James Kung
Lectures and Readings

Lecture 1: The Economic Impact of Western Penetration: the case of Protestantism

(Reading: Bai and Kung, forthcoming [attached]).

Lecture 2: Conflicts in Historical Perspectives

(Rreadings: Bai and Kung,2011 [attached]; Kung and Ma, 2014 [attached]; Kung and Ma, Can Cultural Norms Reduce Conflicts? Confucianism and Peasant Rebellions in Qing China [a new version will be available within the next few weeks]).

Lecture 3: Institutional Change in Chinese agriculture

(Reading: Bai and Kung, "The Shaping of an Institutional Choice: Weather Shocks, The Great Leap Famine, and Agricultural Decollectivization in China", forthcoming [a new version will be available within 2 weeks]).

With the exception of Bai and Kung (2011), the other readings have either been considerably revised or are new.

DIFFUSING KNOWLEDGE WHILE SPREADING GOD'S MESSAGE:

PROTESTANTISM AND ECONOMIC PROSPERITY IN CHINA, 1840-1920*

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Abstract

We provide an account of how Protestantism promoted economic prosperity in China–a country in which Protestant missionaries penetrated far and wide during 1840-1920, but only a tiny fraction of the population had converted to Christianity. By exploiting the spatial variation in the missionaries' retreat due to the Boxer Uprising to identify the diffusion of Protestantism, we find that the conversion of an additional communicant per 10,000 people increases the overall urbanization rate by 18.8% when evaluated at the mean. Moreover, 90% of this effect comes from knowledge diffusion activities associated with schools and hospitals erected by the missionaries.

Key Words: Protestantism, economic prosperity, urbanization, knowledge diffusion, China

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1. INTRODUCTION

There is little doubt that the best-known attempt to associate religion (specifically Christianity) with economic prosperity has been that of Max Weber. His famous work, *The Protestant Ethic and the Spirit of Capitalism* (1930), has spawned a rich literature that attempts to unveil the channel(s) through which culture may have contributed to economic growth.[1] Following this literature, we examine whether Protestantism had any distinct economic impact in China during 1840-1920–a period in which it was forced to open up to the West–in economic and other spheres. We also endeavor to identify a novel channel through which Protestantism–the diffusion of Western knowledge–may have contributed to economic prosperity in China.

With the opening up of China following its defeat by the Western powers in the Opium War (circa 1839-42), the missionary presence in China increased enormously, resulting in a surge in the number of converts by the early 1920s. While the overriding goal of the Protestant missionaries was to spread God's message by disseminating Christian texts, they did far more than that. By erecting several schools and hospitals, and by introducing a qualitatively new curriculum of subjects that were previously unfamiliar to the Chinese, the Protestant missionaries diffused a wide spectrum of what Simon Kuznets (1965) calls "useful" knowledge in the country. According to Jonathan Spence, an eminent historian of China, the strength of the intertwining influences of the (biblical) gospels, Western knowledge (schools and the new curriculum they introduced), and medicine (hospitals), "is impossible to calculate, but the missionaries did offer the Chinese a new range of options, a new way of looking at the world" (1990, p. 208).

By drawing on variations in the diffusion of Protestantism across China's then 1,175 counties, and by using urbanization as a proxy for economic prosperity, we find that Protestantism indeed had a positive effect on urbanization in the 1920s after controlling

[1] While the empirical vindication of Weber's thesis has produced mixed results (compare, e.g., Iannaccone 1998 with Glaser and Glendon 1998), many studies have indeed shown that Protestantism stimulates economic prosperity via a number of channels. These include moral codes (e.g., Lipset and Lenz 2000), a country's openness (La Porta et al. 1998), "spiritual capital" (e.g., Barro and McCleary 2003; Barro 2004), social networks (e.g., Glaeser and Sacerdote 2008), and human capital (e.g., Becker and Woessmann 2009, 2010; Gallego and Woodberry 2010; Woodberry 2012). See also Doepke and Zilibotti (2005, 2008) for the theoretical literature on the "spirit of capitalism" hypothesis.

for a wide gamut of variables. To ensure that urbanization is a reliable measure, we also employ the cumulative number of modern industrial firms established during 1841-1915 as an alternative proxy for economic prosperity, which reaffirms the positive effect of Protestantism.

To address the potential endogeneity issues associated with the diffusion of Protestantism, we construct an instrumental variable based on the fleeing of the Protestant missionaries in response to the Boxer Uprising (circa 1900), premised on the notion that the areas in which the missionaries resettled are likely to be positively correlated with the subsequent diffusion of Protestantism after peace resumed. Taking the geographic distribution of the missionaries before the Boxer Uprising as given, we try to predict where they might have fled. Given the same distance from the Boxer Uprising, the region where a few political elites had offered to protect the foreigners under the agreement of the "Yangtze Compact", i.e. the south of China, was likely to have received the most missionaries. Our instrumental variable is therefore an interaction term between "distance from the nearest Boxer Uprising" and "Yangtze Compact".

The instrumented result finds that the effect of Protestantism on economic prosperity remains significantly positive and with a sizeable magnitude: the conversion of an additional communicant per 10,000 people increases the overall urbanization rate by 18.8% when evaluated at the mean urbanization rate. Our falsification tests find that our instrument is significantly correlated with the diffusion of Protestantism only *after* the Boxer Uprising; with the enrollment density of Protestant schools (but not government schools); and is not significantly correlated with factors that may be related to urbanization or modern industrial development (e.g., Catholicism, railway, or Western business). Together, these findings support the instrument's validity.

We then attempt to identify the channel(s) through which Protestantism impacted economic prosperity during the period in question. To examine the extent to which knowledge diffusion activities can account for the association between Protestantism and economic outcomes, we include Protestantism and four specific "types" of knowledge diffusion activities as variables: (1) the enrollment density of lower primary schools, (2) the enrollment density of higher primary schools, (3) the number of middle schools, and (4) the number of hospitals. The results show that, once we control for these knowledge diffusion activities–which have a significantly positive effect on urbanization–the positive association between Protestantism and economic outcomes disappears.

However, knowledge diffusion activities may be just as endogenous as Protestantism. To address this concern, we employ the knowledge diffusion activities that the same missionary societies undertook in the rest of the world as an exogenous predictor of their behavioral patterns in China, under the assumption that the two are likely correlated. Employing these additional data allows us to estimate a system of three equations in which (1) the interaction between "distance from the nearest Boxer Uprising" and "Yangtze Compact" is employed to predict the degree of Protestantism; (2) Protestantism and the knowledge diffusion activities conducted by the missionaries outside of China are used to predict knowledge diffusion activities in China; and (3) Protestantism and knowledge diffusion activities in China are used to predict economic prosperity. Overall, we find that Protestantism has no direct significant effect on economic prosperity, whereas knowledge diffusion does. Moreover, using the two-stage least squares (2SLS) estimate of the overall effect of Protestantism on urbanization as a benchmark, the channel of knowledge diffusion used accounts for as much as 90% of its effect on economic prosperity.

While our finding essentially complements the human capital story of Becker and Woessmann (2009, 2010), our empirical examination of China's Protestant history sheds additional light on the plausible channel(s) through which knowledge that was "useful" for economic development is diffused.[2] Since the Chinese population did not convert in large numbers to Protestantism (less than 0.1% converted), any positive association between Protestantism and economic prosperity would most certainly be attributed to channel(s) other than a cultural ethic or literacy. Moreover, the spreading of "useful" knowledge does not necessarily require a large fraction of the population to acquire it; evidence that

[2] Becker and Woessmann (2009) show that, while the counties in Prussia that had a larger share of Protestants fared better economically than those with a larger share of Catholics, this difference was not caused by the Protestant work ethic, but rather by the increase in the literacy rate (and, accordingly, human capital) as more people in the former had greater opportunities to read the translated biblical texts, a finding that Cantoni (2013) disputes.

the effect of Protestantism comes primarily from the diffusion of technological ("useful") knowledge lends strong support to this claim.[3]

The remainder of this article is organized as follows. In Section 2, we provide a brief overview of the historical background. In Section 3, we introduce our data sources and define the variables used in our analysis. In Section 4, we test the hypothesis regarding the alleged effect of Protestantism on economic prosperity in China. In Section 5, we ascertain whether the positive effect of Protestantism on economic prosperity actually comes from knowledge diffusion. Section 6 summarizes and concludes the study.

2. HISTORICAL BACKGROUND

2.1 The Development of Protestantism in China

Before the First Opium War (1839-42), which marked the end of China's long-term isolation and the beginning of modern Chinese history, Christianity had been banned in China since 1721, after Emperor Kangxi (1661-1722) disagreed with Pope Clement XI's decree over the Chinese Rites controversy, which led to a complete severance of ties with the Roman Catholic Church.[4] But with the signing of various "unequal treaties" with the Western powers between 1839 and 1842 (especially the Treaty of Nanjing), the Qing government was forced to admit the Western missionaries into China–initially to the five coastal cities or treaty ports, and with the signing of the second round of treaties (especially the Treaty of Tianjin) to the entire country, after which Protestantism spread quickly (Bays 2012). By 1920, more than 94% of China's counties had records of a missionary presence; 84% had records of Protestant communicant numbers, and 78% had established Protestant congregations or evangelistic centers (Stauffer 1922).

The Protestant missions were not only interested in spreading God's message; their conviction that China was backward (and thus needed to adopt Western culture in or-

[3]We thank an associate editor of this journal for pointing this out.

[4]The Chinese Rites controversy was a dispute between the Chinese government and the Roman Catholic Church from the 1630s to the early 18th century. It revolved around whether Chinese folk religious rites and offerings to the emperor constituted idolatry. Pope Clement XI decided in favor of the Dominicans (who argued that Chinese folk religion and offerings to the emperor were incompatible with Catholicism), which led to an enormous reduction in the presence of Catholic missionary activities in China (Hsu 2000, pp. 100-103; see also Bays 2012, p. 28).

der to develop faster) led the missionaries to fundamentally revolutionize education and medicine in China. For instance, in addition to erecting their own schools, the Protestant missionaries introduced a thoroughly Western-based curriculum into China and taught a variety of novel subjects ranging from Mathematics and Astronomy to English, History, and Geography–subjects that differ fundamentally from the traditional Chinese classic texts that for centuries had been the cornerstone of China's civil examination system (Elman 2000). Likewise, by erecting hospitals starting in the 1860s, the Protestant missionaries also introduced Western medicine into China (Bays 2012; Elman 2006). The contrast between traditional Chinese and Western medicine was likewise huge (Needham 1954). Together, these two kinds of activities–related to education (building schools) and health (erecting hospitals)–arguably provided an important channel through which a body of new and "useful" knowledge could be subsequently disseminated.[5]

2.2 Boxer Uprising and "Yangtze Compact"

Not everything foreign was well received in China, however. Protestantism and Western ways more generally aroused resentment among many Chinese as soon as their influences were felt, resulting in the eruption of various violent anti-foreign and anti-Christian incidents.[6] In this context, the Boxer Uprising merely represented the pinnacle of the patriots' hatred of foreigners (Cohen 1978; Hsu 2000; Spence 1990). Originating from north China, the Boxers were a group of spontaneously formed, patriotic anti-imperialists who attacked foreign missionaries around 1900 in 26 prefectures across the country, resulting in the deaths of 188 foreign Protestant missionaries and 5,000 Protestant communicants (Esherick 1987; Yang 1968). Threatened by the Boxers' assault, many missionaries fled for their lives (Austin 2007; Glover 1918).

Just when the anti-foreign outbreaks threatened to spread from the north into the Yangtze provinces (located on the southeastern coastal seaboard of China), Sheng Xuanhuai, the then Ministry of Transportation, disregarded the imperial proclamation, and

[5] Indeed, according to Spence (1990), the effects of Protestantism "came through the spread of Christian texts, the publication of general historical or scientific works, the development of schools, and the introduction of new techniques of medicine" (p. 206).

[6] Perhaps the most prominent example is the Tianjin massacre in the 1860s, in which a hostile Chinese crowd killed the French consul, several traders, and their wives.

urged the provincial heads in the south–from whom he received tremendous support–not to give it circulation. Although the Yangtze Compact was applied initially to only the Lower Yangtze region, it was quickly "followed by the authorities in the other southern provinces with the result that the fighting and the destruction in the north were effectively kept out of South China" (Feuerwerker, 1958, p. 73). In response to the intensified crisis in north China, the Eight-Nation Alliance brought 20,000 armed troops to China to quell the uprising.[7] With peace restored, the number of Protestant communicants nearly tripled from 100,000 in 1900 to 289,874 in 1902 (Bays 2012).

3. DATA

To test the overall effect of Protestantism on economic prosperity, and to identify the channel(s) through which Protestantism impacted economic prosperity, we construct a dataset that allows us to exploit the spatial variation in the development of Protestantism and knowledge diffusion in China for the period 1840-1920. The dataset is based primarily on digitizing Stauffer's (1922) survey; the result is a dataset that covers 1,175 counties in 14 provinces to the south of the Great Wall (see Figure 1). The sample counties covered approximately 2.3 million km^2 or 17.7% of the territory of Qing China, but a disproportionate 80% of the total population (around 350 million) in the 1850s (Ge 2000). In the remaining section we will define the variables we employ in the empirical analysis (Appendix A provides detailed information on the definition of variables and data sources).

Figure 1 about here

3.1 Economic Prosperity (Y): Urbanization and Modern Industrial Firms

To measure the effect of Protestantism on economic prosperity, we need information on the regional distribution of income across China for the period 1840-1920. Unfortunately, such data are not available. As a substitute, and following Acemoglu, Johnson and

[7]The eight nations were Austria-Hungary, France, German, Italy, Japan, Russia, United Kingdom, and the United States. Beijing was made to sign the Boxer Protocol and paid an indemnity of 67 million pound sterling (Spence 1990).

Robinson (2002, 2005), we use the degree of urbanization to proxy for economic prosperity, given its positive and significant correlation with per capita income. As with data on other measures of Protestantism, data on urbanization in China in 1920 are obtained from Stauffer (1922), which contains population statistics on cities with more than 25,000 residents. This allows us to compute, at the county level, the proportion of the population that lives in urban areas as our measure of urbanization–the first of our two dependent variables.

To ensure that urbanization is a sound proxy for economic prosperity, we also employ the cumulative number of modern industrial firms established by Chinese nationals from 1841-1915 as an alternative measure. The overriding criterion of a modern industrial firm, according to Chang (1989), is that its operations must be powered by steam engine or electricity. It also had to be relatively large and: (1) have registered capital of at least 10,000 silver *yuan*;[8] (2) employ at least 30 workers; (3) produce an annual output of at least 50,000 silver *yuan* in value; and (4) have adopted modern (hierarchical) management practices (Chang 1989).[9] In addition to checking the reliability of our measure of economic prosperity, using the number of modern industrial firms as the dependent variable also allows us to construct panel data to rule out unobserved county-specific factors.

3.2 Protestantism and Knowledge Diffusion

We use the number of communicants per 10,000 people to proxy for the level of Protestantism (P). Although the Protestant missionaries managed to cover a vast stretch of China's territory, they had yet to achieve a significant density. Our data show that, of the 989 (out of 1,175) counties with Protestant communicants, 140 counties (slightly more than 14%) had less than one communicant per 10,000 people, 571 counties (about 57%) had between one and ten communicants, and 278 counties (28%) had more than ten per 10,000 people (see Panel A of Figure A1, Appendix B for details). The overall mean of this measure is a mere 8.394.

As mentioned earlier, erecting hospitals and schools were the two primary knowledge

[8]Approximately 1,094 pound sterling (Jastram 1981, pp. 164-188).

[9]Based on a variety of historical archives, Chang (1989) identifies 1,148 such modern industrial firms during this period, 846 of which are located in our sample provinces.

diffusion activities carried out by the Protestant missionaries. The Protestants erected 220 hospitals in 173 sample counties and established lower primary schools in 719 counties (61.1%) and higher primary schools in 314 counties (26.7%), which enrolled 122,089 and 30,067 students, respectively. While enrollment figures for middle schools are not available, Stauffer's (1922) survey reveals that there were 254 middle schools spread across 107 sample counties (9.1%). Together, we are able to employ the number of students per 10,000 people enrolled in Protestant lower primary schools (K_1, abbreviated as enrollment density of Protestant lower primary schools hereafter), the number of students per 10,000 people enrolled in Protestant higher primary schools (K_2, abbreviated as enrollment density of Protestant higher primary schools hereafter), the number of Protestant middle schools (K_3), and the number of hospitals (K_4) to proxy for the level of knowledge diffusion (see Figure A2, Appendix B for details). The summary statistics of these variables are reported in Table 1.

Table 1 about here

3.3 Control Variables

In addition to the key variables of Protestantism and knowledge diffusion, we control for the possible effects of Western penetration, initial economic conditions (of urbanization), and the possible influences of politics, geography, county size, and population density.

Western Penetration. Western influences can be divided into two aspects–religious and economic. Since Catholicism became active in China after various treaties allowed foreigners to enter the country, the possible influence of the Catholic Church must be taken into account. To control for such effect, we employ the number of Catholic missionary stations per 1 million people to proxy for its development in China (see Panel B of Figure A1, Appendix B for details). To control for Western economic influence, we employ two dummy variable measures, viz. treaty ports (county with treaty port = 1) and railway networks (county with railway = 1).

Initial Economic Conditions. Given that differences in initial economic conditions may affect both the diffusion of Protestantism and urbanization, it is necessary to control for differences in economic conditions at the outset. In the absence of information on the share of urban population in 1840, we use the three sizes of cities generated by Rozman (1974) in the form of dummy variables as a proxy: big cities (population of 300,000 and over (3.1%)), medium (70,000-300,000 (2.2%)), and small (30,000-70,000 (0.7%)).

Political Center. To the extent that counties with a prefectural government were distinctly more prosperous, and that the share of government officials in a given urban population was higher in the political centers, we control for the location of the prefectural government seat using a dummy variable.

Geography. As geography may affect economic performance, we use three dummy variables to control for its difference among counties. The first is whether a county is located along the Jinghang or the Grand Canal (3.7%), a vital transportation route between north and south China; the second is whether a county is located on the coast (4.8%); and the third is whether a county is situated along the Changjiang (Yangtze) River (10.8%), the most navigable river in China.

County Size and Population Density. To the extent that foreign missionaries chose to begin their work in populous or larger regions, the development of religion may also be affected by a region's size and population density. We thus include both population density and county size in our empirical estimations, in addition to controlling for the provincial dummies. Details concerning the definition, summary statistics of the pertinent variables, and their sources are all summarized in Table 1.

4. PROTESNTISM AND ECONOMIC PROSPERITY

4.1 Protestantism and Urbanization: Baseline Results

We begin by regressing urbanization (Y), our first proxy for economic prosperity of the 1,175 Chinese counties, on the proxy of Protestantism (P) using the method of ordinary least squares (OLS) based on Equation (1):

$$Y = \rho P + W\beta + \varepsilon \qquad (1)$$

in which ρ represents the effect of Protestantism on economic prosperity. We also control for a number of independent variables (W), including Catholicism, initial economic conditions around 1840, Western economic influences (treaty ports and railway networks), whether a county was a political center, whether a county was located on the coast, along the Changjiang River, or along the Grand Canal, population density, size of the county, provincial dummies, and the constant term. β represents the set of coefficients of these control variables.

Reported in Table 2, our baseline results show that there is a significant and positive relationship between Protestantism and economic prosperity (specifically, the degree of urbanization). For instance, Column (1) of Table 2 shows that Protestantism has the effect of significantly increasing urbanization after controlling for only population density, county size, and provincial dummies. In contrast, the estimated coefficient on Roman Catholicism is insignificant. In terms of magnitude, the conversion of an additional communicant per 10,000 people increases the level of urbanization by 0.215 percentage points. As for the other control variables, population density is, as expected, positively correlated with urbanization.

After controlling for political center and geographic factors (Column (2)), Protestantism remains significant, although the pertinent magnitude decreases slightly from 0.215 (Column (1)) to 0.194 (Column (2)). Not surprisingly, counties in which a prefectural government is seated also tend to have a higher rate of urbanization (about 10 percentage points higher). Some geographic factors also have a positive effect on urbanization; for example, counties located in the coastal region or along the Grand Canal are more urbanized.

Table 2 about here

While the coefficient decreases somewhat (from 0.194% (Column (2)) to 0.162% (Column (3)) as we extend our control to include differences in initial economic conditions, the main effect remains significant. The same is true with the inclusion of the two measures of Western economic influences (Column (4)). The full model, which includes all the control variables, does not change the conclusion that the effect of Protestantism (the number of communicants per 10,000 people) is significant (Column (5)). In terms of magnitude, a one-standard-deviation increase in the density of Protestant communicants

(15.161) increases the level of urbanization by 2.411 percentage points ((0.159*15.161), Column (6)). Given the mean urbanization rate of 4.265% in 1920, this effect accounted for more than half (56.5%) of the overall urbanization rate in China.[10]

4.2 Missionary Presence and the Establishment of Modern Industrial Firms, 1841-1915

To ensure that urbanization is a sound proxy for economic prosperity, we employ the number of modern industrial firms established during 1841-1915 in county i during period t as an alternative measure of our dependent variable, where t is a period spanning five years. Period 1, for instance, covers 1841-1845, Period 2 1846-1850, and so forth. There are 15 periods, denoted by $t = 1, 2 \cdots 15$. As befits the panel data structure, an ideal independent variable would be the yearly density of Protestant communicants. Since we do not have such detailed information, we employ the duration of Protestantism in a county–measured from the year of its recorded presence–as the explanatory variable instead. Denoting the year when formal missionary work began as A_i , the duration of Protestantism since its recorded presence in the first year of each period can be denoted by $P_{it}^d = min\{0, 1836+5t-A_i\}$.[11] We begin our analysis using a simple two-way fixed-effects model as Equation (2):

$$Y_{it} = \rho P_{it}^d + \alpha_i + \lambda_t + \varepsilon_{it} \tag{2}$$

in which α_i is the county fixed effect, λ_t is the period fixed effect, and ε_{it} is the error term. By taking the first-difference we obtain:

$$\triangle Y_{it} = \rho \triangle P_{it}^d + \triangle \lambda_t + \triangle \varepsilon_{it}$$

where $\triangle Y_{it} = Y_{it} - Y_{it-1}$ stands for an enterprise's five-year growth rate. In counties where Protestantism had set up missionary operations, $\triangle P_{it} = 5$, and in counties where Protestantism had not, $\triangle P_{it}^d = 0$. The coefficient ρ thus represents the difference in the annual growth rate of firms' establishment between these two kinds of counties. Reported

[10] To check whether Protestantism has different effects in regions characterized by differing geographic-cum-economic conditions, we interact these variables with Protestantism and find that the main effect of Protestantism remains significant (Appendix C).

[11] For instance, assuming that some Protestant missionaries arrived in a certain county in 1848, in the period 1901-1905 ($t = 13$) the measured duration of Protestantism would be 53 (1901-1848 = 53).

in Column (1) of Table 3, we find that the annual growth rate of modern industrial firms in counties where Protestants had set up missionary operations is about 0.68% higher than in counties where it had not.

Table 3 about here

To ensure that this result is not driven by an unobserved growth trend in the Protestant counties, we include all interaction terms between B_i (a dummy variable indicating whether Protestantism had a recorded presence by the end of 1920) and a full set of time dummies covering all the periods, as represented by:

$$Y_{it} = \rho P_{it}^d + \sum_{\tau=2}^{15} \phi_\tau I_\tau B_i + \alpha_i + \lambda_t + \varepsilon_{it}$$

Reported in Column (2) of Table 3, the result shows that the effect of Protestantism increases only slightly from 0.0068 (Column (1)) to 0.0071 (Column (2)), and remains highly significant at the 1% level. An alternative estimation method that allows controlling for the unobserved growth trend in the Protestant counties (i.e., $T_{it} = 1836 + 5t - A_i$) is to include $B_i T_{it}$ in the estimation instead of using the interaction terms between B_i and a full set of time dummies. The results are strikingly similar (Column (3)).

We then further control for two time-varying variables, including the duration of treaty ports and railway networks (Z_{it}). Moreover, to rule out the possibility that the effects of the time-invariant control variables (W_i) may change over time, we interact them with the full set of time dummies ($I_\tau W_i$) as follows:

$$Y_{it} = \rho P_{it}^d + \sum_{\tau=2}^{15} \phi_\tau I_\tau B_i + Z_{it}\varphi + \sum_{\tau=2}^{15} I_\tau W_i \Phi_\tau + \alpha_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Column (4) of Table 4, which reports the results that include the respective durations of treaty ports and railway networks (Z_{it}), finds that the effect of Protestantism remains highly significant, though the magnitude decreases from 0.0071 (Column (2)) to 0.0058 (Column (4)). In Column (6), which includes all the control variables (W_i) and their interactions with the full set of time dummies, the effect of Protestantism further decreases to 0.0027, but remains highly significant as before.

4.3 Instrumented Evidence

Our estimation of the effect of Protestantism on economic prosperity may be biased by the problems of measurement error in the proxy for Protestantism, reverse causality, and omitted variables. To address these concerns, we exploit the variation in the consequences of the Boxer Uprising in terms of the spatial resettlement of the Protestant missionaries after the Boxers' assault in 26 prefectures across China (Panel A of Figure 2). We reason that the areas to which these missionaries fled should be positively correlated with the subsequent diffusion of Protestantism. Taking the distribution of missionaries before the uprising as given, our task is to predict where they might have fled to. Holding other conditions constant, the Protestant missionaries would have fled to the safest place at the time.

Specifically, given the same distance from the Boxer Uprising, the region protected by the Yangtze Compact was likely to have received the most missionaries. This is illustrated in Panel B of Figure 2, in which a solid black line demarcates the safe and unsafe regions, and where the different shades of grey represent variations in the distance from the nearest conflict area.[12] Given the choice between two counties of equal distance–one in the south and the other in the north, the missionaries would have fled to the county south of the solid black line. This reasoning is well supported by the diary of Reverend Saunders (1900), a fleeing missionary who initially fled to the north, only to discover that in order to be completely safe from the Boxers, he and his family had to cross the treaty line (see Appendix D for details).[13]

Figure 2 about here

Denoting the distance from the nearest conflict area by D and the counties to the south of the Yangtze Compact region by S (where $S = 1$), our instrumental variable is represented by their interaction (DS). To qualify as a valid instrument, DS should be positively and significantly correlated with the level of Protestantism in 1920 (P). We

[12]Distance from the nearest Boxer Uprising is calculated using the Great Circle distance of each county to the nearest Uprising prefecture based on their centroids.

[13]Saunders' experience is by no means unique. For instance, Austin (2007) characterizes the evacuation of the missionaries from Shanxi Province to the coast as essentially an "exodus" (p. 415).

examine this relationship first with a short regression, which includes only "distance to the nearest Boxer Uprising" (D), "Yangtze Compact" (S), and their interaction (DS):

$$P = \delta_1 D + \delta_2 DS + \delta_3 S \tag{4}$$

Reported in Column (1) of Table 4, the result shows that DS is indeed positively correlated with the level of Protestantism.

Table 4 about here

To ensure that the relationship between DS and Protestantism does not capture other unobserved geographic factors, we control for more additional spatial variables. First, we include a county's distance to the sea and to the five earliest treaty ports (as a proxy for locations with the earliest presence of Protestantism), and their respective interaction with S.[14] But since it is impossible to control for every conceivable spatial dimension, we directly control for a county's geographic coordinates–longitude and latitude (x, y). In addition, to rule out the possibility that geographic coordinates may have nonlinear effects, we also include their squared terms, namely x^2, xy and y^2. Our specification can now be rewritten as:

$$P = \delta_1 D + \delta_2 DS + \tilde{W}\gamma + \nu, \tag{5}$$

in which $\tilde{W}$ includes the vector of controls previously employed in the baseline estimations (W) and the additional spatial variables just introduced in the instrumented estimations. As with the baseline estimate, we also control for the provincial dummies; hence the dummy variable indicating the Yangtze Compact region (S) is dropped. Column (2) of Table 4 clearly shows that DS remains positively and significantly correlated with the level of Protestantism in 1920 even with the inclusion of these controls ($\tilde{W}$).

4.3.1 Falsification Tests

For our instrument to be valid, it needs to satisfy exclusion restrictions beyond proving that it is significantly correlated with Protestantism (P)–i.e., that DS did not affect

[14] In Appendix E (Table A4), we further show that distance to the nearest Boxer Uprising has no significant relationship with whether a county was located on the coast, along the Yangtze River, along the Grand Canal, distance to the sea, distance to the five earliest treaty ports, or the dummy of treaty ports and railway networks.

economic prosperity via other alternative channels. To that end, we perform three falsification tests. First, DS should affect the diffusion of Protestantism only after the Boxer Uprising if our logic is correct; a significant relationship between DS and Protestantism before the Boxer Uprising would imply that DS operates through other channels. Second, we compare the effect of DS on the enrollment density of Protestant schools with the enrollment density of government schools. According to our logic, DS should have a positive effect on the enrollment density of Protestant schools (a proxy for missionary activity) but not on the enrollment density of government schools (a proxy for economic development). If DS also has a positive effect on the enrollment density of government schools, then it is likely that DS is correlated with some omitted variables. Third, we also need to rule out the possibility that DS affects economic prosperity via railroad, foreign influences (specifically Western business), the prevailing level of urbanization, and so forth.

To perform our first falsification test, we regress the duration of Protestantism (P_{it}^d) on the interaction between DS and a dummy variable that indicates the post-Boxer Uprising period with a random-effect model on a panel dataset:

$$P_{it}^d = \psi_1 \cdot Post \cdot D_i S_i + \psi_2 \cdot Post \cdot D_i + \tilde{Z}_{it}\Pi + \mu_i + \lambda_t + \nu_{it}, \tag{6}$$

in which $\tilde{Z}_{it}$ represents all the control variables included in Equation (3). Reported in Column (1) of Table 5, the effect of DS on the diffusion of Protestantism is insignificant for the entire period but becomes significant after the Boxer Uprising. Moreover, the size of the coefficients, which is distinctly smaller before 1900, increases sharply (from 0.130 to 1.474) thereafter. In order to obtain the pure effects of DS for all 15 periods covered in our sample, we further interact DS with a full set of time dummies in Column (2). The results consistently show that the effect of Protestantism remains insignificant for each period before the Boxer Uprising, but becomes significant thereafter (Column (2)). We repeat the above exercise using the establishment of domestically owned modern industrial firms as the dependent variable. This reduced-form regression shows that, while our instrument is significantly correlated with domestic firms only after the Boxer Uprising (Columns (3) and (4)), it is insignificantly correlated with Western business (proxied by the establishment of foreign firms) both before and after the Boxer Uprising (Column (5)).

Table 5 about here

We then compare the effect of DS on the enrollment density of Protestant schools with that of the enrollment density of government schools–our second falsification test. Reported in Columns (3) and (4) of Table 4, the results show that, while DS has a positive effect on the enrollment density of Protestant schools, it does not have a significant effect on the enrollment density of government schools. This takes us to our third falsification test, in which we repeat the above exercise but replace primary education with railway (Column (5)), Catholicism (Column (6)), treaty ports (Column (7)), and initial conditions (Column (8)). Consistently, we find that DS does not have a significant effect on these variables, suggesting that our instrument does not capture the effect of a wide gamut of unobserved factors.

4.3.2 Effect of Instrumented Protestantism on Economic Prosperity

Now we can apply our instrument to identify the causal effect of Protestantism on urbanization using the 2SLS method as expressed in Equation (7):

$$\begin{aligned} Y &= \rho P + \eta_1 D + \tilde{W}\beta + \varepsilon \\ P &= \delta DS + \delta_1 D + \tilde{W}\gamma + \nu \end{aligned} \tag{7}$$

The results are reported in Table 6. Unlike the baseline findings in Table 2, in which the coefficient of Protestantism decreases somewhat after controlling for initial economic conditions and Western economic influences, here the pertinent magnitude increases slightly from 0.837 in the estimation (in which initial economic conditions and Western penetration are excluded (Column (1.2), Table 6)), to 0.868 when all the controlled variables are fully accounted for (Column (2.2), Table 6). These results are very encouraging because they show that the effect of instrumented Protestantism remains stable with the inclusion of other possible co-determinants of urbanization. In terms of magnitude, the conversion of an additional communicant per 10,000 people now increases the overall urbanization rate by 18.8% when evaluated at the mean (0.868/4.625), which is much larger than the baseline estimate, suggesting that the baseline estimators are likely biased by the measurement error in the proxy for Protestantism.

But might the Boxer Uprising affect our results directly? To control for this possible effect, we include a dummy variable that indicates the incidence of Boxer Uprising in the 23 prefectures in the regression (Column (3)), and find that it had no significant effect on the development of Protestantism in the 1920s–possibly because missionary activities resumed as soon as the Boxers were defeated.[15] Most importantly, the effect of Protestantism changes little when compared to the estimation for which the direct effect of the Uprising is not controlled (compare, e.g., Column (3.2) with Column (2.2)).

Yet another concern may be that, given that the Boxer Uprising was mainly restricted to north China, it is possible that the results might be driven by counties remote from the Boxer Uprising–especially counties in the south. To check if this is the case, we exclude the two southernmost provinces, Guangdong and Guangxi, and replicate the exercise in Column (2). The results in Column (4) show that the effect of Protestantism remains firmly significant.

Table 6 about here

Turning to the panel data analysis (of the establishment of modern industrial firms), our instrument entails the interaction between D_iS_i and post-Boxer Uprising (*Post*), in which we hypothesize that $Post \cdot D_iS_i$ has a positive effect on the diffusion of Protestantism (P^d_{it}). This specification can be written as:

$$\begin{aligned} Y_{it} &= \rho P^d_{it} + \varpi \cdot Post \cdot D_i + \tilde{Z}_{it}\Phi + \alpha_i + \lambda_t + \varepsilon_{it} \\ P^d_{it} &= \psi_1 \cdot Post \cdot D_iS_i + \psi_3 \cdot Post \cdot D_i + \tilde{Z}_{it}\Pi + \tilde{\alpha}_i + \tilde{\lambda}_t + v_{it} \end{aligned} \tag{8}$$

in which $\tilde{Z}_{it}$ comprises all the control variables that were included in the earlier panel analysis (Equation (3)). The results (reported in Column (1) of Table 7) confirm that our instrument is highly correlated with Protestantism (Column 1.1), and that Protestantism significantly affects the establishment of modern industrial firms (Column 2.2). In terms of magnitude, the effect of instrumented Protestantism (0.0184, Column (1.2))

[15] We thank an anonymous reviewer for pointing this out.

is significantly larger than the baseline estimate of 0.0026 (Column (7), Table 3). To further check robustness, we replace $Post \cdot D_iS_i$ with the interactions between D_iS_i and the three post-Boxer Uprising time dummies, and control for the interaction between D_iS_i and the pre-Uprising time dummies. Reported in Column (2), the results robustly show that D_iS_i is significant only after the Boxer Uprising, and that the effect of Protestantism (0.0181, Column (2.2)) differs little from the result that uses $Post \cdot D_iS_i$ as the pertinent instrument.

Table 7 about here

5. PROTESTANISM, KNOWLEDGE DIFFUSION AND ECONOMIC OUTCOME

5.1 Effect of Protestantism When Controlling for Knowledge Diffusion

To examine the role of knowledge diffusion in determining economic outcome, we estimate the effects of the level of knowledge diffusion and the density of Protestant communicants on urbanization at the county level using:

$$Y = \rho P + K\gamma + W\beta + \varepsilon \tag{9}$$

We do so by adding the four types of knowledge diffusion activities to the regressions one at a time: enrollment density of Protestant lower primary schools (K_1), enrollment density of Protestant higher primary schools (K_2), number of middle schools (K_3), and number of hospitals (K_4).[16] The results demonstrate that the effect of Protestantism decreases with the inclusion of any of these four types of knowledge diffusion activities (Table 8, Columns (2)-(5)). In particular, Protestantism becomes insignificant if either of the two primary school variables is included (Columns (2)-(3)). When all four types of knowledge diffusion activities are included Protestantism becomes insignificant, and its coefficient drops to near zero (Column (6)). To check the robustness of our results, we

[16] A possible limitation of our study relates to the lack of specifics regarding the knowledge diffusion activities conducted by the Catholic churches. While Catholic missionaries also erected various levels and types of schools in China, they had much narrower goals during this period, and were thus much less active than the Protestants in the provision of education and health services (Wiest 2001).

transform the four knowledge diffusion variables into a single variable (K)) using principal component analysis, and find that the effect of Protestantism similarly decreases to near zero (Column (7)).

Table 8 about here

The decomposition of knowledge diffusion indeed yields results that are consistent with our "knowledge diffusion" hypothesis. For example, of the three educational variables, only higher primary school enrollment density and the number of middle schools erected are significant. This finding may be explained by the possibility that, while lower primary schools taught the fundamental tools of education (including reading, writing, and elementary arithmetic), higher primary schools offered practical occupational training (Committee of Reference and Counsel of the Foreign Missions Conference of North America 1922). But only middle schools, where the newly invigorated curriculum of Western subjects was systematically provided, produced what Simon Kuznets (1965) called "useful knowledge". The results in Column (8) bear out these essential differences, especially the huge contrasts between lower primary schooling and the middle schools.

Not surprisingly, the number of hospitals built by the Protestant missionaries was also significant in stimulating urban economic growth in China in the early 1900s. In the absence of further evidence, we can only speculate that the physical health of the workforce was enhanced through an increased awareness of Western medicine and health practices promoted by the Protestant missionaries, which Mokyr (2002) thought was important in bringing about the sharp decline in mortality rate for various diseases in the West long before the relevant cures were found. To further check the robustness of knowledge diffusion hypothesis, we include the number of Bible schools that were erected to diffuse religious knowledge, and find that it has no significant effect on urbanization (Columns (8) and (9))–a result that can be explained by their likely effects of strengthening the Protestant ethic and raising literacy levels, but not of diffusing "useful" Western knowledge.

5.2 A Three-stage Model

5.2.1 Knowledge Diffusion Activities of Protestant Missionary Societies across Countries

A problem with the above exercise, however, is that (aside from the diffusion of Protestantism), knowledge diffusion is also endogenous. Just as we need an instrument to identify the causal effects of Protestantism, we also need one to identify the causal effects of knowledge diffusion. Premised on the assumption that the strategy and actions of a missionary society are likely highly correlated *across* countries, we employ the level of knowledge diffusion activities undertaken by Protestant missions in other parts of the world to predict how much they were likely to "invest" in the same activities in China. Beach (1903) provides region-level data on missionaries' knowledge diffusion activities–specifically day school and higher education enrollments and the number of hospital patients–in 19 regions around the world (see Appendix G for details). But since our unit of analysis is the Chinese county, it is necessary to transform region-level data into mission-level data, and then into county-level data.

To transform region-level data into mission-level data, we begin by measuring the level of knowledge diffusion activities provided by each missionary society, n , in terms of day school enrollments, higher education enrollments, and hospital patients in each region, j, using the share of each type of activities relative to the size of the mission, denoted by k_{1j}^{n} (the share of day school enrollments), k_{2j}^{n} (the share of higher education enrollments), and k_{3j}^{n} (the share of hospital patients).[17] Then, by calculating the average of k_{1j}^{n}, k_{2j}^{n}, and k_{3j}^{n} in the other 18 regions (i.e., excluding China), using $\bar{k}_1^n = \sum_{j=1}^{18} k_{1j}^{n}$, $\bar{k}_2^n = \sum_{j=1}^{18} k_{2j}^{n}$, and $\bar{k}_3^n = \sum_{j=1}^{18} k_{3j}^{n}$, we are able to measure the overall intensity of knowledge diffusion activities pursued by each missionary society in the rest of the world.

Next, to transform the mission-level data into county-level data, we first match the list of missionary societies in China provided by Stauffer (1922) [in Appendix F] with that of the 19 regions of the world provided by Beach (1903). This process tells us which mission invested how much in each of the three knowledge diffusion activities worldwide, as well

[17] In other words, these activities are normalized by the size of the missionary (defined as the number of communicants).

as which mission had a presence in China on a county-by-county basis. Aggregating the worldwide knowledge diffusion activities of those missions with their presence in a particular county gives us a measure that reflects the level of knowledge diffusion activities that these missions had undertaken in the rest of the world. We then apply this measure as our instrument. For example, suppose there are λ missionary societies in Chinese county i. We take the sum of the knowledge diffusion activities of those missions in terms of day schools ($\bar{k}_1^n$), higher education institutions ($\bar{k}_2^n$), and hospitals ($\bar{k}_3^n$) in the rest of the world as a measure of what these missions in county i invested in the rest of the world, denoted by $\tilde{K}_1 = \sum_{n=1}^{\lambda} \bar{k}_{1n}$, $\tilde{K}_2 = \sum_{n=1}^{\lambda} \bar{k}_{2n}$, and $\tilde{K}_3 = \sum_{n=1}^{\lambda} \bar{k}_{3n}$. We obtain a total of three indices of knowledge diffusion activities ($\tilde{K}_m$, $m = 1, 2, 3$). Using principal component analysis, we transform the three correlated variables into a single variable ($\tilde{K}$), which becomes our instrumental variable for knowledge diffusion.

5.2.2 Estimation Results of the Three-stage Model

Using this additional instrument, we are now able to confirm that knowledge diffusion is the main channel through which Protestantism impacts economic prosperity by estimating a system of three equations. In the first equation, we employ the interaction between "distance from the nearest Boxer Uprising" and "Yangtze Compact" to predict the spread of Protestantism. We then employ Protestantism and the knowledge diffusion activities conducted by the missionaries outside of China–our additional instrument–to predict knowledge diffusion activities performed by the same missionaries within China in the second equation. Finally, our third equation estimates the effects of Protestantism and knowledge diffusion on urbanization. This system of simultaneous equations is:

$$\begin{aligned} Y &= \rho P + \theta K && + \eta D + \tilde{W}\gamma_3 + \varepsilon \\ K &= \rho_1 P + \eta_0 \tilde{K} && + \eta_1 D + \tilde{W}\gamma_2 + \mu \\ P &= && \delta_3 DS + \delta_1 D + \tilde{W}\gamma_1 + \nu \end{aligned} \tag{10}$$

The system can be identified as both the order condition and rank condition are met under the specification of Equation (10).

We estimate the system based on Equation (10) using the three-stage least squares (3SLS) method. The 3SLS results reported in Table 9 show that (1) the interaction between "distance from the nearest Boxer Uprising" and "Yangtze Compact" (DS) is positively correlated with the degree of Protestantism (Column (2.1)); (2) the part of Protestantism that is due to the instrument is positively associated with knowledge diffusion (Column (2.2)); and (3) the part of knowledge diffusion that is due to the portion of Protestantism that is linked to the instrument has a positive effect on economic outcome (Column (2.3)). In short, these results unambiguously support the hypothesis that economic prosperity in China was due primarily to the diffusion of knowledge-intensive activities associated with Protestant development. Moreover, our results also show that knowledge diffusion activities undertaken by the Protestant missionary societies in the rest of the world, namely $\tilde{K}$, also positively affected knowledge diffusion in China. The overall effect of Protestantism on urbanization consists of both the direct effect of Protestantism and its indirect effect via knowledge diffusion. Estimated at about 0.865 (0.095 + 0.081 * 9.502), the indirect effect accounts for approximately 89% of the overall effect. Against the 2SLS benchmark estimate of the overall effect of Protestantism on urbanization (0.853, Column (1)), we find that as much as 90% (0.0770 of 0.853) of the overall effect comes from knowledge diffusion.[18]

Table 9 about here

Recall that our exclusion restrictions assumption (that the missionary societies' involvement in education and health matters in the rest of the world ($\tilde{K}$)) does not directly affect the economic development of the counties in which they set up operations (i.e., $\tilde{K}$ is not correlated with the error term ε). This assumption would be violated, however, if some missionary bodies that happened to have a preference for setting up schools and hospitals also preferred to settle in, for example, the more prosperous regions; in that case, $\tilde{K}$ might be correlated with the unobserved characteristics of the regions ($\widetilde{g}$) in which a missionary society settled. Assuming that the same missionary body has similar preferences regarding settlement choice around the world (including China), g (the unobserved economic characteristics of the county in which a missionary society settled)

[18]This figure is obtained by multiplying 0.0851 (Column (2.2), the coefficient of the relationship between knowledge diffusion and Protestantism) by 9.502 (Column (2.3), the coefficient of the relationship between knowledge diffusion and urbanization).

should be positively correlated with $\widetilde{g}$, in which case $\tilde{K}$ could affect economic outcome via g. To rule out this possibility, we include the *average* population density–a proxy for economic prosperity–of the regions in the rest of the world where the missionary societies had set up operations in Equation (10).[19] The underlying assumption is that, should such a bias exist, this additional control variable would be significantly correlated with urbanization. Columns (3) and (4) of Table 9, however, show that it is not. More importantly, Protestantism still does not have a significant direct effect on economic prosperity–more than 90% of its effect comes from knowledge diffusion.

6. CONCLUSION

Using survey data collected by Stauffer (1922) that documented the religious and non-religious activities of the Protestant missionaries in early 20$^{\text{th}}$ century China, we examined the effects of Protestantism in a country where it could not possibly create the same positive economic benefits as it had in Europe, according to Max Weber. But, even after controlling for a wide array of variables that may affect economic prosperity, Protestantism–measured as the density of communicants–was positively associated with both the degree of urbanization and the establishment of modern industrial firms in China in the period examined. This result remains robust even after we instrumented Protestantism with the consequences of the Boxer Uprising.

By focusing on a country with only a tiny fraction of its population converted to Christianity, it would appear highly unlikely for the Protestant "work ethic" or literacy to be the primary channel through which the observed economic effect of Protestantism was identified; this makes the alternative story of knowledge diffusion much more plausible by comparison. Indeed, we found that as much as 90% of the overall effect of Protestantism comes from knowledge diffusion. By establishing a large number of schools and hospitals, the Protestant missionaries effectively created a large stock of the "useful knowledge" required for modern economic development. All of these events occurred at a time when

[19] We calculated the average population density in 1900 in regions around the world where the same missionary societies had set up operations. We then applied these averages to estimate their settlement preferences in China.

China seemed unable to move away from knowledge that was not conducive to economic development, only serves to make our story more credible.

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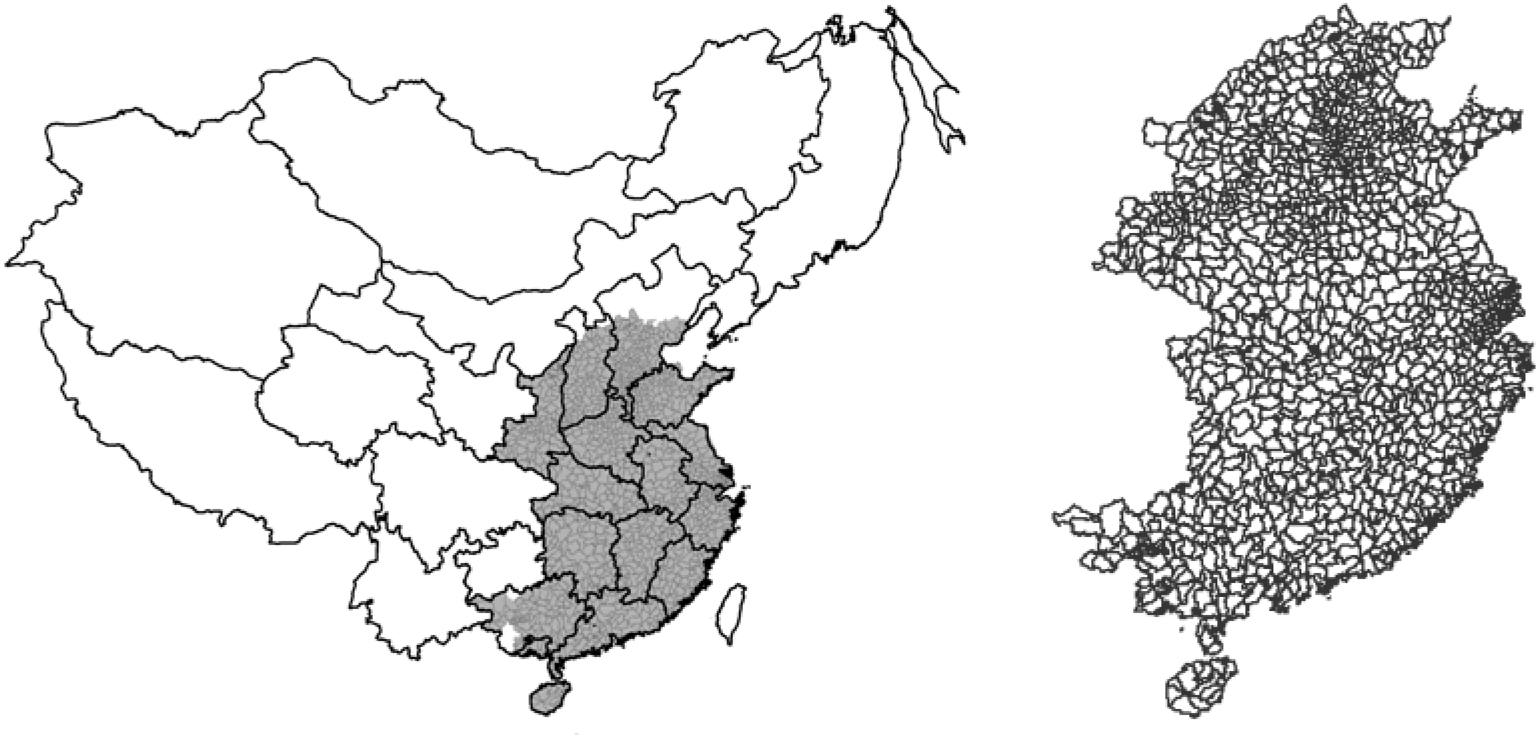
FIGURE 1: The 14 provinces included in the dataset.

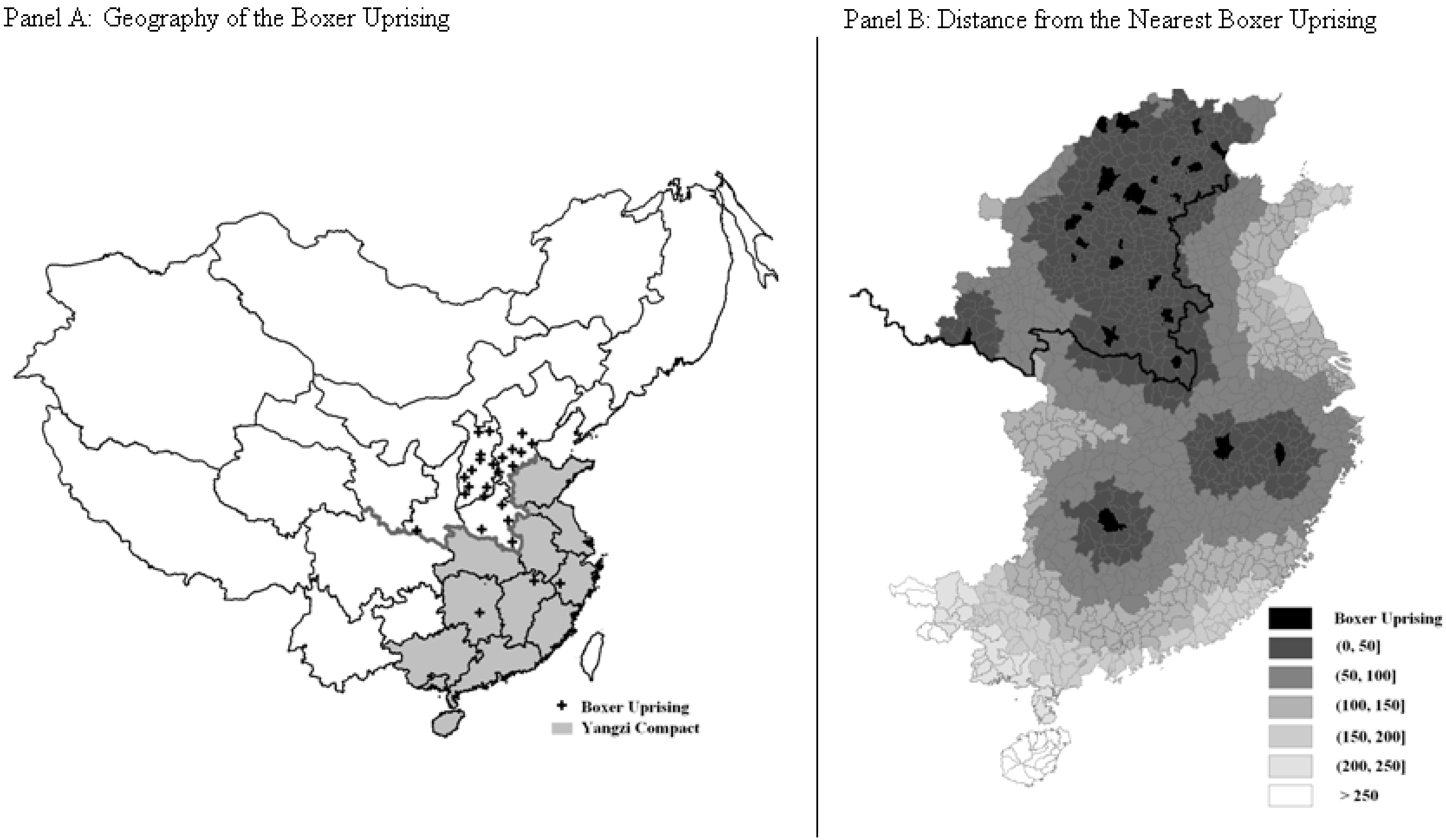


Panel A: Map of Qing China in 1820

Panel B: Sample Counties

Source: CHGIS 2007.

FIGURE 2. The Location of the Boxer Uprising.



Source: CHGIS 2007.

TABLE 1. Definition of variables and summary statistics.

Variable	Definition	Obs.	Mean	S.D.	Data sources
(1) Economic prosperity					
	Urbanization: percentage of urban population to total population	1,175	4.265	(12.296)	A
	Number of firms established	1,175x15	0.049	(0.871)	E
(2) Protestantism					
	Total communicants per 10,000 people	1,175	8.394	(15.161)	A
	Year when the missionary work formally began	916	1896.876	(14.832)	A
(3) Knowledge diffusion					
	Lower primary school (number of students per 10,000 people)	1,175	3.200	(6.874)	A
	Higher primary school (number of students per 10,000 people)	1,175	0.568	(1.738)	A
	Middle school (number)	1,175	0.216	(1.092)	A
	Hospital (number)	1,175	0.187	(0.526)	A
	Bible school (number)	1,175	0.075	(0.384)	A
(4.1) Western penetration					
	Roman Catholicism: Number of Catholic missionary stations per 1 million population	1,175	0.630	(1.269)	A
	Treaty ports	1,175	0.179	(0.383)	D
	Railways	1,175	0.345	(0.475)	D
(4.2) Initial economic conditions					
	Small city (1840)	1,175	0.031	(0.175)	C
	Middle city (1840)	1,175	0.022	(0.147)	C
	Large city (1840)	1,175	0.007	(0.082)	C
(4.3) Political and geographic factors					
	Prefectural government location	1,175	0.150	(0.357)	B
	Grand Canal	1,175	0.037	(0.188)	B
	Changjiang (Yangtze) River	1,175	0.048	(0.213)	B
	Coast	1,175	0.108	(0.311)	B
	Population density	1,175	189.399	(211.683)	A
	Size	1,175	1914.911	(1218.037)	B
(5) Boxer Uprising					
	Distance from the nearest Boxer Uprising (log-term)	1,175	3.944	(0.986)	B
	Latitude	1,175	114.544	(3.618)	B
	Longitude	1,175	31.728	(5.205)	B
	Dist. to the sea (log-term)	1,175	4.351	(1.187)	B
	Dist. to the earliest 5 treaty ports (log-term)	1,175	5.127	(0.897)	B, D

A: Stauffer 1922; B: CHGIS 2007; C: Rozman 1974; D: Yan 1955; E: Chang 1989.

Note: Appendix A provides detailed information on the definition of variables and data sources.

TABLE 2. The effects of Protestantism on urbanization.

	(1)	(2)	(3)	(4)	(5)
Protestantism	0.215***	0.194***	0.162**	0.186***	0.158**
	(0.064)	(0.061)	(0.056)	(0.060)	(0.055)
Catholicism	0.637	-0.229	0.009	-0.173	0.031
	(0.491)	(0.266)	(0.285)	(0.273)	(0.290)
Initial economic conditions:					
Small city			6.491**		6.324*
			(2.990)		(3.025)
Middle city			18.466***		18.106***
			(4.422)		(4.469)
Large city			44.449***		43.841***
			(9.458)		(9.623)
Treaty ports				2.849***	1.716***
				(0.545)	(0.538)
Railways				0.793	0.132
				(0.623)	(0.567)
Prefectural government location		10.296***	4.810***	10.474***	5.009***
		(1.351)	(1.323)	(1.345)	(1.307)
Grand Canal		8.879***	5.796***	8.935***	5.928***
		(1.001)	(1.279)	(0.748)	(1.191)
Changjiang (Yangtze) River		1.848**	-0.529	0.668	-1.174
		(0.635)	(1.354)	(0.895)	(1.332)
Coast		2.503*	2.261*	1.312	1.574
		(1.215)	(1.250)	(1.228)	(1.126)
Population density (log-term)	4.493***	2.622***	1.329**	2.494***	1.293**
	(0.494)	(0.456)	(0.541)	(0.482)	(0.555)
Size (log-term)	2.347***	0.339	-0.291	0.391	-0.267
	(0.538)	(0.465)	(0.397)	(0.493)	(0.437)
Province dummies	Yes	Yes	Yes	Yes	Yes
Observations	1175	1175	1175	1175	1175
R-squared	0.15	0.24	0.34	0.25	0.34

Note: Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Constant terms are not reported.

TABLE 3. Panel analysis: the effect of Protestantism on the establishment of modern industrial firms.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Duration	0.0068***	0.0071***	0.0071***	0.0058***	0.0058***	0.0027***	0.0026***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Time dummies * Protestantism		Yes		Yes		Yes	
Time Trend * Protestantism			Yes		Yes		Yes
Duration of Treaty Ports				Yes	Yes	Yes	Yes
Duration of Railways				Yes	Yes	Yes	Yes
Time dummies * Treaty ports						Yes	Yes
Time dummies * Railways						Yes	Yes
Time dummies * Catholicism						Yes	Yes
Time dummies * Initial economic conditions						Yes	Yes
Time dummies * Prefectural government location						Yes	Yes
Time dummies * Grand Canal						Yes	Yes
Time dummies * *Changjiang* (Yangtze) River						Yes	Yes
Time dummies * Coast						Yes	Yes
Time dummies * Population density (1850s)						Yes	Yes
Time dummies * Size						Yes	Yes
Time dummies (I_τ)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17625	17625	17625	17625	17625	17625	17625
County number	1175	1175	1175	1175	1175	1175	1175
R-squared	0.10	0.10	0.10	0.12	0.12	0.27	0.27

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

TABLE 4. The effect of instrument on Protestantism and other related variables (cross-sectional).

	(1) Protestantism	(2) Protestantism	(3) Protestant primary student	(4) Government primary student	(5) Railways	(6) Catholicism	(7) Treaty ports	(8) City level in 1840
D * South	4.139**	3.234***	1.633**	-9.525	0.120	-0.081	-0.003	-0.043
	(1.879)	(0.742)	(0.696)	(12.181)	(0.088)	(0.094)	(0.043)	(0.078)
D	-1.010*	-1.344**	-0.424	-2.728	0.024	0.061	0.005	-0.018
	(0.545)	(0.523)	(0.400)	(4.153)	(0.026)	(0.035)	(0.011)	(0.062)
Spatial variables* South		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spatial variables		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control variables		Yes	Yes	Yes	Yes	Yes	Yes	Yes
South	Yes							
Province dummies		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1175	1175	1175	1175	1175	1175	1175	1175
R-squared	0.02	0.21	0.17	0.34	0.46	0.20	0.39	0.40

Note: Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Constant terms are not reported. The dummy of safe region is dropped due to collinearity, since we control for province dummies in the regressions. The spatial variables include distance to the sea, distance to the earliest five treaty ports, latitude, longitude, and the squared terms of geographic coordinates (latitude, longitude). The control variables include prefectural government location, Grand Canal, *Changjiang* (*Yangtze*) River, coast, population density, prefecture size, and constant term.

Table 5. Falsification tests: panel analysis.

Dependent Variable	(1) Protestant duration	(2)	(3) Domestic firms (county)	(4) Domestic firms (prefecture)	(5) Foreign firms (prefecture)
D*South *Post-1900	1.474***				
	(0.235)				
D*South	0.130				
	(0.343)				
D*South*1911		1.4680***	0.0738***	0.1301***	0.0311
		(0.4609)	(0.0113)	(0.0339)	(0.0269)
D*South*1906		1.6469***	0.0534***	0.0906***	0.0136
		(0.4609)	(0.0113)	(0.0339)	(0.0269)
D*South*1901		1.6998***	0.0239**	0.0613*	0.0326
		(0.4609)	(0.0113)	(0.0339)	(0.0269)
D*South*1896		0.1199	0.0077	0.0161	0.0196
		(0.4494)	(0.0108)	(0.0330)	(0.0265)
D*South*1891		0.1005	-0.0031	0.0128	0.0093
		(0.4494)	(0.0108)	(0.0330)	(0.0265)
D*South*1886		0.0970	0.0016	0.0062	0.0071
		(0.4494)	(0.0108)	(0.0330)	(0.0265)
D*South*1881		0.1885	-0.0032	-0.0009	-0.0025
		(0.4493)	(0.0108)	(0.0330)	(0.0265)
D*South*1876		0.2317	0.0037	0.0104	0.0107
		(0.4493)	(0.0108)	(0.0330)	(0.0265)
D*South*1871		0.2079	0.0029	0.0037	-0.0076
		(0.4493)	(0.0108)	(0.0330)	(0.0265)
D*South*1866		0.1433	-0.0013	0.0087	-0.0030
		(0.4493)	(0.0108)	(0.0330)	(0.0265)
D*South*1861		0.0790	0.0021	0.0060	0.0029
		(0.4493)	(0.0108)	(0.0330)	(0.0265)
D*South*1856		0.0806	0.0038	0.0054	0.0058
		(0.4493)	(0.0108)	(0.0330)	(0.0265)
D*South*1851		0.0957	0.0020	0.0020	0.0070
		(0.4493)	(0.0108)	(0.0330)	(0.0265)
D*South*1846		0.1185	0.0014	0.0028	0.0042
		(0.4493)	(0.0108)	(0.0330)	(0.0265)
D*South*1841		0.1109	0.0021	0.0007	-0.0031
		(0.4388)	(0.0105)	(0.0313)	(0.0257)
D*Post 1900	Yes	Yes	Yes	Yes	Yes
D	Yes	Yes	Yes	Yes	Yes
$\tilde{Z}_{it}$	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes
Observations	17625	17625	17625	2700	2700
County number	1175	1175	1175	180	180
R-squared	0.63	0.63	0.34	0.65	0.36

Notes: Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. $\tilde{Z}_{it}$ includes all control variables in Column (6) of Table 3 and all interaction terms between spatial variables and a full set of time dummies. Column (3) reports the results based on county-level data; in Column (4), we collapse the data into prefecture level (in Qing China the prefecture was an administrative unit between the province and the county); In Column (5), we regress the establishment of foreign firms using the specification of Column (3).

TABLE 6. Instrumented evidence.

	(1)		(2)		(3)		(4)	
	(1.1)	(1.2)	(2.1)	(2.2)	(3.1)	(3.2)	(4.1)	(4.2)
	1st step	2nd step	1st step	2nd step	1st step	2nd step	1st step	2nd step
Protestantism		0.837**		0.868**		0.828**		0.916**
		(0.381)		(0.405)		(0.397)		(0.438)
D * South	3.234***		3.273***		3.284***		3.362***	
	(0.716)		(0.601)		(0.611)		(0.725)	
D	-1.344***	-1.044	-1.432***	-0.669	-1.476***	-0.239	-1.281***	-0.738
	(0.504)	(0.749)	(0.394)	(0.735)	(0.554)	(0.668)	(0.288)	(0.759)
Incidence of Boxer Uprising					-0.168	1.883**		
					(1.142)	(0.850)		
Small city			5.481**	2.353	5.494**	2.420	4.790**	0.082
			(2.430)	(2.362)	(2.417)	(2.344)	(2.107)	(2.115)
Middle city			5.420***	13.455***	5.433***	13.511***	5.652**	13.049***
			(1.969)	(4.662)	(1.976)	(4.611)	(2.211)	(5.058)
Large city			19.595***	26.198**	19.612***	26.777**	16.088***	23.163**
			(5.905)	(11.504)	(5.933)	(11.440)	(5.758)	(10.647)
Catholicism			0.496***	-0.376	0.493***	-0.322	0.450***	-0.328
			(0.152)	(0.286)	(0.151)	(0.285)	(0.129)	(0.305)
Treaty ports			1.841***	0.601	1.833***	0.755	3.142***	-0.155
			(0.690)	(0.963)	(0.700)	(0.956)	(0.564)	(1.554)
Railways			0.625	-0.319	0.627	-0.304	-0.034	-0.130
			(1.483)	(1.294)	(1.485)	(1.204)	(1.538)	(1.252)
Spatial variables * South	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spatial variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,175	1,175	1,175	1,175	1,175	1,175	1,013	1013
R-squared	0.21	.	0.22	.	0.22	.	0.20	.

Note: Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. The spatial variables include distance to the sea, distance to the earliest five treaty ports, latitude, longitude, and the squared terms of geographic coordinates (latitude, longitude). The control variables include prefectural government location, Grand Canal, *Changjiang* (*Yangtze*) River, coast, population density, prefecture size, and constant term.

TABLE 7. Instrumental evidence: panel analysis.

	IV Fixed-effect model			
	(1)		(2)	
Dependent varia-	(1.1) P	(1.2) Y	(2.1) P	(2.2) Y
P		0.0184***		0.0181***
		(0.0037)		(0.0052)
D*South *Post-1900	1.4659***			
	(0.2351)			
D*South*1911			1.3292***	
			(0.4473)	
D*South*1906			1.5081***	
			(0.4473)	
D*South*1901			1.5611***	
			(0.4473)	
D*South*1896			-0.0158	-0.0097
			(0.4276)	(0.0131)
D*South*1891			-0.0345	-0.0192
			(0.4276)	(0.0128)
D*South*1886			-0.0373	-0.0135
			(0.4275)	(0.0131)
D*South*1881			0.0549	-0.0220*
			(0.4275)	(0.0128)
D*South*1876			0.0988	-0.0149
			(0.4275)	(0.0128)
D*South*1871			0.0756	-0.0155
			(0.4275)	(0.0128)
D*South*1866			0.0116	-0.0207
			(0.4275)	(0.0132)
D*South*1861			-0.0522	-0.0143
			(0.4275)	(0.0132)
D*South*1856			-0.0504	-0.0114
			(0.4275)	(0.0131)
D*South*1851			-0.0356	-0.0119
			(0.4275)	(0.0131)
D*South*1846			-0.0130	-0.0149
			(0.4275)	(0.0130)
D*Post 1900	Yes	Yes	Yes	Yes
$\tilde{Z}_{it}$	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes
Observations	17,625	17,625	17,625	17,625
County number	1,175	1,175	1,175	1,175
R-squared	0.63	0.16	0.63	0.17

Notes: Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. $\tilde{Z}_{it}$ includes all control variables in Column (6) of Table 3 and all interaction terms between spatial variables and a full set of time dummies.

TABLE 8. Protestantism, knowledge diffusion, and urbanization.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Protestantism	0.158**	0.090	0.063	0.098**	0.100**	0.049	0.002	0.049	0.001
	(0.055)	(0.056)	(0.044)	(0.041)	(0.044)	(0.043)	(0.041)	(0.043)	(0.040)
Knowledge diffusion (index)							3.445***		3.464***
							(0.591)		(0.517)
Lower primary school		0.225				0.023		0.024	
		(0.132)				(0.112)		(0.110)	
Higher primary school			2.231***			1.064**		1.070**	
			(0.691)			(0.483)		(0.468)	
Middle school				4.340***		2.878***		2.896***	
				(0.457)		(0.367)		(0.473)	
Hospital					7.323***	2.078*		2.153*	
					(1.889)	(1.127)		(1.119)	
Bible school								-0.288	-0.134
								(2.658)	(2.446)
Control variables (W)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,175	1,175	1,175	1,175	1,175	1,175	1,175	1,175	1,175
R-squared	0.34	0.35	0.41	0.43	0.39	0.45	0.44	0.45	0.44

Notes: Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. The control variables (W) include Catholicism, small city, middle city, large city, treaty ports, railways, Grand Canal, *Changjiang* (Yangtze) River, coast, population density (log-term), size (log-term), province dummies, and constant term.

TABLE 9. Estimation results using the three-stage model.

	(1) Y	(2)			(3)	(4)		
		(2.1): P	(2.2): K	(2.3): Y		(4.1): P	(4.2): K	(4.3): Y
Protestantism (P)	0.853**		0.081*	0.095	0.851**		0.085**	0.082
	(0.434)		(0.043)	(0.844)	(0.424)		(0.041)	(0.838)
Knowledge diffusion activities (K)				9.502**				9.851**
				(4.684)				(4.719)
Knowledge diffusion activities in the rest of the world ($\tilde{K}$)			0.287***				0.295***	
			(0.090)				(0.092)	
D * South		3.205**				3.310**		
		(1.494)				(1.527)		
Population density in the rest of the world (g)					-0.168	-0.248	-0.005	-0.888
					(0.456)	(0.706)	(0.071)	(0.809)
Control variables ($\tilde{W}$)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,130	1,130	1,130	1,130	1,097	1,097	1,097	1,097
R-squared	.	0.22	0.51	.03	.	0.22	0.50	.

Notes: Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. The control variables ($\tilde{W}$) include distance to the nearest Boxer Uprising (D), the list of spatial variables, the interaction between the spatial variables and south, Catholicism, small city, middle city, large city, treaty ports, railways, Grand Canal, *Changjiang* (Yangtze) River, coast, population density (log-term), size (log-term), province dummies, and constant term.

Autarky and the Rise and Fall of Piracy in Ming China

JAMES KAI-SING KUNG AND CHICHENG MA

We examine the impact of rigorous trade suppression during 1550–1567 on the sharp rise of piracy in this period of Ming China. By analyzing a uniquely constructed historical data set, we find that the enforcement of a "sea (trade) ban" policy led to a rise in pirate attacks that was 1.3 times greater among the coastal prefectures more suitable for silk manufactures—our proxy for greater trade potential. Our study illuminates the conflicts in which China subsequently engaged with the Western powers, conflicts that eventually resulted in the forced abandonment of its long upheld autarkic principle.

Piracy was rampant in China between 1550 and 1567, during which time the number of pirate attacks topped 30 each year. This followed nearly two centuries when piracy had been rare with about one incident a year.[1] In these two difficult decades, the Chinese pirates stationed mainly on islands off the southeast coasts raided more than two-thirds of all coastal prefectures and occupied a third of them.[2] Chinese pirates plundered silk and other popular export items, in the process kidnapping, and even killing were common affairs (So 1975; Geiss 1978; Wills 1979).[3] The attacks were severe; they produced

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[1] Numbers are obtained from the *Ming shilu* (Veritable Records of the Ming Emperors) to be introduced in the section "Data."

[2] More than 80 percent of the pirates were ethnic Chinese; the Japanese and Southeast Asians accounted for the remainder (*Ming shilu*). The frequently raided areas included seven prosperous prefectures in the lower Yangzi region—a region that spans the provinces of southern Jiangsu and northern Zhejiang, and Fujian Province (See Li 2000 for the geography of the lower Yangzi region).

[3] While many of these attacks were believed to be modest in scale, involving as they were fewer than one hundred pirates, there were incidences where several thousands of them were found to have been involved in outright military confrontations with the imperial troops.

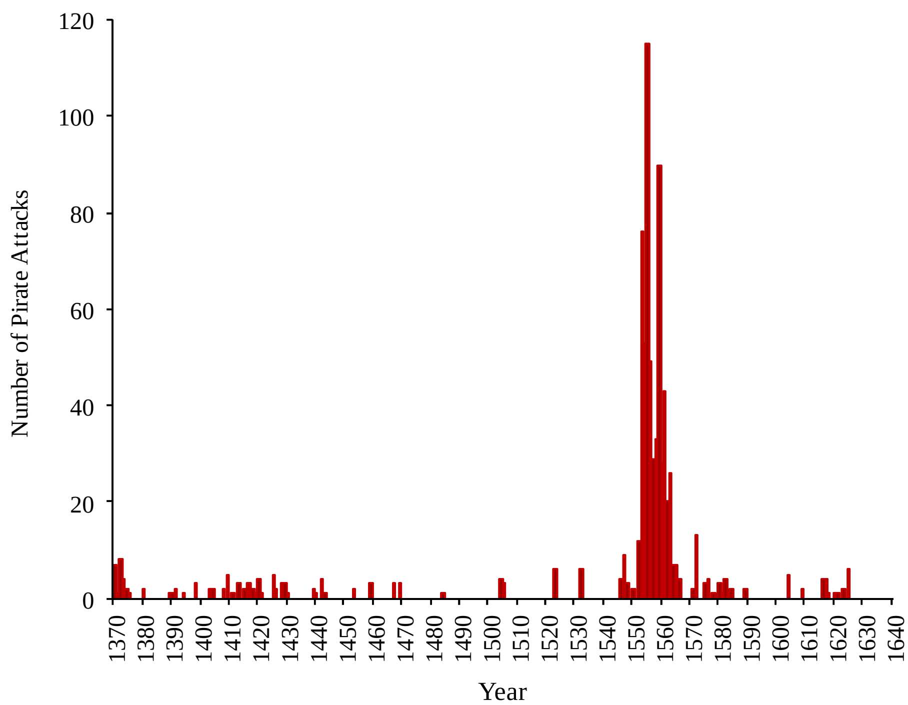

FIGURE 1
NUMBER OF PIRATE ATTACKS ON COASTAL CHINA BY YEAR

Note: Data on pirate attacks are from the *Ming shilu* (1368–1644).

massive casualties, and local populations seemingly devoted large resources to defend themselves; for example, by erecting walls.[4]

The great wave of piracy has two intriguing features. First, the majority of the pirates had actually been Chinese *merchants* before turning outlaws (So 1975; Wills 1979). Second, it waned after 1567 just as suddenly as it had arisen in 1550; henceforth attacks returned to the same low levels that had prevailed before (Figure 1). Local officials and historians have been aware of the fluid boundary between merchants and pirates. Merchants had long carried out trade despite a "sea ban" (*haijin*) policy enacted by the Ming in 1368. Trade, although technically illegal, was widely tolerated until 1550 when the *Jiajing* emperor decided to enforce the ban. While hundreds of "smugglers" were killed, others were prevented from making landfall by Ming's coastal defense force; at the same time, coastal inhabitants found to engage in foreign

[4] Nearly 80 percent (77) of the counties in coastal Jiangsu and Zhejiang Provinces had allegedly built walls, collectively nicknamed "the Southern Great Wall of China," during this period to keep out the pirates (*Zhejiang tongzhi* (Provincial Gazetteer of Zhejiang) 1735; *Jiangnan tongzhi* (Jiangnan Gazetteer) 1736).

trade were executed. This harsh enforcement thus pushed merchants into becoming pirates (So 1975; Geiss 1978; Wills 1979; Boxer 1980; Brook 1998).[5] But as soon as the imperial authorities legalized private foreign trade in 1567, the pirates reverted to their previous roles as merchants.

We use a unique panel data set of pirate attacks that covers all 33 coastal prefectures from 1371 to 1640 and examine the effect of this "sea ban" policy on the rise (and fall) of piracy. In particular, as merchant pirates were primarily concerned with maximizing profits, we examine whether prefectures with greater trade (raid) potential actually suffered from greater pirate attacks after 1550 as a result of the Ming authorities' crackdown on foreign trade. Our primary measure of a prefecture's trade (raid) potential is whether a coastal prefecture in China was a major silk-producing area (*silk center*). As alternative proxies, we also measure what prefectures had already developed a port for conducting foreign trade prior to the Ming dynasty, as well as their urbanization rate around 1390.

The analysis shows that the rise in pirate attacks in mid-sixteenth-century China was due to the rigorous enforcement of the "sea ban." Indeed, pirate attacks on a silk-producing prefecture after 1550 were 1.3 times more likely than on a non-silk center, but not before 1550 or after the policy's abolishment in 1567. These results remain robust to controlling for a number of covariates that may also determine the incidence of pirate attacks; these include the number of famines, population pressure, coastal defense (measured by the number of naval garrisons stationed at the coastline), and the number of islands off a prefecture's coastline. Our results are also robust to the use of a restricted sample that limits the time window to only the same emperor, which helps to avoid the confounding effect caused by the possible heterogeneous preferences regarding foreign trade among the different emperors.

However, our key explanatory variable—a prefecture's trade (raid) potential—is clearly endogenous to possible omitted variables that may be correlated with both pirate attacks and trade (raid) potential, such as knowledge of navigation and ships that would facilitate piracy, and economic prosperity more generally given that the pirates may have been aiming at the treasures of the wealthy (e.g., gold, silver, or even stored grains) rather than the products earmarked for trade.

[5] The dual identity of a merchant pirate cannot be better illustrated by Xu Fuyuan, the governor of Fujian Province at the time: "when the (foreign trade) market is open pirates become merchants, and when the market is closed merchants become pirates" (Chao 2005, p. 203).

To address this concern, we exploit the exogenous variation in trade potential among China's coastal prefectures as our instrumental variable. Premised on the fact that mulberry leaves were a critical input in the upstream production process of sericulture in the historical context of China, we employ the share of land with loamy soil—the texture of which is most suitable for cultivating mulberry trees—to proxy for the suitability of planting this crop to instrument the silk center variable. But since loamy soil is also suitable for planting other staple crops (such as wheat), which were likely closely correlated with the level of income in an agricultural society, it may impact piracy via the channel of economic prosperity rather than trade potential. To allay this particular concern, we control for the percentage of land suitable for planting the major staple crops (wheat, rice, sorghum, soybean, millet, and other minor cereal crops) and the amount of grain tax levied on each prefecture to proxy for the output of staple crops in the Ming dynasty. Our instrumented results remain robust.

Another concern is that the periods selected for our difference-in-differences analysis might be contaminated by the "spillovers" of European trade expansion with China after the Voyages of Discovery (in the late 1490s) and Japanese political turmoil during 1467–1590 (the Warring States period when the lack of centralized political control may have predisposed warlords to prey along the China coast). While our restricted sample which limits the time window to 1522–1572 (that is, within the period of European trade expansion as well as Japan's Warring States period) can address this concern, for robustness we also include two interaction terms—one between trade potential and the number of European ships to Asia, and the other between trade potential and Japan's Warring States period, respectively, as additional controls. The results after adding all these covariates as controls remain robust as well.

Our study has implications for Chinese economic history. If pirate attacks were the unwitting outcome of an autarkic ideology and policy of China's late imperial regimes, their episodic spike foreshadowed a crisis that culminated in the first Opium War of 1839–1842, when China was defeated by Britain and forced to open up to trade.[6] Our study of early pirate attacks thus contributes to the literature that sees autarky as explaining why China's growth trajectory was so different from those of the West (e.g., Elvin 1973; Hall 1986; Landes 2006).[7]

[6] By forcing China to open up five treaty ports on the coast beyond Guangzhou, the Opium War effectively ended China's long-standing autarky (see, e.g., Spence 1990).

[7] A natural extension of our study is to examine if there are any long-term effects of pirate

HISTORICAL BACKGROUND

Most people who lived on the southeastern coast of China depended heavily on maritime commerce for their livelihood (So 1975). China's maritime trade with Japan, Korea, Southeast Asia, India, and Arabian countries had prospered as early as the seventh century. Historians have noted that China's maritime commerce was already flourishing by the Song dynasty, 960–1279 (Elvin 1973). This prosperity seems to have persisted into the early Ming period as Chinese merchants visited ports in Japan, Southeast Asia, and India frequently (Brook 1998; Findlay and O'Rourke 2007). Moreover, China's commercial prosperity is also borne out by the three hundred or so tributary trips made to the Ming court by ambassadors from about sixty different Asian countries between 1400 and 1500 (*Daming huidian* (Collected Statutes of the Ming Dynasty) 1502).

After 1500 Europe's trade with China began to rise. Thanks to Vasco da Gama's discovery of the Cape of Good Hope route to Asia in the late 1490s Europeans expanded their trade into China, whose products—particularly silk—enjoyed immense demand in Europe at the time (Elvin 1973; Ma 1998; Brook 1998; O'Rourke and Williamson 2002). As a result, the China coast witnessed a notable influx of European merchant explorers between 1517 and 1550.[8]

Lured by the growing demand for Chinese goods and the greater profitability of foreign trade, many merchants on the China coast began to trade with both Europeans and other Asians.[9] By the 1540s maritime trade in China had become very active. Altogether more than one hundred and thirty Chinese merchant groups coexisted at the time, quite a few of them allegedly had a crew of several thousands and were armed (Chen 1934). These groups formed a powerful alliance under the leadership of Wang Zhi—the most powerful merchant pirate at the time who allegedly had a fleet that numbered several hundreds and a crew

attacks on economic development, as history is replete with anecdotal evidence that many coastal towns and cities that were once prosperous hardly ever revived after having been dealt a blow by the pirates (Geiss 1978; Lin 1987; Von Glahn 1996; Zheng 2001). Such an endeavor, however, is beyond the scope of this study.

[8] Before the Voyages of Discovery very few European traders travelled to China by sea. Since the 1500s approximately one hundred and eighty Europeans (mainly Portuguese) were found to have stationed on the islands off the Chinese coast in the 1520s, and by the 1550s the number had increased to over six hundred, and to about one thousand by the 1620s (Chao 2005; Ljungstedt 1836; Ptak 1982).

[9] The lucrative profitability of trading is well-illustrated by the evidence that, whereas one *dan* (approximately 50 kg) of raw silk was sold for 100 *silver liang* (approximately US$20 today) in China's lower Yangzi region, it could be sold for 500 *silver liang* in the Philippines in the 1580s (Quan 1986). See also Findlay and O'Rourke (2007).

of more than one hundred thousand at his command (Wills 1979; Chao 2005).[10] To facilitate trade and to escape surveillance, these Chinese merchants established trading bases on the islands off the southeastern coast of China and west of Japan (Figure 2).[11] These illicit traders would acquire goods along the coast and ship them from their bases to the foreign traders (Wills 1979; Chao 2005). Historians regard such trading between Chinese and foreign merchants as "regular" (Brook 1998, p. 124). As a result, some islands off the coastal provinces of Fujian and Zhejiang, which prior to 1517 had been nothing more than sleepy towns, had become bustling metropolises by the 1540s.[12]

Unfortunately, China's expanding foreign trade was hindered by the Ming dynasty's 1368 "sea ban." This policy prohibited the Chinese people from engaging in foreign or specifically maritime trade. The so-called trade in Ming China was confined to primarily "tributary trade"—a form of limited "commerce" in which China asserted itself as the hegemonic power, with the vassal states making periodic trips of homage to the imperial court to offer gifts to the emperor in exchange for a limited amount of goods (Fairbank 1968). There are different views regarding the imposition of the "sea ban." Some suggest the emperor banned trade to avoid coastal unrest due to interactions between the Chinese and the foreigners (Fairbank 1968; Chao 2005). Others see the ban as reflecting an imperial preference for an autarkic economy and a policy that followed the Confucian ideology of "putting agriculture before business (*zhongnong qingshang*)" (Boxer 1980; Brook 1998; Landes 1998).

Until the 1550s the imperial authorities tolerated the budding trade along the China coast.[13] But then a crackdown began and the Ming armies scuttled more than 1,200 illicit boats and killed hundreds of smugglers in 1548 and 1549 (Wills 1979; Chao 2005). To further curtail smuggling, coastal defense forces now effectively prevented merchants from making landfall, let alone doing business as they had been allowed.[14] At the

[10] The other well-known merchant pirates were Xu Hai, Xu Dong, Li Guangtou, Mao Haifeng, and Peng Lao, most of who were from southeast China (Chen 1934; Chao 2005).

[11] Wang Zhi, for instance, lived in western Japan for the most part.

[12] According to one estimate (Lin 1987), there were at least fourteen major trading bases off the China coast during the mid-sixteenth century, of which Shuangyu Island (near Ningbo Prefecture, Zhejiang Province) was the largest and most prosperous (Figure 2). According to some Ming officials, in 1548 coastal prefectures in Zhejiang and Fujian provinces saw fleets of commercial vessels commuting back and forth up to thirty times a day (*Huangming jingshi wenbian* (Writings on Statecrafts in the Ming Empire) 1643).

[13] However, some attribute this tolerance to the Chinese merchants' bribery of the corrupt coastal officials in exchange for their acquiescence and protection (Skinner 1985; Brook 1998).

[14] The ban did not lead to a complete stoppage of production (in particularly for silk), because

same time, the imperial authorities relied on neighborhood *pai jia* to discourage coastal inhabitants from trafficking with merchants. Every ten households were organized into a single unit of *pai*; if someone in a *pai* was caught committing the pertinent crime then all ten households in that *pai* would be executed (Hu 1987; Brook 2005).[15]

An unwitting outcome of these draconian measures adopted by the Ming authorities was that they created incentives for the merchants who had settled on the nearby islands to raid China's coastal cities and towns.[16] They turned to piracy because it was the only way to get access to trade goods and recapture the profits they lost from the ban. As Wang Zhi—the head of the merchant pirate alliance, once declared: "…if [the authorities] resume the customs in the ports of Zhejiang, and permit the people to trade with Japan, the pirates would not come again.…" (Chao 2005, p. 196). The rise of pirate attacks along the China coast is demonstrated in Figures 1 and 2. After nearly two centuries of isolated pirate attack, they jumped to 30 a year starting in 1550 and the manufacturing centers of the lower Yangzi region and Fujian Province were their primary targets.

But the imperial authorities' attempt to suppress piracy "backfired"—to borrow Charles C. Mann's (2011) word—when pirate attacks surged. After a decade and a half, the imperial authorities softened its stance regarding the legitimacy of maritime trade as it became aware of the pirates' raids and the consequent sharp deterioration in living standard in the distressed coastal communities (Von Glahn 1996; Brook 1998).[17] *Longqing* assumed the imperial throne in 1567 and quickly legalized foreign trade by issuing licenses to Chinese junks.[18] As Figure 1 shows, pirate activities plunged and remained low until the end of the Ming dynasty in 1644.

they faced sustained demand both in the domestic market and from the imperial authorities (Fan and Jin 1995).

[15] The primary goals of the scheme (enacted around 1550) were to curtail smuggling in the coastal provinces in the southeast and banditry in the inland provinces. We know from available evidence that this scheme was widely adopted in the coastal provinces of Fujian, Zhejiang, and Guangdong after 1550, and later extended to most other provinces (Brook 2005). We have however no systematic information on the number of people who were punished because of trade violations.

[16] Note that the merchant pirates seldom attacked their own hometowns but raided other places with high trade potential. This is evident from the fact that pirates originating from Fujian Province raided the provinces of Zhejiang and Jiangsu (*Ming shilu*).

[17] The majority of coastal inhabitants relied heavily on maritime commerce, and many local officials repeatedly petitioned the emperor to relax the "sea ban" policy to reduce the economic cost to their communities (So 1975; Chao 2005).

[18] Trade with any country, except Japan, became legal. However, the licensing system broke down by the 1620s as the Ming dynasty went into decline. See Von Glahn (1996, p. 118) for details on China's licensed foreign trade after 1567.

DATA

To test the hypothesis that the sharp rise in pirate attacks in China in the 1550s was caused by the prohibitions on foreign trade by the Ming authorities, we construct an annual panel data set that ranges over all 33 coastal prefectures from 1371 to 1640.[19] We begin our analysis from 1371—two years after the founding of the Ming dynasty and end our analysis in 1640—four years before the end of the Ming dynasty. In both cases, the censoring is designed to avoid the unrest associated with dynastic transitions.

Pirate Attacks

Our dependent variable is measured by the annual number of attacks made on a coastal prefecture. An attack occurred when pirates used violence in order to secure goods in the coastal towns and cities of China. The data come from the *Ming shilu* (Veritable Records of the Ming Emperors), the official record of imperial edicts and official memorials about events of national significance. It provides the time and place of each attack but it only provides further details irregularly.[20] To curtail smuggling and piracy, the Ming authorities had already set up a vigorous coastal defense system of 450 naval garrisons (*weisuo*) manned by 100,000 soldiers in the 1380s. In any case, pirate attacks were violent: plundering, looting, and even murder, they were thus hard to miss.

We compared the lists of attacks drawn from the *Ming shilu* with the *Mingdai wokou kaolue* (Investigation into Piracy in the Ming Dynasty; Chen 1934). The author of this highly specialized publication carefully documented the time and place of each pirate attack based on historical sources different from the *Ming shilu*.[21] The two sources are very

[19] A prefecture was an administrative unit ranking below a province and above a county in Ming China's administrative structure which has remained valid to this day. We use the longer period of 1371–1640 for our baseline regression to reflect the change in piracy in the entire Ming period. We also use the shorter period of 1522–1572 to check the robustness of our main results (Table 4).

[20] Two examples of pirate attacks as they were documented in the *Ming shilu*: Case 1: "The fifth year of *Hongwu* emperor (1372), August: Pirates attacked Funing County of Fuzhou Prefecture (in Fujian Province), plundering and killing over three hundred and fifty local inhabitants, and burning more than one thousand houses" (*Ming shilu*, volume 75 of the *Taizong* emperor reign). Case 2: "The thirty-third year of *Jiajing* emperor (1554), March: More than two thousand pirates landed in Nansha and plundered the prefectures of Suzhou and Songjiang (in Jiangsu Province). The General Tang Kekuan led the imperial army to counter the pirates at Caitaogang, killing over one hundred and eighty pirates" (*Ming shilu*, volume 408 of the *Shizong* emperor reign).

[21] These sources included *Huangming yuwo lu* (Records on the Resistance Against Piracy in

consistent; the correlation is strong between the two sets of data (0.82, significant at the 1 percent level). The advantage of Maoheng Chen's (1934) work derives from its reliance on a variety of historical sources; this allows the omission by some authors to be amended by others, and thus provides useful cross-referencing. However, Chen's relied heavily on local gazetteers. Since only the more affluent prefectures/counties had the wherewithal to compile local gazetteers, selection bias may be a problem. In the light of these considerations, we base our empirical analysis on the *Ming shilu* and use Chen's (1934) data for robustness checks.

Trade Potential

Silk Center. Silk was in high demand abroad during the sixteenth century (Brook 1998; Ma 1998). Our empirical analysis exploits the regional variation in the potential for silk trade (or raid in the case of pirate attacks). We do so because silk was the most sought-after good among the pirates: "…the treasure that pirates sought was silk. When they found the workshops of silk production, they jumped for excitement…they even kidnapped Chinese women to secret spots and forced them to weave silk" (Chao 2005, p. 192).[22] We thus employ a dummy variable indicating whether the imperial authorities had set up a silk bureau in that prefecture (as reported by Fan and Jin 1993). Analogous in status to state-owned enterprises in contemporary times, these bureaus produced a variety of silk products for use by royal personnel and government officials and located in centers of local production. Of the 33 coastal prefectures in Ming China, 11 were silk centers. This variable is time-invariant because the geographic distribution of silk production rarely changed over time.

However, since China also exported many other commodities such as porcelain, tea, paper, and sugar (Brook 1998), the silk center variable does not fully capture the trade potential of China's coastal prefectures. To address this inadequacy, we employ two additional measures to proxy for trade potential.

Imperial Ming) (1596), *Chouhai tubian* (The Atlas of Coastal Defense) (1562), *Yanhai woluan benmo* (The Causes of Pirate Unrests on the Coast) (1658), *Ming shi* (History of the Ming Dynasty) (1739), *Wobian shilue* (A Brief Account of Pirate Unrest) (1558), *Jinghai jilue* (A Brief Record of Eradicating Piracy) (1630), as well as a rich array of local gazetteers. See Chen (1934).

[22] The strong demand for Chinese silk is further evidenced by the fact that in the 1580s, after the "sea ban" policy was removed, the import of Chinese silk contributed over 90 percent of customs revenue in Manila—the major port for transpacific trade in Asia (Quan 1986).

Historical Port. Our first alternative measure is a dummy variable that is coded 1 if a prefecture had developed a port for conducting foreign trade during the Song and Yuan dynasties (906–1368)—a time when China's maritime commerce began to prosper. Given that China's pre-Ming overseas trade was concentrated in ports like Quanzhou and Ningbo (in the southeastern region), the potential for foreign trade was likely greater in prefectures with such facilities. In fact, the bulk of trading activities that occurred prior to the advent of the great wave of pirate attacks took place near the ports in Quanzhou (the island of Yuegang, for instance) and Ningbo (the island of Shuangyu). Of the 33 coastal prefectures in total in Ming China, 12 had a historical port.

Urbanization. Another proxy for trade potential is the urbanization rate. As Paul Bairoch (1988) and Jan de Vries (1976) have pointed out, prior to the Industrial Revolution only prosperous areas were able to support dense urban populations. In the absence of reliable GDP figures, urbanization rate is thus a reasonable proxy for the economic prosperity of preindustrial societies. China is no exception: historians of China have indeed found that the urbanization rates were closely correlated not only with the level of commercialization but also with exports (Skinner 1977; Xu and Wu 2000).[23] We draw the share of the population living in settlements larger than 1,000 inhabitants by prefecture in the 1390s from Shuji Cao (2000). The mean urbanization rate among the coastal prefectures of Ming China is 11.3, with a maximum of 28.3.

Figure 2 shows how many pirate attacks each coastal prefecture suffered between 1550 and 1567 and the locations of silk centers. As one can readily see, pirate attacks were concentrated in silk centers. In sharp contrast, few attacks were observed in north China, where the potential for trade was limited. Note that few pirate attacks occurred on the coast of Guangdong Province or more specifically the Pearl River delta region. While the capital, Guangzhou, had been an important trading port since the seventh century, the coast of the province produced much less silk than either the lower Yangzi region or coastal Fujian Province in the Ming and early Qing period and it was less urbanized. So it is not so surprising that attacks in the Pearl River delta region were less frequent.

[23] Li (2000) has found that regions specialized in producing silk, porcelain, and other exports in late imperial China were also more developed in their off-farm sectors, and were more urbanized. Fu (1989) also attributes the growth of the lower Yangzi region (particularly the prefectures of Suzhou, Huzhou, Shengze, and Puyuan) during the Ming and Qing dynasties to the rise of a silk industry and a flourishing commerce.

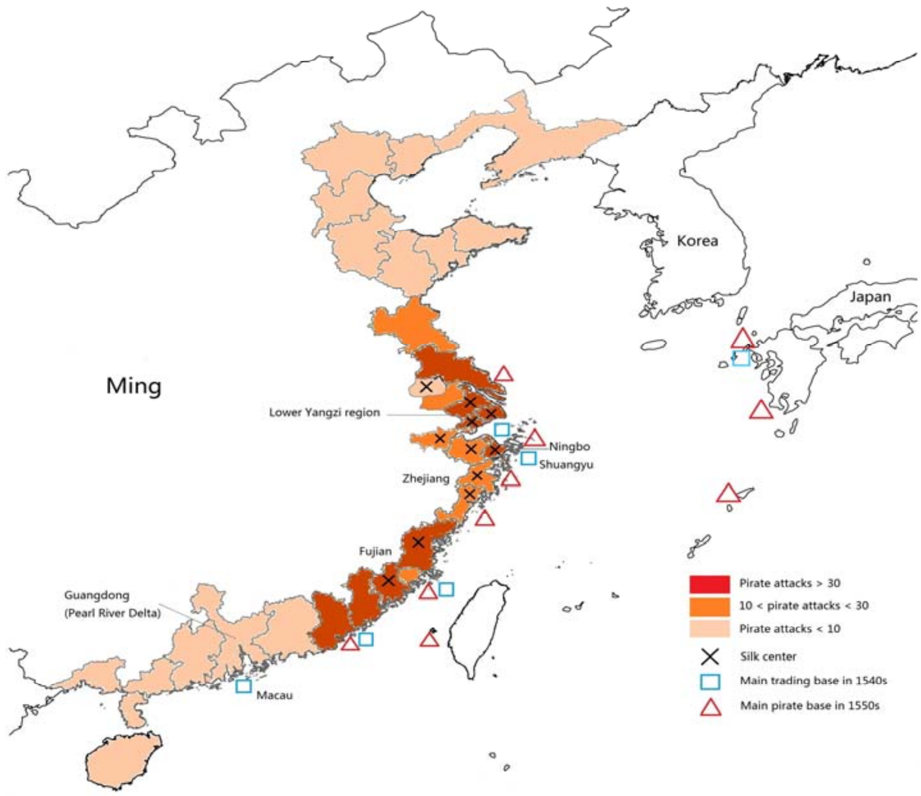

FIGURE 2
PIRACY IN MID-SIXTEENTH CENTURY CHINA

Notes: Pirate attacks refer to the total number of pirate attacks between 1550 and 1567, enumerated based on the *Ming shilu.* The location of a silk center is based on Fan and Jin (1993). The locations of trading bases and pirate bases are based on Wills (1979) and Chao (2005). The map of Ming China (of the year 1391) is based on CHGIS, Version 4, Harvard-Yenching Institute (2007).

Controls

Famine. There are several social forces that might spur pirate attacks. The first pertains to famine or negative economic shocks, which have been documented to trigger conflict (Miguel, Satyanath, and Sergenti 2004; Bai and Kung 2011). Historians of China have indeed made the case that famine led to piracy in Ming China (So 1975; Brook 1998). To control for its possible effect on pirate attacks, we control for the number of famines that had occurred in a prefecture on an annual basis.[24]

[24] Those suffering from famine likely raided neighboring prefectures, so we employ

Population Density. Population pressure is another potential source of conflict (Malthus 1798; Bruckner 2010). Chinese historians have documented a rapid increase in population in the latter half of the Ming dynasty (Ho 1959; Cao 2000). Faced with land scarcity, coastal populations could turn to maritime trade, but were likely compelled to resort to pirate attacks when trade was banned. We thus need to control for China's growing population. The data here are scarcer and we are only able to produce provincial population density for the periods of 1370s–1460s, 1470s–1550s, and 1560s–1640s.[25]

Islands. Pirates used offshore islands to launch attacks on the coasts and to sell the raided goods for export. In fact, the intensity of pirate attacks on Zhejiang and Fujian is partly due to the vast number of uninhabited islands off the coasts of these two provinces.[26] But islands should not play a decisive role in the rise and fall of piracy, based on the fact that over time pirate attacks had shifted from the eastern and southeastern coasts—for instance, from the coasts of Zhejiang and Fujian Provinces during the sixteenth century—to the Pearl River delta region in the south in the late eighteenth and early nineteenth centuries (Antony 2003). To control for the possible influence of islands and their varying effects over time, we employ an interaction term between the number of islands off a prefecture's coastline (*islands* hereafter) and the pertinent time dummies.[27]

Naval Deterrence. Last but not least, we control for the number of naval garrisons per prefecture, as they were the most direct deterrent of pirate activities.

The definition, sources, and descriptive statistics (mean and standard deviation) of the main variables employed in this analysis are summarized in Table 1.

the number of famines in adjacent, coastal prefectures as an alternative measure and obtain similar results (not reported).

[25] As with the case of famine, those in provinces where population pressure was greatest were more likely to raid provinces other than their own. We thus also use mean population density in neighboring coastal provinces as an alternative measure and obtain similar results.

[26] The islands of Zhoushan off the coast of Zhejiang Province and the Islands of Penghu off the coast of Fujian Province are among some prominent examples.

[27] The map of the islands in 1391 is based on Harvard-Yenching's (2007) CHGIS (China Historical Geographic Information System). At that time, the islands identified in the CHGIS were located within 1,572.50 kilometers from the Ming coastline (the farthest being a group of islands in Nansha, near Southeast Asia). For each island, we calculate the distance between its central point and the midpoint of the coastline of each prefecture, and choose the shortest distance to identify the particular prefecture to which an outlying island correspondingly belonged.

TABLE 1
SOURCE OF VARIABLES AND DESCRIPTIVE STATISTICS

Variable	Source	Mean	S.D.	Min	Max
Pirate attacks	*Ming shilu* (Veritable Records of the Ming Emperors)	0.09	0.81	0	25.00
Silk center	Fan and Jin (1993)	0.33	0.47	0	1.00
Historical port	Sun (1989)	0.36	0.48	0	1.00
Urbanization	Cao (2000)	11.30	5.90	0	28.30
Famine	Meng (1999)	0.67	1.02	0	5.00
Naval deterrence	*Chouhai tubian* (The Atlas of Coastal Defense)	2.27	1.00	0	4.08
Population density	Liang (1980)	3.49	0.95	2.22	6.04
Islands	CHGIS, Version 4, Harvard-Yenching Institute (2007)	5.79	13.13	0	72.00
Loamy land	Harmonized World Soil Database (HWSD), FAO and IIASA (2007)	0.40	0.41	0	1.00
Suitability for staple crops	Global Agro-Ecological Zones (GAEZ), FAO (2002)	3.12	1.21	1.76	5.76
Grain tax (in *shi*)	*Daming yitongzhi* (Comprehensive Records of the Great Ming Dynasty)	452.94	840.94	5.20	3,960.64
European ships (in 1,000 tons)	De Vries (2003)	29.78	3.62	0	120.94

Notes: See the text.
Sources: See the text.

EMPIRICAL STRATEGY AND RESULTS

We start with some simple tests of our hypothesis that pirate attacks on prefectures with greater trade potential rose rapidly after the 1550 imperial suppression of export trade, and declined sharply after 1567 upon the removal of the "sea ban" policy. To provide a benchmark, we estimate a fully flexible equation that assumes the following form

$$piracy_{it} = TP_i \times year_t + X'_{it} + prefecture_i + year_t + e_{it} \tag{1}$$

where $piracy_{it}$ stands for the number of pirate attacks on a prefecture in each year, and TP_i refers to whether a prefecture was a *silk center*. X'_{it} is a vector of other covariates (*famine*, *population density*, *naval deterrence*, and the interaction terms between *islands* and a full set of year dummies); $prefecture_i$ denotes the prefecture-fixed effects capturing all time-invariant and prefecture-specific characteristics (such as geography, culture, and historical background); $year_t$ denotes the time-fixed effects controlling for the common shocks to piracy in all the prefectures; and e_{it} is the disturbance term. The set of interaction terms between *silk center* and a full set of year dummies, viz. $TP_i \times year_t$, are the key estimates. These interaction terms are intended to capture the differential intensity of pirate attacks between prefectures that were designated silk centers and those that were not on an annual basis. To the extent that the surge in piracy was caused by the intensified suppression of trade, we expect the coefficients of TP_i to be significantly greater in magnitude between 1550 and 1567 but constant before 1550 and after 1567.

The flexible estimation results are reported in Figure 3, in which we plot the coefficients of the interaction term $TP_i \times year_t$ using *silk center* as the proxy for TP_i. The results using *historical port* or *urbanization* are extremely similar. It is striking that, regardless of how trade potential is measured, prefectures with greater trade potential did not experience more pirate attacks until 1551. After 1551 the coefficient of the pertinent interaction term jumps up consistent with the idea the emperor's suppression of foreign trade had forced the merchants into piracy. Equally striking is the differential intensity in pirate attacks between prefectures with varying trade potential disappears at the end of the 1560s.

Next, we estimate the same set of relationships with a structured specification

$$piracy_{it} = TP_i \times Post1550 + TP_i \times Post1567 + X'_{it} + prefecture_i + year_t + e_{it} \quad (2)$$

where all variables are defined in the same way as in equation 1. The only difference between equation 1 and equation 2 is that in equation 2 we interact TP_i with only the two pertinent time dummies of *Post*1550 and *Post*1567 (instead of each year). The main results of equation 2 are reported in Table 2. In Panel A, trade potential is measured by *silk center*, and in Panels B and C by *historical port* and *urbanization*, respectively. In all cases, we control for the prefecture-fixed effects and year-fixed effects, and use robust standard errors clustered by prefecture to control for possible correlation within a prefecture. Reported in column 1, our benchmark OLS estimate shows that pirate attacks on silk centers rose significantly from 1550 to 1567. In terms of magnitude, the size of the pertinent coefficient (of 1.308) indicates that the average number of pirate attacks on the silk centers increased by 1.3 times more than the non-silk centers after the Ming cracked down on foreign trade (i.e., *Silk center* × *Post*1550). Conversely, the significantly negative coefficient of –1.307 for the *Post*1567 period suggests that after maritime trade was sanctioned pirate attacks on the silk centers returned to the common low prior level.

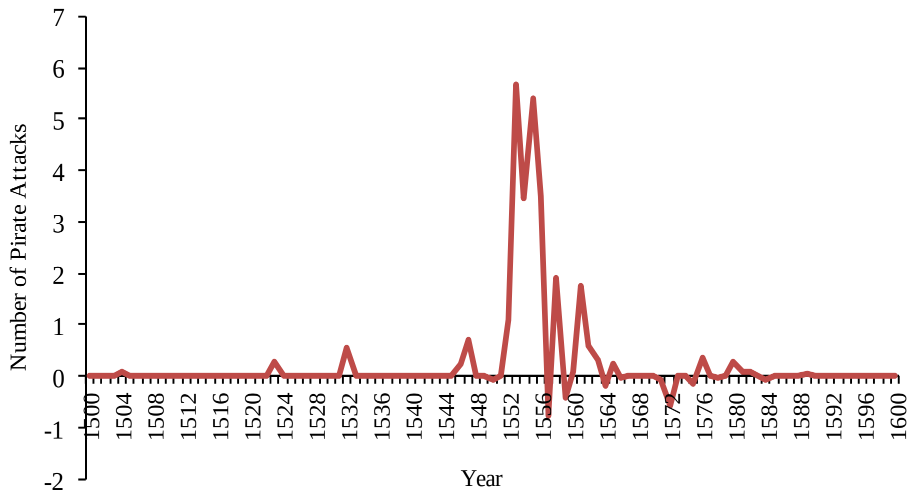

FIGURE 3
COMPARISON OF PIRATE ATTACKS ON THE SILK CENTERS AND NON-SILK CENTERS, BY YEAR

Notes: To highlight the difference in pirate attacks between the silk and non-silk centers, we focus on the shorter window of 1500–1600. The same results are obtained using the full period of 1371–1640.

In column 2 of Table 2, we include in the regression all other covariates, namely *famine*, *population density*, *naval deterrence*, and the interaction terms between *islands* and the two policy dummies.

Estimates on the two interaction terms are strikingly similar to those reported in column 1 in terms of both level of significance and magnitude. In addition, given that the dependent variable is left censored (nearly 90 percent of the values are zero), we use a Tobit estimation. Reported in column 3, the results are strikingly similar; this lends greater credence to our baseline results. We also aggregate the data into decades and perform the same estimations in columns 4 and 5 (instead of 1567, 1570 is thus used as the cutoff date of the removal of the "sea ban" policy). To ensure that data obtained from *Ming shilu* are reliable, we employ Chen's (1934) data on piracy as a robustness check. Reported in column 6, the coefficients match those based on the *Ming shilu* (columns 1 and 2).

Panels B and C of Table 2 report the estimates using *historical port* and *urbanization* as the alternative measures of trade potential, the results of which are also strikingly similar. For example, the

TABLE 2
CAUSE OF PIRATE ATTACKS: MAIN RESULTS

	The dependent variable is *pirate attacks*					
	Yearly Data (*Ming shilu*)	Yearly Data (*Ming shilu*)	Yearly Data (*Ming shilu*)	Decadal Data (*Ming shilu*)	Decadal Data (*Ming shilu*)	Yearly Data (Chen 1934)
	OLS	OLS	Tobit	OLS	Tobit	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A						
Silk center × *Post*1550	1.308*** (0.366)	1.288*** (0.368)	2.275*** (0.092)	10.895*** (3.132)	12.178*** (2.616)	1.486*** (0.401)
Silk center × *Post*1567	–1.307*** (0.367)	–1.306*** (0.369)	–2.501*** (0.169)	–11.056*** (3.149)	–13.351*** (2.784)	–1.512*** (0.403)
R-squared	0.23	0.23	0.34	0.47	0.23	0.24
Panel B						
Historical port × *Post*1550	1.410*** (0.393)	1.400*** (0.390)	2.421*** (0.092)	11.854*** (3.321)	13.275*** (2.829)	1.277*** (0.424)
Historical port × *Post*1567	–1.409*** (0.395)	–1.416*** (0.393)	–2.867*** (0.171)	–12.008*** (3.348)	–14.951*** (3.007)	–1.299*** (0.427)
R-squared	0.24	0.23	0.34	0.49	0.23	0.23
Panel C						
Urbanization × *Post*1550	0.127*** (0.026)	0.126*** (0.027)	0.282*** (0.005)	1.072*** (0.226)	1.429*** (0.224)	0.131*** (0.021)
Urbanization × *Post*1567	–0.126*** (0.027)	–0.127*** (0.027)	–0.158*** (0.010)	–1.073*** (0.234)	–1.225*** (0.226)	–0.131*** (0.022)
R-squared	0.25	0.24	0.34	0.51	0.24	0.25
Controls in each panel:						
Famines	No	Yes	Yes	Yes	Yes	Yes
Population density	No	Yes	Yes	Yes	Yes	Yes
Naval deterrence	No	Yes	Yes	Yes	Yes	Yes
Islands × *Post*1550	No	Yes	Yes	Yes	Yes	Yes
Islands × *Post*1567	No	Yes	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,910	8,910	8,910	891	891	8,910

TABLE 2 — continued

*** = Significant at the 1 percent level.
Notes: Robust standard errors are clustered by prefecture and reported in parentheses. In columns 4 and 5, 1570 (instead of 1567) is employed as the year in which the "sea ban" policy was removed.

the coefficients of *historical port* are very close to those of *silk center* in terms of both magnitude and level of significance.[28] Regarding the effect of *urbanization*, the estimates in column 2 suggest that after 1550, an additional percentage point of the urbanization rate increases the number of pirate attacks by a 13 percentage points each year, and *decreases* the number of pirate attacks at the same rate after 1567.[29] These results lend further support for the finding that the rising incidence of piracy in mid-sixteenth-century China was caused to a much larger extent by the imperial authorities' crackdown on foreign trade.

ROBUSTNESS CHECKS

Instrumented Evidence

Our key explanatory variable—a prefecture's trade potential (TP_i)—is the outcome of a complex social process. One might well worry that our estimations is biased by some omitted variables that are correlated with both *pirate attacks* and trade potential. For instance, it is likely that those living in regions with more maritime trade would more likely possess skills—such as knowledge of navigation and ships—that would facilitate piracy. Another possible omitted variable is level of income. Prefectures with greater trade potential were usually richer. The pirates may have been aiming at the treasures of the wealthy (e.g., gold, silver, or even stored grains) rather than the products earmarked for trade. Should that be the case, our hypothesis of pirate attacks being triggered by the authorities' suppression of trade would have violated the exclusion restrictions condition. There is also a concern about measurement error. Despite our effort in constructing three measures to proxy for a prefecture's trade potential, it would be unrealistic to expect them to fully capture the variable in question. Hence, the estimates will remain attenuated.

[28] We also employ the number of years a historical port had acquired its status as an alternative measure of trade potential and obtain similar results.

[29] To fully measure the variations in trade potential, we also aggregate the three variables into a single index by taking their first principal components. The results are similar to those using a single measure and thus are not reported separately.

To address these concerns, we exploit the exogenous variation in trade potential among China's coastal prefectures using the suitability of soil for growing mulberry leaves as the instrumental variable for silk center. Until the early 1920s mulberry plantation was an integral part of sericulture. Silkworms, whose cocoons produce the raw silk fiber, grow by eating mulberry leaves. Thus prior to any extensive production of raw silk mulberry trees must be planted. Then during the intensive feeding periods, the leaves must be stripped from the trees so that the worms can get fresh food five or six times a day (Bell 1999). Because mulberry leaves are highly perishable they were difficult to transport over any distance, most raw silk production facilities were thus located in sites where it was feasible to plant mulberry on a large scale (Fan and Jin 1993). This depends crucially on the soil.

Mulberry trees need well-drained soils. On the China coast, loamy soil is thus the most suitable for large-scale mulberry plantations (Dai 1934). Soil texture is exogenously determined and, although its spatial distribution is likely correlated with mulberry plantation and silk production, it should have no direct correlation with pirate attacks, and hence is a plausible instrumental variable for silk center. We calculate the percentage of loamy land in a prefecture (*loamy land* hereafter) based on the Food and Agriculture Organization's Harmonized World Soil Database (HWSD). The texture of soil does not change over time (Rowell 1994), so contemporary data on soil texture is thus a valid proxy for soil texture in Ming times.[30]

A drawback of using *loamy land* as instrument is that this type of land is suitable for cultivating much more than just mulberry trees; including many other (non-exported) staple crops such as wheat, rice, and millet. In an agricultural society like Ming China, the output of these staple crops was closely correlated with the level of income or economic prosperity. As a result, the areas dominated by loamy land may experience more pirate attacks because of their economic prosperity (grains, not merely silk, were there to be plundered). To address this concern, we use two proxies that are likely to control for the impact of loamy soils on prosperity to some extent. The first is land suitability for planting the major staple crops, which is calculated based on the combination of climate, soil, and slope characteristics

[30] In addition, mulberry also grows better when the soil pH-value lies somewhere between 6.5–7.5 (in a range of approximately 4.5–8.5 in China). Our results (not reported) change little when we use the percentage of loamy land and the percentage of land with a pH-value of 6.5–7.5 as instruments. However, this result should be interpreted with caution since soil pH-value can be affected by human intervention.

[Food and Agriculture Organization, 2002 Global Agro-Ecological Zones (GAEZ) database]. The GAEZ data base provides from 0 (very unsuitable) to 9 (very suitable) index of land suitability for all the major staple crops grown in the Ming dynasty: wheat, rice, sorghum, soybean, millet, and other minor cereal crops such as broomcorn millet.[31] For each prefecture, we take the average of the indices of the six major staple crops outlined above to be our measure of land suitability for these crops.

The advantage of using land suitability for staple crops is that it is exogenously determined (Nunn and Qian 2011), yet it reveals nothing about the actual output of these crops. As an alternative, we use the volume of the grain tax levied on each prefecture. Indeed taxes were likely correlated with agricultural output. Specifically, we use the amount of grain tax (measured in *shi*, a volume measure in imperial China; one *shi* is equivalent to 100 liters) per km^2 collected from each prefecture in the 1460s as the pertinent measure. The tax data are obtained from *Daming yitongzhi* (Comprehensive Records of the Great Ming Dynasty), which was compiled in the 1460s.

We report the instrumented results in Table 3. Because the endogenous variable is an interaction term between *silk center* and the time dummies, the instrumental variable should also be an interaction term between *loamy land* and the same set of time dummies accordingly. We begin our regressions without including any covariates in column 1, and in column 2 we add back all the controls, including land suitability for cultivating the staple crops, amount of grain tax, and their interactions with the specific time dummies. The 2SLS results are consistent with those of the OLS (Table 2) in terms of both direction and level of significance. Moreover, the magnitudes of the instrumented estimates of the two interaction terms are greater than those of the OLS results by about two times, suggesting that the OLS estimates of the effect of *silk center* on *pirate attacks* were likely attenuated by omitted variables and measurement error.

Restricted Reference Period

Another concern is that the reference period (1371–1550) in our difference-in-differences analysis is very long. Indeed a total of 12 emperors ruled over China over that time, and each may have

[31] As for *loamy land*, we calculate the approximate percentage of land in a prefecture suitable for cultivating these staple crops after matching the land suitability map with the map of the Ming's prefecture-boundary.

TABLE 3
CAUSE OF PIRATE ATTACKS: INSTRUMENTED RESULTS

	The dependent variable is *pirate attacks*	
	(1)	(2)
Silk center × *Post1550*	2.567***	3.087***
	(0.421)	(0.907)
Silk center × *Post1567*	−2.516***	−3.122***
	(0.447)	(0.899)
Famines	No	Yes
Population density	No	Yes
Naval deterrence	No	Yes
Islands × *Post1550*	No	Yes
Islands × *Post1567*	No	Yes
Suitability for staple crops × *Post1550*	No	Yes
Suitability for staple crops × *Post1567*	No	Yes
Grain tax × *Post1550*	No	Yes
Grain tax × *Post1567*	No	Yes
Year-fixed effects	Yes	Yes
Prefecture-fixed effects	Yes	Yes
Observations	8,910	8,640

*** = Significant at the 1 percent level.
Notes: Robust standard errors clustered by prefecture are reported in parentheses. The table reports the second-stage results of the 2SLS estimations in which *silk center* is instrumented by *loamy land*.

had different approaches to foreign trade, and the enforcement of the “sea ban.” We shorten our reference period to 1522–1549 so that it is contained in the same single imperial reign (that of *Jiajing*) as the treatment period (1550–1567). Likewise, we also exclude the years after 1572, as it was *Longqing* emperor who abolished the ban in 1567. For robustness reason, we also arbitrarily restrict the sample period to 1530–1587, i.e., only 20 years before the “sea ban” became intensified and 20 years after its eventual abolition. Reported in Table 4, the results based on these two restricted periods do not differ from the main findings—the effect of the “sea ban” policy remains positive and significant.

Europe and Japan’s Role in Policy Change

Our difference-in-differences estimation requires that there were no other shocks—especially shocks that are correlated with *pirate attacks*

TABLE 4
ROBUSTNESS CHECKS USING RESTRICTED SAMPLES

	The dependent variable is *pirate attacks*	
	1522–1572	1530–1587
	(1)	(2)
Panel A		
Silk center × *Post1550*	1.348***	1.336***
	(0.405)	(0.399)
Silk center × *Post1567*	−1.410***	−1.326***
	(0.373)	(0.358)
Panel B		
Historical port × *Post1550*	1.586***	1.511***
	(0.397)	(0.398)
Historical port × *Post1567*	−1.430***	−1.413***
	(0.413)	(0.388)
Panel C		
Urbanization × *Post1550*	0.136***	0.133***
	(0.028)	(0.029)
Urbanization × *Post1567*	−0.135***	−0.127***
	(0.027)	(0.026)
Controls in each panel:		
Famine	Yes	Yes
Population density	Yes	Yes
Naval deterrence	Yes	Yes
Islands × *Post1550*	Yes	Yes
Islands × *Post1567*	Yes	Yes
Year-fixed effects	Yes	Yes
Prefecture-fixed effects	Yes	Yes
Observations	1,683	1,848

*** = Significant at the 1 percent level.
Notes: Robust standard errors clustered by prefecture are reported in parentheses.

around 1550 or 1567. A possible omitted factor relevant to this period is the unprecedented growth in European demand for Chinese goods. Indeed the number of Europeans arriving in China (stationing near the coast) rose steadily after 1517, and the volume of illicit trade between the Chinese and the Europeans grew even faster. As a result, we cannot assume that the rise in the number of pirate attacks after 1550 was triggered by an intensified "sea ban" policy alone; Europe's insatiable hunger for Chinese goods may also have played a part.

The rise of European trade does not pose a serious threat to our results, however, because the results of our regressions based on the restricted period of 1522–1572 (or 1530–1587) are fully consistent with those of the full sample. These shorter periods fall within the period of Europe's trade expansion to China. Furthermore, we include the total *tonnage* of European commercial ships that arrived in Asia after 1490s (*European ships*) as a proxy in our regressions for a further check of robustness, assuming that the share of Chinese goods in Europe's Asian imports did not decrease over time.[32] Decadal data on *European ships* are obtained from Jan de Vries (2003).[33]

Including this proxy for increasing export demand in the regressions has no effect on the coefficients of interest (see column 1 of Table 5). Not only does the effect of the "sea ban" policy (*Silk center* × *Post*1550 and *Silk center* × *Post*1567) remain significant, its coefficient also hardly changes (compare with the result in column 4 of Table 2, where Europe's trade demand is not controlled for). These results squarely suggest that the upsurge in pirate attacks between 1550 and 1567 was caused primarily by the intensification of the "sea ban" policy rather than due to Europe's rising trade demand for Chinese goods.

The regression could also be contaminated by the "spillovers" of the political instability in Japan during 1467–1590 (i.e., during the Sengoku or Warring States period). The lack of centralized political control then may have predisposed Japanese warlords and traders to turn to preying along the China coast (Sansom 1961). Again, this should not pose a serious problem because our regression based on the restricted period of 1522–1572 (or 1530–1587) also falls within Japan's Warring States period and that the results of this robustness check are consistent with those of the full sample. To fully address this hypothesis, we add two interaction terms to identify the effect (if any) of this possible Japanese influence. To capture the possible effect of the Japanese political turmoil, we interact *silk center* with the *Post*1467 time dummy. By the same token, to capture the effect of Japan's reunification we interact *silk center* with the *Post*1590 time dummy.[34] Reported in column 2 of Table 5 inclusion of Japan's political influence does not change our main results.[35]

[32] Our assumption is premised on the fact that maritime trading routes connecting China to other parts of Asia were already well-developed by the early sixteenth century, around which time the Chinese merchants were found to have been actively trading in many Asian ports such as Malacca and India (Findlay and O'Rourke 2007).

[33] We do not employ the number of European commercial ships to measure trade volume because vessel size varied considerably during this period of trade expansion.

[34] Japanese pirates' activities were effectively halted by Toyotomi Hideyoshi's reunification of Japan in 1590, when he initiated the *Sword Hunt* and confiscated all weaponry from the peasantry. In particular, the Daimyo were required to swear by the oaths to ensure that no

TABLE 5
CAUSE OF PIRATE ATTACKS: EUROPEAN AND JAPANESE IMPACTS

	The dependent variable is *pirate attacks*	
	(1)	(2)
Silk center × *Post1550*	10.807***	1.304***
	(3.142)	(0.368)
Silk center × *Post1567*	−11.235***	−1.331***
	(3.140)	(0.370)
European ships × *silk center*	3.815	
	(3.196)	
Silk center × *Post1467*		−0.033
		(0.024)
Silk center × *Post1590*		0.037
		(0.021)*
Controls	Yes	Yes
Year-fixed effects	Yes	Yes
Prefecture-fixed effects	Yes	Yes
Observations	891	8,910

* = Significant at the 10 percent level.
*** = Significant at the 1 percent level.
Notes: Robust standard errors are clustered by prefecture and reported in parentheses. In all columns, we have controlled for *famine*, *population density*, *naval deterrence*, and *islands*. *European ships* × *silk center* is included to examine the effect of Europe's changing demand for trade with China on piracy. *Silk center* × *Post1467* and *Silk center* × *Post1590* are included to capture the possible effects of the Japanese political turmoil and the reunification, respectively, on piracy.

CONCLUSION

This article has examined the link between a rigorous suppression of illicit international trade and a spike in piracy in China in the mid-sixteenth century. To do so, we constructed a unique data set based on rich and reliable historical materials to trace both pirate attacks and to proxy a locality's trade (raid) potential. By employing a difference-in-differences regression framework, we show that the geography of pirate attacks was indeed determined by the returns that a coastal prefecture could potentially offer to such violent undertakings.

seafarer would engage in piracy; those who failed to comply would be deprived of their fiefdoms (Berry 1989).

[35] To save space, we report only the results obtained using the yearly data.

While a natural extension of our work would be to study the possible long-term effects (if any) of the pirate attacks on economic development, for the time being our finding leads curiously to the larger questions of why various emperors of late imperial China (beginning with the Ming dynasty) were so hostile toward international trade, and what implications this has had for both world and Chinese economic history in the ensuing centuries—especially at the juncture where the growth trajectories of China and Europe began to diverge. This brief episode of Chinese history is important, for it illuminates the conflicts in which China subsequently engaged with the Western powers, conflicts that culminated eventually in the forced abandonment of its long upheld autarkic principle.

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CLIMATE SHOCKS AND SINO-NOMADIC CONFLICT

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Abstract—Employing droughts and floods to proxy for changes in precipitation, this paper shows nomadic incursions into settled Han Chinese regions over a period of more than two thousand years—the most enduring clash of civilizations in history—to be positively correlated with less rainfall and negatively correlated with more rainfall. Consistent with findings that economic shocks are positively correlated with conflicts in modern sub-Saharan Africa when instrumented by rainfall, our reduced-form results extend this relationship to a very different temporal and geographical context, the Asian continent, and long historical period.

I. Introduction

MILITARY conflict and war are sources of human suffering (World Bank, 2003), and, by destroying human and physical capital, they have a negative impact on economic growth (Kiker & Cochrane, 1973). The disastrous consequences of war and conflict have motivated research interest in understanding and measuring their causes (Bruckner & Ciccone, 2007; Collier & Hoeffler, 1998, 2001, 2002; Fearon & Laitin, 2003; Miguel, Satyanath, & Sergenti, 2004).[1] In this literature, exogenous variations in climate, rainfall in particular, are recognized as causal links between economic shocks and civil conflicts (Bruckner & Ciccone, 2007; Ciccone, 2008; Miguel et al., 2004). Accordingly, we employ climatic variations as an exogenous predictor of what is perhaps the longest and most enduring clash of civilizations in history: the Sino-nomadic conflict. This conflict lasted for more than two millennia and extended along four thousand miles of military defenses, resulting in the building of the Great Wall of China to separate the Han Chinese from the northern nomadic peoples.

The nomads discussed here refer to a sizable group of peoples from the steppes of Central Asia, Mongolia, and Eastern Europe (the Pontic steppe), peoples that both the Romans and the ethnic Han Chinese considered to be "barbaric." The aggressive invasions undertaken by these Eurasian nomads play an important role in the history of both the Eastern and Western civilizations. In Europe, for instance, these invasions occurred as early as those of the Cimmerians in the eighth century B.C. and as recently as those that took place during the migration period (300–900). Similar invasions were initiated by the Mongols and Seljuks in the High Middle Ages (1000–1300) and by the Tatars in early modern times (starting around 1500).

Nomadic economies were heavily dependent on the grazing of vast herds of animals, but these peoples often lived under unfavorable continental climatic conditions with relatively little rainfall. Under normal weather conditions, the autarkic nature of nomadic economies in terms of balancing natural resources (fodder and water) with livestock and the human population can be maintained (Graff & Higham, 2002). In times of drought, however, water shortages lead to a shortage of fodder and, accordingly, a reduction in food (meat) production, leaving the looting of settled agricultural neighbors, such as the ethnic Han Chinese, the only alternative for survival.[2]

It is well documented that stochastic climatic fluctuations have had an adverse impact on many nomadic economies, even in contemporary times.[3] A number of historians have also found that nomadic incursions into the agricultural hinterlands of the Han were actually made in response to deteriorating economic conditions brought about by adverse changes in the natural environment over the roughly two thousand years during which the Han were frequently intimidated—and in some instances fully conquered—by their nomadic neighbors across the northern frontier (Toynbee, 1987; Barfield, 1989; Huntington, 1907; Graff & Higham, 2002; Jagchild, 1989; Khazanov, 1994).[4] However, no systematic empirical studies have yet emerged from this otherwise rich corpus of work.

Employing drought as a proxy for lower precipitation and, conversely, floods (specifically levee breaches of the Yellow River) as a proxy for higher precipitation, we show that negative rainfall shocks are positively correlated with violent invasions on the Asian continent, specifically the frequent nomadic incursions of settled Han Chinese areas—sedentary agricultural communities—over more than two millennia. Following other studies that have employed rainfall to identify the causal effect of economic shocks on conflicts (Miguel et al., 2004; Bruckner & Ciccone, 2007;

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[1] Studies have identified a variety of factors, ranging from labor market conditions (Collier & Hoeffler, 1998, 2001, 2002) and economic growth (Elbadawi & Sambanis, 2002; Fearon & Laitin, 2003; Miguel et al., 2004) to ethnic fractionalization and democracy (Sambanis, 2002), as having an effect on the incidence of civil wars and even international conflicts (Ostrom & Job, 1986; Russet, 1990; Hess & Orphanides, 1995).

[2] The Eurasian nomads domesticated horses and developed a host of weaponry, ranging from the chariot and cavalry to horse archery, which they used to invade Europe, Anatolia, and China.

[3] For instance, "In the USSR, the crop capacity of wild plants in semi-deserts fluctuates between 1:5.4 in different years, and for different grass-crops it even fluctuates as much as 1:40. Clearly, the resulting adverse impact of this fluctuation in crop yields has had a negative impact on pastoralism. For example, while there were 5.1 million head of sheep and goats in Turkmenia in 1956–60, in 1962 the number dropped to 4.2 million" (Khazanov, 1994, p. 72). According to Barth (1964), even a small climatic change can easily upset the "nomadic equilibrium."

[4] Huntington (1907) and Toynbee (1987) proposed the "climatic pulsation" thesis, which explains nomadic aggressions by the long-term, cumulative effect of climate change. A more recent development of this thesis stresses the material dependency of nomadic societies on their sedentary counterparts (Barfield, 1989; Khazanov, 1994; Jagchild, 1989; Graff & Higham, 2002), that is, when their natural equilibrium was upset by climatic change, nomads became dependent on sedentary economies for certain material goods, and war was the typical means of acquiring those goods.

Ciccone, 2008), we employ a reduced-form specification to estimate the impact of rainfall shocks on Sino-nomadic conflict.[5] Our work thus adds to the literature by demonstrating the existence of a strong relationship between negative income shocks and violence in a temporal and geographical context that differs radically from that of sub-Saharan Africa and one that persisted for more than two thousand years.

The remainder of the paper is organized as follows. Section II introduces our data sources and variables and presents descriptive evidence of Sino-nomadic conflict. In section III, we outline our empirical strategy and econometric models. Our empirical results are presented and discussed in section IV, followed by a brief conclusion in section V.

II. Variables, Data, and Descriptive Evidence

In this paper, we focus on the historical interactions between Inner Asia and China—interactions that were played out along a vast stretch of frontier, with the Great Wall at its center, over more than two thousand years. We divide China's territory into two broad regions (Graff & Higham, 2002). Designated as China proper, the first region refers to the densely populated, irrigated agricultural region inhabited by the Han majority, a region considered to be the origin, or cradle, of ancient Chinese civilization.[6] Also known in Chinese as the central plains (*Zhong Yuan*), China proper includes the provinces that are primarily clustered around the middle and lower reaches of the Yellow River (Henan and parts of Shanxi, Shaanxi, Hebei, and Shandong provinces in today's China, denoted as region 1 in figure 1). The second, nomadic, region (region 2) comprises what is today the northwestern Chinese provinces of Tibet, Qinghai, Xinjiang, and Inner Mongolia, three formerly Manchurian provinces in the northeast; the now independent republic of Mongolia; and parts of Russia. In contrast to China proper, the nomadic region was sparsely populated and inhabited mainly by non-Han ethnic groups (Graff & Higham, 2002; Barfield, 1989). Moreover, and in contrast to the Han Chinese who had settled into sedentary agriculture, the nomads in the northwestern and northeastern parts of China undertook seasonal migrations and relied on raising vast herds of animals on the steppes and mountain slopes of Inner Asia for their livelihood.

A. *Definition of Variables*

Our dependent variable is simply the frequency of nomadic invasions into the settled communities of the Han Chinese.[7] Although we lack detailed narratives of China's military operations, such as the use of weapons and logistics (see, for example, Graff & Higham, 2002), detailed historical records of the time (year) of a battle's outbreak and the initiating party serve our purpose. These records allow us to identify, in an unambiguous fashion, the party that initiated the battle, thus also allowing us to test our hypothesis. In our estimation, we employ the decadal frequency of attacks initiated by nomads (y_{1t}) to proxy for nomadic invasions. Because such invasions may be correlated with attacks initiated by the sedentary Han on the nomadic regions, it is also necessary to control for the decadal frequency of attacks initiated by the sedentary state on nomads (y_{2t}) in our estimations. Although our data set contains no information on the exact location of each battle, the rich historical narrative of Sino-nomadic warfare in China (Hu, 1996) does tell us that the majority of these battles were fought along the Great Wall of the Qin (221–206 B.C.) and Ming dynasties (1368–1644). We provide a summary of this information in figure 2.

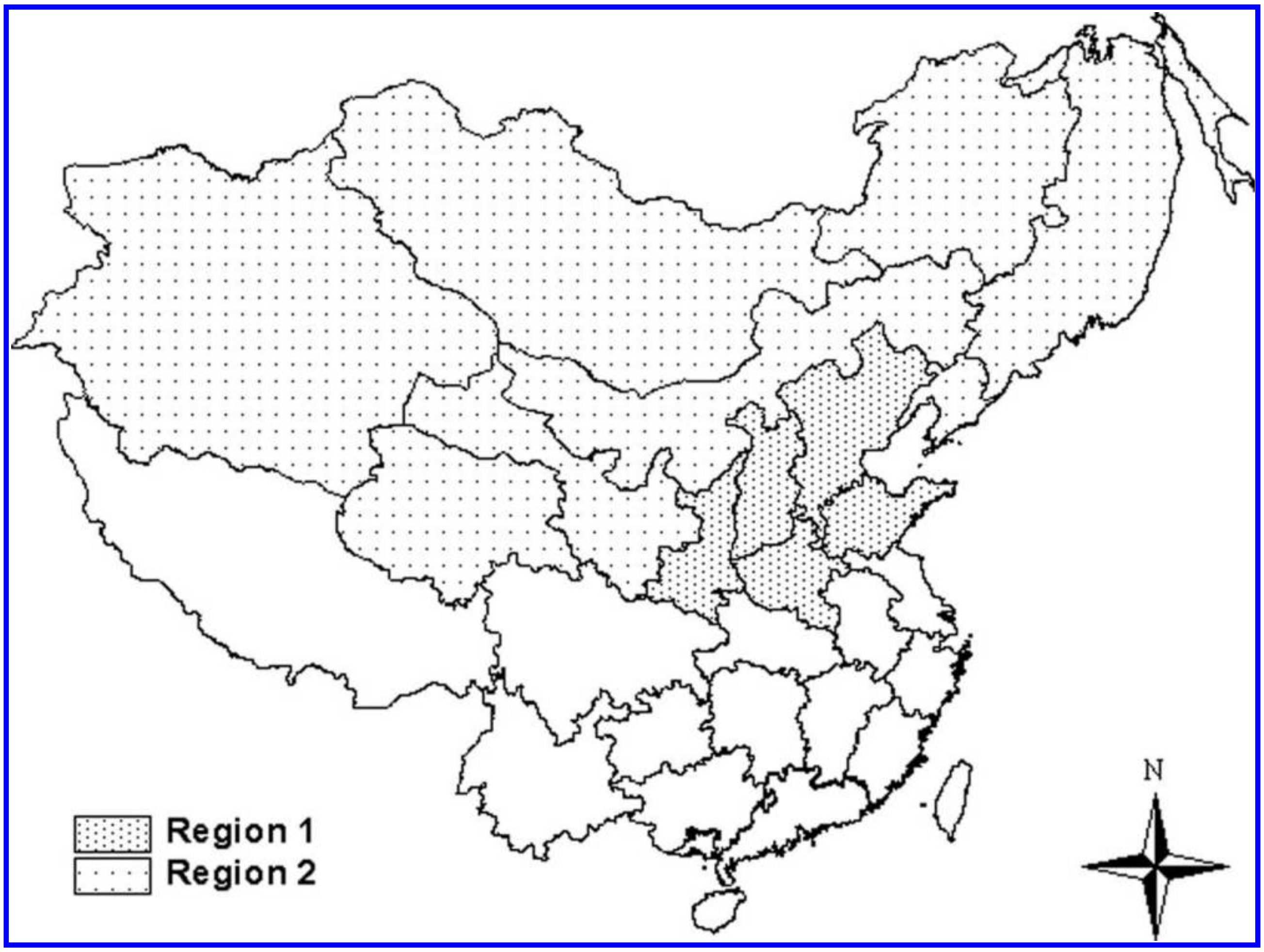
An ideal measure of poor weather in the nomadic zone would be actual deviations in rainfall from normal levels. Unfortunately, such information is not available. However, as we are able to establish strong correlations in precipitation between the two pertinent regions, both of which share the monsoon characteristics of northeast Asia (Zhang & Lin, 1992), using contemporary climate data (Appendix A), we are confident that incidences of droughts and floods in the agricultural zone serve as a good proxy for the probability of lower and higher precipitation in the nomadic zone. More specifically, we employ the decadal share of years with recorded drought disasters (x_{1t}) as our proxy for the probability of lower precipitation. These droughts occurred in region 1 (see figure 1), which was located south of the Great Wall and north of the Qinling Mountain–Huai River line, the isotherm of 0 degrees centigrade in China in January (see figure 2). Similarly, we use the decadal share of years with a levee breach of the Yellow River (x_{2t}) to proxy for the probability of higher precipitation (the location of these floods is also indicated in figure 2), because the flooding caused by such a levee breach is the most severe in the Chinese setting. We must emphasize that the effects of

[5] Rainfall shocks affect not only the economy of nomads in general and their production of food more specifically, but also the returns and costs to the agricultural economy associated with invasions. For instance, in decades afflicted by droughts, agricultural output falls and the marginal returns to looting also fall accordingly. To make up for the shortfall, nomads increase the frequency of their invasions. By the same token, although flooding is likely to render the use of horses ineffective, and thus to encourage nomads to reduce the frequency of their attacks in the short run, it may effectively encourage more looting in the longer run if it enhances the fertility of the soil. We owe this insight to an anonymous referee, but as we are unable to identify the precise channels of climate shocks, we focus on estimating their overall effect.

[6] Although the southern part of China also belongs to China proper by contemporary standards, it was not part of the ancient Chinese civilization under study. Moreover, it lies in a completely different ecological zone from that of the central plains.

[7] Our proposed analysis of Sino-nomadic conflict is premised on the single factor of geography: the location of these sedentary and nomadic societies. If there were periods in which the nomads conquered the Han and consequently became sedentary themselves, then we must consider these nomads as having been "converted," as their economic way of life would have altered. We deal with the econometric issues arising from this exception in appendix C.

FIGURE 1.—THE GEOGRAPHY OF CONFLICT: LOCATIONS OF THE SEDENTARY AND NOMADIC REGIONS



(1) Region 1: China proper (Henan, Shanxi, Shaanxi, Hebei, and Shandong provinces of today's China); central plains; and the middle and lower reaches of the Yellow River. Region 2: Northwest—Qinghai, Xinjiang, Gansu, Ningxia and Inner Mongolia provinces of today's China and the Republic of Mongolia; Manchuria—Heilongjiang, Jilin and Liaoning provinces of today's China and parts of Russia; and boundaries of Qing-China, 1820.
Source: "CHGIS, Version 4" (Cambridge, MA: Harvard Yenching Institute, 2007).

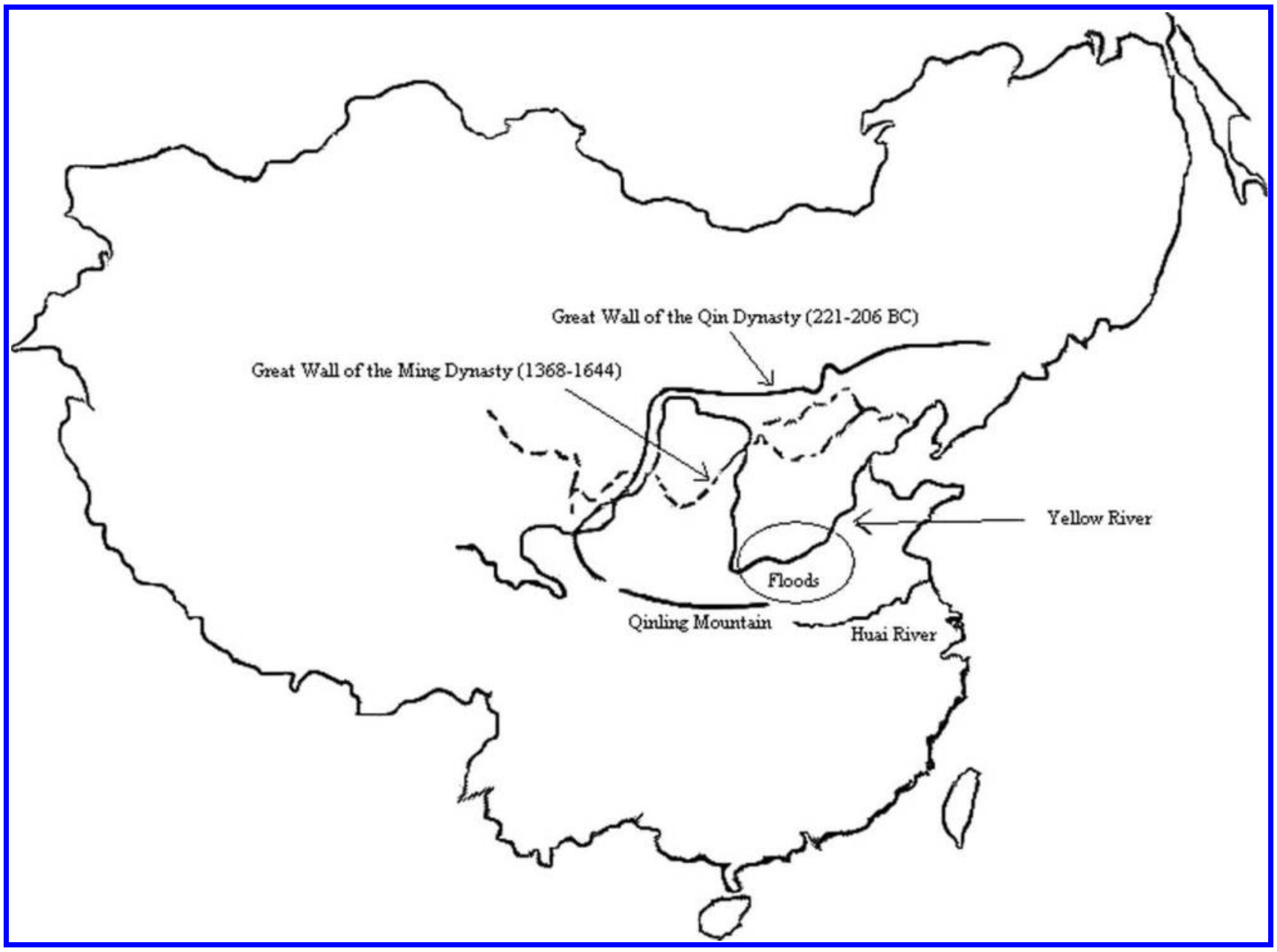
drought and flooding on the two regions were radically different. Whereas the nomads tended to suffer more than their Han counterparts in the event of lower precipitation (drought), they tended to suffer less than the Han in the event of a levee breach of the Yellow River, because such a breach would lead to floods in the Han region but not in the nomadic region.

To ensure that our estimations are reasonably robust, it is necessary to control for a number of factors. The first is the possible impact of snow and frost, because they may be correlated with our key explanatory variables of drought and flood. Accordingly, following the construction of these key explanatory variables, we employ the decadal share of years with recorded snow disasters (w_{1t}) and the decadal share of years with recorded frost and other cold-related calamities (w_{2t}) to proxy for the possible effect of these adverse temperature deviations. Moreover, as paleoclimatologists have shown, average temperatures have changed significantly in the past thousand years (Zhang, 1996), which is likely to be correlated with our two key explanatory variables. It is thus also necessary to control for the possible effects of changes in average temperatures (w_{3t}).[8]

Equally important is that we control for instances in which the nomads actually settled in the central plains and ruled the Han Chinese after their conquest, an extreme case in point being the settlement and governance of all of China by the Manchu during the Qing dynasty. That such nomadic settlement in the central plains reduced the odds of invasion suggests that the nomadic-ruled sedentary regime had a qualitatively different relationship with the nomads who still resided in the nomadic region. Once again, the Qing dynasty provides a good case in point. Unlike its predecessors and cemented by intermarriage among royal families, the Qing regime enjoyed a mellifluous relationship with

[8] As paleoclimatologists provide information only on past temperatures in relation to the present (the difference in degrees between past and present temperatures), we have to add present temperatures to their estimations to obtain the actual temperatures of the distant past. Our calculations of present temperatures are based on data provided by the National Climate Data Center for the 1957–1990 period.

FIGURE 2.—LOCATIONS OF SINO-NOMADIC BATTLES, DROUGHTS, AND FLOODS



Source: "CHGIS, Version 4" (Cambridge, MA: Harvard Yenching Institute, 2007).

various Mongolian tribes (Graff & Higham, 2002). In light of such anecdotal evidence, we control for the three time periods in which we expect to observe significantly fewer nomadic invasions. In addition, we perform a robustness check by dropping the years in which the agricultural lands were directly under nomadic control.[9] The first of these periods stretches from 317, which saw the collapse of the West Jin empire, to 589, which saw its reunification by the Sui dynasty (w_{4t}). The second, w_{5t}, covers three subperiods: the Jurchen Jin (1126–1234), pre-Yuan Mongol (1234–1279), and Mongol Yuan (1279–1368) subperiods. Finally, the third period, w_{6t}, from 1644 to 1839, began with the foundation of the Qing dynasty and lasted until the outbreak of the Opium War. Additionally, we include the decades −22 (220–211 B.C.) to 183 (1830–1839) as a variable to control for the time trend (w_{7t}).[10]

[9] We thank an anonymous reviewer for alerting us to the need to do this.

[10] To the extent that data on the more contemporary periods are more accurate and detailed, failure to control for such a bias is likely to result in spurious correlations.

B. Data Sources

The data used in this study cover 2,060 years (from 220 B.C. to 1839 A.D.) of Sino-nomadic warfare in China. They are compiled from four Chinese sources: *A Chronology of Warfare in Dynastic China* (China's Military History Editorial Committee, 2003), *A Compendium of Historical Materials on Natural Disasters in Chinese Agriculture* (Zhang et al., 1994), *A Concise Narrative of Irrigation History of the Yellow River* (Editorial Committee of Irrigation History of the Yellow River, 1982), and the *Handbook of the Annals of China's Dynasties* (Gu, 1905). The chronology of warfare contains detailed information on warfare between the sedentary and nomadic regimes, including the year of occurrence and the battle initiator, and the *Compendium* provides information on both climatic conditions in general and various natural calamities in particular. The irrigation history provides important information on all of the levee breaches of the Yellow River in ancient China, including their exact time of occurrence, and the final source contains information on the periods during which China proper was ruled by the conquering nomads. The summary statistics

TABLE 1.—DEFINITION OF VARIABLES, DATA SOURCES AND SUMMARY STATISTICS

Variables		Proxies	Mean	s.d.
Dependent variables				
Nomadic attacks	y_{1t}	Frequency of attacks initiated by the nomads on the sedentary society in a given decade[a]	2.52	*(3.50)*
Sedentary attacks	y_{2t}	Frequency of attacks initiated by the sedentary society on the nomads in a given decade[a]	1.89	*(2.35)*
Explanatory variables				
Lower precipitation	x_{1t}	Share of years with records of drought disasters on the central plains in a given decade[b]	0.50	*(0.31)*
Higher precipitation	x_{2t}	Share of years with records of levee breaches of Yellow River in a given decade[c]	0.18	*(0.21)*
Control variables				
Snow disasters	w_{1t}	Share of years with records of snow disasters on the central plains in a given decade[b]	0.12	*(0.14)*
Low-temperature disasters	w_{2t}	Share of years with records of low-temperature calamities (for example, frost) on the central plains in a given decade[b]	0.16	*(0.19)*
Average temperature	w_{3t}	Average temperature[e]	9.46	*(0.89)*
Nomadic conquest 1	w_{4t}	= 1 if the central plains of China were governed by the nomads (317–589)*[d]	0.13	*(0.33)*
Nomadic conquest 2	w_{5t}	= 1 if the central plains of China were governed by the nomads (1126–1368)*[d]	0.11	*(0.32)*
Nomadic conquest 3	w_{6t}	= 1 if the central plains of China were governed by the nomads (1644–1839)*[d]	0.09	*(0.29)*
Time trend	w_{7t}	Decade: −22−183; years: 219 B.C.–1839 A.D.[d]	80.50	*(59.61)*

*Nomadic conquest of the central plains is indicated by the decadal share of their reign in relation to the Han. For instance, the nomadic conquest period is 317–589; thus, for the decade 310–319, there are three years during which the central plains were ruled by the nomads, and the corresponding share is 0.3.
[a]China's Military History Editorial Committee (2003).
[b]Zhang et al. (1994).
[c]Editorial Committee of Irrigation Committee of the Yellow River (1982).
[d]Gu (1998).
[e]Zhang (1996).

TABLE 2.—CORRELATION MATRICES OF THE VARIABLES EMPLOYED IN THE REGRESSION ANALYSIS

	Nomadic Attacks y_{1t}	Sedentary Attacks y_{2t}	Lower Precipitation x_{1t}	Higher Precipitation x_{2t}	Snow Disasters w_{1t}	Low-Temperature Disasters w_{2t}	Average Temperature w_{3t}	Nomadic Conquest 1 w_{4t}	Nomadic Conquest 2 w_{5t}	Nomadic Conquest 3 w_{6t}	Time Trend w_{7t}
y_{1t}	1.000										
y_{2t}	0.142**	1.000									
x_{1t}	0.153**	−0.001	1.000								
x_{2t}	0.024	−0.134*	0.472***	1.000							
w_{1t}	0.038	−0.149**	0.366***	0.097	1.000						
w_{2t}	−0.066	−0.067	0.557***	0.243***	0.401***	1.000					
w_{3t}	−0.006	0.013	−0.205***	−0.373***	0.023	−0.140**	1.000				
w_{4t}	−0.119*	0.250***	−0.069	−0.225***	0.020	−0.010	−0.087	1.000			
w_{5t}	0.156**	−0.121*	0.290***	0.081	0.396***	0.226***	−0.028	−0.141**	1.000		
w_{6t}	−0.192***	−0.054	0.494***	0.223***	0.176**	0.503***	−0.258***	−0.127*	−0.119*	1.000	
w_{7t}	0.143**	−0.069	0.720***	0.626***	0.293***	0.468***	−0.202***	−0.235***	0.269***	0.512***	1.000

Significant at *10%, **5%, ***1%.

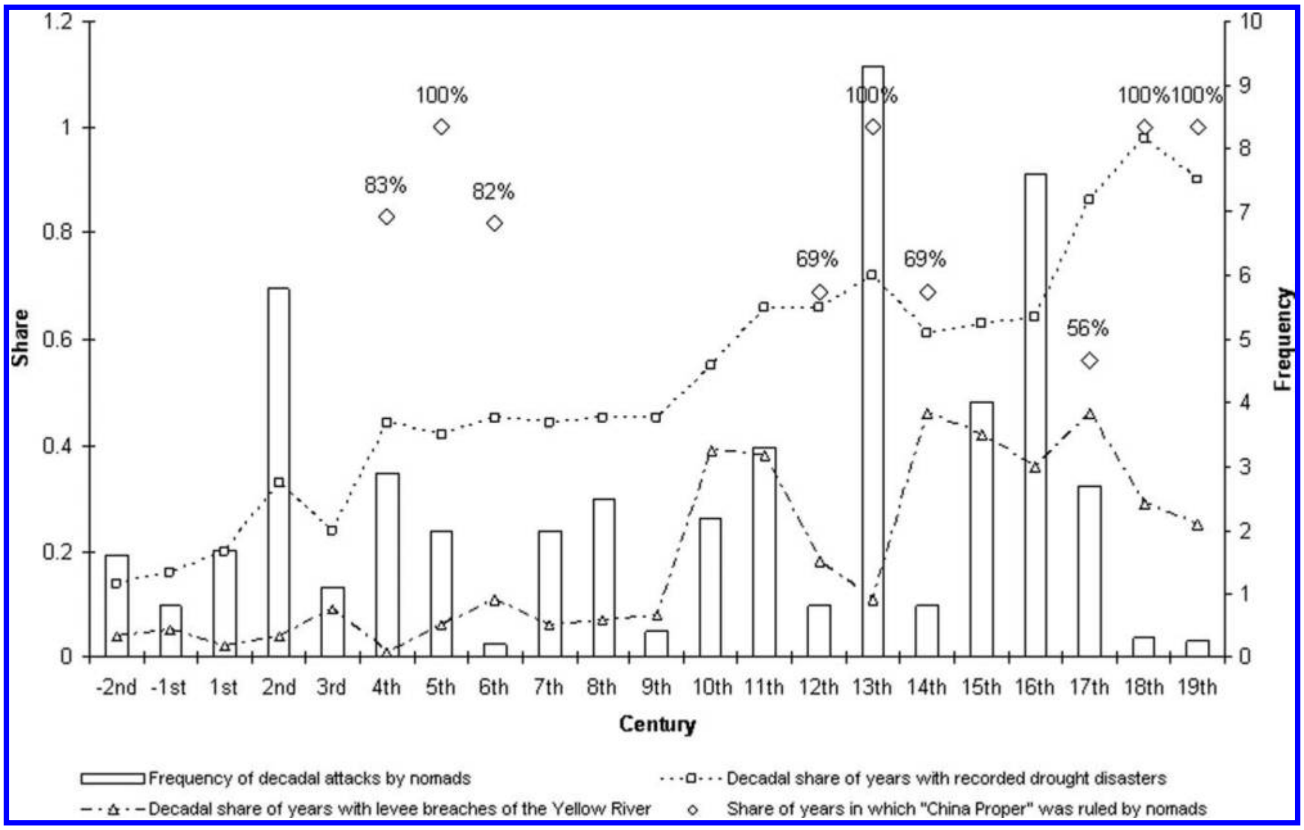
of all of the pertinent variables employed in our empirical analysis are presented in table 1.

Historians are of the view that collections of war data can be politically biased. Such bias is arguably severe in this study, as our data were reported only by Chinese sources, who may have had the incentive to reduce the frequency of nomadic attacks on the one hand and exaggerate the strength of Han Chinese retaliation on the other. Because cross-referencing all of our data with data collected from sources in different countries would be a monumental task, and infeasible, we validate only those pertaining to the Sino-Manchurian-Mongolian wars of the sixteenth to seventeenth centuries with similar data from Perdue (2005) in appendix B. Columns 1 and 2 of this appendix present the year and particulars of each battle employed in this study using Perdue's periodization, and columns 3 and 4 present a summary of his description of these battles and the relevant pages on which they are cited to allow comparison. Of the 24 battles employed in this study, 18 are explicitly identified in Perdue's study, with an additional 5 described but not named. The only instance for which we fail to find a match is the one battle fought between the Qing army and Lobzang Danjin in 1724, which is included in our data source but nowhere mentioned in Perdue. We are thus satisfied with the accuracy of our data on Sino-nomadic conflict.

C. *Descriptive Evidence of the Relationship between Precipitation Changes and Nomadic Invasions*

To support our hypothesis, we present descriptive evidence to demonstrate how changes in precipitation are correlated with the frequency of nomadic invasions. First, as table 2 shows, the decadal share of droughts (x_{1t}) is positively correlated with the frequency of nomadic attacks (y_{1t}), although the levee breaches of the Yellow River (x_{2t}) are not significantly correlated with these attacks, possibly because the breaches are correlated with other independent variables.

FIGURE 3.—TRENDS OF NOMADIC ATTACKS, DROUGHTS AND LEVEE BREACHES OF THE YELLOW RIVER



Data source: Same as table 1.

Second, the bar chart in figure 3 shows the relationship between the decadal share of droughts (x_{1t}) (represented by the rectangular-shaped dashed line) and levee breaches of the Yellow River (x_{2t}) (represented by the triangular-shaped dashed line) with the frequency of nomadic attacks (y_{1t}). In addition, the scattered, unconnected diamonds labeled with different percentages represent the share of years that China proper was ruled by nomads in a given century (w_{4t}, w_{5t}, w_{6t}).

The most striking finding in figure 3 is that nomadic invasions tend to be positively correlated with increasing incidences of drought and negatively correlated with increasing incidences of flooding. For instance, Sino-nomadic conflict intensified during the second century A.D., a period that coincided with growing incidences of drought, eventually resulting in the conquer of China proper (317–589). Likewise, the secular increase in incidences of drought-related disasters between the ninth and thirteenth centuries also predictably led to an intensification of conflict. This period witnessed the Mongol defeat of the Chechen Jin, who had conquered the central plains only a century earlier. The nomadic rule of China proper, in contrast, appears to have reduced the incidence of conflict. For instance, although incidences of drought remained relatively stable between the fourth and ninth centuries, incidences of Sino-nomadic conflict varied sharply, dropping precipitously in the fifth century following the conquer of the central plains by the nomads, who then became sedentary themselves, in the subsequent century. A similar pattern can be seen in the sixteenth to nineteenth centuries. Despite a sharp increase in drought over this period, conflicts actually declined, particularly in the eighteenth and nineteenth centuries, following the conquer of China proper by the nomads in 1664 and the firm establishment of the Qing dynasty.

III. Estimation Strategy

Battles are rarely isolated events, particularly when two parties retaliate against each other over extended periods of time. To account for the inherent path-dependent nature of battles, it is appropriate to employ dynamic models in our empirical estimations. The baseline estimation of the effects of adverse precipitation on invasions assumes the following autoregressive distributed lag (ARDL) model,

$$y_{1t} = \mu_1 + \sum_{i=1}^{r} \alpha_{1i}^{1} y_{1t-i} + \sum_{i=0}^{p1} \beta_{1i}^{1} x_{1t-i} + \sum_{i=0}^{p2} \beta_{2i}^{1} x_{2t-i} + \pi^1 W_t + \varepsilon_t^1, \quad (1)$$

where y_{1t-i} is the ith lag of y_{1t}, r is the length of the lags of y_{1t-i}, x_{1t} and x_{2t} are our explanatory variables, and W_t is a 7 × 1 vector of our control variables. When dynamic regression models are employed, it is important to determine the appropriate lag period. Of the commonly employed procedures, we opted for the general-to-simple approach (although it may overfit the model), mainly because the results generated by the alternative—the simple-to-general approach—are subject to biased and inconsistent estimations. We also employ the Akaike (1973) information criterion (AIC) to select the lag order, the purpose of which is to minimize the AIC to ensure it is less than the largest number of lags. Furthermore, we test the model's stability by checking whether the roots of the characteristic equation,

$$A(\lambda) = 1 - \alpha_{11}^1\lambda - \alpha_{12}^1\lambda^2 - \cdots - \alpha_{1r}^1\lambda^r = 0,$$

are greater than 1 in terms of absolute value. Finally, we check whether there is any remaining autocorrelation by computing the Durbin-Watson statistics. Following Jorgenson (1966), the model that we adopt is essentially a rational lag model that can reveal not only the short-run effects of the variables but also their possible impact over the long run. In the ARDL model, $C(L)y_t = \mu + B(L)x_t + \varepsilon_t$, L is the lag operator, and the long-run effect can be computed by $B(1)/C(1)$.

As previously noted, nomadic invasions into the Han hinterland may be correlated with attacks initiated by the sedentary agricultural regime on the nomadic regions. We thus need to control for this possibility by including the decadal frequency of battles initiated by the sedentary state on the nomads (y_{2t}) in our estimation. As this variable has a possible simultaneity bias, however, the unqualified inclusion of it and its lags in equation (1) is problematic. To correct for possible simultaneity, we extend equation (1) into equation (2):

$$Y_t = \mu + \sum_{i=1}^{P} A_i Y_{t-i} + BX_t + \Pi W_t + \varepsilon_t \quad Y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix}, \quad (2)$$

where ε_t is a vector of disturbances that is not autocorrelated with the zero means and the contemporaneous covariance matrix, $E[\varepsilon_t\varepsilon'_t] = \Omega$. For example, without loss of generality, equation (3) expresses the structure of a vector autoregression (VAR) with both first- and second-order lags:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{pmatrix} \alpha_{11}^1 & \alpha_{21}^1 \\ \alpha_{11}^2 & \alpha_{21}^2 \end{pmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{pmatrix} \alpha_{12}^1 & \alpha_{22}^1 \\ \alpha_{12}^2 & \alpha_{22}^2 \end{pmatrix} \begin{bmatrix} y_{1t-2} \\ y_{2t-2} \end{bmatrix} + \begin{pmatrix} \beta_1^1 & \beta_2^1 \\ \beta_1^2 & \beta_2^2 \end{pmatrix} \begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix}. + \Pi W_t + \begin{bmatrix} \varepsilon_t^1 \\ \varepsilon_t^2 \end{bmatrix} \quad (3)$$

In this special case, there are two equations comprising 28 unknown parameters, with 14 in each equation. As previously noted, the VAR model requires us to select the lag order first. Then we can test the residual autocorrelation after running the regressions and checking the stability condition of the model to ensure that all eigenvalues of the coefficient matrix lie inside the unit circle.

IV. Empirical Results

A. Baseline Results

Table 3 reports the results of our estimates of the overall effect of precipitation changes on the frequency of nomadic attacks based on the ARDL model. Columns 1 and 2 report the baseline results, whereas columns 3 and 4 control for the lags in attacks initiated by the Han Chinese. We test the lag order of the ARDL model by minimizing the AIC when the lag order is less than the largest number of lags, which is 2 in this case (the same results can be obtained by using the general-to-simple approach). The Durbin-Watson test results (the p-values are over 0.7 in both columns) suggest that residual serial correlation is not an issue of concern (H_0: no serial correlation). Because the roots of $A(\lambda) = 1 - \alpha_{11}^1\lambda - \alpha_{12}^1\lambda^2 - \cdots - \alpha_{1r}^1\lambda^r = 0$ are all larger than 1, the stability condition is also satisfied.

These estimation results demonstrate a strong, positive relationship between negative rainfall shocks and Sino-nomadic conflict. For instance, the positive coefficient of the lower precipitation variable (drought) suggests that less rainfall significantly increases the frequency of nomadic invasions, whereas more rainfall reduces it. In terms of marginal effects, an additional year of drought in a particular decade increases the probability of nomadic invasions in that decade by 0.2600 times, and a much larger effect of about 0.576 times is seen over the longer term (0.2600/[1 − 0.348 − 0.201], column 2). In column 4, which includes attacks initiated by the sedentary agricultural regime with two lags, the magnitudes of both short- and long-run effects are about the same as those of the nomadic invasions: 0.2577 and 0.559 (0.2577/[1 − 0.341 − 0.198], column 4). In the case of floods, an additional year of levee breaches of the Yellow River in a particular decade reduces the likelihood of nomadic invasions by 0.3635 times in the short run and 0.806 times in the long run. Where the lagged effect of attacks by the sedentary agricultural regime is included (column 4), the corresponding reductions in nomadic invasions due to a favorable climate for the nomadic regime are, respectively, 0.3617 times in the short run and 0.785 times over the long run.

As with the key explanatory variables, the lags in nomadic attacks are all significant and positive, whereas snow and low temperature calamities are statistically insignificant. All three of the period variables of nomadic conquest have negative relationships with the dependent variable at varying degrees of statistical significance. The first period is significant at the 10% level, whereas the second is insignificant, and the third is significant at nearly the 1% level. The lags in attacks initiated by the sedentary agricultural regime are not significant, which implies that nomadic invasions were unlikely to be responses to such attacks. In any case, the inclusion of these control variables fails to change

TABLE 3.—BASELINE ESTIMATIONS WITH AUTOREGRESSIVE DISTRIBUTED LAGS

	Nomadic Attacks			
	(1)	(2)	(3)	(4)
Nomadic attacks: Lag 1	0.343***	0.348***	0.340***	0.341***
	[0.072]	[0.069]	[0.073]	[0.070]
Nomadic attacks: Lag 2	0.206***	0.201***	0.208***	0.198***
	[0.075]	[0.069]	[0.075]	[0.069]
Nomadic attacks: Lag 3	−0.007		−0.021	
	[0.071]		[0.074]	
Sedentary attacks: Lag 1			0.097	0.097
			[0.106]	[0.099]
Sedentary attacks: Lag 2			−0.034	−0.039
			[0.106]	[0.099]
Sedentary attacks: Lag 3			−0.005	
			[0.102]	
Lower precipitation	2.765**	2.600**	2.703**	2.577**
	[1.136]	[1.057]	[1.144]	[1.061]
Lower precipitation: Lag 1	−0.179		−0.207	
	[1.109]		[1.118]	
Higher precipitation	−3.244**	−3.635**	−3.312**	−3.617**
	[1.531]	[1.411]	[1.545]	[1.416]
Higher precipitation: Lag 1	−1.130		−0.908	
	[1.618]		[1.646]	
Snow disasters	1.871	1.833	1.817	1.824
	[1.728]	[1.696]	[1.743]	[1.705]
Low-temperature disasters	−0.746	−0.830	−0.890	−1.002
	[1.467]	[1.434]	[1.487]	[1.449]
Temperature	−0.463*	−0.399	−0.455	−0.400
	[0.278]	[0.259]	[0.280]	[0.260]
Nomadic conquest 1	−1.489**	−1.417**	−1.561**	−1.512**
	[0.683]	[0.658]	[0.729]	[0.694]
Nomadic conquest 2	−1.278	−1.174	−1.142	−1.075
	[0.820]	[0.784]	[0.840]	[0.795]
Nomadic conquest 3	−3.639***	−3.461***	−3.562***	−3.408***
	[1.095]	[1.026]	[1.105]	[1.031]
Time trend	0.011	0.009	0.011	0.009
	[0.007]	[0.006]	[0.007]	[0.006]
R^2	0.39	0.38	0.39	0.39
Observations	203	204	203	204
Lag order selection	2	2	2	2
AIC (r)[a]	5.010	4.978	5.035	4.993
Durbin's Test (p-value)	0.783	0.991	0.795	0.913
Stability condition:	Satisfies	Satisfies	Satisfies	Satisfies

Standard errors in brackets; constant terms are not reported. Significant at *10%, **5%, ***1%.
[a]AIC of equations with less than two lags are not reported.

the sign or significance of the key explanatory variables, which suggests the highly robust nature of our estimation.

B. Robustness Checks

As nomadic invasions into the Han hinterland may be correlated with attacks on the nomads initiated by the sedentary agricultural regime, we include this variable in some of our baseline estimations. Due to the possible simultaneity bias, however, we need to check the robustness of our results using VAR estimations. Table 4 presents the results. As with our baseline results, we perform all of the necessary procedures required of a dynamic regression model and satisfy the attendant conditions accordingly (for example, order of lags, residual autocorrelation, stability). The results of the first equation (of nomadic attacks) in estimation 2 (in which only two lag orders are included; column 2.1 of Table 4) are trivially different from those in column 4 of table 3, which suggests that there is no serious simultaneity bias of invasions by both sides and helps to reaffirm the robustness of our baseline estimates.

As the historical climate data used in this study are taken from the Han agricultural region, it is also of interest to examine the effects of climatic shocks on Han decisions to invade the nomadic territories. We find that of the four different climatic events, only floods (columns 1.2 and 2.2, table 4) and "snow disasters" (column 1.2, table 4) significantly reduce the frequency of such attacks. The lag effects of invasions initiated by the Han are strikingly similar to those initiated by the nomads; for instance, the pertinent coefficients of the first and second lags of Han-initiated invasions are, respectively, 0.325 and 0.182 (column 2.1, table 4), which are strikingly similar to those of the first (0.341) and second (0.198) lags of the nomad-initiated invasions (column 2.2, table 4). A more interesting finding is that although the first lag of nomad-initiated invasions is

Table 4.—Robustness Check – Vector Autoregression Model

	(1)		(2)	
	(1.1)	(1.2)	(2.1)	(2.2)
	Nomadic Attacks	Sedentary Attacks	Nomadic Attacks	Sedentary Attacks
Nomadic attacks: Lag 1	0.345***	−0.019	0.341***	−0.029
	[0.069]	[0.048]	[0.067]	[0.047]
Nomadic attacks: Lag 2	0.206***	0.146***	0.198***	0.121**
	[0.072]	[0.050]	[0.067]	[0.047]
Nomadic attacks: Lag 3	−0.022	−0.062		
	[0.070]	[0.049]		
Sedentary attacks: Lag 1	0.104	0.354***	0.097	0.325***
	[0.100]	[0.070]	[0.096]	[0.067]
Sedentary attacks: Lag 2	−0.040	0.198***	−0.039	0.182***
	[0.101]	[0.071]	[0.095]	[0.067]
Sedentary attacks: Lag 3	−0.003	−0.057		
	[0.097]	[0.068]		
Lower precipitation	2.540**	0.911	2.577**	1.041
	[1.034]	[0.725]	[1.024]	[0.722]
Higher precipitation	−3.642***	−1.661*	−3.617***	−1.623*
	[1.374]	[0.963]	[1.366]	[0.964]
Snow disasters	1.764	−1.958*	1.824	−1.739
	[1.663]	[1.166]	[1.645]	[1.160]
Low-temperature disasters	−0.960	−0.420	−1.002	−0.490
	[1.410]	[0.989]	[1.398]	[0.986]
Temperature	−0.405	−0.052	−0.400	−0.040
	[0.253]	[0.177]	[0.251]	[0.177]
Nomadic conquest 1	−1.509**	0.673	−1.512**	0.632
	[0.683]	[0.479]	[0.670]	[0.473]
Nomadic conquest 2	−1.056	−0.284	−1.075	−0.360
	[0.773]	[0.542]	[0.767]	[0.541]
Nomadic conquest 3	−3.441***	−0.091	−3.408***	−0.038
	[1.001]	[0.702]	[0.995]	[0.701]
Time trend	0.009	0.001	0.009	0.000
	[0.006]	[0.004]	[0.006]	[0.004]
R^2	0.387	0.334	0.387	0.327
Observation	203		204	
Lag order selection:	2		2	
Test for residual autocorrelation (H_0: No serial correlation):				
Lag 1 (p-value)	0.732		0.917	
Lag 2 (p-value)	0.463		0.355	
Stability condition	Satisfies		Satisfies	

Standard errors in brackets. Constant terms are not reported. Significant at *10%, **5%, ***1%.

not significant, the second is, which implies that the Han's delayed response may have been retaliatory; that is, the sedentary regime may have required time to reorganize its military resources and retaliate.

In light of the 700-year occupation of the agricultural lands by the nomads (out of the 2,060 years under study), one final robustness check is to drop the years in which the nomads directly controlled these lands. We do so by replicating the ARDL and VAR estimations using the smaller sample.[11] Consistent with our previous findings, the estimation results based on the ARDL method also show that lower precipitation increases the frequency of nomadic attacks, whereas higher precipitation reduces it (column 1, table 5). The results of the VAR estimation (column 2.1, table 5) are trivially different from those in column 1 of the same table.

[11] Because of the possible endogeneity of nomadic control of the agricultural lands, we correct for this potential sample selection bias. The results, shown in table A2, remain robustly consistent with the general results.

V. Conclusion

Throughout history, many settled civilizations have been invaded and conquered by what some historians refer to as "barbaric tribes," leading eventually to the downfall of one of the two groups. For more than two thousand years, the Han Chinese were subject to the bullying of their northern nomadic neighbors, the longest and most enduring clash in the history of ethnic conflict. The clash of civilizations is an important subject, but one to which the field of economics has made few contributions. A paucity of data is, in our view, the major impediment to such studies. By constructing a time-series data set from a few rich historical Chinese sources and following the approach pioneered by Miguel et al. (2004) and others in exploiting the effects of exogenous variations in rainfall on the probability of conflicts, we provide evidence of a reduced-form relationship between negative rainfall shocks and violent invasions in a temporal and geographical context that is very different from that of sub-Saharan Africa, and one that persisted for more than two millennia.

TABLE 5.—ROBUSTNESS CHECK—DROPPING PERIODS WHEN THE AGRICULTURAL LANDS WERE CONTROLLED BY THE NOMADS

	ARDL	VAR	
	(1)	(2.1)	(2.2)
	Nomadic Attacks	Nomadic Attacks	Sedentary Attacks
Nomadic attacks: Lag 1	0.397***	0.397***	−0.040
	[0.091]	[0.087]	[0.064]
Nomadic attacks: Lag 2	−0.036	−0.036	0.162**
	[0.092]	[0.088]	[0.065]
Han attacks: Lag 1	0.177	0.177	0.278***
	[0.122]	[0.117]	[0.086]
Han attacks: Lag 2	−0.014	−0.014	0.152*
	[0.118]	[0.112]	[0.083]
Lower precipitation	2.767**	2.767**	1.335
	[1.178]	[1.126]	[0.828]
Higher precipitation	−3.671**	−3.671**	−0.546
	[1.790]	[1.711]	[1.258]
Snow disasters	−0.344	−0.344	−2.409
	[2.313]	[2.212]	[1.626]
Low-temperature disasters	0.962	0.962	−1.442
	[1.990]	[1.902]	[1.399]
Temperature	−0.786***	−0.786***	0.168
	[0.269]	[0.257]	[0.189]
Time trend	0.010	0.010*	−0.003
	[0.006]	[0.006]	[0.004]
R^2	0.41	0.41	0.26
Observation	128	128	128

Standard errors in brackets. Constant terms are not reported. Significant at *10%, **5%, ***1% level.

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APPENDIX A

Weather Correlations between the Agricultural and Nomadic Regions

Our primary goal here is to identify whether there are any significant correlations in weather between the agricultural (region 1, figure 1) and nomadic regions (region 2, figure 1) using contemporary data. To achieve this goal, we employ a fixed-effects model

$$P_{2ij} = \rho P_{1ij} + \alpha_i + \varepsilon_{ij},$$

where P_{1ij} and P_{2ij} denote monthly precipitation in regions 1 and 2, respectively, in the ith month of the jth year. To check the robustness of this estimation, we replace P_{rij} with $\frac{P_{rij}}{|P_{ri}|}$ $(r = 1,2)$, given that the weather distribution ranges in the two regions are likely to be different. This check allows us to test whether deviations from normal weather in region 1 are correlated with those in region 2. Premised on the underlying assumption that abnormal precipitation can cause floods or droughts, the significant correlation between P_1 and P_2 supports the notion that a flood in region 1 is correlated with higher precipitation in region 2 and, conversely, that a drought in region 1 is correlated with lower precipitation in region 2.

TABLE A1.—CORRELATIONS IN CLIMATE BETWEEN REGIONS (FIXED-EFFECTS MODEL)

	P_2		$\frac{P_2}{\lvert P_2 \rvert}$	
	(1.1) Random Effect	(1.2) Fixed Effect	(2.1) Random Effect	(2.2) Fixed Effect
P_1	0.229***	0.122***		
	(0.016)	(0.016)		
$\frac{P_1}{\lvert P_1 \rvert}$			0.141***	0.141***
			(0.023)	(0.023)
Observations	408	408	408	408
Number of months	12	12	12	12
R^2	0.83	0.83	0.09	0.09

Standard errors in brackets. Constant terms are not reported. Significant at *10%, **5%, ***1%.

With about 160 monitoring stations located in the two regions, the U.S. National Climate Data Center collected and houses data on monthly precipitation and temperature (both average and minimum) for the 1957–1990 period. Climate analysis typically entails dividing the global surface into grids based on a region's latitudes and longitudes. For the entire world, 2,592 grids are drawn over a 5 × 5 degree basis (72 longitude × 36 latitude grid boxes). Region 1 occupies about three grids, whereas region 2 occupies 20. Based on the weather data provided by the pertinent monitoring stations, we are able to generate the weather for each grid, including those of regions 1 and 2.

The results of these regressions (columns 1 and 2, table A1) strongly support our claim that the precipitation characteristics of regions 1 and 2 are highly correlated. Although there have been dramatic climatic changes in the past several thousand years, the climatic relationship between these two regions has remained relatively stable; after all, East and North Asia share similar monsoon characteristics—as much now as in ancient times (Zhang & Lin, 1992).

APPENDIX B

Validity Check of the War Data, 1677–1759

(1) Year	(2) Warfare Data used in This Paper	(3) Warfare Description in *China Marches West*	(4) Page
Period 1: Manchus, Mongols, and Russians in conflict, 1670–1690			
1677	Galdan attacked Ochirtu	In 1676 or 1677 Galdan defeated and killed Ochirtu Khan. Major attacks were reported in the Ordos region.	p. 139
1688	Galdan attacked Khalkha	On August 28, 1688, the Tusiyetu Khan and Galdan fought a pitched battle for three days.	p. 150
Period 2: End of Galdan, 1690–1697			
1690	Qing attacked Galdan at Ulan Butong	Qing ordered an attack on September 3, 1690, at Ulan Butong.	p. 155
1696	Qing attacked Galdan at Jao Modo	On June 12, 1696, the two armies met in a battle at Jao Modo.	p. 188
Period 3: Imperial overreach and Zunghar survival, 1700–1731			
1715	Tsewang Rabdan attacked Hami in 1715	Tsewang Rabdan attempted invasion of Hami in 1715.	p. 222
1717	Zunghars Tsewang Rabdan occupied Tibet	In the summer of 1717, Tsewang Rabdan sent his best general, Tsering Dondub. . . . Tsering Dondub led his troops into Lhasa.	p. 234
1717	Qing attacked Zunghars	By April 1717, 8,500 troops . . . prepared to advance to capture Turfan. . . . Far enough to run into Zunghar patrols.	p. 231
1718	Qing aided Tibet at the Kara-Usu River	There was a battle of the Manchu commanders Seleng and Elunte with Tsewang Rabdan's forces at the Kara-Usu River on Oct. 5, 1718.	p. 223
1718	Qing aided Tibet and attacked Zunghars	Kangxi ordered the Manchu general Erentei to march on Lhasa with seven thousand men.	p. 234
1718	Qing defeated Zunghars at Tibet	The Qing destroyed the entire force in September 1718.	p. 235
1723	Qing army defeated Lobzang Danjin in Qinghai, in 1723	On Nov. 16, 1723, the Qing army battled with Lobzang outside the Taersi.	p. 245
1724	Qing defeated Alabutansubatai	Not found.	
1727	Qing depressed the rebellion in Tibet in 1727	There were disturbances in Tibet in 1727.	p. 248
1730	Qing attacked Zunghars at Keshetu	A great review of the troops was held in Beijing in June 1729; [they] returned to the capital in January 1731.	p. 252
1731	Qing and Zunghars battled at Hoton Nor	On July 23 the Zunghars poured in, . . . surrounded the Qing army at Hoton Nor.	p. 254
1731	Qing and Zunghars battled at Urumchi	Yue Zhongqi's successful raid on Urumchi.	p. 254
1731	Qing attacked Zunghars at Erchudeng River	Furdan was routed too quickly for this feint to have any effect.	p. 254
Period 4: The final Blows, 1734–1771			
1748	Qing suppressed the Jinchuan rebellion	In early 1748, . . . establish a connection between Tibet and the Jinchuan rebels. . . .	p. 267
1750	Qing suppressed the chaos in Tibet	Chaos in both Tibet and Zungharia in the 1750s put an end to these connections.	p. 267
1755	Qing defeated Zunghars Dawaci	By the middle of 1755, . . . hearing of the Qing approach, Dawaci fled to Gedengshan.	p. 274
1756	Qing defeated Amursana	By October 1756, Qing troops had fought and defeated . . . Amursana. Amursana fled farther west.	p. 287
1757	Qing succeeded in defeating Amursana and his supporters	In early 1757 . . . the Qing emperor thought that now was the perfect opportunity to capture Amursana . . . settled for an inconclusive victory.	p. 288
1758	Qing suppressed the rebellion of Turki at Kucha	The Turki army then burst out of Kucha on the evening of July 28, 1758, and fled west.	p. 290
1759	Qing suppressed the rebellion of Turki at Blackwater Camp	Qianlong sent his best frontier general to besiege the rebels . . . Battled at Blackwater Camp . . . On December 13, 1759, the Qianlong emperor proclaimed the completion of the Zunghar campaigns.	p. 290

Columns (1) and (2) are from China's Military History Editorial Committee (2003); columns 3 and 4 are from Perdue (2005).

APPENDIX C:

Conflicts between the Nomads and the Han—Correction of Selection Bias

In our robustness check, we drop the three periods in which nomadic conquest of the Han led to the nomads becoming sedentary themselves. However, whether the agricultural lands were controlled by the nomads is a possibly endogenous issue. To avoid the problem of sample selection bias, we use the following model:

$$y'_{1t} = \mu_1 + \sum_{i=1}^{r} \alpha^1_{1i} y'_{1t-i} + \beta^1_1 x_{1t} + \beta^1_2 x_{2t} + \pi^1 W_t + \varepsilon^1_t,$$

$$I_i = 1(B'x_t + \delta^{1'} w_{1t} + \delta^{2'} w_{2t} + \delta^{6'} w_{6t} + \gamma' z_{3t} > 0).$$

which means that the central plain was ruled by the ethnic Han.

The second equation determines the sample selection; y'_{1t} is observed when

$$B'x_t + \delta^{1'} w_{1t} + \delta^{2'} w_{2t} + \delta^{6'} w_{6t} + \gamma' z_{3t} > 0 \, and \, I_i = 1.$$

The maximum likelihood estimation in table A2 (column 2.1) shows that lower precipitation increases the frequency of nomadic attacks, whereas higher precipitation reduces it. This robustness check supports our baseline results.

TABLE A2.—CONFLICTS BETWEEN THE HAN AND THE NOMADS

	ARDL-Selection Bias Corrected			
	Two-Step Estimation		Maximum Likelihood Estimation	
	(1.1)	(1.2)	(2.1)	(2.2)
	Ruled by Han	Nomadic Attacks	Ruled by Han	Nomadic Attacks
Nomadic attacks: Lag 1		0.382***		0.380***
		[0.086]		[0.086]
Nomadic attacks: Lag 2		−0.016		−0.021
		[0.086]		[0.085]
Han attacks: Lag 1		0.153		0.171
		[0.113]		[0.110]
Han attacks: Lag 2		−0.014		−0.018
		[0.111]		[0.110]
Lower precipitation	−1.897***	3.072***	−1.886***	3.190***
	[0.615]	[1.472]	[0.618]	[1.173]
Higher precipitation	3.951***	−3.488	3.953***	−3.571*
	[0.850]	[2.703]	[0.851]	[1.834]
Snow disasters	−2.753***	−0.747	−2.736***	
	[0.944]	[2.849]	[0.951]	
Low-temperature disasters	−2.376***	1.143	−2.386***	
	[0.816]	[2.496]	[0.818]	
Temperature	0.700***	−0.740*	0.701***	−0.748***
	[0.174]	[0.450]	[0.174]	[0.277]
Time trend	−0.004	0.009	−0.004	0.009
	[0.003]	[0.007]	[0.003]	[0.006]
Observation	204	132	204	132

Standard errors in brackets. Constant terms are not reported. Significant at *10%, **5%, ***1%.