The Economic Effects of Civil War: Evidence from Chinese National Railroads, 1906 - 1923[1]

Dan Li[2]

Department of Economics, Boston University

First Version: December 2006
Current Version: October 2007

(Job market paper, comments welcome and appreciated)

Abstract

During the Later Qing Dynasty and so-called "Warlord Period" (1906-1923) China suffered from numerous and violent internal conflicts, or "civil wars". These conflicts are thought to have slowed the pace of economic development and, especially, growth in infrastructure. I study these alleged impacts using a new panel data set linking archival data for Chinese railroads to detailed information on civil wars. I show that conflict had negative effects on business transportation flows, operative revenue, and investment, with the latter operating primarily through Tobin's Q. These effects occurred during the same period as the conflict, but also persisted after the fighting had stopped. My findings suggest that, in the absence of internal strife, China would have experienced more rapid growth during a crucial phase of its modern economic history.

Keywords: Civil war, Qing Dynasty, Warlord, Railroad, China

JEL code: N45, N75, N95

[1] I am grateful to Robert A. Margo for guidance and support. I thank Chun-Yu Ho, Alex Wai-Yip Ho, Kevin Lang, Daniele Paserman, Zhongjun Qu, Sujata Visaria and Florence Kondylis for their suggestions on paper improvements and all participants in workshop at Boston University, the Harvard Economic History Tea, Northeast Universities Development Consortium Conference 2007, NBER Development of the American Economy Summer Institute 2007, the 2007 Economic History Association Meetings, the 2007 Economic and Business Historical Society Conference for helpful comments. This research was supported by a dissertation fellowship from the Economic History Association.
[2] Email: danli@bu.edu ; URL: Http://people.bu.edu/danli ; Tel: 1-617-353-3743; Address: Department of Economics, 270 Bay State Road, Boston University, Boston, MA 02215.

I. Introduction

Civil wars can be highly damaging in economic terms. In the short run, a civil war diverts human and physical capital from civilian to military activities, some of which is destroyed in the process. In the case of labor, the numbers are staggering: according to Fearon and Laiten (2003) there have been over 16 million deaths worldwide due to civil wars over the period 1945 to 1999, about five times the number occurring during wars between nations. Civil wars may also retard investment in new physical capital as well as damage the fabric of society -- its institutions and organizations, or “social capital” (Collier 1999; Collier, Hoeffler, and Soderbom 2004).

In light of these considerations it is not surprising that economists have attempted to measure the economic effects of civil war. The vast majority of such studies concentrate on aggregate outcomes, such as output per worker, per capita consumption, or real wages (see, for example, Engerman 1966; Goldin and Lewis 1975, 1978; Murdoch and Sandler 2002; Kang and Meernik, 2005). However, it is highly likely that the effects of civil war are highly diverse, for example, across locations or industries. Such diversity is invisible at the macroeconomic level but may be very important in understanding the fundamentals and the processes underlying the aggregate consequences.[3]

This paper investigates the economic impact of civil war on a particular industry in a particular country – namely, the railroad industry in China during the Later Qing Dynasty and so-called “Warlord” period from 1906 to 1923. Economic historians have documented how railroad expansion raised aggregate output through the integration of factor and goods markets and the concomitant encouragement of regional specialization in industrial leaders like the Great Britain or the United States (Hawke 1970; Fishlow 1965; Fogel 1964, 1979) as well as “backward” nations such as Brazil (Summerhill 2005), Tsarist Russia (Metzer 1975) and India (Hurd 1975; Collins 1999).

[3] A novel example is Abadie and Gardeazabal (2003), an investigation of the economic effect of conflict in the Basque Country, which examines the stock performance of firms with a significant presence in that area, experiencing a truce announcement and a truce termination. A positive relative stock performance is found when truce becomes credible, and the opposite when truce termination is announced. There is growing literature on micro evidence on war’s impact, which includes Bellows & Miguel (2006), Blattman (2006), Kondylis (2007), Shemyakina (2006), Akresh et al. (2007), an incomplete list.

Historians of China have also suggested that political instability in the form of civil wars retarded railroad expansion, thereby limited China's growth prospects in the early twentieth century (Liang 1982; Huenemann 1984). During the period considered in this paper China lacked a stable central government; instead, large swaths of the country were ruled by warlords. With considerable frequency as well as deadly consequences these warlords engaged in battles both small and large with each other, occasionally with the assistance of foreign powers such as the United States and Japan. It is these conflicts that I, following the standard nomenclature, call civil wars; my goal is to estimate their impact on railroad outcomes.

Although it is easy to find anecdotal evidence that, say, any particular conflict between two warlords resulted in destruction affecting the railroads – for example, track that was laid waste in the heat of battle – it is a very different matter to demonstrate that such damage was sufficiently frequent and economically (and statistically) significant to affect the moments of the distribution of railroad outcomes – for example, the average revenue per track mile. To do so it is necessary to collect economic information on individual railroads and to match this information, in an appropriate geographic manner, to data on civil wars.

In this paper I make use of a panel dataset, newly collected from archival sources, on seventeen Chinese railroads. Using GIS methods I have linked the railroad data to information on civil wars – for example, when and where a conflict occurred, its severity of damage to a railroad, and so on. A variety of time series models linking railroad outcomes to wars are then estimated.

My preferred estimates indicate that civil war in early twentieth China indeed had negative consequences for the development of a railroad network, although these effects vary with the nature of the outcome as well as in the short and long run. In particular, I show that conflict reduced business passenger flows and operating revenues, and investment. These effects were very substantial; the occurrence of a war reduced current (that is, in the same period) revenue by approximately one-third. I also show that the effects on investment operated largely through Tobin's Q; that is, the occurrence of a war in the previous period depressed Tobin's Q, which reduced the investment.

The remainder of the paper is organized as follows. Section 2 provides the necessary historical background on China. The data are described in Section 3. Section 4 contains theoretical framework and the empirical methodology, and results are presented in Section 5. Section 6 concludes.

II. Historical Background

2.1 The Later Qing Dynasty and the Warlord Period

During the 1800s China was ruled by the Manchus Qing. Their leadership could be described – politely – as increasingly ineffective as the century progressed. An early harbinger of decline was China's humiliating defeat in the First Opium War (1839-1842) which, among other things, illustrated the outdated state of the Chinese military.[4] Internal weakness invited later invasions, which resulted in more defeat and humiliation.[5] China's government was forced to accept unequal treaties, including opening up ports, paying large amounts for reparations, ceding lands, and making various other concessions of sovereignty to foreign "spheres of influence". Coupled with the external disasters, domestic rebellions were rampant across the nation, further weakening an already shaky regime.[6]

Finally, after a succession of external and internal threats, Emperor Guangxu (1871-1908), and later, Empress Dowager Cixi (1835-1908) — the actual ruler of the

[4] During the late eighteenth and early nineteenth centuries trade between Chinese and European merchants expanded, which caused hostility toward the west by the conservative Qing regime. Because of the unpopularity of European manufactured products in China and huge demand for Chinese goods such as silk, tea and ceramics in the European market, China experienced a substantial trade surplus. It is said that in order to help balance Britain's huge trade deficit with China, the British introduced opium to China; by 1838, the British were selling 1,400 tons annually to China. In the same year, the Qing regime tried to ban the opium trade and the British declared war on China, leading to the Opium War.

[5] These included the Second Opium War (1856-1860), the Sino-French War (1884-1885), the first Sino-Japanese War (1894-1895) and the Intrusion of Eight Nation Alliance in 1901 (see Elleman, 2001 for details).

[6] Among them, the most famous are the Taiping Rebellion (1851–1864) and the Boxer Rebellion (1899-1901).

country — realized that, if China was to survive as an independent nation, it would have to undergo reform, of which the establishment of a modern Western-style army was the first order of business. However, the Qing dynasty failed to create a unified modern national army for several reasons. First, during the Taiping Rebellion, regional armies, such as Zeng Guofang's Xiang Army and Li Hongzhang's Huai Army, proved to be more efficient than the national army in suppressing the rebels. Recognizing their value, the Qing government authorized the army commanders to retain full control over their local militia and, later, extended the power to civil administration (Mccord 1993). Second, the Qing government simply could not provide financial resources to the regional armies, which led to the decentralization of military financing (Van De Ven 1996). As a result, armies were beholden to the local power structure not to the central court. Third, the Manchus rulers themselves were reluctant to create a unified army in one organization, since they conventionally used the fragmentation of military power as a means of maintaining dynastic control over the military (Mccord 1993). Unfortunately, the early failure to establish a unified national defense was an important factor in the subsequent emergence of a "warlord" culture in the early twentieth century (see below).

After the overthrow of the monarchy in 1911, the center of political life was lost and the republican government was not able to fill the power vacuum. From 1912 to1928, China fell into the "so-called" Warlord Period.[7] Nominally republican, there were nonetheless some 1,300 warlords who, needless to say, did not get along with each other. The most comprehensive assessment concludes that 140 conflicts occurred between warlords during this period, some crossing provincial boundaries (Ch'en 1968).

The most powerful of the warlords controlled one or more provinces and small ones could only influence several districts. Figure 1 shows the dominant regions of major warlords in 1924. The most dominant collaborated routinely with foreign powers, to an extent that the fighting became encumbered (and influenced) by foreign interests. A

[7] Scholars have not reached a consensus on the exact dating of the warlord period. For instance, Waldron (1993) takes 1916—the year of death of Yuan Shi-Kai as the beginning point; Chen (1968) thinks 1912— the year when the Republic China was declared -- was the start. The yaer 1928 --- the year of victory of Northern Expedition (1926-1928) against the northern warlords to unite China under Guomingdang control — is conventionally taken to be the end of the "warlord" period. However, some historians, like Ch'I (1976) and Sheridam (1977) argue that the Guomingdang did not successfully eliminate "warlordism".

striking illustration can be seen in a cartoon (Figure 2) from the German satirical journal, *Kladderadatsch* (1848-1944) depicting two Chinese generals fighting with each other as puppets of foreign powers. This image was reproduced in 1925 in the highly influential Chinese Journal called *Dongfang Zazhi* (1904-1948).[8]

2.2 Railroad History before 1927

The construction of a railroad network in China was first proposed by a group of political reformers during the so-called “Self-Strengthening” period (1876-1894). The reform movement was slow to bear fruit, however, because political conservatives argued that western technology would weaken the Confucian status quo (Huenemann 1984). The reformers gained ground only after the Chinese defeat in Sino-French war (1884-1885), during which an inadequate transportation infrastructure was perceived to be responsible for the defeat. Under the leadership of Liu Ming Chuan (1836-1896), the province of Taiwan was the first to begin construction, in order to improve coastal defense, as well as a source of the government revenue (see Kent 1907 for details). Nonetheless, construction was very slow; prior to the outbreak of the First Sino-Japanese War in 1894, no more than 411 kilometers of tracks were built on mainland China. China’s subsequent defeat in this war in 1895 gave further impetus to the railroad movement and this time the process took hold, perhaps because various foreign powers entered the scene. Accordingly the network expanded rapidly, from less than 411 kilometers in 1894 to 9,306 kilometers in 1911. As will become clear, it is useful to divide up the network into three categories: (1) state-owned or national railroads. Even though many lines were built with foreign loans and under the instruction of foreign engineers, their management was largely vested in the hands of Chinese directors; (2) foreign-owned railroads, which were fully controlled by foreign owners; for example, the Russian-controlled Chinese Eastern Railroad and the Japanese South Manchurian Railroad; and (3) private railroads, which were financed by merchant-gentry coalitions.

During the Warlord Period (1912-1928), the pace of railroad construction

[8] Dongfang Zazhi (Eastern Miscellany), 22(1925):13.

diminished from an annual increase of 523 kilometers (1894-1911) to 307 kilometers. Moreover, about sixty-five percent of the railroad construction (about 1720 kilometers) during this period was located in Manchuria which was (relatively speaking) under peaceful governance by the local warlord Zhag Zuo-Lin and his foreign partners, the Japanese. Measured at about the middle of the Warlord Period (1920), about 63 percent of the network falls into category #1 (state owned); a third in category #2 (foreign); and a tiny fraction, 4 percent, was prviately controlled (category #3).

Since the private railroad was virtually irrelevant (most of them were short lines serving very localized markets) and the foreign-owned railroads were protected by their respective governments, the national railroads were naturally attractive to the warlords both as a revenue source and as a means of deploying their troops. For example, during the so-called "Second Revolution" in 1913 a crucial campaign was fought along the line of Tianjin-Pukou railroad. In July 1920, fighting between the Anhui and Zhili factions took place on the juncture of Beijing-Hankou rail line and Beijing-Suiyuan rail line. Apart from the property damage caused by wars, traffic suspension and the commandeering of rolling stock by warlords, the railroad system suffered from regional trade embargoes frequently imposed by warlords, increased exaction of transit duties for military finance, and the augmented risk of long-distance shipments during time of war.

III. Data

The primary source for the railroad data is an eighteen volume survey prepared by the government (Department of Transportation, Republic of China, 1935). The data available for most companies include balance sheets, income and expense statements, operation performance statements, records of construction/investment, and records of the loss caused by wars and floods in each year. Using these records I was able to put together a firm level panel data set for seventeen railroads containing information on yearly track mileage, business passenger and freight flows, operating revenue and expense, employment, and capital stocks, along with the information on civil wars and floods just mentioned (see Table 1 for details).[9]

3.1 Firm level data

Total passenger flow includes private business passengers and government passengers (officials and troops). According to pricing policies in effect at the time, the government passengers were entitled to a discounted ticket (about half the price of a normal ticket). However, most of the railroad companies were not able to collect the fees and, consequently, in my study these “free riders” do not contribute to passenger revenues, which I exclude from analysis. Business tickets were of three classes, where prices of the second and first-class tickets were double and triple that of the third-class respectively. During war time, some private passengers who purchased the first or second-class tickets were not able to get the first or second-class seats if soldiers took their seats. Therefore, no one was willing to buy the expensive higher-class tickets and the railroad companies suffered a loss in passenger income due to the decline in the number of high-profit-margin customers, even though the total number of business passengers remained unchanged.

Total freight flow consists of business freight, government-related freight, and the freight for the railroad construction, with the last two excluded in my study for the similar reasons as for the passenger flows. For some railroads, data are available on the compositions of business freight flow, which can be grouped into agricultural products, wood products, farm animals, mineral products and industrial products, with the largest being agricultural products.

Operating revenue includes main business revenue (transport revenue), other revenue and the revenue from leasing cars to other railroad companies. The operating revenue that appears on the income statements is accounting revenue and does not

[9] The number of the railroads belonging to the national systems slight varied from one year to another during my study period. My selection includes the railroads belonging to the national system in year 1930. The data for non State-Owned railroads – concession and private railroads during the same period are insufficient for me to conduct systematic analysis. The national lines provided more than half of the nation’s total mileage in my study period (see Huenemann, 1984, p. 136).

necessarily represent the actual cash inflow because, as noted before, the transport revenue from transporting government-related passengers (freights) and from transporting the materials for the railroad construction itself were not realized, although they appear on the income statements. Therefore, reported revenue was usually larger than the real cash inflow. Unfortunately, there were no statistics on the uncollectible debt from government or the warlords- for my study period. According to Xu (2004)'s study of the national railroads' financial status during a later period from 1927 to 1935, the uncollectible debt of the government and the warlords amounted to about 10 percent of operating revenue and 24.4 percent of operating profit per year on average.

Operating expenses, collected from various divisions of the railroad company, consist of six major items: management costs, transportation operating costs, transport input purchasing costs, transport equipment maintenance fees, rail track maintenance fees, and the cost for leasing cars from other railroad companies. For example, Figure 3 shows the organization structure for Beijing-Fengtian Railroad Company. The management fee and the transport operating cost are the expenses of the general business office and train operating office, respectively. Operating revenue and expense are deflated by the wholesale price index (see Wang 2002; 1906 is the base period). Real profit is the difference between real operating revenue and expense.

Railroads had both formal and informal employees. On average, formal employees made about four times the annual salary of a (full-time) informal employee. However, informal employees were not guaranteed full-time jobs. Nominal gross investment is obtained by subtracting the previous year's capital stock from this year's capital stock, and real investment is nominal investment deflated by the price index just mentioned. The sample size for employment and investment is much smaller than that for other variables.

3.2 Data on civil wars and floods

Political scientists define a "civil war" to be a conflict involving groups from the same culture, nationality, or society. Two criteria are used: 1) the groups must be from the same country and fight for control of the political center, control over a particular region, or to force a major change in policy. 2) the conflict is significant, in the sense of causing a large number of deaths – typically, one thousand or more. The civil wars I investigate satisfy the first of these two criteria because the warlords were Chinese, fighting with each other to obtain control over the Beijing government (the political center), to expand their political control over a larger territory, or to unify the country. In addition, I restrict my attention to conflicts in which the death toll exceeds 1,000.

A civil war could damage a railroad company in five different ways -- interruptions in operation, dismantling the tracks, commandeering railroads for deploying troops, physical threats to railroad staff and confiscation of the locomotives and boxcars. However, my data source does not record the last three types of damages; it only records the number of operational days stopped by war and the quantity of tracks damaged during a war.[10] Therefore, in addition to the constraint on the death toll, above, I consider a railroad to have "experienced" a civil war in year *t* if a war took place along the line and caused an interruption of more than 20 days a year in a section of a line or dismantled more than one seventh of the tracks. Civil wars according to this definition are distinguished from other types of events – for example, very short conflicts, civilian riots, or non-violent protests – that might also have resulted in a high death toll.

In my dataset, if one war lasted more than one year along a line, the railroad is presumed to have experienced civil war in consecutive years. If a war took place in the vicinity of more than one line, each railroad is treated as experiencing a war. Table 2 presents a chronological list of civil wars in this study, with the duration of each individual war varying from case to case. A war is a sequence of battles; some battles cause damage to a railroad and some do not. Consider a particular, very short war between the Wan and Zhi factions. Most major battles occurred on the juncture of the Jing-Sui and Jing-Han lines located in Hebei Province in July 1920 (see Figure 4). At the

[10] Although the matter could stand further investigation it is unlikely that not having data on all of the five types of damages noted in text will bias my results because the first two – interruptions in operations, or damage to track, is likely to be highly correlated with the last three.

beginning, the Wan Faction won several battles and the Zhili faction retreated along the Jing-Han line. Later, the Feng Faction joined the Zhili's side and the allies defeated Wan. Then, the Wan army was forced to retreat along the Jing-Sui line. According to my measurement protocol both lines experienced a war in the same year since more than one seventh of the track was damaged.

Next consider a longer war – the so-called "National Protection War" between the alliance of southern warlords and the Yuan Shi-Kai government. This war, which had seven major battles, lasted from December 1915 to June 1916. Among them, two took place in Sichuan province, four in Hunan province and one in Zhejiang province. Since there was no railroad in Sichuan at that time, railroads did not come into play. The four battles in Hunan occurred far away from the two local railroads (Zhu-Ping and Yue-Han railroads) and did not cause direct damage to a railroad. Thus, I do not treat these railroads experienced a war at that time. Only the battle in Zhejiang caused a stop in the operation of more than fifty days of Fu-Hang-Yong railroad in 1916. Consequently, as Table 2 indicates, the involved railroad in the National Protection War includes only the Fu-Hang-Yong railroad.

In summary, a civil war is an event that caused measurable damage to a railroad, as defined above, within a specific year. According to this definition, four of the seventeen railroads experienced more than one war, six experienced exactly one war, and seven escaped conflict altogether.

In thinking about the damage caused by a war, it is useful to compare this with other types of "disasters". Fortunately, I am able to do so because the data also contain information on floods, a ubiquitous problem in China. Analogous to my definition of war, I consider a flood to be serious if it disrupted the operation of at least one section of a railroad for more than twenty days.

Figures 5-6 use the Jing-Han railroad line as an illustrative example to show how a war might affect transport volumes and financial status before conducting a more formal (econometric) analysis. There is an obvious drop in business passenger flow in 1920, when a war occurred, while, for freight flow, there is a drop after 1920. Figure 6 depicts yearly revenue and expense, from which no evident relationship between these two variables and the war is observed.

IV. A Model of Firm Behavior Under Uncertainty

4.1 Assumptions

Before laying out the theoretical model, I make three assumptions meant to capture key aspects of the behavior of the seventeen Chinese national railroad companies during the specific historical period in China. The assumptions are the following:

- Unlike state-owned companies in communist China, the railroad companies I am analyzing were in business to make money; thus, I assume profit-maximizing behavior. Pressure to make money, in particular, came from external forces; companies frequently borrowed capital from foreign powers which they had to repay. These foreign lenders practiced "due diligence" by sending agents to monitor the railroad's activities. Lastly the government wanted railroads to make money (because their revenue stream depended on this) and were in no mood to tolerate deviations from profit maximization.
- Chinese managers were in charge, even during war time. This is suggested by the fact that the bulk of management positions were filled by Chinese not foreigners. For example, out of the fifteen departments of Jing-Feng Railroad (Figure 3), only four departments (Engineering office, Train operating office, Foreign accounting office and Machinery factory) were headed by foreigners in 1911 and later, these positions were replaced by Chinese. The director was almost always filled by Chinese. Consequently, the national railroads could not be the foreigner's political instrument, as described in the conventional Chinese literature on railroads (e.g. Mi 1980), and, thus, would not be diverted from serving the goal of profit maximization. During the outbreak of civil war, although warlords might disrupt a company's activities, they would not simply expropriate the assets because this could bring on retaliation from a

foreign power.

- Civil wars are exogenous to the local presence of railroads. It is true that railroads were of strategic importance for military campaigns. However, no scholars of the Warlord Period (e.g. Rowe, 1944; Ch'en, 1968; Waldron, 1991; Lary, 1980) have suggested that the mere presence of railroad in a particular area was the cause of a civil war.[11] Moreover, when a war broke out, there is no evidence that each individual battle was more likely to occur in the vicinity of a railroad (e.g. the four battles in Hunan province during the National Protection War took place far away from the local railroads). Hence, the location choice of the battlefields is likely to be exogenous to the presence of railroads.

4.2 Theoretical Framework

Based on the previous assumptions, a railroad company chooses the optimal level of investment, labor and current inputs, and output in order to maximize its value which is defined as the summation of total discounted profit flow.

$$V(k_t, u_t) = \max_{I_t}(\pi(k_t, u_t) - I_t(u_t) - C(I_t, k_t) + \frac{1}{1+r}E\{V(k_{t+1}, u_{t+1})\} \quad (1)$$

Firms optimize over a single control variable, I_t; k_t is the endogenous state variable-the capital stock. Profit, $\pi(k_t, u_t)$, is equal to the revenue $R(k_t, u_t)$ minus the expenditure $X(k_t, u_t)$ before investment.

$$\begin{aligned}\pi(k_t, u_t) &= R(k_t, u_t) - X(k_t, u_t) \\ &= \sum_j \bar{p}_j n_j(k_t, u_t) - \sum_l x_l(k_t, u_t)\end{aligned} \quad (2)$$

Railroad companies are multi-product firms because they carry both passenger traffic and freight traffic.[12] Hence, the total income is the summation of revenues from various

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[11] The exogeneity of war ultimately may or may not be true but since the causes of these wars have never been examined quantitatively. In my another ongoing project, I attempt to build a model predicting the probability of the occurrence of war controlling for the characteristics of the region controlled by warlords (e.g. output, population, the presence of waterway and railroad and so on) and the personal characteristics of warlords (e.g. education background, No. of wives and sons, their foreign partners and so on). Currently, I am in the middle of colleting the data. Thus, up to this stage, let me take this assumption as if it is true.

[12] Apart form transport revenue, firms may also have a small portion (normally, less than 5%) of income from other businesses (see, for example, Figure 7 which shows that Jing Feng Railroad Company had machinery, material and bridge factories, all of which generate non-transport revenues)

products *j*, which is the product of a fixed price $\overline{p}_j$[13] and quantity of outputs (e.g. number of passengers or tons of freight). Business traffic flow is assumed to be constant return to scale in capital k_t. The operating expenditure $X(k_t, u_t)$ consists of costs of various factors of production, l: costs of capital assets (the installment payments and interests on loans), wage payments, and costs on current inputs (e.g. costs on fuel and other non-durable goods). Each cost function, $x_l(k_t, u_t)$, is again assumed to be constant return to scale in capital k_t. The uncertainty u_t enters each function as an exogenous shock. Thus, the profit $\pi(k_t, u_t)$, as a whole, exhibits constant return to capital.

The evolution of the firm's capital stock k is given by

$$k_{t+1} = (1-\delta)k_t + I_t(u_t) \tag{3}$$

Here, δ is the depreciation rate. Current investment (or disinvestment) I_t is affected by the exogenous shock u_t.

Following the previous literature, the adjustment cost function $C(I_t, k_t)$ is homogeneous of degree one in (I_t, k_t), consistent with constant returns to scale. I use the functional form proposed in Summers (1981).

$$C(I_t, k_t) = \frac{a}{2}\left[\left(\frac{I_t}{k_t}\right) - b\right]^2 k_t \tag{4}$$

Here, the parameter a reflects the importance of adjustment costs whereas b represents the steady-state investment/capital stock ratio associated with no adjustment costs. In other words, bk_t is the level of investment necessary to maintain the plant.

By using this specification, the first order condition for investment I_t yields a linear model.

[13] The railroad rate for most companies was very rigid. Even though prices were not recorded each year, it seems from the data sources that each firm set the price at the very beginning for each product and remains fixed since then. I also compare the passenger rate for companies in my data source and that in another data source (The Yearbook of Railroads in 1933 by the Department of Railroads, Republic of China) for the same set of companies in 1933 and no significant differences are found.

$$1 + C_I(I_t, k_t) = \frac{1}{1+r} E\{V_k(k_{t+1}, u_{t+1})\}$$

$$\Rightarrow \frac{I_t}{k_t} = b + \frac{1}{a}\left(\frac{1}{1+r} E\{V_k(k_{t+1}, u_{t+1})\} - 1\right) \tag{5}$$

Equation (5) tells us that as $\frac{1}{1+r} E\{V_k(k_{t+1}, u_{t+1})\}$, the discounted shadow value of capital (Tobin's Q), rises then $\frac{I_t}{k_t}$ increases.

The envelope conditions implies

$$V_k(k_t, u_t) = \pi_k(k_t, u_t) - C_k(I_t, k_t) + \left(\frac{1-\delta}{1+r}\right) E\{V_k(k_{t+1}, u_{t+1})\} \tag{6}$$

Applying forward differencing and iterating we get

$$V_k(k_t, u_t) = E_t\left\{\sum_{h=0}^{\infty}\left(\frac{1-\delta}{1+r}\right)^h \left[\pi_k(k_{t+h}, u_{t+h}) - C_k(I_{t+h}, k_{t+h})\right]\right\} \tag{7}$$

Thus, the marginal value of capital is equal to the discounted stream of marginal profits minus the additional impact of capital on adjustment costs. Given the constant return to scale in profit and adjustment cost Hayashi (1982) shows that the marginal Q is equal to average Q.

$$V_k(k_t, u_t) = \frac{V(k_t, u_t)}{k_t} \tag{8}$$

4.3 Empirical implementation

The natural hazard—flood is added as the other source of uncertainty into the empirical analysis for several reasons. First, it is interesting to compare the impact of the man-made disaster-civil war to that of the natural hazard-flood because of their different natures. The warlords were rational agents and had certain control over the consequences and timescales of the war, which provides the chance for the management of railroad companies to apply diplomacy with them in order to prevent/reduce the loss in case of a war; however, the geophysical hazard-flood is an unpredictable and, thus, non-preventive accident to the railroad during my study period. Second, the flood and war might occur in the same year to a railroad and including floods makes the impact of a war distinguishable from that of floods. In this study, the impact of flood is assumed to be short-lived and constraint within one year. I use several different specifications for the timing of a war's impact, which will be described later in section 4.4.

4.3.1 Estimation for business transport volumes, operating revenue and expense, and employees

The total mileage of a railroad track is used rather than the railroad company's overall capital stocks because the later consists of both transportation capital stocks and other various capital stocks (e.g. manufacturing factories, shops, commercial land attached to the company and so on), which do not correlate with the transport output variables under investigation. According to assumption of constant return to scale, dependent variables are expressed as the number per kilometer. The regression is as follows.

$$y_{it} = \eta + \alpha War_{it} + \beta Flood_{it} + \gamma_t + \theta_i + \varepsilon_{it} \qquad (9)$$

where y_{it} could be yearly number of business passengers/KM, tons of freight /KM, revenue/KM, expense/KM and employees/KM. war_{it} is a vector of uncertainty measures indicating there is war-related impact in year *t*. Similarly, $flood_{it}$ is a vector of uncertainty measures for flood-related impact in year *t*. γ_t is the time dummy aiming to account for time specific effect, such as nationwide disasters and change in inflation regime. θ_i is firm dummy meant to capture firm-specific effect. η is the constant and ε_{it}, the residual.

4.3.2 Estimation for investment

The empirical estimation of the Tobin's Q model of Equation 5 is as follows.

$$(\frac{I_{it}}{k_{it}}) = \eta + \phi q_{it} + \alpha War_{it} + \beta Flood_{it} + \gamma_t + \theta_i + \varepsilon_{it} \qquad (10A)$$

where q_{it} indexes Tobin's Q. war_{it} and $flood_{it}$ are the same vector of uncertainty dummies as in Equation 9, which is similar to the uncertainty measures in Q model in Bond et al (2007) meant to capture the impact of the unexpected shocks on firms' investment behavior. γ_t is, again, the time fixed effect and, θ_i, firm fixed effect here capturing the permanent differences across firms in their conventional investment level. η and ε_{it} are the same as in Equation 9.

In the conventional literature on investment, the lagged investment ratio is usually included in the regression. Just as Bond (2002) points out even though we might not have direct interest in the coefficients on the lagged dependent variables, "allowing for dynamics in the underlying process may be crucial for recovering consistent estimates of other parameters". He further shows that the OLS regression usually yields inconsistent estimators, but, GMM is a proper methodology for firm-level data investment estimation. Thus, I also estimate the following equation by using GMM.

$$(\frac{I_{it}}{k_{it}}) = \eta + \phi q_{it} + \alpha War_{it} + \beta Flood_{it} + \xi(\frac{I_{i,t-1}}{k_{i,t-1}}) + \gamma_t + \theta_i + \varepsilon_{it} \qquad (10B)$$

Since q_{it} in equation (10) is an unobservable, it is necessary to construct a proxy. In most empirical works on q investment theory, the measure of q is based on stock market valuation. However, since the railroad companies in my study did not go public on a stock market, there is not stock price available. Instead, following Abel and Blanchard (1986), I try to estimate the firm value directly by using an auxiliary econometric model.

Assuming the expected net profit, $\prod_{it}$, namely, $(\pi_{it} - I_{it} - C_{it}(I_{i,t+h}, k_{i,t+h}))$ as in Equation 1, is based on the information set in a previous period.

$$E(\prod_{it} | \Omega_{i,t-n}) = \prod_{i,t-n} \qquad (11)$$

where $\Omega_{i,t-n}$ is information set in time t-n, based on which the managers estimate the future profit $E(\prod_{it})$. n is the time lag, which captures the time lag between ordering new capital goods and their installation, which is especially true for a huge investment for railroad companies. In this study, n is set to be 1 and a firm's profit flows follow AR(1) process, namely,

$$\prod_{it} = \rho_i \prod_{i,t-1} + \omega_i + \xi_{i,t} \tag{12}$$

where $\prod_{i,t-1}$ is the previous year's net profit. If a war affects the contemporary year's profit, it will affect the expectation of the next period's profitability through the AR(1) process, and then, affect Tobin's Q.

The expected firm value is the summation of future profit flow, $V^E_{it+1} = \tau E(\prod_{i,t+1}) + \cdots + \tau^n E(\prod_{i,t+n}) + \cdots,$, with $\tau = 1/(1+r)$, where r is the interest rate of firms borrowing money from foreigners, which is 5% per year for most of the railroad loans. Thus, the fundamental valuation for q can be represented as follows.

$$q^E_{it} = \frac{V^E_{it+1}}{k_{it+1}} = \frac{1}{(1-\tau\rho_i)(1-\delta)K_t}\left(\frac{\omega_i}{1-\tau} + \rho_i \prod_t\right) \tag{13}$$

δ , the rate of depreciation is assumed to be 10% per annum for all firms.

4.4 On the timing of a war's impact

A critical issue is to decide on the temporal dimension of the impact of war since empirical results might be sensitive to different specifications of the time horizon. For example, if a long horizon is chosen, there is the risk that the causality between the war and railroads' performance might be tenuous with the passage of time; if a short-term war can have continuous (or latent) effects on a railroad's performance, a single snapshot is unlikely to capture these effects; if a war could be expected by people, its impact might come before the war takes place and any specification that fails to take account of this could underestimate a war's impact. Unfortunately, there are no "rules" for choosing the temporal dimension in empirical studies on wars' impact on economic variables. For example, Kang and Meernik (2005) exclude the years in which war occurs, focusing on the aftermath for which they adopt a long time horizon. Rasler and Thompson (1985), on the other hand, presume that the long-run impact is zero and focus instead on short run effects. In this paper, I use three alternative specifications to discover the exact timescale of a war's impact on a railroad.

In the first specification, taking the hypothesis that the impact of war on economic growth is primarily contemporaneous (Rasler and Thompson 1985) I assume a war only affects a railroad in the year in which it occurs in the vicinity of the railroad and for which their pre-defined damages to the railroad. Thus, in Equations 9 and 10, there is only one dummy variable war_{it} (hereafter, contemporaneous-effect dummy), which equals one if a war is occurring, and zero otherwise. I call this **Model I.**

In the second specification, **Model II**, additional dummies are included. The first of these, $war_{i,t+1}$ (hereafter, pre-war-effect dummy) takes the value one in the year prior to the occurrence of the war to a railroad no matter the war is less or more than one year. The idea here is to test whether any effects of a war can be observed before it actually occurs – which may happen if railroad managers had inside information or simply anticipated (rationally) future hostilities. For example, in Tables 1 and 2, the Jin-Pu line experienced a war in 1912 (the Second Revolution) and consecutive wars in 1917 and 1918 (War of Protection of Law). According to the specification, $war_{i,t+1}$ takes the value one in both 1911 and 1916. Following the similar pattern, I also include two dummies, $war_{i,t-1}$ and $war_{i,t-2}$ (hereafter, lagged-effect dummy), to take account of the lagged impact of war on a railroad's economic activities. $war_{i,t-1}$ ($war_{i,t-2}$) takes 1 if a war has taken place in the previous one (two) periods, otherwise, zero.[14]

The third specification, **Model III**, relies on the assumption that rather than having contemporaneous or short-enduring influence, war has long lasting impacts on economic activities. In addition to the per-war-effect dummy $war_{i,t+1}$, a new dummy, war_{ic},

[14] I tried to add more war dummies into the regressions and the results did not change. Thus the current results are robust to the specification with more pre-war or lagged-war dummies.

(hereafter, cumulative-effect dummy) is added to capture the long-lasting impact of war, with the dummy taking 1 started from a railroad experiences its first war to the end of the sample period. Put it in another way, this specification assumes that there is a shift in economic variables since the occurrence of war. In my data, the earliest "first war" occurred in 1911 (e.g., Zheng-Tai Line) and the latest in 1920 (e.g., Guang-Jiu and Zhang-Xia Lines), which implies that the longest and the shortest continuous impact of war lasted for 13 and 4 years (include the year of war), respectively, up to the end of my sample period of 1923. On average, the timescale of the first war's impact is 7.8 years for the ten lines that experienced wars. If the coefficient on this dummy is significant and negative it means that, over the sample period, as measured, the war effect is, cumulatively speaking, negative. This could be because the railroad never makes up what it lost during the period it is at risk or it could mean having experienced a war once increases the odds that a railroad will experience conflict again.

Summary statistics for non-investment dependent variables and the associated war-related and flood-related dummies are shown in Table 3. The statistics for the investment ratio, the estimated Q, and the uncertainty measures used in Equation 10 are shown in Table 4.

V Empirical Results

All regressions include a railroad fixed effect which should provide some protection against omitted variable bias. In my preliminary work, I experimented with specifications using time dummies versus linear time trends but, as my substantive findings did not change, the discussion in the text is focused on the results from the regressions with linear trends. Results for non-investment variables from both specifications can be found in Tables 5-9, with those pertaining to the linear trend specification in even numbered columns. Table 10 shows regression results for equations of 10(A, B) for the investment ratio, which is the ratio of the increase in the capital stocks to the capital stocks in the previous year.

5.1 On Commercial Business Volumes

The bulk of a railroad's business volume consisted of commercial business flows (excluding government-related business flows and firms' internal transport flows). The significant and positive coefficients on time trend (Tables 5 and 6) show approximately a 5 percent increase in passenger flow, and an 11 percent freight flow in each year. The steady and significant growth in commercial business volume suggests that the "fundamentals" affecting Chinese railroads were strong. This is not surprising in light of the fact that railroads were beginning to link inland areas to the coastal regions, even in regions served by the Yangtze River. As in other countries railways in China had advantages in terms of speed and, in addition, were not as constrained by seasonality as was the case with river transportation; see Liang (1982, p. 20).

The impact of civil war on business passenger flows is clearly evident in Table 4. Regardless of the specification, the occurrence of a war results in an immediate decline in passenger flows; in addition, the coefficients on the lagged dummies indicate that the effects persisted. The cumulative impact, as revealed by the cumulative-impact dummy, is substantial – nearly a 43 percent decline from the occurrence of the first war. In terms of business passenger flows, in other words, a railroad would have been fortunate indeed to have avoided the occurrence of civil war.

For choosing these two competing specifications over the continuous impact of war, I employ the J test developed in Davidson and MacKinnon (1981). The test results indicate that Model II should be rejected. Hence, Model III is preferred with respect to measuring the timing of impact. The point estimate in Column 6 shows no pre-war effects; but significant negative cumulative war impact, with the large negative magnitude of 43%. Interestingly, I find no effect of floods on business passenger flow, suggesting that railroads viewed "natural disasters" very differently from "man-made" ones.

In the estimation for business freight flows (see Table 6), the impact of civil war is significantly negative as was the case for passenger flows. However, unlike the war's impact on business passenger flow, the war's impact on freight flow seems to be temporary rather than long-lasting, with around forty-three percentage decline during the war year as shown in Column 1-4 and the coefficient estimates on both the lagged-effect dummy (Column 4) and the cumulative-effect dummy (Column 6) being insignificant.

The negative sign of the coefficients to the war-related dummies is plausible since, according to Collier (1999), the deteriorating infrastructure and security raise the transport costs during war time, which should have led to a negative impact of war on the freight flow. Moreover, the inter- or intra-provincial trades were blocked or taxed heavily by the warlords during war time, which reduced the overall trading volume. The only exception is the pre-war dummy which is positively associated with business freight flows in Column 6, but the estimates are not statistically significant.

By contrast, flooding is found to have a dramatic positive effect on railroad freight traffic.[15] Among the 196 observations in my panel, floods occur eighteen times in total, with the high concentration occurring where railroad tracks essentially paralleled the major waterways. For example, the Jing-Han line followed more or less the same shipping route as that of the Grand Canal-Yangtze River, which experienced four floods in my sample period. This is not to say that railroad capital avoided damage from flooding – far from it – but rather than railroads could be put back into operation more quickly after major floods, and thus served as a substitute in the short run.

5.2 On Financial Status

In the analysis of firms' financial status, the J test rejects the first two specifications and thus I focus on the third specification-Model III (Column 6 in Tables 7 and 8). The estimation results for operating expense (Table 8) resemble those for operating revenue (Table 7) in terms of statistical significance level and the signs of the coefficients. The

[15] In my preliminary study, I make three specifications for examining the impact of floods exactly as the three models specified for war's impact. All the other flood-related dummies are found to be statistically insignificant. Hence, I only include one flood dummy in order to capture the floods' contemporaneous impact on railroads in my regressions.

growth rates of revenue and expense per kilometer are 8% and 7%, respectively. The size of the estimated impact of war on either expense or revenue per KM is very large; the point estimates indicate that after a railroad experiences its first war, revenue fell by 30 percent, and, expense, by 20 percent.[16]

The dramatic effect on expenditures reflects, in part, the sorry state of financial markets in China at the time – in particular, the inability of railroads to draw on sources of working capital during times of distress except at rates of interest well in excess of the norm for the time (see Huenemann 1984). Because they lacked access to working capital at the margin and, in addition, in most cases had little in the way of cash reserves to draw on, reductions in revenues translated nearly one for one into reductions in expenditures. The magnitudes of the attendant multiplier effects on workers and companies that supplied railroads with raw materials and other inputs are sheer guesswork but undoubtedly were negative, based on my findings.

5.3 On Firm Decisions

5.3.1 War's impact on employment

Regression results for employment are presented in Table 9. The dependent variable is the log of employees per kilometer (KM). The coefficients of the war dummies are jointly insignificant suggesting that employment did not suffer during war episodes.

The absence of an employment effect is not entirely surprising as there are good reasons to believe that Chinese railroads engaged in labor hoarding, particularly for skilled labor (Oi, 1962). For example, at the beginning of the operation of Jing-Feng railroad, the skilled labors (e.g. drivers, engineers) were British, who were costly to replace or even irreplaceable. In order to solve the problem of shortage of the skilled

[16] My analysis assumes that the occurrence of war is exogenous to the presence of a railroad but after a war begins it is certainly possible that the warring parties viewed the railroads as a source of money or supplies via pilferage or extortion. As far as I have been able to determine the accounting reports on revenues do not reflect this possibility but the records also contain some information on certain types of "taxes" paid that, curiously, vary more from year to year than one might expect ex ante. In future work I plan to conduct some sensitivity analyses allowing for the possibility that some or all of said taxes represent theft or extortion by warlords.

labor supply, the railroad established the first railroad school (Tang-Shan Railroad School, now, Southwestern University of Transportation) in 1896. Later, large railroads companies (e.g. Jing-Han) followed the similar pattern, establishing schools varying from primary to university level,[17] with most of its graduates working in the transportation sector. Given such a high training costs, it was unwise for the management to lay off employees during war time. Meanwhile, during the warlord period, the real wages were declining (Yan, 2007), which made the "labor hoarding" less expensive.

Consequently, labor productivity (revenue divided by number of employees) declined during war time since the war exerted a negative demand shock to the railroads. A regression of the log of labor productivity on the pre-war effect, cumulative-effect dummies controlling for floods, time and firm fixed effects, the coefficient estimates on $war_{i,t+1}$ and $war_{i,c}$ are -0.28 (s.e. 0.14) and -0.52 (0.14), respectively.

5.3.2 War's impact on the national railroads' investment

For investment, only results for two Models (II and III) with both time-specific and firm-specific fixed effect are listed in Table 9, with the results for Model I being omitted in order to save space.[18] The odd and even columns represent the results for Models II and III under three different settings, respectively.

For the OLS estimation (Columns 1-4), fifteen out of seventeen railroads are included because investment (namely, data on capital stocks) is unavailable for Miao-Ji and Zhang-Xia Railroads. Moreover, the investment data for the rest of the railroads started after 1915. Hence, the sample size for investment is much smaller than that for other economic variables (98 vs. about 200). Column 1 shows that war-related dummies are statistically insignificant, suggesting war might not influence a firm's investment ratio.

[17] In contemporary China, many universities with transportation in the title are those evolved from railroads school established in my study period.
[18] Since Model I is nested within Model II, the added independent variables in specification 2 do not change the results of the specification 1. Thus, the omission of the results for specification 1 will not affect the main results.

Another potentially important factor—creditor is added to the basic Models II and III. When a firm obtains a loan from Britain or Japan, a dummy variable is included in the regressions as shown in Columns 3 and 4. Among the fifteen railroads, eight borrowed money from Britain, five from Japan, and only two had domestic creditors. The newly added independent variables do not alter the point estimates for the coefficients on wars and floods. However, it changes the estimation for the constant term to the level of insignificance. Instead, the coefficient estimates on creditor suggest that possessing a loan from Britain has negative impact on the level of investment ratio compared with a loan from a domestic creditor.

Columns 5 and 6 list the results for GMM estimation with a lagged dependent variable. The GMM methodology further reduce the sample size from 100 to 70 during the estimation process, which include the reduction in number of observations due to first differencing and one more railroad being dropped—Long-Hai Railroad due to insufficient number of time periods for instruments. The first differencing eliminates the fixed effects for individual railroads and drops Creditor dummies.

As we notice, the results in Column 5 and Column 6 differ from each, suggesting that the results might be sensitive to the selected specification. Davidson-MacKinnon non-nested test (1993) is used to test the fitness of these two specifications, Model II is rejected. In model III (Column 6), both Q and war_{ic} are found to have predictable power on the level of the investment ratio.[19] the coefficient estimate on the cumulative-effect dummy (-0.24, s.e. 0.1) -- war_{ic} shows that the level of the investment ratio is negatively correlated with the first war that it experienced and this destructive power of war was not short-lived, instead, it continued until the end of the study period. The coefficient on Tobin's Q is 0.7 (s.e. 0.01), suggesting that firms' investment decision relies on the expected future profit flow. The statistically significant coefficient estimates for Tobin's Q is also found in OLS estimation (Columns 1-4).

[19] I regress Q on war_{ic} controlling for the fixed effect and there is no significant correlation between the two independent variables, indicating Q, which was determined by the profit in previous period, has independent explanatory power from war_{ip}. The regression of Q on the Pre-war-effect dummy--$war_{i,t+1}$ is also conducted without any significant correlation being observed.

I am aware that my point estimate for Q is extraordinarily larger compared to the estimated coefficients for Q variable in other studies. For example, Bontempi et al (2004) obtain the coefficient on Q of 0.17 for 52,000 Italian firms covering all industries from 1982 to 1995, in which fundamental Q is used as in my study. Bond et al (2005) provide a coefficient estimate on Q around 0.025 for a panel of 655 quoted non-financial UK firms from 1987-2000, controlling for various measures of stock market uncertainty, with Q estimated as the ratio of firm stock value to its asset. However, the estimated magnitude of the impact of Q on the investment here is not a puzzle for Chinese railroad industry in its early development stage. Kmenta and Williamson (1966) argue that firm investment behavior is highly correlated with "the phase of the industry's life-cycle" and find that, for the US railroad industry from 1872 to1941, the industry tends to increase the investment more given the profit in years during its "early period of adolescence 1872-1895" than its two later mature stages. Since Chinese railroad industry is in its childhood stage and quickly gains its popularity as a reliable and cheap transport mode in Chinese society during my study period, it is no surprise that the management is very optimistic in expanding the business given the a certain level of expected future profitability.

I next perform additional regression of the log investment ratio on the log Q to capture the elasticity (not reported). However, as showed in the descriptive statistics in Table 4, the investment ratio could be negative for some firms, which means disinvestment occurs. Thus the log of negative numbers is discarded, which reduces the sample size to 57. However, the OLS yields a significant and positive coefficient estimate on the log Q of 3.28 (s.e. 0.82) for Model II controlling for firm- and time- specific fixed effect. Similar results on the war-related dummies are found as those from the regression on the level. Unfortunately, GMM can not be conducted for log values because of the discontinued time series of log investment.

In summary, the conclusions could be reached on the impact of war on investment ratio that on one hand, war affected the investment decision through affecting managers' expectation of future profitability (Tobin's Q); on the other hand, wars had direct negative impact on the investment ratio, e.g. the destructive power of war threatened the management from more investment.

5.3.3 War's impact on the overall network expansion

My analysis thus far focuses on the impact on the investment activities of existing railroads. It includes, for example, significant slowdowns in the construction process, including in some cases that of the main line.[20] However, focusing on the investment activities of existing railroads may significantly underestimate the overall effect of the on railroad investment. The overall impact includes that on the existing railroads as well as on potential entrants, which are obviously not included in my data set.

For the potential entrants, the instability during the warlord period also prevented foreign direct investment (FDO), private investment and government investment. In order to show an overall picture of the wars' impact, I construct a hypothetical line representing the overall railroad network expansion (national railroads, foreign-owned railroads and private railroads) if China would not have experienced the warlord period (the dotted line in Figure 7). I use the average growth rate of the network of the pre- and post- warlord period and apply this growth rate to recover the railroad expansion during the warlord period. Comparing the hypothetical railroad expansion path with the real one (the solid line), in the absence of the warlord period, the size of the railroad network at the eve of the second Sino-Japanese war in 1937 (44,082 KM) could almost approach the size of railroad network at the eve of Chinese Economic reform in 1979 (49,900 KM).

5.5 Robustness Check

I have performed several robustness checks on the estimation methodology and data (not reported). First, I estimated the equations jointly by using Zellner's seemingly

[20] War could slow down the construction process. For example, the construction process of four railroads (Jing-Sui, Yue-Han, Nan-Yun and Long-Hai in Table 1), which did not finish the construction of the main line before 1912, was pretty much delayed. For example, Long-Hai Line (total length of the main line of 1,759 KM) was started in 1905 and finished till 1952, with annual average growth in length of 37.4 KM. By contrast, Jin-Pu line (1009 KM) was finished in only four years before the warlord period from 1908 to 1912, with annual average growth of 252.3 KM.

unrelated regression technique (SUR). SUR is an appropriate robustness check method in my study sincethe errors could be heteroskedastic and contemporaneously correlated. For example, if floods have caused a famine in a region where a railroad was located, this natural disaster would have affected the passenger flow by forcing people to leave. On the other hand, it might increase freight flow by transporting more food to the region. Therefore, it would also affect transport revenue. If the floods have also caused the damage to the company, expenditure on maintenance would increase. The greater the correlation of the disturbances among equations the greater the efficiency gains from running the equations jointly (Greene, 1997, p. 694). The results from SUR do not significantly deviate from the reported results, with a slight increase in significance.

Second, for investment, I re-estimated Q by using a predicted value for revenue from a regression on business transport volumes. As mentioned in the data section book-recorded revenue does not necessarily represent the real cash income since the transport revenue from transporting government-related passengers (freight) were not realized but recorded, indicating the missing part could be possibly huge during war time. If there is no collinearity between the business transport volumes and government-related transport volumes, the predicted value for revenue is close to the real revenue. Thus, the profit based on the estimated value is closes to the real profit, and then, the newly estimated Q could be accurate. No substantial differences arise when the new Q is used, suggesting that my previous coefficient estimation for Q is likely to be plausible.

VI Conclusions

Chinese modern history (later nineteenth and early twentieth century) is never entirely free from wars (both anti-invasion wars and civil wars). Most historians or political scientists focus on the social structure of militia factions or the biographies of great warlords. Apart from documenting the unequal treaties signed after China’s defeat in each anti-invasion war, the study on economic consequence or impact of wars seems missing. Clearly, war is a costly endeavor. Loss of life, the ruin of laws and institutions, the destruction of material possessions and many other war-related damages all play a part in the cost of war.

This paper aims to provide a micro-empirical analysis of Chinese civil wars' economic impact by focusing on an important indsutry – the railroad indsutry from 1906 to 1923. A new panel data set is constructed, including both economic activities of the seventeen naitonal railroads and a list of civil wars which took place along the railroad and caused damage to the company. The empirical results show negative impacts on railroad business volumes was large and very persistent, which led to a reduction of the operating revenue. Things became even worse when war discouraged the management from additional investment, which largely reduced the overall railroad expansion in pre-communist China. It, in turn, made a laggard economy miss the chance of benefiting from a well-connected rail network.

Certainly, the estimates in my paper only presents a fraction of the overall impact of the civil wars during this historical period. Further work should concentrate on the additional effects of civil war during a formative period of modern Chinese economic history.

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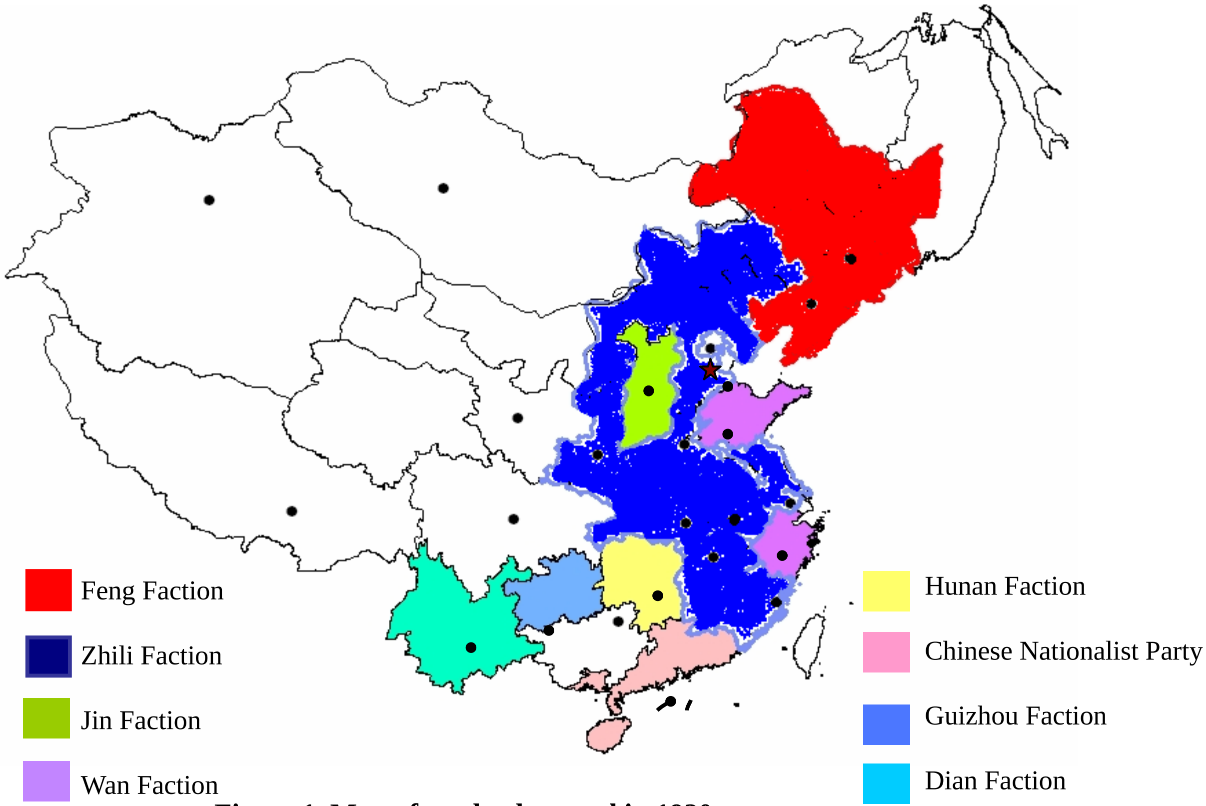

Figure 1. Map of warlord control in 1920

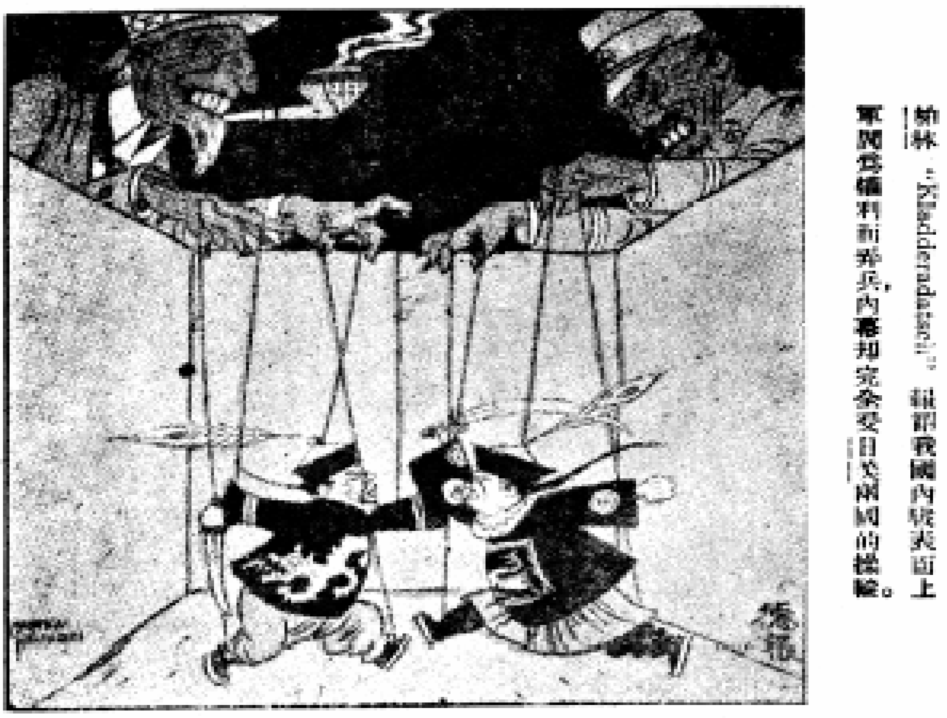

Figure 2. A cartoon first appeared in a German journal –Kladderadatsch (1848-1944) and reproduced in a Chinese journal-Dongfang Zazhi in 1925 (Eastern Miscellany: 1904-1948)

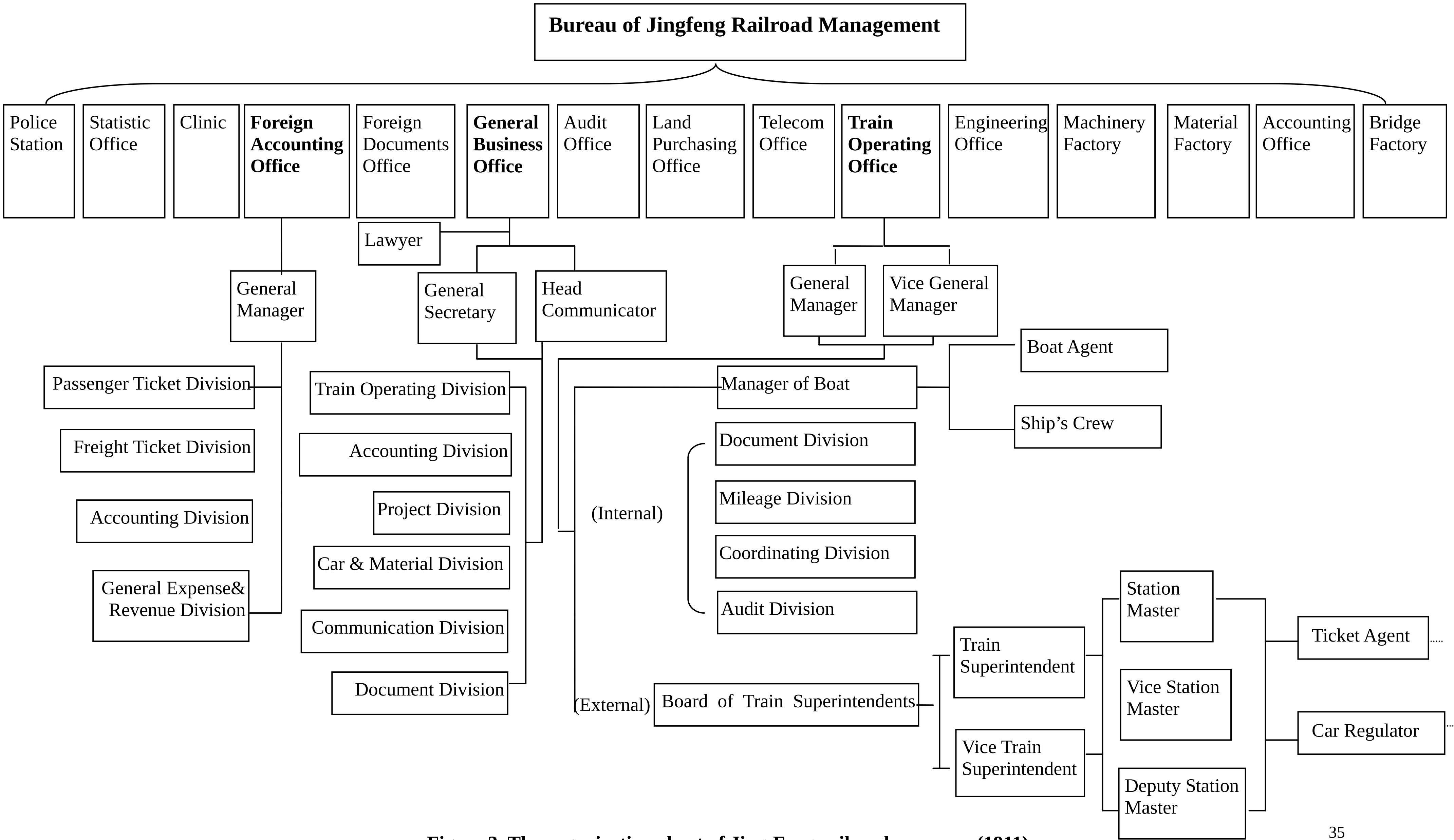

Figure 3. The organization chart of Jing-Feng railroad company (1911)

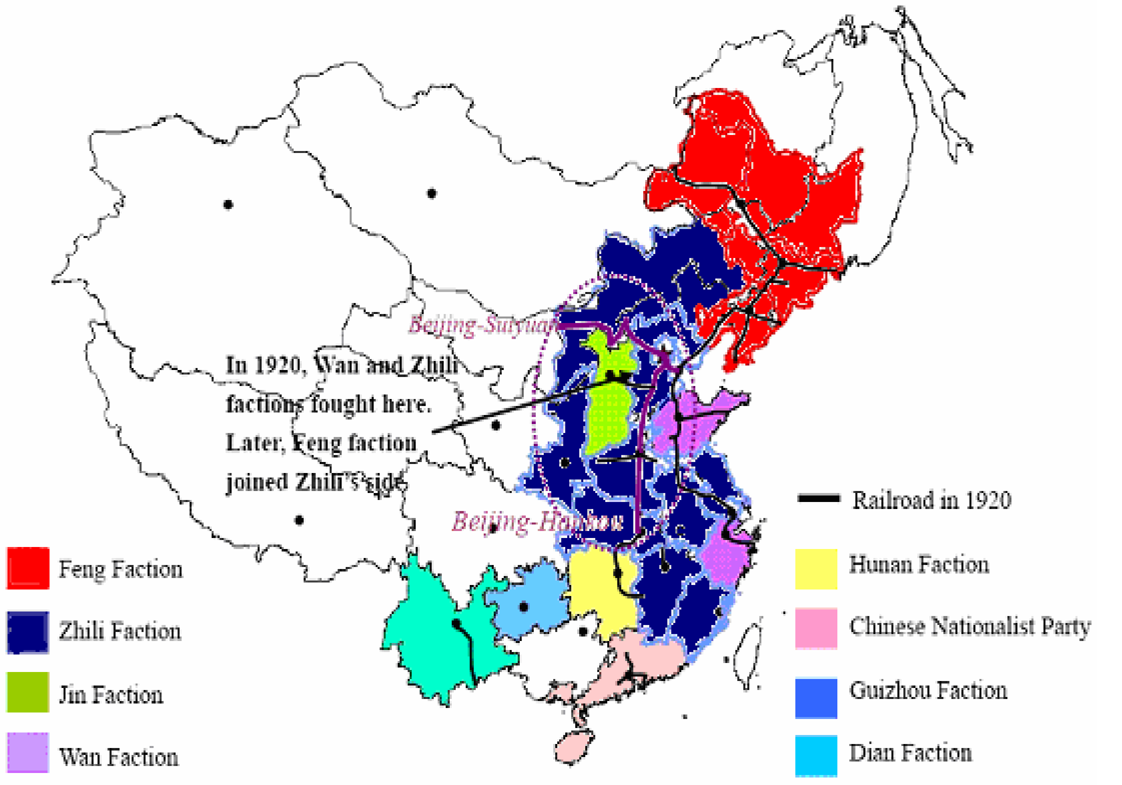

Figure 4. Jing-Han Line and Jing-Sui Line in the war of Wan Faction and Zhili Faction in July 1920

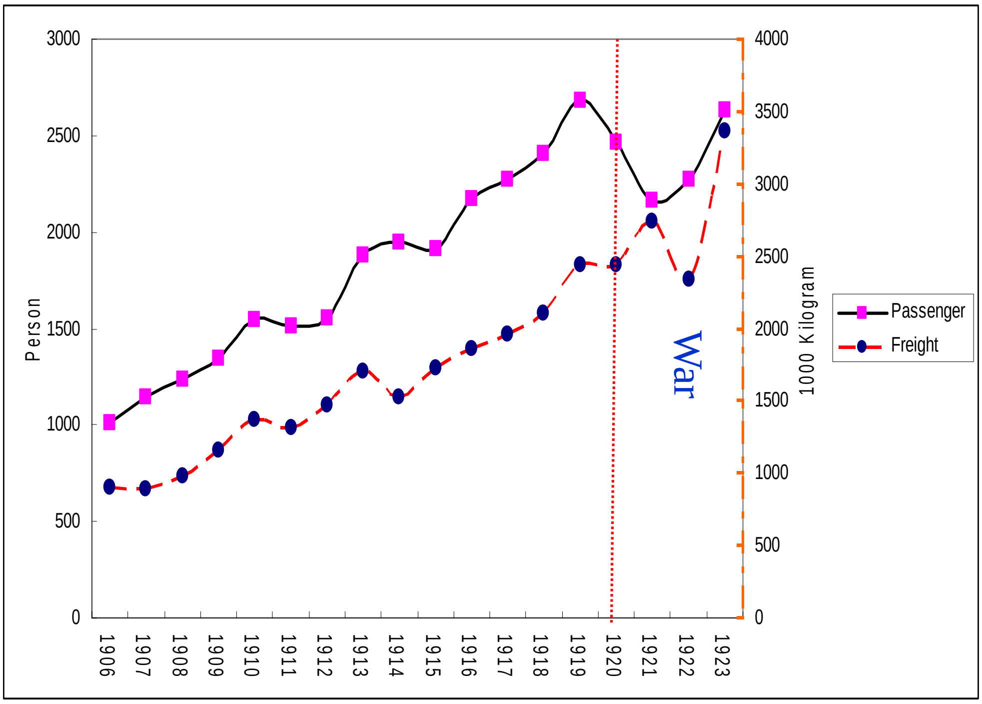

Figure 5. Passenger & freight flows and war for Beijing-Hankow Line (1906-1923)

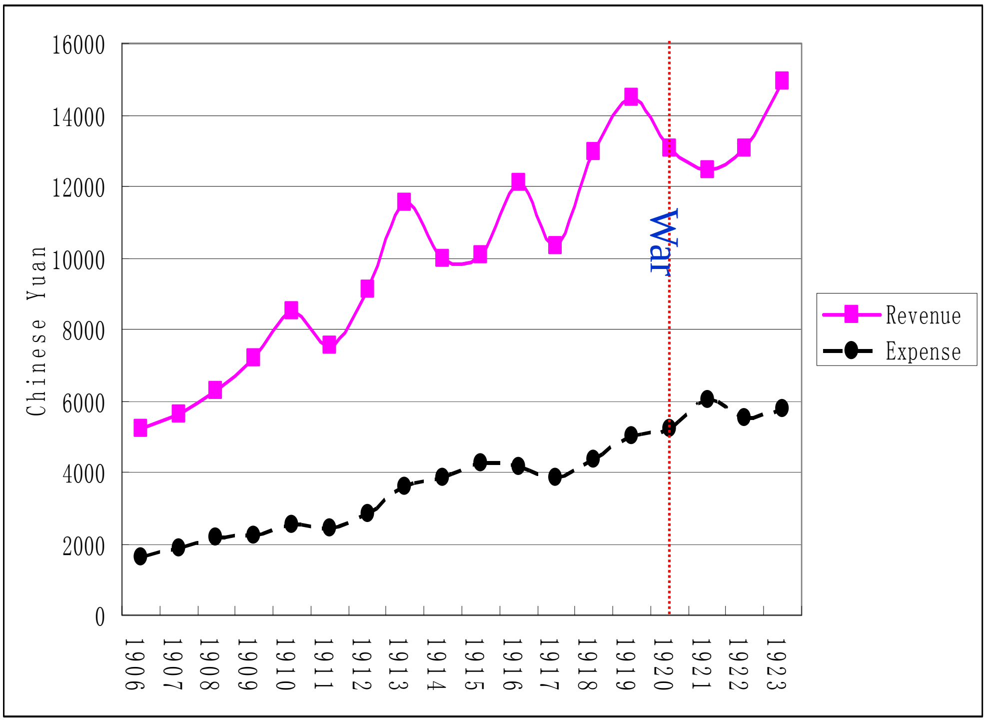

Figure 6. Real operating revenue & expense and war for Beijing-Hankow Line (1906-1923)

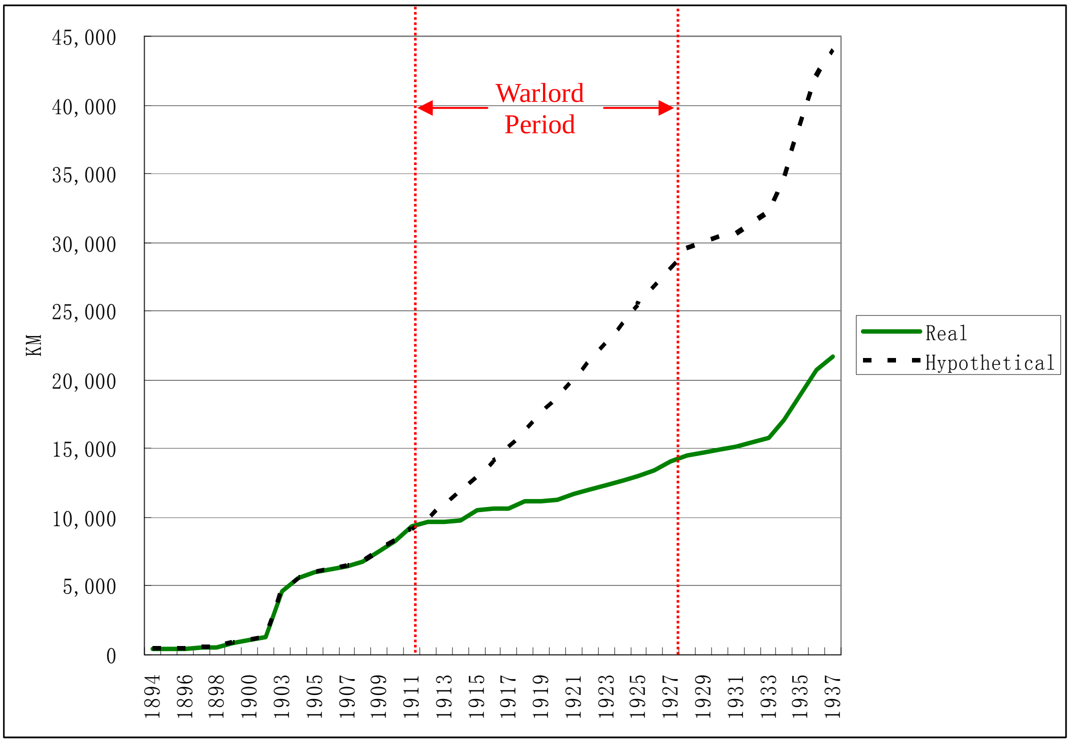

Figure 7. The real and hypothetical total length of railroad in Mainland China: 1894 - 1937
Source: Huenemann (1984, pp. 76-77) and the author's calculation

Table 1. Seventeen Chinese national railroads 1906-1923

No.	Railroad (Start-End)	Name	Provinces (or Major Cities) Crossed	First year of construction	First section opened	Whole line opened	Length (KM) In 1920	Years of Wars	Years of Floods
1	Beijing-Shenyang	Jing-Feng (Bei-Ning)[2]	Hebei (Beijing, Tianjin) Liaoning	1877	1881	1911	855.02	None	1915
2	Beijing-Hankou	Jing-Han (Ping-Han)	Hebei (Beijing), Henan, Hubei	1896	1898	1906	1510.01	1917, 20	1908, 17,19,22
3	Beijing-Suiyuan-Baotou	Jing-Sui (Ping Sui)	Hebei (Beijing), Shanxi, Inner Mongolia	1905	1909	1922	719.65	1917, 20	1912, 14,17,18
4	Tianjin-Pukou	Jin-Pu	Hebei (Tianjin), Shandong, Anhui, Jiangsu	1908	1912	1912	1009	1912,17, 18,20,22	1917,18
5	Shanghai-Nanjing	Hu-Ning (Jing-Hu)	Jiangsu (Shanghai)	1897	1898	1908	400.34	1913	None
6	Zhuzhou-Pingxiang[3]	Zhu-Ping	Hunan, Jiangxi	1899	1905	1905	89	1918	None
7	Shanghai-Hangzhou-Ningbo	Fu-Hang-Yong	Jiangsu (Shanghai), Zhejiang	1906	1908	1913	264	1916	None

8	Shijiazhuang-Taiyuan	Zheng-Tai	Hebei, Shanxi	1904	1907	1907	333.51	1911	1910,13,14,17
9	Jilin-Changchun	Ji-Chang	Jilin, Changchun	1909	1912	1912	157.16	None	None
10	Guangzhou-Jiulong	Guang-Jiu	Guangdong, Hong Kong	1906	1910	1911	178.6	1920	1914
11	Daokou-Qinghua	Dao-Qing	Henan	1902	1905	1907	183.63	None	1918
12	Qingdao-Qinan[4]	Miao-Ji	Shandong	1899	1904	1904	393	None	1914
13	Xiamen-Zhangzhou	Zhang-Xia	Guangdong	1907	1910	1910	73	1920	None
14	Wuchang-Changsha	Yue-Han: Xiang-E section[6]	Hunan, Hubei, Guangdong	1901	1904	1936	50	1917, 18, 21	None
15	Jiujiang-Nanchang	Nan-Yun	Jiangxi	1908	1911	1915	145.73	None	None
16	Haihou-Kaifeng-Luoyang-Tongguan[5]	Long-Hai	Jiangsu, Henan, Shanxi, Shan'xi, Gansu	1905	1909	1952	224.73	None	None
17	Si Ping Jie-Nan Yuan	Si-Yao	Liaoning	1916	1917	1923	200	None	None

Note: 1. There was 6786.38 kilometers (4217.06 miles) in total.
2. The names of some railways changed during the Republican China and the names in the parenthesis were the ones used after the capital moved from Beijing to Nanjing in 1927.
3. Zhuzhou-Pingxiang line was merged to Xiang E section of Yue Han Railroad in 1918 and later, it was merged to Zhegan railway in 1937.
4. Before 1914, this railroad is under German's control and from 1915-1922, it is under Japanese control. In 1923, it was returned to Chinese.
5. Before 1925, the data is only available for the section Luyang-Kaifeng section (Bian Luo Line).
6. For Yue-Han railroad, the data is only available for one section-the Xiang-E section.

Data source: The History of Transportation— Railroads Section (18 volumes), Department of Transportation of Republican China, 1935

Table 2. Civil wars caused direct damage to the national railroads in China during 1906-1923

(presented in chronological sequence)

Name[1]	Warring Groups		Year	Involved Railroads
	Group A	Group B		
Jin Independence War against Qing Dynasty	Shanxi Provincial Army	Qing Government	Sept-Oct 1911	Zheng-Tai
The Second Revolution	Sun's Nationalist Party	Yuan Shi-Kai Government	Jul- Sept 1912	Jin-Pu
The First Nanjing War	Sun's Nationalist Party	Yuan Shi-Kai Government	Jul -Sept 1913	Hu-Ning
National Protection War	Ally of Southern Warlords	Yuan Shi-Kai Government	Dec 1915 - Jun 1916	Fu-Hang-Yong
Zhang Xun's Restoration of Qing Emperor	Zhang Xun's Army	Beiyang Warlord Government	Jul 1918	Jing-Sui, Jing-Han, Jin-Pu
War of Protection of Law	Sun's Nationalist Party	Beiyang Warlord Government	Aug 1917 – May 1918	Jin-Pu
Jing-Guo War	Tang Jirao's Army	Beiyang Warlord Government	Sept 1917- Jan1918	Yue-Han: Xiang -E Section
War of Yueyang	Xiang Faction	Warlord Beiyang army	Mar 1918	Zhu-ping
Zhi-Wan War	Zhi and Feng Factions	Wan Faction	Jul 1920	Jing-Han , Jing-Sui, Jin-Pu
Yue-Gui War	Yue Faction	Gui Faction	Aug 1920 - Aug 1921	Guang-Jiu, Zhang -Xia
Xiang-E War	Xiang Faction	E faction	Jun-Sept 1921	Yue-Han: Xiang-E Section
The First Zhi-Feng War	Zhi Faction	Feng Faction	Apr-Jun 1922	Jing-Han , Jin-Pu

Note: 1. The listed civil wars are large-scale wars in the sense of causing a large number of deaths – typically, one thousand or more and each war consisted of a cerntain number of major battles.

Source: The Major Battles in Military History of Modern China, Published by National Defense University of Taiwan.

Table 3. Descriptive statistics for non-investment variables and uncertainty measures

Variables	Obs	Mean	S. D.	Min	Max
Business Passengers/KM (Person)	201	4566.21	5462.18	274.85	26514.84
Business Freight Flows/KM (Ton)	197	214424.40	775902.30	0.00	5120258.00
Operating Revenue/KM (Yuan in 1906)	204	7753.28	9927.58	136.30	121275.70
Operating Expense/KM (Yuan in 1906)	204	4155.80	2302.99	501.59	11635.80
Employees/KM (Person)	151	10.11	9.42	1.88	70.92
Pre-war-effect dummy -- $war_{i,t+1}$	204	0.07	0.25	0	1
Contemporaneous-effect dummy -- $war_{i,t}$	204	0.09	0.28	0	1
One-year-lagged-effect dummy -- $war_{i,t-1}$	204	0.07	0.25	0	1
Two-year-lagged-effect dummy -- $war_{i,t-2}$	204	0.05	0.23	0	1
Cumulative-effect dummy -- war_{ic}	204	0.36	0.48	0	1
Flood-effect dummy -- $flood_{i,t}$	204	0.08	0.28	0	1

Table 4. Descriptive statistics for investment variables and uncertainty measures

Variables	Obs	Mean	S.D.	Min	Max
Investment ratio[1], I_{it}/K_{it}	98	0.09	0.90	-0.90	8.89
Tobin's Fundamental Q	98	2.12	2.29	0.00001	14.14
Pre-war-effect dummy -- $war_{i,t+1}$	98	0.08	0.28	0	1
Contemporaneous-effect dummy -- $war_{i,t}$	98	0.12	0.33	0	1
One-year-lagged-effect dummy -- $war_{i,t-1}$	98	0.10	0.30	0	1
Two-year-lagged-effect dummy -- $war_{i,t-2}$	98	0.08	0.27	0	1
Cumulative-effect dummy -- war_{ic}	98	0.59	0.49	0	1
Flood-effect dummy -- $flood_{i,t}$	98	0.09	0.29	0	1
Debtor dummy-Britain	98	0.61	0.49	0	1
Debtor dummy-Japan	98	0.27	0.44	0	1

Note: 1. The gross investment is obtained by subtracting the previous year’s capital stock from this year’s capital stock. The investment ratio is calculated by dividing the gross investment by the capital stock at the beginning of a financial year.

Table 5. The impact of wars on business passenger flows

Dependent variable: ln (Business Passenger Flows in Persons/KM)	(1)	(2)	(3)	(4)	(5)	(6)
Pre-war-effect dummy -- wari,t+1			0.08	0.08	-0.11	-0.11
			[0.09]	[0.07]	[0.09]	[0.09]
Contemporaneous-effect dummy -- wari,t	-0.36	-0.35	-0.41	-0.41		
	[0.09]***	[0.07]***	[0.09]***	[0.09]***		
One-year-lagged-effect dummy -- wari,t-1			-0.12	-0.13		
			[0.09]	[0.09]		
Two-year-lagged-effect dummy -- wari,t-2			-0.09	-0.11		
			[0.10]	[0.10]		
Cumulative-effect dummy -- waric					-0.42	-0.43
					[0.09]***	[0.08]***
Flood-effect dummy -- floodi,t	0.03	0.07	0.04	0.08	0.03	0.06
	[0.09]	[0.09]	[0.09]	[0.09]	[0.08]	[0.08]
Time Trend		0.05		0.05		0.07
		[0.01]***		[0.01]***		[0.01]***
Constant	7.52	7.61	7.52	7.61	7.44	7.36
	[0.34]***	[0.14]***	[0.32]***	[0.13]***	[0.32]***	[0.14]***
Time Dummy	Yes	No	Yes	No	Yes	No
Railway Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	201	201	201	201	201	201
Adjusted R-square	0.90	0.90	0.90	0.90	0.90	0.90

Note: Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6. The impact of wars on business freight flows

Dependent variable ln (Business Freight Flows in Tons/KM)	(1)	(2)	(3)	(4)	(5)	(6)
Pre-war-effect dummy -- $war_{i,t+1}$			0.26	0.32	0.27	0.32
			[0.24]	[0.23]	[0.24]	[0.23]
Contemporaneous-effect dummy -- $war_{i,t}$	-0.45	-0.44	-0.44	-0.43		
	[0.21]**	[0.20]**	[0.23]*	[0.21]**		
One-year-lagged-effect dummy -- $war_{i,t-1}$			-0.003	-0.04		
			[0.23]	[0.22]		
Two-year-lagged-effect dummy -- $war_{i,t-2}$			-0.29	-0.31		
			[0.26]	[0.26]		
Cumulative-effect dummy -- war_{ic}					-0.19	-0.26
					[0.22]	[0.20]
Flood-effect dummy -- $flood_{i,t}$	0.56	0.56	0.59	0.59	0.51	0.52
	[0.21]***	[0.20]***	[0.22]***	[0.21]***	[0.22]**	[0.20]**
Time Trend		0.11		0.11		0.12
		[0.01]***		[0.01]***		[0.02]***
Constant	5.38	7.77	5.37	7.72	5.36	7.62
	[0.78]***	[0.32]***	[0.78]***	[0.32]***	[0.79]***	[0.35]***
Time Dummy	Yes	No	Yes	No	Yes	No
Railway Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	196	196	196	196	196	196
Adjusted R-square	0.92	0.92	0.92	0.92	0.92	0.92

Note: Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7. The impact of wars on operating revenue

Dependent variable: ln (operating revenue/KM)	(1)	(2)	(3)	(4)	(5)	(6)
Pre-war-effect dummy -- $war_{i,t+1}$			0.01	-0.04	-0.06	-0.09
			[0.12]	[0.11]	[0.12]	[0.08]
Contemporaneous-effect dummy -- $war_{i,t}$	-0.05	-0.12	-0.09	-0.16		
	[0.11]	[0.10]	[0.12]	[0.11]		
One-year-lagged-effect dummy -- $war_{i,t-1}$			0.08	-0.07		
			[0.12]	[0.12]		
Two-year-lagged-effect dummy -- $war_{i,t-2}$			-0.14	-0.12		
			[0.13]	[0.13]		
Cumulative-effect dummy -- war_{ic}					-0.27	-0.30
					[0.11]***	[0.10]***
Flood-effect dummy -- $flood_{i,t}$	-0.01	0.07	0.01	0.08	0.02	0.08
	[0.11]	[0.10]	[0.12]	[0.11]	[0.11]	[0.10]
Time Trend		0.07		0.07		0.08
		[0.01]***		[0.01]***		[0.01]***
Constant	8.60	8.73	8.59	8.70	8.53	8.50
	[0.41]***	[0.16]***	[0.42]***	[0.16]***	[0.41]***	[0.18]***
Time Dummy	Yes	No	Yes	No	Yes	No
Railway Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	204	204	204	204	204	204
Adjusted R-square	0.81	0.82	0.81	0.81	0.82	0.82

Note: Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8. The impact of wars on operating expense

Dependent variable: ln (Operating expense/KM)	(1)	(2)	(3)	(4)	(5)	(6)
Pre-war-effect dummy -- $war_{i,t+1}$			0.06	0.05	0.01	0.006
			[0.10]	[0.09]	[0.10]	[0.09]
Contemporaneous-effect dummy -- $war_{i,t}$	-0.02	-0.03	-0.02	-0.03		
	[0.09]	[0.08]	[0.10]	[0.09]		
One-year-lagged-effect dummy -- $war_{i,t-1}$			0.08	-0.05		
			[0.10]	[0.10]		
Two-year-lagged-effect dummy -- $war_{i,t-2}$			-0.00004	0.007		
			[0.11]	[0.10]		
Cumulative-effect dummy -- war_{ic}					-0.21	-0.20
					[0.09]**	[0.08]**
Flood-effect dummy -- $flood_{i,t}$	0.03	0.03	0.02	0.03	0.05	0.05
	[0.09]	[0.09]	[0.10]	[0.09]	[0.09]	[0.09]
Time Trend		0.06		0.07		0.07
		[0.01]***		[0.01]***		[0.007]***
Constant	7.72	7.96	7.72	7.96	7.67	7.81
	[0.34]***	[0.13]***	[0.35]***	[0.14]***	[0.34]***	[0.15]***
Time Dummy	Yes	No	Yes	No	Yes	No
Railway Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	204	204	204	204	204	204
Adjusted R-square	0.71	0.72	0.71	0.71	0.72	0.72

Note: Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 9. The impact of wars on employment

Dependent variable: ln (Employees/KM)	(1)	(2)	(3)	(4)	(5)	(6)
Pre-war-effect dummy -- $war_{i,t+1}$			0.12	0.11	0.14	0.12
			[0.10]	[0.09]	[0.10]	[0.09]
Contemporaneous-effect dummy -- $war_{i,t}$	-0.02	0.02	-0.004	0.03		
	[0.09]	[0.08]	[0.10]	[0.09]		
One-year-lagged-effect dummy -- $war_{i,t-1}$			-0.002	-0.02		
			[0.09]	[0.09]		
Two-year-lagged-effect dummy -- $war_{i,t-2}$			-0.07	-0.03		
			[0.11]	[0.10]		
Cumulative-effect dummy -- war_{ic}					0.06	0.05
					[0.10]	[0.09]
Flood-effect dummy -- $flood_{i,t}$	0.03	0.02	0.03	-0.02	0.02	0.02
	[0.09]	[0.08]	[0.09]	[0.08]	[0.09]	[0.08]
Time Trend		0.04		0.04		0.03
		[0.006]***		[0.01]***		[0.01]***
Constant	2.47	2.43	2.47	2.42	2.51	2.47
	[0.23]***	[0.13]***	[0.24]***	[0.13]***	[0.24]***	[0.15]***
Time Dummy	Yes	No	Yes	No	Yes	No
Railway Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	151	151	151	151	151	151
Adjusted R-square	0.75	0.76	0.74	0.76	0.75	0.77

Note: Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 10. Estimation of investment ratio under wars

Dependent variable: investment ratio= I_{it}/K_{it}	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) GMM	(6) GMM
Fundamental q_{it}	0.71	0.71	0.71	0.71	0.7	0.70
	[0.01]***	[0.01]***	[0.01]***	[0.01]***	[0.01]***	[0.01]***
Pre-war-effect dummy -- $war_{i,t+1}$	0.06	0.06	0.06	0.06	-0.001	-0.06
	[0.08]	[0.07]	[0.08]	[0.07]	[0.07]	[0.06]
Contemporaneous-effect dummy -- $war_{i,t}$	-0.03		-0.03		-0.03	
	[0.07]		[0.06]		[0.07]	
One-year-lagged-effect dummy -- $war_{i,t-1}$	0.04		0.04		-0.04	
	[0.07]		[0.07]		[0.06]	
Two-year-lagged-effect dummy -- $war_{i,t-2}$	0.005		0.006		-0.05	
	[0.07]		[0.07]		[0.06]	
Cumulative-effect dummy -- war_{ic}		0.01		0.02		-0.24
		[0.09]		[0.09]		[0.10]***
Flood-effect dummy -- $flood_{i,t}$	-0.16	-0.17	-0.16	-0.17	-0.04	-0.04
	[0.07]**	[0.07]**	[0.07]**	[0.07]**	[0.06]	[0.06]
Creditor dummy -- Britain			-2.63	-2.62		
			[0.13]***	[0.13]***		
Creditor dummy -- Japan			0.003	0.02		
			[0.12]	[0.12]		
Lagged investment ratio (I_{it-1}/K_{i-1})					0.007	0.003
					[0.015]	[0.01]
Constant	0.09	-2.55	0.07	0.07	0.016	0.02
	[0.42]	[0.09]***	[0.12]	[0.12]	[0.013]	[0.01]*

Time Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Railway Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	98	98	98	98	70	70
Adjusted R-square	0.97	0.97	0.97	0.97		
Sargan-Hansen test(df)					0(40)	0.88(40)
First-order serial correlation test					-0.21	-2.79
Second-order serial correlation test					0.38	-0.34
J test- ($\hat{\alpha}$ and t-statistic)					0.05(0.03)	0.95(0.42)

Notes: Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

For (5) and (6) Standard errors are in brackets. GMM coefficients are one-step estimates.

Instrument validity is tested using the Sargan-Hansen test of the overidentifying restrictions. The tests use the minimized value of the corresponding two-step GMM estimators.

The tests for the first- and second-order serial correlation are implemented as in Arellano & Bond (1991). These test the first-differenced residuals for GMM.

Davidson-MacKinnon non-nested J test (1993) is implemented as OLS on: $(invk_{it} - \widehat{invk}_{it(5)} = \alpha(\widehat{invk}_{it(6)} - \widehat{invk}_{it(5)})$ in Column 5 and $(invk_{it} - \widehat{invk}_{it(6)} = \alpha(\widehat{invk}_{it(5)} - \widehat{invk}_{it(6)})$ in Column 6. The coefficient and t-statistics are reported.

Standard errors are in brackets.* significant at 10%; ** significant at 5%; *** significant at 1%.