshall, 1920; Rosenthal and Strange, 2004; Duranton and Puga, 2004) and persistence of industrial activities (Dell and Olken, 2020), we propose that the military investment may have affected industrial growth through several mechanisms: input-output linkages, shared facilities and human capital, and the development of supporting institutions.

5.1 Input-output Linkages and Fixed Capital Accumulation

Large investments in the military sector may have driven growth in both backward- and forward-linked sectors, especially as Imperial China initially had very few industries. Although munition factories relied heavily on imported machinery and inputs, archives show that some of the materials were obtained from local markets due to the high transportation costs of obtaining material from inland counties. For example, when establishing the Hubei Arsenal (*Hubei Qiangpaochang*), Zhang Zhidong simultaneously built an affiliated iron factory to ensure the supply of iron and steel. Similarly, memorials to the throne state that the Shandong Arsenal (*Shandong Jiqiju*) relied on the local market for the supply of coal.[35]

As most of the munition factories lacked detailed records of their input and output, we use data from the 1929 U.S. census to measure the linkages between the military industry and other industries. The U.S. census provides information on all of the upstream industries for the firearm industry, allowing us to construct backward linkages. The underlying assumption is that the production processes of the Chinese munition factories and historical U.S. firms were similar.[36] This is a sensible assumption despite the distance between the two countries, as the Chinese factories imported machinery, technicians, and a large portion of raw materials from the West; the efforts to develop its own production process were made at a much later time.[37]

We also exploit the variations in counties' access to trade to establish this mechanism. We use the fact that inland counties were more likely than port counties to face demands for local resources as the cost of reaching the foreign market was high. Anecdotal evidence sug-

[35]The Hanyang example obtained from Wang (2009). The other examples are obtained from *Zhongguo jindai bingqi gongye dang'an shiliao (Historical Archives of the Military Industry in Early Modern China)*, vol. 1, page 136 (The Second Historical Archives of China, 1993).

[36]To be specific, We have to assume that the relative links with the firearm industry of any two upstream industries with the firearm industry in the 1920s U.S. are the same as in contemporary China. In practice, if we care more about the qualitative rather than the quantitative interpretation of this channel analysis, the assumption can be relaxed, requiring that the *ranking* of the links of the upstream industries with the firearm industry in the 1920s U.S. is the same as in contemporary China.

[37]When the failure of the First Sino-Japanese War ended the movement in 1895, officials agreed that the production process still heavily relied on the West, with most domestic factories constantly purchasing foreign machinery and inputs. See *Zhongguo jindai bingqi gongye dang'an shiliao*, vol. 1, pages 38-41 (The Second Historical Archives of China, 1993).

gests that while the Jiangnan Arsenal (located in Shanghai, the largest port) imported heavily throughout the period, factories in inland counties relied more on domestic upstream products.[38] The rationale for these case studies provides a testable hypothesis: if munition factories affected other industries through backward linkages, then counties with *less*access to trade should have had more industries associated with the military industry as these counties had few options apart from developing their own upstream industries to meet the demands of local munition factories. In contrast, although port counties generally had more industries in the early twentieth century (Ma, 2008), they were *less* likely to develop industries through backward linkages from the military sector, as munition factories could easily acquire inputs from abroad. Therefore, we expect the mechanism of backward linkages to be stronger for inland counties.[39]

To test this hypothesis, we use the following regression equation with a triple difference form for industry k in county i :

$$\begin{aligned} IndustrialOutput_{ik} = \alpha &+ \beta_1 MilitaryInvestment_i \times Linkage_k + \beta_2 Linkage_k \times Port_i \\ &+ \beta_3 MilitaryInvestment_i \times Linkage_k \times Port_i + \lambda_i + \eta_k + \varepsilon_{ik} \end{aligned} \tag{5.1}$$

where $Linkage_k$ is the standardized input-output linkage between industry k and the military industry. $Port_i$ is a dummy variable equal to 1 if a county had a treaty port and 0 otherwise. One major difference from previous cross-sectional analysis is that, as we adopt the triple difference form and use county-industry variations, we include λ_i and η_k to control for county and industry fixed effects, which absorb county- and industry-specific variations such as the total value of industrial output in 1933. The coefficient β_1 captures the effect of military investment on linked industries in non-port counties, and $\beta_1 + \beta_3$ captures the effect in port counties. We expect β_1 to be positive and β_3 to be negative.

Table 6 shows the regression results obtained after using input linkages constructed from the 1929 U.S. census. The estimated coefficient shows the differences in effect when local military investment increases by 1%. Column (1) reports the full sample results and shows that, when the input linkage with the military industry increases by one standard deviation, the effect of military investment on an industry's output increases by 0.094%. This represents an

[38] For example, the inland Sichuan Arsenal mainly used expensive domestic coal, so it invented a method to rely on hydro power and reduce coal consumption (Fan, 2003).

[39] Lane (2021) finds that industrial policies did not benefit upstream sectors in the context of trade liberalization, as the targeted sectors could import inputs instead of buying them from domestic upstream producers.

increase by approximately 16% of the average treatment effect 0.578%. Column (2) provides empirical evidence for the substitution of imports and domestic industrial goods. The estimated coefficient of the interaction term of military investment and input linkage is 0.125, whereas the triple interaction term is -0.130. This result indicates that although military investment had a positive effect on the non-port counties through input linkages, access to ports cancelled out this effect. The interaction term of linkage and port is large, positive, and statistically significant, indicating that the port counties indeed had higher industrial output values, but that the effect was independent from the military investment received. When we divide the sample into port and non-port counties in Columns (3) and (4), the estimated coefficient of the interaction term between military investment and input linkage is close to 0 for port counties, but remains positive and statistically significant for non-port counties. This suggests that the linkage effect does not exist for port counties. The overall result is consistent with the hypothesis that military investment drives local production by creating demands for upstream industries. As the 1929 U.S. census data only report upstream and not downstream industries, we also use the 2002 input-output table of the machinery industry in China to conduct robustness checks. As shown in Appendix Table A7 shows, the backward linkage effects are similar to but larger than the forward linkage effects.

A mechanism similar to the input-output linkages is fixed capital accumulation. Large investments might have boosted the accumulation of local machinery, generated an agglomeration effect, and benefited subsequent industrial production through shared facilities (Duranton and Puga, 2004). In our context, the establishment of munition factories might have increased the use of machinery in other industries by producing machines for civilian firms or by shifting to the production of goods in civilian industries. In both cases, counties with munition factories are expected to have higher capital-labor ratios in civilian industries at later time points. To examine this mechanism, we further divide total military investment into machinery and non-machinery sections, based on records obtained from Fan (2003). The results in Columns (1) to (3) of the Table 7 show that investment in machinery had the greatest effect in boosting subsequent industrial growth. We then use the input data from the 1933 census to compute the capital-labor ratios and use them as the outcome variables. Columns (4) to (6) show that counties with more military investment tended to have more machinery in 1933, but not higher capital-labor or machine-labor ratios, than those with less military investment.

5.2 Human Capital Accumulation and Knowledge Spillover

Human capital accumulation and knowledge spillover contributed to persistent economic growth in the early phases of industrialization (Mokyr, 2009; Kelly, Mokyr, and Gráda, 2014). In particular, public investment in national defense can generate spillovers in technological progress in other sectors (Moretti, Steinwender, and Van Reenen, 2019; Gross and Sampat, 2020). Officials in late nineteenth-century China intended to boost human capital accumulation through large investments. As Zuo Zongtang, one of the later advocates of this program, stated in a memorial to the throne in 1866, "The aim of learning to build ships is not for the ships *per se*, but the techniques of building and driving these ships ... we have to establish school and select talented young people to learn western language, books, and math skills ..."[40] However, these efforts were limited in scale as the central government feared that this knowledge would threaten the monarchy (Cantoni and Yuchtman, 2013).

We combine different measures of human capital to empirically analyze its role in generating spillovers to civilian industrial sectors. First, we use the number of modern secondary schools established since the central government started reforming the education system in 1902. We collect the county-level number of secondary schools in 1916 from the Census for Education Department and use this as a measure of educated people. Second, we collected the list of science-related Chinese elites in various disciplines, i.e., "scientists", from Li and Zha (2002), to capture knowledge elites who promoted industrialization in other contexts (Squicciarini and Voigtländer, 2015). If the movement helped accumulate human capital for industrial production, then we expect to observe more schools or scientists in counties with more investment than in counties with less investment.[41]

We use cross-sectional data to link military investment, human capital, and industrial output in 1933. We present the results in Table 8. Columns (1) to (3) show that counties with more military investment also had more scientists, but no effects are found on secondary schools. Columns (4) to (7) compare the effects of military investment without and with human capital variables. Column (4) copies our baseline 2SLS results for comparison. In Column (5), the number of secondary schools is significantly and positively correlated with industrial development, but the estimated coefficient for military investment is similar to that of the baseline. This result is consistent with that in Column (1), which shows that military investment did not

[40] *Yangwu Yundong*, vol. 5, page 28, cited in Fan (2003), page 599.

[41] The scientists in historical China include not only inventors, but also people who were educated and produced written works about science. Therefore, these people are comparable to knowledgeable elites in Western Europe.

affect the number of secondary schools, whereas secondary schools themselves contributed to industrial development. Column (6) shows that the number of scientists is positively correlated with the value of industrial output in 1933 and that the estimated coefficient of military investment drops from 0.578 to 0.469, indicating that knowledgeable elites explain a small portion of the military investment impact on later industrial growth. The results in Column (7) put secondary schools and scientists in the regression together and again confirm the previous implication. Overall, the results shown in Table 8 suggest that military investment fostered human capital accumulation by increasing the number of local knowledge elites and that human capital per se was an important factor for long-term industrial growth.

5.3 Role of Supporting Institutions

Long-distance trade may help foster institutions that contribute to long-term economic development (Acemoglu, Johnson, and Robinson, 2005). Munition factories, as the first group of large manufacturing factories in Imperial China that carried out international transactions for the supply of inputs, might have also fostered institutions that facilitated business with foreigners and the subsequent entry of firms. After all, international transactions, which often involve large cash transfers and high risks, can only take place with the help of intermediaries such as banks that facilitate cash transfers and trading companies that connect producers and customers. These intermediaries had a very limited scale in China before the 1850s, but quickly developed in the following decades in response to the demands from early Chinese industries (Cheng, 2003). Another institutional arrangement that facilitates trade involves self-initiated ports (SIPs), which were established by the Chinese government as direct competitors to treaty ports. Compared with the latter, which were forced to open in response to requests made by foreign powers, SIPs enjoyed similar advantages in trade but did not grant fiscal, political, or legal privileges to foreigners. This allowed the government to enjoy the benefits of trade without losing sovereign rights (Kung, 2022). Military investments might therefore have guided the locations of banks, trading companies, and SIPs, all of which facilitated subsequent local industrial growth.

We collect the data on trading companies and foreign banks from Huang (1995) and the list of SIPs from Yan (2012). We then quantitatively examine these channels. Panel A in Table 9 presents the results obtained using the cross-sectional regression. As shown in Columns (1) to (3), military investment increased the number of banks but not of trading companies or the chance to become a SIP. In Columns (4) to (6), we gradually add the variables for supporting institutions to the instrumental variable regression. The results show that the effect of military investment shrinks to 0.167 after adding the number of banks but remains similar after including the variables for trading companies and SIPs. When the number of banks, trading companies, and the SIP dummy are simultaneously included in the regression, as shown in Column (7), the estimated coefficient for military investment is decreased and is not statistically significant. We repeat the exercise using panel data in Panel B. The results are similar to those obtained using cross-sectional data and suggest that banks, and not trading companies or SIPs, increasingly emerged following the establishment of munition factories and financial institutions supporting subsequent industrial development. Our results are consistent with those of recent studies on banking access and industrialization in historical settings (Heblich and Trew, 2019).

We also examine whether military investment attracted foreign direct investment (FDI). Economic historians find that FDI drove domestic industrial growth during this period (Ma, 2008). As shown in Appendix Table A8 and Figure A7, we find no significant effect of military investment on the number of foreign firms over time. In fact, unlike munition factories that were often located in provincial capitals, most foreign firms were located in treaty ports. This result indicates that FDI and military investment were separate drivers of industrial growth in early twentieth-century China.

6 Conclusion

This study examines a unique historical setting to understand the drivers of industrialization. We focus on the spillover effect of Imperial China's efforts to strengthen its defense sector using modern technology in the short and long term. We find that investment in the defense sector had a positive and persistent effect on other industrial sectors, leading to the formation of industrial clusters decades later. To identify the causal relationship, we exploit the feature of military investment having been largely determined by local officials' political connections formed before the movement, rather than by economic interests.

To explain our finding, we show that the input-output linkages were a salient mechanism by which co-agglomeration occurred across sectors. Other factors that led to persistent economic development, such as human capital accumulation and supporting institutions, also played significant roles.

Imperial China's experience during the late nineteenth century is particularly interesting because its economy is comparable to those of many developing countries today; it was characterized by weak state capacity and limited modern industries. Our analysis suggests that those types of developing countries can still benefit from importing machinery and promoting manufacturing industries, but that these benefits may be undermined by entry barriers to private firms.

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Table 1: Summary Statistics

	Variables	N	Mean	Std.Dev	Source
Dependent Var.	# Net Firms	1432 × 80	0.0431	1.335	A, B
	Private	1432 × 80	0.0399	1.310	A, B
	Government-Supervised Firms	1432 × 80	0.0019	0.050	A, B
	Industrial Output	1432	111.5	2046	C
	# Factory	1432	13.05	121.7	C
Independent Var.	# Military Firm	1432	0.016	0.169	D
	Military Investment (10,000 taels)	1432	3.525	60.27	D
Selection Criteria	Foreign Enclaves	1432	0.006	0.079	E
	Foreign Firm (Before 1860)	1432	0.003	0.053	F
	Prov./Pref Capital	1432	0.238	0.426	G
	Distance (Coastline)	1432	406.6	325.5	H
	Distance (River)	1432	4.103	6.552	H
	Distance (Coal)	1432	339.8	288.8	I
	Distance (Iron)	1432	54.84	47.44	I
Confounding Factor	Political Importance (General)	1432	0.284	0.451	G
	Political Importance (Important)	1432	0.203	0.403	G
	Political Importance (Most Important)	1432	0.040	0.196	G
	Protestantism	1432	7.101	13.45	J
	Longitude	1432	113.4	4.686	K
	Latitude	1432	31.43	5.203	K
	Distance (Treaty Port)	1432	246.4	153.1	E, K
	Distance (Courier Roads)	1432	97.95	105.9	L, K
	Distance (Battlefield)	1432	422.3	293.0	M, K
	Soil Suitability for Cotton	1432	5.613	1.314	N
	Soil Suitability for Tea	1432	6.485	2.150	N
	Soil Suitability for Soy	1432	5.867	1.008	N
	Soil Suitability for Wheat	1432	5.785	0.886	N
	Soil Suitability for Sweet Potato	1432	7.456	0.811	N
	Taiping Rebellion	1432	0.314	0.464	O
	Political Instability	1432	0.391	0.819	P
	Distance (Copper)	1432	84.90	71.11	I
	Historical Textile Center	1432	0.027	0.161	Q
	Distance (Railroad)	1432	174.9	168.8	R, K

Notes: A: Du (1991); B: Du (2019); C: Liu (1937); D: Fan (2003); E: Yan (2012); F: Chang (1987); G: Zhao (1998); H: Harvard Yenching Institute (2007); I: Lai (1912); J: Stauffer (1922); K: Harvard Yenching Institute (2016); L: Skinner, Yue, and Henderson (2008); M: China's Military History Editorial Committee (2003); N: Food and Agriculture Organization (2012); O: National Defense University (2013); P: Jiang (2009); Q: Guo (1990); R: Zhang (1997).

Table 2: Balance Check

	(1) Control group	(2) Treatment group	(3) Unconditional diff.	(4) Conditional diff.	(5) Conditional diff. (CEM)
Panel A: Selection Criteria					
Prov/Pref Capital	0.23	0.88	0.644***		
	[0.01]	[0.09]	[0.106]		
Foreign Enclaves	0.00	0.31	0.310***		
	[0.00]	[0.12]	[0.018]		
Foreign Firms (Before 1860)	0.00	0.13	0.124***		
	[0.00]	[0.09]	[0.013]		
Distance (Coastline)	407.68	308.25	-99.428		
	[8.64]	[86.85]	[81.819]		
Distance (River)	4.12	2.88	-1.238		
	[0.17]	[0.65]	[1.647]		
Distance (Coal)	340.61	267.95	-72.661		
	[7.68]	[61.72]	[72.596]		
Distance (Iron)	55.05	36.11	-18.936		
	[1.26]	[9.17]	[11.919]		
Panel B: Confounding Factors					
Political Importance (General Important)	0.29	0.06	-0.224**	-0.207*	-0.165
	[0.01]	[0.06]	[0.113]	[0.125]	[0.130]
Political Importance (Important)	0.20	0.63	0.427***	0.397***	0.376***
	[0.01]	[0.13]	[0.101]	[0.109]	[0.116]
Political Importance (Most Important)	0.04	0.31	0.276***	0.052	0.052
	[0.00]	[0.12]	[0.049]	[0.052]	[0.059]
Protestantism	6.91	23.67	16.760***	8.673**	10.035***
	[0.35]	[4.14]	[3.354]	[3.566]	[3.627]
Longitude	113.36	115.89	2.532**	0.581	0.706
	[0.12]	[1.23]	[1.177]	[0.558]	[0.525]
Latitude	31.43	32.35	0.929	1.148	0.978
	[0.14]	[1.19]	[1.308]	[0.960]	[1.025]
Distance (Treaty Port)	247.69	130.65	-117.033***	-36.364	-42.201
	[4.05]	[39.13]	[38.372]	[33.155]	[29.671]
Distance (Courier Roads)	98.59	40.74	-57.852**	-5.602	0.097
	[2.81]	[22.90]	[26.577]	[19.227]	[16.236]
Distance (Battlefield)	423.62	305.75	-117.875	10.249	11.864
	[7.77]	[83.27]	[73.611]	[23.802]	[23.052]
Soil Suitability for Cotton	5.61	5.56	-0.053	-0.042	-0.052
	[0.03]	[0.37]	[0.330]	[0.350]	[0.363]
Soil Suitability for Tea	6.47	7.54	1.067**	0.725*	0.657*
	[0.06]	[0.33]	[0.540]	[0.378]	[0.356]
Soil Suitability for Soy	5.86	6.10	0.240	0.001	0.046
	[0.03]	[0.31]	[0.253]	[0.251]	[0.256]
Soil Suitability for Wheat	5.78	5.79	0.005	-0.138	-0.156
	[0.02]	[0.24]	[0.223]	[0.216]	[0.210]
Soil Suitability for Yam	7.45	7.86	0.411**	0.281	0.267*
	[0.02]	[0.09]	[0.204]	[0.174]	[0.148]
Taiping Rebellion	0.31	0.50	0.189	0.045	0.059
	[0.01]	[0.13]	[0.117]	[0.126]	[0.137]
Political Instability	0.37	1.88	1.501***	1.142***	1.187***
	[0.02]	[0.42]	[0.202]	[0.220]	[0.237]
Distance (Copper)	85.16	61.37	-23.795	-1.110	1.259
	[1.89]	[20.91]	[17.873]	[15.265]	[13.005]
Historical Textile Center	0.03	0.00	-0.027	-0.087*	-0.080*
	[0.00]	[0.00]	[0.040]	[0.045]	[0.048]
Distance (Railroad)	175.88	88.57	-87.313**	-30.919	-22.896
	[4.48]	[46.67]	[42.399]	[23.630]	[22.358]
Panel C: Industrial Output					
Industrial Output (log)	1.22	16.58	15.358***	11.621***	11.993***
	[0.11]	[0.48]	[0.991]	[1.053]	[1.202]
N	1416	16	1432	1432	1052

Notes: This table reports the balance check of the treated and untreated counties. Panel A compares the selection criteria variables. Panel B compares various economic and social development variables, with and without controlling for the selection criteria. Panel C compares additional economic variables that were only available at the prefecture level, with and without controlling for the selection criteria. The comparisons in Columns (3) and (4) use the full sample, whereas those in Column (5) use the CEM sample.

Table 3: Impact of Munition Factories Establishment on Firm Entry

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	# New-Entry Firms (logged)										
$I(MF_{it} \geq 0)$	0.496***	0.355***	0.345***	0.342***	0.342***	0.342***	0.343***	0.333***	0.333***	0.334***	0.334***
	[0.092]	[0.066]	[0.065]	[0.064]	[0.064]	[0.064]	[0.064]	[0.068]	[0.068]	[0.068]	[0.068]
County FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Pref × Year	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Selection Criteria		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Political Importance			Y	Y	Y	Y	Y	Y	Y	Y	Y
Western Influence				Y	Y	Y	Y	Y	Y	Y	Y
Geographic Conditions					Y	Y	Y	Y	Y	Y	Y
Agricultural Conditions						Y	Y	Y	Y	Y	Y
Taiping Rebellion							Y	Y	Y	Y	Y
Political Instability								Y	Y	Y	Y
Copper Mine									Y	Y	Y
Historical Textile Center										Y	Y
Transportation											Y
Adjusted R^2	0.364	0.424	0.428	0.428	0.429	0.429	0.429	0.435	0.435	0.435	0.435
N	114560	114560	114560	114560	114560	114560	114560	114560	114560	114560	114560

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the number of new-entry firms at county-year level in natural log form (plus one). $I(MF_{it} \geq 0)$ is a dummy variable that equals to one when county i had built any munition factories by year t. *Selection Criteria* include whether a county were provincial or prefectural capitals, distance to coastline, waterway, coal mine and iron mine, as well as dummy variables indicating the existence of foreign enclaves or foreign firms before 1860. *Political Importance* includes its official-rated importance level (least important, general, important, most important). *Western Influence* includes distance to the historical battlefields with European countries and the number of Protestants per 10,000 people in 1920s. *Geographic Conditions* includes longitude, latitude and distance to treaty ports. *Agricultural Conditions* includes soil suitability of cotton, tea, soy, wheat, and yam. *Taiping Rebellion* is a dummy variable indicates whether a county was a battleground during the Taiping Rebellion. *Political Instability* includes a dummy variable to indicate whether a county experienced warfare from 1910 to 1925. *Copper Mine* measures distance to copper mines. *Historical Textile Center* indicates whether a county was a historical textile center. *Transportation* measures a county's distance to railways and roads. All the above cross-sectional control variables are interacted with the decade fixed effects. Standard errors are clustered at the prefecture level.

Table 4: Robustness Check

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	# New-Entry Firms (logged)									
	Treated	CEM	Sub-sample			Quadratic	IHS	Private	Gov't	Pref level
$I(MF_{it} \geq 0)$	-0.016	0.352***	0.358***	0.358***	0.353***	0.331***	0.431***	0.297***	0.050***	0.323***
	[0.020]	[0.067]	[0.071]	[0.073]	[0.065]	[0.066]	[0.087]	[0.063]	[0.013]	[0.044]
County FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Pref
Pref $\times$ Year	Y	Y	Y	Y	Y	Y	Y	Y	Y	Prov$\times$Year
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.780	0.452	0.378	0.473	0.330	0.441	0.427	0.430	0.081	0.560
N	1280	84160	16320	68640	108720	114560	114560	114560	114560	19360

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Column (1) keeps only the 16 treated counties. In Column (2), we use the coarsen exact matching sample. Column (3) reports the results after restricting sample to the counties in provincial capitals. Column (4) keeps only southern provinces: Jiangsu, Anhui, Zhejiang, Jiangxi, Hunan, Hubei, Fujian, Guangdong, Guangxi, Yunnan, Guizhou, Sichuan. Column (5) excludes Jiangsu province. In Column (6), we add the quadratic forms of the control variables. In Column (7), we make an alternative transformation (inverse hyperbolic sine) to the outcome variable. Columns (8) and (9) analyze the entry of private firms and government-supervised firms, respectively. In Column (10), we run the regression at the prefecture level. *Controls* are the baseline control variables in Table 3. Standard errors are clustered at the prefecture level.

Table 5: Impact of Military Investment on Industry Development in 1933

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	OLS	1st Stage	2SLS								
	Industrial	Military	Industrial Output								
	Output	Investment	Baseline	Treated	CEM	IHS	Add controls		Post 1872	Placebo IV	Pref level
Military Investment	0.597***		0.578***	0.275	0.568**	0.597***	0.487**	0.556**	0.703***	0.191	0.330*
	[0.099]		[0.218]	[0.801]	[0.246]	[0.229]	[0.225]	[0.217]	[0.264]	[0.162]	[0.192]
Instrument		0.186***									
		[0.032]									
Distance to Prov. Gov								-0.004			
								[0.003]			
Pref FE	Y	Y	Y	Y	Y	Pref	Y	Y	Y	Y	Prov
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
1st-stage excluded F-stat			33.24	9.48	30.13	33.24	30.98	33.36	31.01	155.86	10.75
Adjusted R^2	0.330	0.332	0.330	0.528	0.328	0.328	0.339	0.330	0.436	0.312	0.487
N	1432	1432	1432	16	1052	1432	1432	1432	1427	1432	221

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is industrial output value in 1933 in natural log form (plus one). *Military Investment* is military investment from 1861 to 1894, also in natural log form (plus one). *Instrument* is the instrument variable as described in Section 4.2. *Controls* are the baseline control variables in Table 3. Column (1) reports the OLS results. Column (2) reports the first-stage result. The rest columns report the 2SLS results. Column (3) reports the baseline 2SLS results using the full sample. Column (4) restricts the sample to the 16 treated counties, only including the selection criteria as controls and using Bootstrap standard errors. Column (5) use the CEM matched sample. In Column (6), we use the inverse hyperbolic sine transformation to the industrial output value. In Column (7), we add quadratic form of the control variables. In Column (8), we control for the distance to the locations of provincial governors. In Column (9), we exclude counties with munition factories before 1872. In Column (10), we use the placebo instrument, defined by the number of the correspondences related to the Chinese philosophy. In Column (11), we run the regression at the prefecture level. Standard errors are clustered at the prefecture level.

Table 6: Mechanisms: Input Linkage

	(1)	(2)	(3)	(4)
	All Sample		Port	Non-port
	Industrial Output			
Military Investment × Input Linkage	0.094***	0.125***	-0.005	0.125***
	[0.013]	[0.020]	[0.019]	[0.020]
Military Investment × Input Linkage * Port		-0.130***		
		[0.027]		
Input Linkage × Port		1.456***		
		[0.239]		
County FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Adjusted R^2	0.503	0.512	0.632	0.375
N	8592	8592	300	8292

Notes: *** p<0.01, ** p<0.05, * p<0.1. All results are ordinary least squares estimates at the county-industry level. The dependent variable is the industrial output value in 1933 in natural logarithmic form (plus 1). *Military Investment* is military investment from 1861 to 1894 in natural log form (plus one). *Input Linkage* is the input linkage between a civil industry and the firearm industry, calculated from the 1929 U.S. industrial census. *Port* is a dummy variable that equals 1 when a county had a treaty port from 1840 to 1930 and zero otherwise. The sample was restricted to the port and non-port counties in Columns (3) and (4), respectively. Standard errors are clustered at the prefecture level.

Table 7: Mechanisms: Machine

	(1)	(2)	(3)	(4)	(5)	(6)
	Industrial Output			# Machine	# Machine/L	K-L ratio
Military Investment	0.578***			0.457***	0.052	0.133
	[0.218]			[0.127]	[0.035]	[0.097]
Non-Machine Investment		0.578***				
		[0.219]				
Machine Investment			0.791**			
			[0.309]			
Pref FE	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.330	0.330	0.328	0.373	0.203	0.276
N	1432	1432	1432	1432	1432	1432

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variables are the industrial output value in 1933, number of machines, number of machines per capita, and capital-labor ratio, all in natural logarithmic form (plus 1). *Military Investment* is the military investment from 1861 to 1894 in natural logarithm form (plus 1). *Non-Machine Investment* and *Machine Investment* are military investments in non-machine goods and machines, respectively. *Controls* includes the baseline control variables in Table 3. Standard errors are clustered at the prefecture level.

Table 8: Mechanisms: Human Capital

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	# School	# Scientist	# Natural Scientist	Industrial Output			
Military Investment	0.007	0.044***	0.026*	0.578***	0.556**	0.469*	0.470*
	[0.011]	[0.015]	[0.014]	[0.218]	[0.233]	[0.247]	[0.253]
log (1 + # School)					2.894***		2.619***
					[0.760]		[0.756]
log (1 + # Scientist)						2.463***	2.007**
						[0.843]	[0.804]
Pref FE	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.217	0.256	0.116	0.330	0.354	0.345	0.364
N	1432	1432	1432	1432	1432	1432	1432

Notes: *** p<0.01, ** p<0.05, * p<0.1. All results are 2SLS estimates using cross-section data. The dependent variables in Panel A are the number of secondary modern schools, the number of scientists and the industrial output values in 1933, all in natural log form (plus one). The dependent variables in Panel B are the number of different types of scientists in natural log form. *Military Investment* is military investment from 1861 to 1894 in natural log form (plus one). # *School* is the number of modern secondary schools in 1916; # *Scientist* is the number of scientists who were born after 1840, both in natural log form (plus one). *Controls* includes the baseline control variables in Table 3. Standard errors are clustered at the prefecture level.

Table 9: Mechanisms: Supporting Institutions

Panel A: Cross-section data	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Banks	Trading Company	Self-initiated Port	Industrial Output			
Military Investment	0.104***	-0.006	-0.007	0.167	0.579***	0.624***	0.234
	[0.024]	[0.014]	[0.014]	[0.304]	[0.215]	[0.186]	[0.212]
Banks				3.938***			3.685***
				[1.101]			[0.840]
Trading Company					0.272		-0.694
					[1.695]		[1.566]
Self-initiated Port						6.848***	6.478***
						[1.336]	[1.342]
Pref FE	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.513	0.663	0.110	0.378	0.330	0.375	0.418
N	1432	1432	1432	1432	1432	1432	1432
Panel B: Panel data	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Banks	Trading Company	Self-initiated Port	# New-Entry Firms			
$I(MF_{it} \geq 0)$	0.076**	0.006	0.001	0.293***	0.335***	0.334***	0.295***
	[0.037]	[0.009]	[0.002]	[0.056]	[0.068]	[0.068]	[0.055]
Banks				0.536***			0.528***
				[0.089]			[0.085]
Trading company					-0.235***		-0.183***
					[0.073]		[0.059]
D (Self-initiated Port)						0.087	0.090
						[0.057]	[0.058]
County FE	Y	Y	Y	Y	Y	Y	Y
Pref * Year	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.266	0.382	0.003	0.457	0.437	0.435	0.458
N	114560	114560	114560	114560	114560	114560	114560

Notes: *** p<0.01, ** p<0.05, * p<0.1. The results in Panel A are 2SLS estimates using cross-section data. The results in Panel B are DID estimates using panel data. *Military Investment* is military investment from 1861 to 1894 in natural log form (plus one). $I(MF_{it} \geq 0)$ is a dummy variable that equals to one when county i had built munition factories by year t. *Bank* is the number of banks in natural log form. *Trading Companies* is the number of trading companies in natural log form. *D(Self-initiated Port)* is a dummy variable that equals to one if a county had a self-initiated port. *Controls* includes the baseline control variables in Table 3. Standard errors are clustered at the prefecture level.

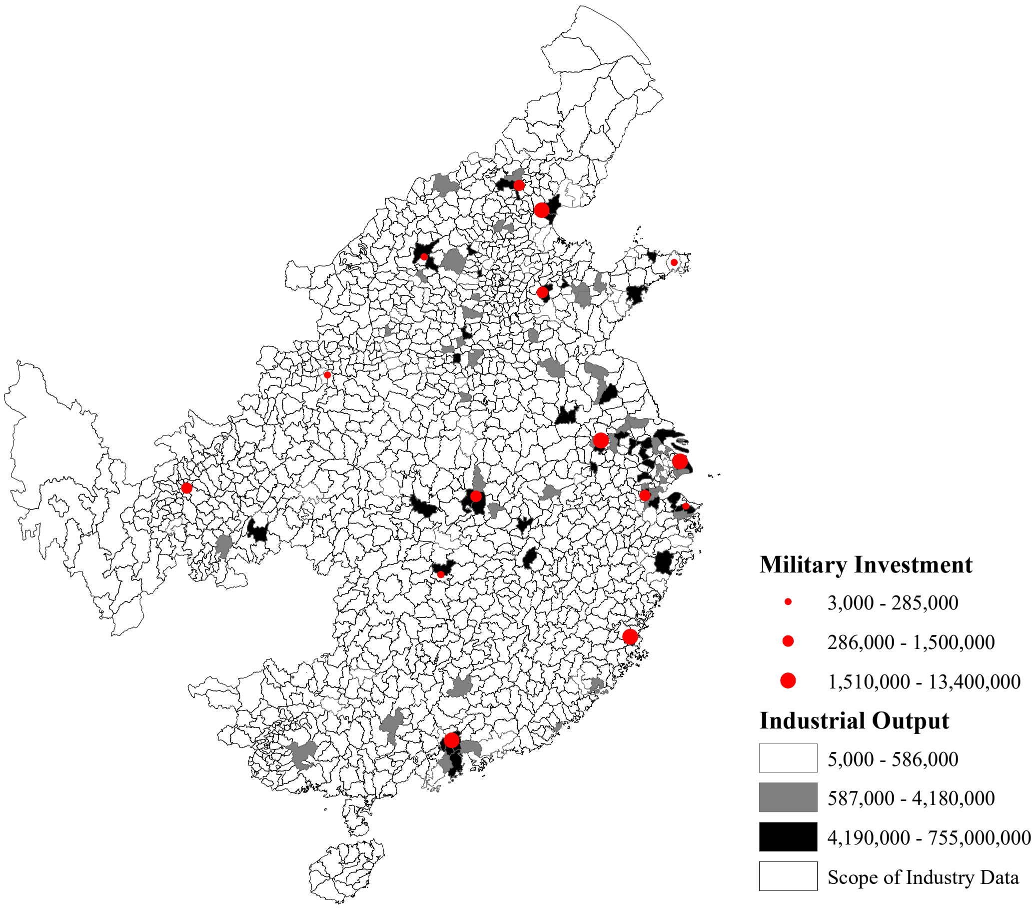

Figure 1: Spatial Distribution of Military Investment (1861-1894)
and the Industrial Output Value (in 1933)

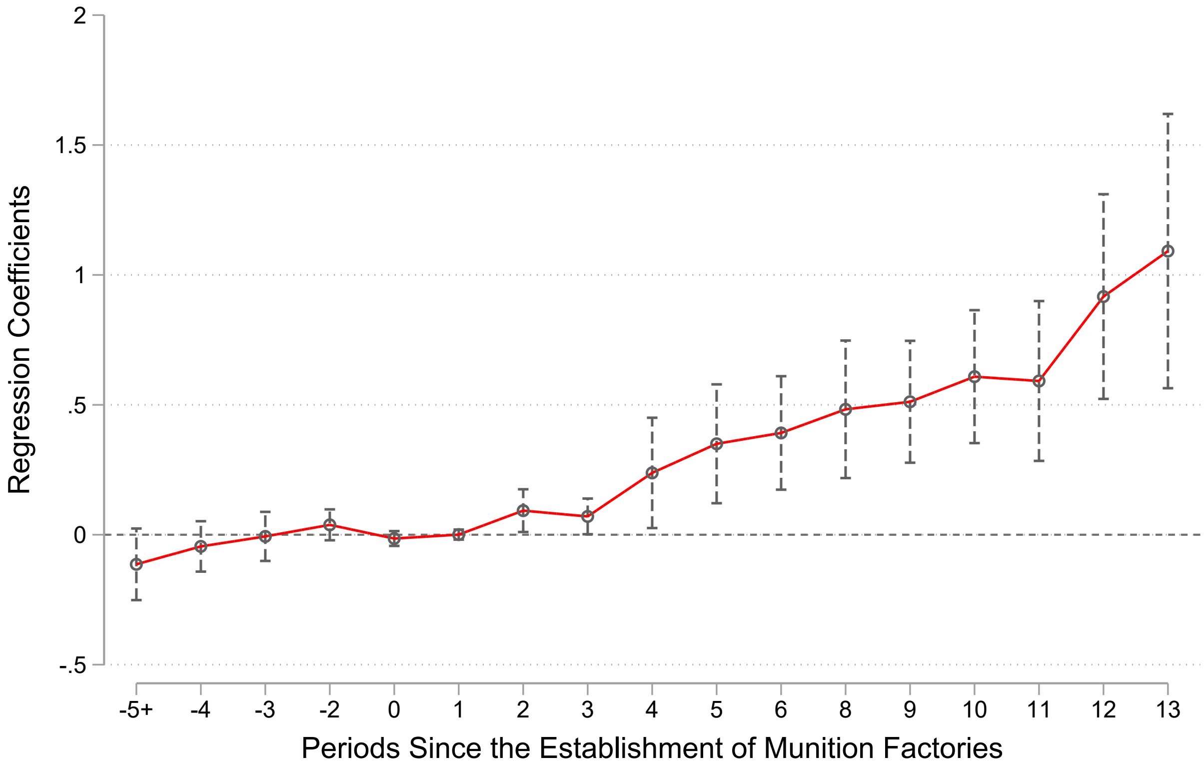

Figure 2: Dynamic Effects of Military Investments on Industrial Development

Online Appendix for
Military Investment and the Rise of Industrial Clusters: Evidence from China's First Industrial Policy, 1858-1937

A Examples of Memorials Discussing Location Choice of Factories

We list examples of memorials to the throne, in which provincial governors discussed potential concerns about the location choices of munition factories. Most of the original archival material we use are from the archives of the Grand Council and other collections of official documents. The sources with munition factories are selected and compiled into *Zhongguo jindai bingqi gongye dang'an shiliao* (The Second Historical Archives of China, 1993).

Below are several translated clips of the memorials to the throne that discuss the locations of factories. All of the clips are obtained from memorials copied by the Grand Council. The page number indicates the location in the collection book.

Ding Baozhen on Sichuan Jiqiju Firearms are necessary for national defense. Foreign firearms are well made in recent years. Troops in Sichuan province have used these firearms but do not know how to fix them. . . As I will now be the provincial governor in Sichuan province, I plan to set up a munition factory and produce firearms ourselves. I have already chosen a place in the provincial capital. As for funding, I will rely on Likin. . . if it is not enough, I will turn to the tea tax (page 141).

Wang Wenshao on Hunan Jiqiju It is important to set up factories along the coast, but we should consider the inland as well. The middle part of Hunan province is famous for producing coal and iron. When the factories were first built, we already relied on domestic coals, but we have to turn to foreigners for coals as they are of better quality. . . (page 128)

Yinggui on Fujian Jiqiju I plan to build a factory, as the provincial governor, and send some capable people to be in charge. The monthly expenses can come from Likin (page 118).

Li Hongzhang on Jiangnan Zhizaoju I think that if we ask foreign merchants to purchase the machinery, it would be too risky due to the long distance and high price. Sending people overseas would take a long time. Therefore, it would be a good idea just to purchase existing factories from foreigners so we can immediately start production (page 53).

B Data Appendix

We provide additional information about our outcome variables on industrial development from 1858 to 1937, constructed from different datasets, and our main independent variables, i.e., the establishment of and investment in munition factories.

B.1 Industrial data

B.1.1 The entry of industrial firms, 1858 to 1937

The county-level data on the entry of industrial firms provide the number of established firms every year, from 1858 to 1937. The original data collected by Du (1991, 2019) are at the firm level and inform on each firm's year of establishment, name, location, capital, names of founders, sources of materials, and whether it is government-supervised or privately owned. We aggregate the original firm-level data to the county level based on the year of establishment.

The original data include industrial, mining, and shipping companies with capital more than 10,000 yuan, and banks with capital more than 50,000 yuan. The exchange rate in 1933 was 1 dollar for 3.5 yuan. We do not include banks in our analysis. Du (1991, 2019) compiled the data largely from first-hand statistics released by the Chinese government and supplemented it with data from the Japanese government, industrial surveys, and second-hand studies conducted by other historians. To ensure high data quality, we cross-check the information with another high-quality, independently constructed source (Chang, 1989) and find that the records are similar.

The data on firm entry provide the most comprehensive record of industrial growth in China before 1949. Although annual information on firms' exit and scale is not available, the use of firm entry is more suitable for our setting, in which a country witnessed the birth of its industrial sector and was expected to witness a boom in new firms instead of an expansion of incumbent firms, whose number was very limited. The use of firm entry to capture industrial development is common in other studies on early twentieth-century China.[42]

B.1.2 Industrial census in 1933

The industrial data from 1933 are obtained from the only industrial census conducted in China before WWII. The original data provide detailed information on production at the firm level,

[42] Recent studies that adopt this strategy are Bai (2019) and Liu (2020).

but have never been published. We use existing data aggregated at the county level by Liu (1937) as the main dependent variable.

The industrial census was initiated by the central government of the Republic of China and conducted by the Institute of Economic and Statistical Research (*Zhongguo jingji yanjiusuo*) for the National Resources Commission. The data collection process started in April 1933 and ended in October 1934, followed by the calculation of data, which was completed in May 1935. The full survey covered 1,206 firms in 15 provinces, except for the city of Shanghai, whose survey was done separately as the city was an industrial harbor and itself had 1,229 factories. The firms in the sample were selected under two criteria: whether they used primary power and whether they had more than 30 workers. The sample did not consider munition factories, power plants, mints, or film makers. The original survey included 171 items, such as information on organization, capital, land area, source of power, machinery, input, output, workers, and wages.

Surveyors received comprehensive training before their departure to each county. The training consisted of explanations of detailed terms in the forms and provided models of machinery, principal materials, and input. The surveyors were equipped with standardized weights and measures and detailed maps of each province. Once they arrived in a county, the surveyors contacted the provincial government for a full list of factories. They then went to individual counties to check the factories' names and addresses. They visited individual firms to fill out the request forms, using detailed questions about the firms' production processes. The surveyors spent at least half a day in each firm. They contacted the Institute by mail about their process at least once a week. The collected numbers were double-checked by the Institute to ensure consistency.

The existing report, separately published in two sets, only has aggregated information. The first set of reports is for individual industries, consisting of inputs and outputs by industry, and the second set has the input and output information at the county level. We derive our main dependent variable of industrial output in 1933 from the county-sector report and use the industry-level report to construct input-output linkages.

Scholars in Chinese economic history recognize the high quality of this census. Liu and Yeh (2016)'s seminal work on China's growth in accounting describes the census as "the only survey of its kind before the War," which "is the decisive reason for limiting our estimate to that year (1933)."[43] Regarding coverage of this survey, "[w]hile there are undoubtedly some omissions, they probably consist mostly of small handicraft workshops."[44] The director of the survey, Dajun Liu, who held a degree of economics and statistics from the University of Michigan and a professorship in Tsinghua University, believed that the quality of the survey is comparable to contemporary ones conducted in the U.S. and Europe. Based on the census, Ou (1933) and Liu and Yeh (2016) conduct their studies on China's economic growth, which laid the foundation for later work on China's industrial sector in the early twentieth century, such as Chang (1967) and Rawski (1989).

B.2 Data on Munition Factories

Data on the establishment of and investment in each munition factory are collected and calculated by Fan (2003). Fan (2003) collects the original information largely from memorials to the throne and supplements missing terms using data from newspapers, local gazetteers, and personal records. For each firm, Fan (2003) reports total investment and investment in machinery for the years 1874, 1884, and 1894. We aggregate total investment for munition factories and machinery.[45]

Fan (2003)'s study provides the most comprehensive data thus far on investment in munition factories. However, as some of the reported expenditures were based on estimates due to a lack of records or inconsistency in measures, the investment data may have measurement errors. We use the instrumental variable approach to solve this problem.

C Construction of the Political Network of Zeng Guofan

To construct the political network of Zeng Guofan, we first collect his writings from *Zeng Guofan Quanji* (The Complete Works of Zeng Guofan, hereinafter the Complete Works) (Zeng, 2011). As the most comprehensive collection of his work, this comprises 31 volumes of Zeng Guofan's writings, of which 10 volumes are his correspondences with colleagues. To avoid reverse causality between the program and his correspondence, we only consider his correspondence *before* the program, from 1841 to 1860, which gives us 2,238 letters and 267 cor-

[43] Liu and Yeh (2016), page 32.
[44] Liu and Yeh (2016), page 429.
[45] Fan (2003), Appendix 5. Several large munition factories (for example, Jiangnan Zhizaoju, Jinling Jiqiju, Huaijun Xingying Zhizaoju, and Tianjin Jizhiqi), which had more detailed original data, have displayed investment in finer categories (including separate reports of expenditures on salaries and raw materials) and more frequently.

respondents. We further restrict our selection of politicians to those who became provincial governors between 1861 and 1894 and had enough power to make decisions on military investments. The list of provincial governors is obtained from Wei (2013). Provincial governors in the Qing dynasty were *Xunfu*, although some provinces also had *Zongdu*, who ranked higher than *Xunfu* and governed one or more provinces. We consider both *Xunfu* and *Zongdu* as provincial governors. We then perform textual analysis to extract all movement-related letters. The textual analysis is conducted as follows. First, we randomly choose 100 letters and read them to extract generic keywords related to the movement. The keywords are gunpowder (*huoyao*), ammunition (*ziyao*), cartridge (*zidan*), bomb (*zhadan*), firearm (*huojian*), steamship (*lunchuan*), cannon (*pao*), gun (*qiang*), and machine (*jiqi*). Then, we search the letters using these keywords and obtain 277 letters. We mark these letters as movement-related. Finally, we use the number of movement-related letters written by provincial governors in each province to measure their proximity to Zeng Guofan. We focus on movement-related letters, as Zeng Guofan discussed Western technology in them and they are closely related to our subject of study.

D Discussions on Efficiency of the SSM

We find that the SSM had a positive effect on industrial growth and led to the formation of clusters of civilian industries in the long term through multiple mechanisms. The existence of external economies of scale, however, does not imply that the program was the most efficient way of promoting private industries. In fact, historians have long questioned the efficiency of military investments during the SSM. As the aim of this program was to boost national defense, factories were usually under government supervision and did not seek to maximize profits (Feuerwerker, 1958; Perkins, 1967; Fan, 2003). In addition, the relatively capital-intensive military sector was not consistent with China's labor-abundant comparative advantage. After private firms were allowed to enter the market, the textile industry became China's leading industry until WWII (Rawski, 1989), suggesting that investments in textile industries might have yielded higher returns than in the military sectors.

To better understand the efficiency of the SSM in promoting industrial growth, we compare this program with other similar programs, such as Japan's Meiji Restoration in the nineteenth century and China's industrial programs implemented after 1949. Given that the aim of the SSM was strengthening the military sector, this comparison cannot be used to evaluate the efficiency of the program *per se*, but can help understand the conditions required for industrial policies to be effective.

The Meiji Restoration of Japan started in 1868, a few years later than the SSM, but was much more influential and marked a turning point in Japan's economic growth. Before the Meiji Restoration, Japan was an agrarian economy dominated by a fragmented political structure. The Meiji Restoration also began from the military sector, as did the SSM, but involved much more profound reforms such as quick technological adoption, political centralization, state-led investments in railroads, the expansion of universal primary education, and tax and land reforms; the movement successfully made Japan an industrialized economy by the early twentieth century (Perkins and Tang, 2017). From 1874 to 1895, Japan's industrial sectors experienced a rapid increase; its total factor productivity growth rate was 1.46% in the non-primary sector from 1885 to 1889 and remained high until 1940.[46]

There are numerous discussions about why Japan and Imperial China, the two countries that initiated similar reforms for its military sectors, achieved distinct results. Recent studies show that both the public and private sectors provided assistance to industrial firms during the Meiji Restoration, with the state playing an essential role in the expansion of railroads (Perkins and Tang, 2017) and private parties facilitating finance and technological adoption (Tang, 2011, 2013). This was in contrast with Imperial China's experience of the state prohibiting the entry of private firms before 1895. A recent study attributes the salient effect of the Meiji Restoration to its successful political centralization, which was possible due to Japan's small size compared with China (Koyama, Moriguchi, and Sng, 2018). Our analysis suggests that in decentralized Imperial China, officials' personal connections and attitudes played a major role in the establishment of munition factories.

We also compare the SSM with other nationwide industrial programs that were implemented in the People's Republic of China: the "156 Million-Rouble Plants" in the 1950s and the "Construction of the Third Front" Program in the 1960s; we base this on recent studies by Heblich, Seror, Xu, and Zylberberg (2021) and Fan and Zou (2021). The three programs, which took place in the same country, faced similar geographic conditions and cultural environments. Yet, both the above studies find spillover effect on private industries and improvements in productivity, whereas we find limited spillover before 1895 and no positive effects on productivity.

[46]Detailed statistics are obtained from Fukao, Makino, and Settsu (2020). The real GDP of the mining and manufacturing sectors increased by 150%, of the construction sector by 100% and of the trade, service, transportation, and communication sectors by 63% from 1874 to 1895.

Differences in the political environment may explain the differences between the SSM and later industrial programs. The SSM was initiated by provincial officials and lacked coordination across different provinces, whereas the later programs were top-down, implemented by a much stronger central government, and had a more stable and supportive domestic political environment. Therefore, both the later programs involved not only the transfer of machinery, but large investments in human capital and technology. These factors might have contributed to the more salient effects of these later industrial programs.

Table A1: List of Munition Factories

Name	Location	Foundation Date	Total Investment (10,000 taels)
*Jiangnan Zhizaoju**	Shanghai	1865	1337.259
*Jinling Jiqiju**	Jiangning	1865	308.587
*Fuzhou Chuanzhengju**	Min Xian	1866	1312.156
*Tianjin Jiqiju**	Tianjin	1867	782.769
*Huaijun Xingying Zhizaoju**	Tianjin	1867	238.541
*Xi'an Jiqiju**	Chang'an	1869	6.800
*Fujian Jiqiju**	Min Xian	1869	19.966
Lanzhou Jiqiju	Gaolan	1871	57.032
Yunnan Yangpaoju	Kunming	1872	0.500
*Guangdong Jiqiju**	Panyu	1873	251.871
*Zhejiang Jiqiju**	Renhe	1874	22.444
*Hunan Jiqiju**	Changsha	1875	10.205
Lanzhou Huoyaoju	Gaolan	1875	35.000
*Shandong Jiqiju**	Shandong	1875	95.277
*Sichuang Jiqiju**	Chengdu	1877	100.875
Kuche Huoyaoju	Kuche	1878	28.300
Akesu Zhizaoju	Wensu	1879	42.100
*Fujian Huoyaoju**	Min Xian	1880	2.500
Guizhou Yangpaoju	Guizhu	1880	0.800
*Dagu Chuanchang**	Tianjin	1880	148.835
*Jinling Yanghuoyaoju**	Jiangning	1881	80.235
*Ningbo Zhizao Junxieju**	Yin Xian	1881	0.300
Jilin Jiqiju	Fengtian	1881	129.347
*Zhejiang Huoyaoju**	Renhe	1882	8.600
Lvshun Chuanwu	Jinzhou	1882	269.643
*Shenjiying Jiqiju**	Wanping	1883	150.000
Yunan Jiqiju	Kunming	1883	36.000
Tainan Jiqiju	Tainan	1883	2.210
*Shuishi Jiqichang**	Wendeng	1883	12.620
*Suigongjun Xingying Zhizaoju**	Wendeng	1884	15.878
*Hubei Jiqiju**	Jiangxia	1884	2.680
*Shanxi Xinhuoyaoju**	Yangqu	1884	4.600
Taiwan Jiqiju	Taiwan	1885	50.907
*Hubei Qiangpaochang**	Hanyang	1890	134.700

Note: Munition factories with * were in the sampled provinces.

Table A2: Impact of Munition Factory Establishment on Industrial Firms (Capital)

	Capital of New Entry Firms		
	Total	Private Firms	Gov-Supervised Firms
	(1)	(2)	(3)
$I(MF_{it} \geq 0)$	3.239***	2.900***	0.692***
	[0.575]	[0.537]	[0.171]
Controls	Y	Y	Y
County FE	Y	Y	Y
Pref × Year	Y	Y	Y
Adjusted R^2	0.279	0.279	0.071
N	114560	114560	114560

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the total capital of new-entry firms at the county-year level in natural logarithmic form (plus 1). $I(MF_{it} \geq 0)$ is a dummy variable that equals 1 when county i had built munition factories by year t. Standard errors are clustered at the prefecture level.

Table A3: Spillover Effect

	(1)	(2)	(3)
	Full sample	Drop Treated Counties	
	Industrial Output		
Military Investment	0.578***		
	[0.218]		
Distance (Military Firm)		0.001	
		[0.003]	
$I(adjacentMilitaryInvestment) > 0$			0.120
			[0.810]
Controls	Y	Y	Y
Pref FE	Y	Y	Y
Adjusted R^2	0.330	0.235	0.235
N	1432	1416	1416

Notes: *** p<0.01, ** p<0.05, * p<0.1. All results are OLS estimates. The dependent variable is the industrial output value in 1933 in natural logarithm form (plus 1). *Military Investment* is the military investment from 1861 to 1894 in natural logarithmic form. *Distance (Munition Factories)* is the distance between each county and its nearest county with military investment. $I(adjacentMilitaryInvestment) > 0$ is a dummy variable that equals 1 if military investment took place in a county's adjacent counties. Standard errors are clustered at the prefecture level.

Table A4: Exclusion Restrictions

	(1)	(2)	(3)	(4)
	In 1880	(1851–1880)	In 1911	In 1905
	Pop (density)	Pop Growth Rate	# Newspapers	# Key Officials
Instrument	-0.171	-0.005	0.286	0.073
	[0.962]	[0.014]	[0.382]	[0.060]
Controls	Y	Y	Y	Y
Prov FE	Y	Y	Y	Y
Adjusted R^2	0.670	0.643	0.584	0.425
N	207	207	206	206

Notes: *** p<0.01, ** p<0.05, * p<0.1. All results are OLS estimates at the prefecture level and control for provincial fixed effects. The dependent variables are the population density in 1880, population growth rate from 1851 to 1880, the number of newspaper per capita in 1911, and the number of key officials in 1905. The independent variable is the instrument variable as described in Section 4.2. *Controls* includes the baseline control variables listed in Table 3, aggregated to the prefecture level. Standard errors are clustered at the prefecture level.

Table A5: Balance Check Between Early- and Late-Established Munition Factories

	(1) Before 1872	(2) After 1872	(3) Unconditional diff.	(4) Conditional diff.
Panel A: Selection Criteria				
Prov/Pref Capital	0.86	0.88	0.018	
	[0.14]	[0.09]	[0.160]	
Foreign Enclaves	0.71	0.25	-0.464**	
	[0.18]	[0.11]	[0.208]	
Foreign Firms (Before 1860)	0.14	0.06	-0.080	
	[0.14]	[0.06]	[0.132]	
Distance (Coastline)	179.07	254.20	75.133	
	[122.99]	[78.65]	[143.986]	
Distance (River)	2.01	2.54	0.534	
	[1.09]	[0.53]	[1.068]	
Distance (Coal)	281.30	256.55	-24.747	
	[76.44]	[61.91]	[106.749]	
Distance (Iron)	14.27	40.81	26.538	
	[12.05]	[9.52]	[16.497]	
Panel B: Confounding Factors				
Political Importance (General Important)	0.00	0.13	0.125	0.122
	[0.00]	[0.09]	[0.131]	[0.078]
Political Importance (Important)	0.14	0.69	0.545**	0.102
	[0.14]	[0.12]	[0.205]	[0.125]
Political Importance (Most Important)	0.86	0.19	-0.670***	-0.224
	[0.14]	[0.10]	[0.179]	[0.155]
Protestantism	29.42	20.33	-9.088	-4.209
	[6.90]	[2.92]	[6.296]	[6.597]
Longitude	117.46	116.63	-0.829	-1.523*
	[1.52]	[1.17]	[2.045]	[0.746]
Latitude	32.57	32.48	-0.088	1.796
	[2.04]	[1.23]	[2.299]	[1.751]
Distance (Treaty Port)	70.62	117.55	46.938	-0.939
	[60.34]	[33.03]	[63.685]	[53.320]
Distance (Courier Roads)	38.44	57.39	18.955	28.421
	[18.19]	[29.86]	[47.203]	[32.250]
Distance (Battlefield)	142.76	283.10	140.341	35.789
	[128.70]	[73.05]	[139.016]	[43.886]
Soil Suitability for Cotton	5.27	5.65	0.384	0.429
	[0.45]	[0.37]	[0.642]	[0.485]
Soil Suitability for Tea	6.87	7.55	0.681	0.212
	[0.82]	[0.33]	[0.731]	[0.567]
Soil Suitability for Soy	6.21	6.03	-0.184	-0.193
	[0.35]	[0.35]	[0.580]	[0.459]
Soil Suitability for Wheat	5.87	5.79	-0.084	-0.069
	[0.36]	[0.25]	[0.450]	[0.339]
Soil Suitability for Yam	7.86	7.86	0.000	-0.065
	[0.14]	[0.09]	[0.165]	[0.162]
Taiping Rebellion	0.57	0.50	-0.071	-0.216
	[0.20]	[0.13]	[0.236]	[0.177]
Political Instability	2.43	1.50	-0.929	-1.593*
	[0.69]	[0.35]	[0.697]	[0.800]
Distance (Copper)	65.18	76.98	11.798	33.758
	[18.21]	[26.29]	[41.930]	[30.397]
Historical Textile Center	0.00	0.00	0.000	0.000
	[0.00]	[0.00]	[0.000]	[0.000]
Distance (Railroad)	131.08	98.36	-32.718	-10.316
	[81.01]	[46.80]	[88.525]	[42.135]
N	7	16	23	23

Notes: This table reports the balance check between the treated counties with munition factories established before and after 1872 when *Zeng Guofan* died. Panel A shows the comparison of the selection criteria. Panel B compares the confounding factors after controlling for the selection criteria.

Table A6: Total Factor Productivity

	(1)	(2)	(3)	(4)
	OLS		2SLS	
	Industrial Output			
Military Investment	0.597***	-0.022	0.578***	-0.027
	[0.099]	[0.021]	[0.218]	[0.019]
K		0.944***		0.941***
		[0.057]		[0.051]
L		0.274***		0.279***
		[0.102]		[0.093]
Controls	Y	Y	Y	Y
Pref FE	Y	Y	Y	Y
Adjusted R^2	0.330	0.994	0.330	0.994
N	1432	1432	1432	1432

Notes: *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the industrial output value in 1933 in natural logarithmic form (plus 1). *Military Investment* is the military investment from 1861 to 1894 in natural logarithm form. *K* and *L* are the total amount of capital and the number of workers at county level, respectively, both in natural logarithmic form (plus 1). Standard errors are clustered at the prefecture level.

Table A7: Mechanisms: Input-output Linkage (2002 Census)

	(1)	(2)	(3)	(4)	(5)	(6)
	Full	Port	Non-port	Full	Port	Non-port
	Industrial Output Value in 1933					
Military Investment × Input Linkage	0.126***	-0.003	0.126***			
	[0.020]	[0.017]	[0.020]			
Input Linkage × Port	1.361***					
	[0.232]					
Military Investment × Input Linkage * Port	-0.129***					
	[0.026]					
Military Investment × Output Linkage				0.090***	-0.015	0.090***
				[0.030]	[0.021]	[0.030]
Output Linkage × Port				0.964***		
				[0.230]		
Military Investment × Output Linkage × Port				-0.105***		
				[0.036]		
County FE	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.511	0.632	0.375	0.505	0.632	0.373
N	8592	300	8292	8592	300	8292

Notes: *** p<0.01, ** p<0.05, * p<0.1. All results are OLS estimates. The dependent variables are the industrial output value in 1933 in natural log form. *Military Investment* is military investment from 1861 to 1894 in natural log form. *Input Linkage* and *Output Linkage* are the input linkage and output linkage between other industrial sectors and the manufacturing sector, calculated from the 2002 industrial census of China. *Port* is a dummy variable that equals to one when a county had a treaty port from 1840 to 1930. Standard errors are clustered at the prefecture level.

Table A8: Mechanisms: Foreign Firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	[1841,1916]		[1895,1916]		[1905,1916]		In 1933	
	OLS	IV	OLS	IV	OLS	IV	IV	
	log(1 + # Foreign Firm)						Industrial Output (1933)	
Military Investment	0.042***	0.001	0.044**	-0.009	0.042***	-0.006	0.577***	0.579***
	[0.016]	[0.010]	[0.017]	[0.015]	[0.015]	[0.013]	[0.217]	[0.212]
Log (1 + # Foreign Firm)([1861,1894])							-0.100	
							[2.076]	
Log (1 + # Foreign Firm)([1895,1916])								0.113
								[1.161]
Pref FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.624	0.570	0.417	0.274	0.427	0.277	0.330	0.330
N	1432	1432	1432	1432	1432	1432	1432	1432

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The dependent variables are the entry of foreign firms in different stages and industrial output value in 1933, both in natural logarithm form. *Military Investment* is military investment from 1861 to 1894. *# Foreign Firm ([1861,1894])* is the total number of foreign firms established during the SSM. *# Foreign Firm ([1895,1916])* and *# Foreign Firm ([1905,1916])* are the total number of foreign firms from 1895 to 1916, and from 1905 to 1916, respectively. *Controls* includes the baseline control variables listed in Table 3. Standard errors are clustered at the prefecture level.

Figure A1: Locations of the Munition Factories

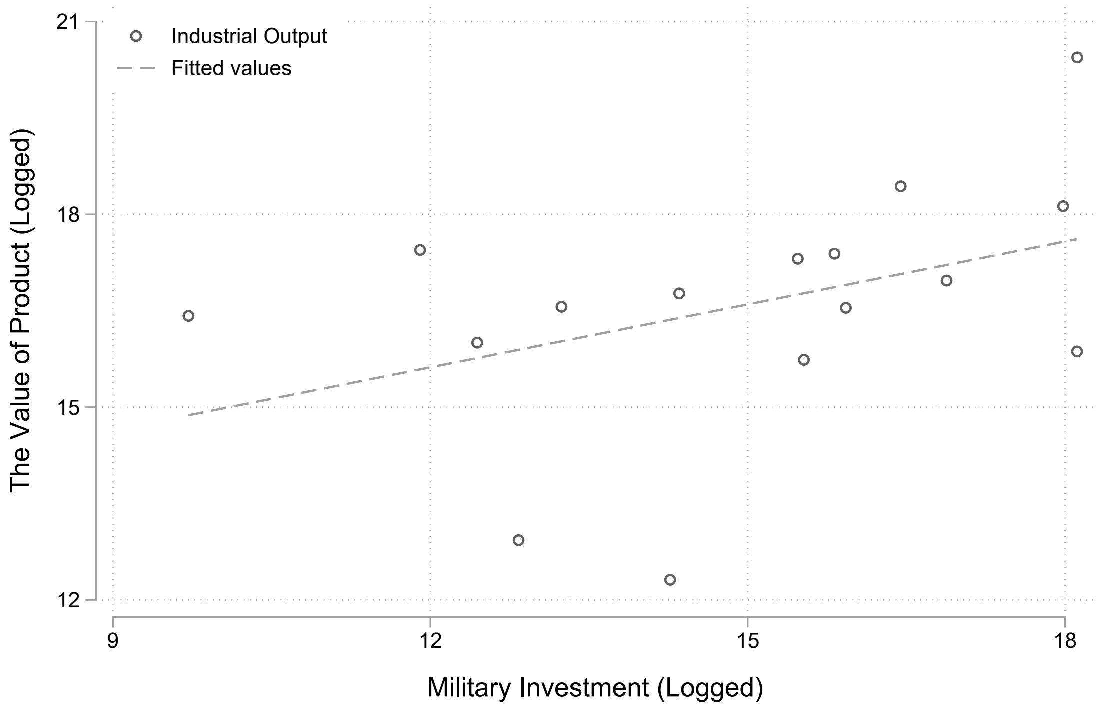

Figure A2: Correlation between Military Investment and Industrial Output Value

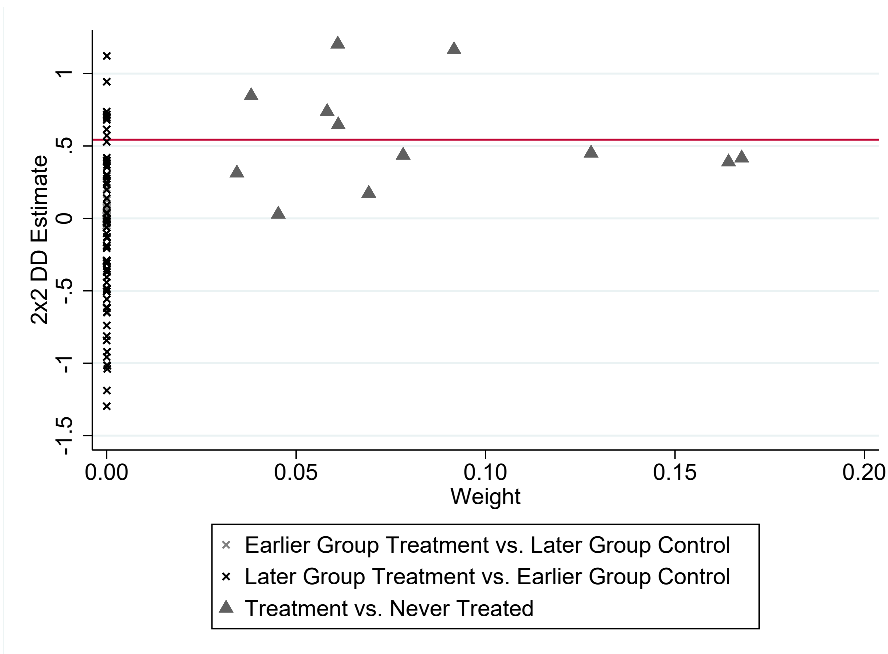

Figure A3: Goodman-Bacon decomposition

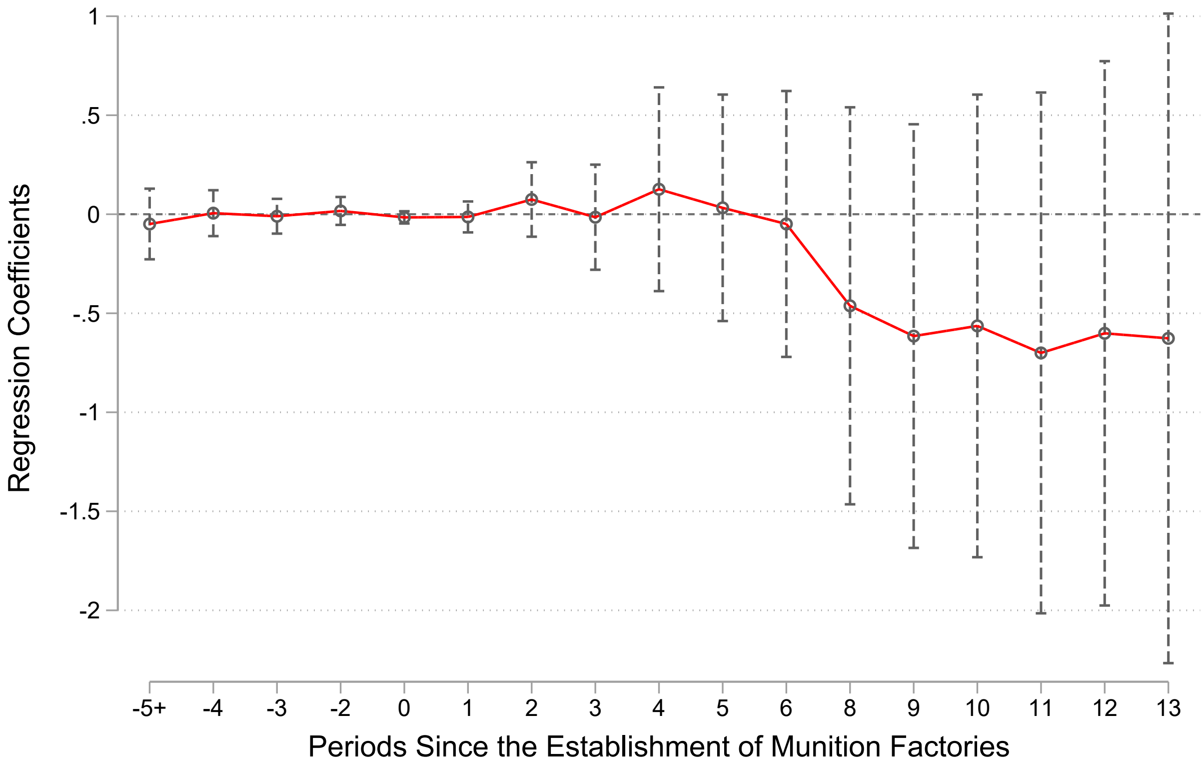

Figure A4: Dynamic Effects of Military Investments on Industrial Development: 16 Treated Counties

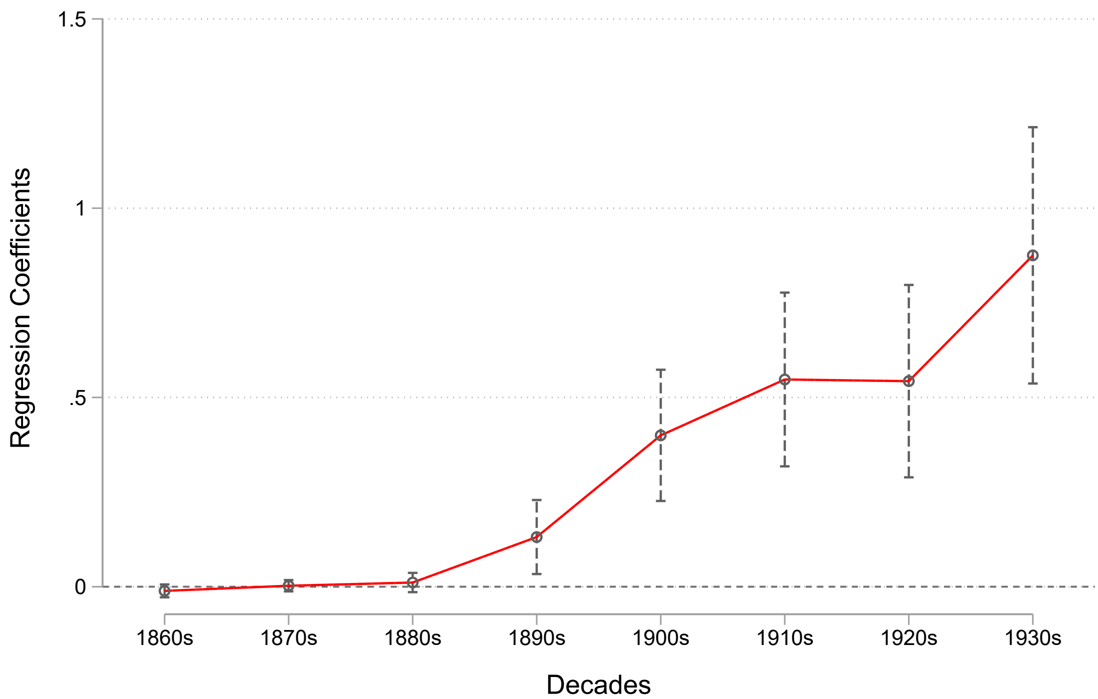

Figure A5: The Effects of Military Investments on Industrial Development by Decades (1860-1937)

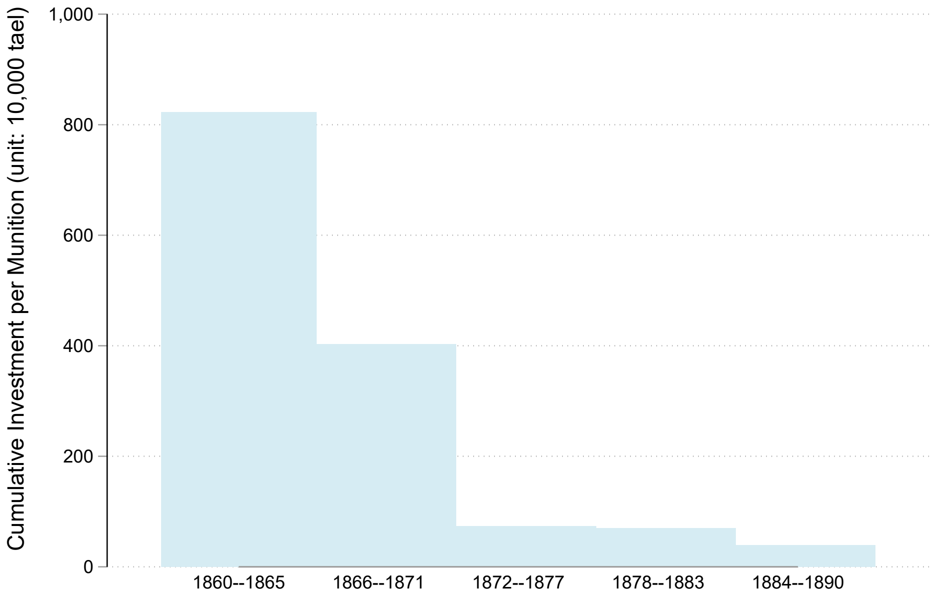

Figure A6: Average Investment in Munition Factories by Years of Establishment

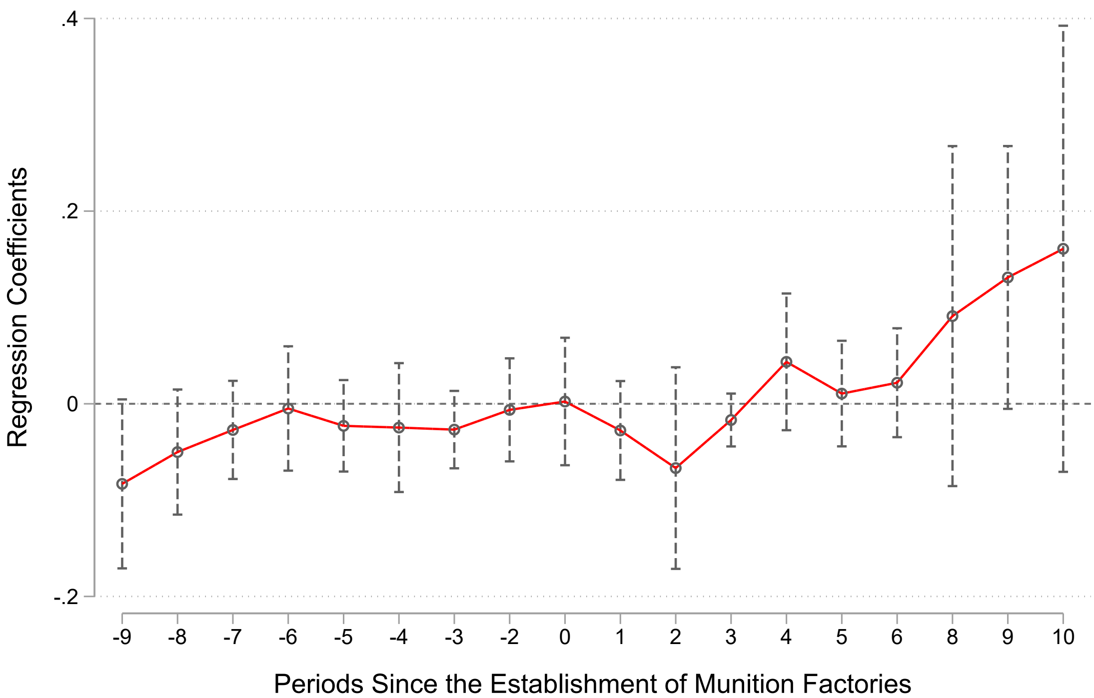

Figure A7: Dynamic Effect of Military Investments on Foreign Firm Entry (1 period: 5 years)