Robin Hood on the Grand Canal

Economic Shock and Rebellions in Qing China, 1650-1911 *

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Abstract

Social scientists have long pondered the effects of economic shocks on social conflict. However, the causal evidence discovered so far is limited to a small subset of economic shocks, and the findings are still inconclusive. This paper uses the abandonment of China's Grand Canal — perhaps the largest infrastructure project in the pre-modern world — in 1826 as a natural experiment to study the link between economic shocks and social conflicts. Using a dataset covering 575 counties from 1650 to 1911, we find that negative economic shocks significantly generated social instability: in the period after the canal's abandonment, the annual frequency of rebellions was 0.0094 higher in counties that bordered the canal than in those that did not. The magnitude of the effect accounted for about 124% of the sample mean and was robust across various specifications. We then compare the relative explanatory power of alternative explanations, and conclude that the reform was most likely to trigger rebellions by reducing the rebels' opportunity costs, specifically by interrupting trade in urban areas. We briefly discuss the possible implications in terms of the underlying social structure in urban regions, and tentatively attempt to explore its persistent effects on gangs, secret societies and organized violence in the 20^{th} century.

Keywords: Economic Shocks; Conflict; Rebellions; the Grand Canal; China

JEL Classification Numbers: O13, O17, D74, H56, N45, N95, Q34.

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In the eastern provinces of China, too, several great rivers form, by their different branches, a multitude of canals, and, by communicating with one another, afford an inland navigation much more extensive than that either of the Nile or the Ganges, or, perhaps, than both of them put together.

—Adam Smith (1776)

1 Introduction

Social scientists have long pondered the effects of economic shocks on social conflict. They have provided substantial evidence that these two factors are negatively correlated (Collier and Hoeffler, 1998, 2004; Fearon and Laitin, 2003; Humphreys, 2005; Buhaug and Rød, 2006; Ross, 2006; Angrist and Kugler, 2008; Bellows and Miguel, 2009; Kung and Ma, 2014a). An emerging literature seeks to isolate exogenous variations to identify their causality. However, most of the causal evidence is limited to climate shocks on agricultural productivity (Miguel et al., 2004; Miguel, 2005; Mehlum et al., 2006; Miguel, 2007; Burke et al., 2009; Miguel and Satyanath, 2011; Ciccone, 2008) and price shocks to global commodities (Besley and Persson, 2008; Brckner and Ciccone, 2010; Dube and Vargas, 2013), and the findings are still inconclusive (Bazzi and Blattman, 2014; Burke et al., 2015; Sarsons, 2015). This paper attempts to contribute to the literature using a novel natural experiment – the abandonment of China's Grand Canal in 1826 – to examine the link between economic shocks and social conflicts.

The Grand Canal is perhaps the largest and oldest infrastructure in the pre-modern world. It spans $1,776$ km ($1,104$ miles) in length, passing through six provinces in the north-eastern and central-eastern plains of China. This area was populated by over 126 million inhabitants in the early 19^{th} century, accounting for about 15% of the world's population. The first parts of the canal date back to the 5^{th} century BC, while the various sections were finally integrated into a nationwide system during the Sui Dynasty (581–618 AD). The primary purpose of the canal was to transport tribute grain — the most important grain tax — from southern China to Beijing, the capital city of the empire. In early 19^{th} century, approximately 3.5 million piculs of rice (roughly 560 million lbs) were delivered annually. The canal also benefited the adjacent regions by reducing the transport costs for long-distance trade. Grain junks were allowed to carry set amounts of duty-free commodities during their service, and private junks used the canal extensively for trade, travel and pleasure. The Grand Canal thus developed into one of China's most popular trade routes.

Starting in 1826, the Qing government gradually abandoned the Grand Canal as the exclusive route for tribute grain transportation and stopped maintaining it. This change resulted in a drastic decline in trade around the canal. The dismissal of official grain junks directly reduced the number of commodities transported on the canal, and private trade suffered as the canal became clogged with silt. By the early $20^{th} century$, much of the canal was no longer navigable, which resulted in the general decline of the canal corridor economic belt. Historians have long argued that the abandonment of the canal was responsible for the subsequent wave of social unrest in late Qing

Dynasty (Esherick, 1988), yet this hypothesis has never been systematically tested.

The abandonment of the canal provides an ideal opportunity to study the link between economic shocks and social conflicts for three main reasons. First, the reform was unexpected, and was primarily based on the political, rather than economic, considerations of the new emperor. This provides plausibly exogenous shocks to the local economy. Second, there is rich information available on social unrest in historical China over a long period of time. We constructed an original dataset consisting of 575 counties over 262 years (from 1650 to 1911). It is based on the historical records officially compiled by the Qing Court, which provided detailed information on the time, location and activities for each rebellion throughout the Qing Dynasty. Lastly, by focusing on variations within a single country, our sample is relatively homogeneous with respect to ethnicity, institution and culture, which are important factors in the conflict literature (Hegre and Sambanis, 2006; Laitin, 2007; Djankov and Reynal Querol, 2010; Kung and Ma, 2014b; Janus and Riera-Crichton, 2015; Jha, 2013).

We begin our analysis with a standard differences-in-differences (DID) strategy. Specifically, we compare the relative change in the number of rebellions in counties along the canal relative to non-canalside counties. Our findings across various specifications suggest a higher number of rebellions associated with the canal's abandonment: compared to non-canalside counties, those bordering the canal experienced 0.0094 more rebellions after the reform (relative to before). The effect corresponds to a 124% increase relative to the sample mean (0.0076), and is significant at the 95% confidence interval.

We then refine the baseline model with binary treatment by allowing continuous measures of intensity. To this end, we exploit two sources of cross-county variations: (i) the length of the canal within a county and (ii) the distance from the county to the canal. Consistent with our expectations, we find that the number of rebellions increases with the length of the canal within the county, and decreases with distance from the county to the canal. Estimates from more flexible specifications further verify that these effects are specific to counties within 150 km of the canal. We interpret this as the range of the canal's impact.

In order to take into account the canal's gradual abandonment, we extend the two-period model to continuous measures of reform progress. The most natural way to do so is to use the number of years since the reform as a linear measure of completeness. The results suggest that the impact increases as the reform unfolds. More flexible decade-by-decade estimates allow us to further explore the nonlinear dynamics of rebellions over time. After the canal's abandonment, the number of rebellions kept increasing for over 30 years. Then the effect appears to fade, but it remained positive and significant throughout our study period. In this specification, the coefficients estimated for periods prior to the reform also serve as a verification of the common trends assumption that validates our identification method.

We conducted several robustness checks to assess the quality of the previous identification. To address concerns that our results suffer from omitted variable bias, we include a set of control variables from the literature on the determinants of conflict: weather, geography, agricultural technology and culture. Our results are robust to the inclusion of all these factors. To explore whether there is reverse causality in the later periods of the sample, we restrict our analysis to truncated sample periods, and the results confirm that our findings are not affected by excluding potentially endogenous periods. Finally, to avoid the spurious correlations due to noise, we conduct a falsification test that compares the estimated treatment effects with the distribution of placebo treatment effects when county locations are randomly assigned. The results of the falsification test confirm that it is unlikely that noise in the data is affecting our results.

What are the mechanisms underlying the the observed effects? We investigate two hypotheses proposed in the conflict literature: (i) the decline in *state capacity* and (ii) the reduction in *opportunity costs*. After comparing the evidence regarding competing theories' explanatory power, we find that the opportunity cost hypothesis appears to be more consistent with what we observe in the data. In particular, the increase in rebellions in counties bordering the canal seems to have been due to the interruption of trade in urban sectors. We briefly discuss the possible implication in terms of the underlying social structure in urban regions, and relate this to the evolution of gangsters, the emergence of communism in the early 20^{th} century, and the presence of armed conflicts during the Cultural Revolution.

Our study contributes to the emerging literature on the causal relationship between economic shock and conflict (See Blattman and Miguel (2010) for an overview), which primarily focuses on economic shocks associated with weather volatility (Miguel et al., 2004; Miguel, 2005; Mehlum et al., 2006; Miguel, 2007; Burke et al., 2009; Miguel and Satyanath, 2011; Ciccone, 2008) and commodity price (Besley and Persson, 2008; Brckner and Ciccone, 2010; Dube and Vargas, 2013). Such shocks, while causally well-identified, represent a narrow subset of economic shocks that is transitory, rural specific, and not policy relevant. This paper examines the effects of permanent shocks initiated by government policy on the urban sector, which has distinct implications that are rarely documented in previous studies. First, while transitory shocks only change current economic conditions, permanent ones affect all subsequent periods as well as people's expectations about the future [1]. Consistent with Iyigun et al. (2017), we find that conflicts induced by a permanent shock tend to be very frequent and persistent. Second, unlike their rural counterparts, the labor force in densely populated urban areas has more collective consciousness and organized politics. Such areas are likely to become hotbeds of gangsters and organized crimes if there is a lack of socio-economic opportunities. This pattern, which is confirmed in our data, is consistent with case studies on the evolution of gangs and the mafia in the United States (Haller, 1971; Hagedorn and Macon, 1988; Critchley, 2008). Finally, our findings suggest that openness to trade is a potential policy approach to preventing violent conflict.

This paper is also related to the impact of transportation infrastructure. Economic historians have documented extensive evidence regarding the impact of transportation infrastructure, particularly the building of highways and railroads (Fogel, 1979, 1994; Fernald, 1999; Haines and

[1] It is unclear whether a permanent shock would exhibit more or less detrimental effects than the transitory shocks, due to the interplay of "adaptation" and "intensification" effects. See Iyigun et al. (2017) for a detailed discussion of these two terms.

Margo, 2006; Baum-Snow, 2007; Atack et al., 2008; Michaels, 2008; Atack et al., 2010; Duranton and Turner, 2012; Donaldson, forthcoming; Donaldson and Hornbeck, forthcoming; Perlman, 2016) . While most of them focus on the economic consequences, we provide evidence of the non-economic consequences of transportation infrastructure. Recent work exploring this topic includes Sokoloff (1988), Burgess and Donaldson (2010), Agrawal et al. (2017), and Perlman and Schuster (forthcoming). Our paper also departs from the existing literature by focusing on abandonment rather than construction. Policy makers should take into account the detrimental effect of infrastructure abandonment revealed in our analysis.

The canal's abandonment appears to have produced persistent effects on secret societies and organized violence in the 20^{th} century, which speaks to the growing literature on the legacies of historical events (See Nunn (2009) for a decent review). Several channels behind such persistence have been well explored, from formal institution (Sokoloff and Engerman, 2000; Acemoglu and Robinson, 2001; Dell, 2010), to culture (Tabellini, 2008; Fernndez and Fogli, 2009; Tabellini, 2010; Nunn and Wantchekon, 2011; Voigtländer and Voth, 2012; Grosjean, 2014; Chen et al., 2017) and genetics (Ashraf and Galor, 2013; Arbatli et al., 2015; Galor and Klemp, 2017). Our findings, while preliminary, highlight the role of social structure as another possible channel. In this sense, it follows the idea proposed by Moscona et al. (2017), which establishes segmentary lineage organization in Sub-Saharan Africa as a predictor of modern civil wars.

This paper also offers an alternative explanation of the waves of China's substantial social unrest. A growing literature shows that conflicts throughout China's history have been significantly related to variations in climate (Bai and Kung, 2011; Chen, 2015), technology (Jia, 2014) and social norms (Kung and Ma, 2014b). This paper suggests government policies have also been responsible. In this sense, our research is closely related to Bai and Jia (2016), who attribute China's political instability in the early 20^{th} century to the 1905 abolition of the civil service exam.

The remainder of the paper is organized as follows. The next section presents the background of the Grand Canal and its abandonment. Section 3 presents the data, while Section 4 formalizes our empirical strategy and demonstrates the baseline results. Section 5 describes the robustness checks. Section 6 discusses the possible mechanisms and their implications, and Section 7 concludes.

2 Background

2.1 The Grand Canal

The $1,776$ km Grand Canal is the longest and oldest artificial waterway in the world. Located in the north-eastern and central-eastern plains of China, it links Beijing in the north with Hangzhou in the south (see Figure 1)[2]. Construction of the first parts of the canal date back to the 5^{th} century BC, while the various sections were finally integrated into a nationwide system during the Sui Dynasty (581–618 AD). Its scale was unparalleled in its time (Elvin, 1973). More than 126

[2]The canal cuts across four provinces (Zhili (now Hebei), Shandong, Jiangsu, and Zhejiang) and runs very close to Henan and Anhui

million people lived in the six canalside provinces in 1820, which accounted for about 15% of the world's population.

The canal was originally constructed to secure the food supply of China's capital and most populous city, Beijing, which had a population of over a million in 1820. Many of its residents consisted of the court, official personnel, scholars, imperial soldiers and their families (Morse, 1913; Chi, 1936), and did not produce their own rice. Rice production was clustered in the southern part of China where there was abundant, fertile land and suitable weather (rain and sunshine) for agriculture [3]. Therefore a huge amount of rice was shipped to the capital, primarily via the Grand Canal. In the early 19^{th} century, approximately 3.5 million piculs of rice (roughly 560 million pounds) were delivered to the capital annually (Huang, 1918). Maintaining the well-functioning of the canal was one of the most crucial tasks for the Qing government (Hummel, 1991; Leonard, 1988; Cheung, 2009).

The canal also benefited the adjacent regions by facilitating regional trade and providing urban employment. The government allowed the grain junks to carry an estimated 200 million pounds of duty-free commodities annually in the early 19^{th} century (Ni, 2005). The popular commodities ranged from bamboo, woods, paper, china and silk to pears, jujube and walnuts. Private junks also used the canal extensively for trade, travel and pleasure (Gandar, 1894; Hinton, 1952). A total of over 10 million piculs (roughly 1.5 billion pounds) of commodities were transported along the canal each year. The Grand Canal also created numerous jobs in urban areas. Workers were hired either by the government in boat construction and canal maintenance, or by the private sector in restaurants, hotels and commercial services.

The Grand Canal thus boosted the economy along its route and created large commercial cities. For example, Linqing was a minor county before the construction of the canal. It developed into a trade center by the early Qing Dynasty, and was promoted to a municipality in 1777. The prosperity of the corridor was also reflected in its population density. In 1820, the population density in prefectures along the canal was 45% higher than non-canalside prefectures.

2.2 Abandonment of the Grand Canal

The canal was gradually abandoned after 1826 as part of a reform initiated due to a combination of natural and human factors. In 1825, the breach of the embankment dam at the intersection between the Yellow River and the canal temporarily interrupted grain transportation via the canal. Daoguang Emperor (1821 – 1850), the $7th$ emperor of the Qing Dynasty, unexpectedly decided to abandon the Grand Canal and use the east-China Sea route instead. This decision was more political than economic because this shift gave the new emperor the opportunity to appoint his trusted followers and to establish his own authority. The canal was abandoned gradually rather than rapidly due to safety considerations.

In 1826, the government experimented with shipping 1.63 million piculs (roughly 260 million

[3] Figure B1 shows the suitability index for wetland rice farming in China. Most areas around Beijing are not suitable for growing rice. The most suitable lands are cluster in the south.

pounds) of tribute rice collected in Jiangsu by sea. It was first shipped from Shanghai to Tianjin in 1,562 chartered ships, and then conveyed to Beijing (Hinton, 1952). The sea transportation area expanded to Jiangsu and Zhejiang after 1852, which accounted for half the amount of rice in the tribute grain system. The lack of use led to negligence in the canal's maintenance, which worsened its condition. The government officially announced the canal's abandonment in 1901 when much of it had become too clogged to navigate. Figure B3 plots the amount of tribute rice shipped via the canal using a 5-year moving average. Although the amount fluctuated over time, there was a consistent drop in the amount shipped via the canal right after the 1826 experiment. Therefore, we use 1826 as the first post reform year in our baseline analysis [4].

The abandonment of the Grand Canal inevitably led to the decline of the economic belt that had developed alongside it. As the only north-south waterway in east China, the reform forced most commodities to be transported by land, which was 9-10-fold more costly in pre-modern China (Watson, 1972; Shiue, 2002). Meanwhile, jobs that relied on the canal trade disappeared, the economies of the regions near the canal declined, and unemployment increased. As shown in Figure 2, regions adjacent to the canal did not recover from this recession until the early 20^{th} century. The population of Linqing fell from over $200,000$ in the late $18th$ century to less than $50,000$ by the early 20th century (Cao, 2001).

There is considerable anecdotal evidence that the canal's abandonment led to great social disorder in the region. For example, a 19^{th} century ballad popular in Shandong called "Broken the boat, disordered the world" lamented the destructive consequences of the closure of the canal. Esherick (1988) argues that the disruption of the canal was responsible for the Boxer Rebellions in the late 19^{th} century. Another famous example is the Green Gang, the prominent criminal organization in the early 20^{th} century formed by workers who lost their jobs due to the closure of the canal (Martin, 1996). Our paper is the first to systematically test the effect of the canal's abandonment on local instability.

3 Data

We constructed a state-of-the-art panel dataset from a number of historical sources spanning the period 1650 – 1911. Our dataset, which covers 575 counties in six provinces adjacent to the Grand Canal, allows us to empirically test the effect of the canal's abandonment on social instability. We conduct our empirical analyses at the county level, the most disaggregated administrative division in historical China, to assess the considerable heterogeneity that is likely to exist at more aggregate levels (e.g. provinces and prefectures) [5].

[4] In the flexible analysis section, we vary the cutoff year and estimate the treatment effects every 10 years. The results confirm our argument that the reform produced a significant effect immediately after the beginning of the experiment in 1826.

[5] For example, Cao County had experienced 21 rebellions throughout the Qing Dynasty, while the most stable county in the same prefecture only experienced three.

3.1 Rebellions

Our main dependent variables are the presence and number of rebellions reported in each county and year. This information comes from *Qing Shilu* (Veritable Records of the Qing Emperors), the official record of imperial edits and official memorials about events of national significance. According to Chinese historians, *Qing Shilu* is the most complete and systematic source of original information on social unrest during the Qing Dynasty (Kung and Ma, 2014b). It provides detailed records on the place and time of rebellions meticulously complied by the Qing Court. In order to unambiguously identify the link between local economic shock and social instability, we focus our analysis on the onset of rebellions, excluding the wars that spread across regions and lasted for years . During our sample period, there were a total of 1,141 reported rebellions (4.35 annually). The sample means of the presence and number of rebellions are 0.0073 and 0.0076, respectively.

3.2 Intensities of the Canal's Impact

We determine the intensity of the canals impact by the geographic locations of the counties. The locations are obtained from the digital maps available at the China Historical GIS Website [6]. We employ both discrete and continuous measures of intensities. The discrete measure is a dummy variable indicating whether the county bordered the canal. In our sample, 73 of the 575 counties are along the canal boundary. The continuous measures of intensities are defined in two ways: the distance from the county seat to the canal and the length of the canal contained within the county's boundaries. The average distance from the canal is 118 km in the sample, while the farthest county is 499 km away. The length of the canal segment contained in a county is 32.45 km on average, and the longest is 91.44 km.

3.3 Control Variables

We included the following controls from the conflict literature to eliminate certain omitted variables:

Climate The first control variable we consider is climate shocks (Miguel et al., 2004; Miguel, 2005; Hsiang et al., 2011, 2013). We obtained climate information from two independent sources. One is the historical temperature reconstructed by Mann et al. (2009) at 5×5 arc degrees based on 1,209 geological proxy records over the past 1,500 years (e.g., tree-ring, coral, sediment, etc.). We assigned the grid-cell temperature to counties in our sample and define temperature anomaly as a temperature that was beyond one standard error of the mean of all years. In our sample, an anomalous temperature was recorded every 3 years in a county. The other source is the presence of extreme drought and flood compiled by Chen and Kung (2016). A representative county in our sample experienced extreme drought every 10.24 years and extreme flood every 13.44 years. We

[6] http://www.fas.harvard.edu/∼chgis/

plot the spatial and chronological distribution for each of the three climate measures in Figure B4. We do not see any evidence of climate shock specific to the canal area or around 1826.

Geography We include two geographical measures in our analysis. The first is the terrain ruggedness index suggested by Nunn and Puga (2012), which is defined as the square root of the sum of the squared differences in elevation between one central grid cell and the eight adjacent cells (Riley et al., 1999). Grid-cell elevation per 30×30 arc seconds is obtained from GTOPO30 (Survey, 1996). For each county, the ruggedness index is constructed by computing the mean of all grid-cells contained in it. The spatial distribution of the ruggedness index is depicted in Figure B5, with a mean of 16.92 and a standard deviation of 19.53. Second, given that the Yellow River was the site of the breach of the embankment dam in 1825, the river is also likely to play a role in initiating the reform. Therefore, we include the distance from the Yellow River as a second control for geography and find that the average distance from the river is 297 km.

Technology Jia (2014) suggests that social conflicts are also subject to technological changes in the agricultural sector, especially the introduction of New World crops (Jia, 2014; Iyigun et al., 2015). Such changes may also lead to inconsistent estimates to the extent that the crops spread along the canal. Therefore, we also controlled for the planting duration of maize and sweet potato, the two most important New World crops in China (Jia, 2014; Chen and Kung, 2016). Figure B6a shows the year when the two crops were first adopted, which does not appear to be dependent on the canal. Figure B6b calculates the number of counties in which the crops have been adopted for each year. Again, the spread of the crops does not coincide with the reform.

Culture The literature maintains that culture is another factor that underpins violence (Jha, 2013; Voigtländer and Voth, 2012; Grosjean, 2014). In China, Confucianism represents one type of cultural norm that is associated with conflict (Kung and Ma, 2014b). Therefore, we include the number of *jinshi* — the highest attainable qualification under China's civil exam, which focused on Confucianism — as a measure of culture. In our sample, the average number of *jinshi* is 0.16 per county year. The spatial and chronological distribution of *jinshi* is depicted in Figure B7a, and does not appear to be associated with the reform.

Table 1 summarizes the sources and descriptive statistics of all the variables used in our analysis. In addition to the main variables above, we also used additional variables to help distinguish between the mechanisms that potentially explain our findings. The sources and descriptive statistics of these variables are listed as "Supplements" in Table 1. A more detailed description of them is included in the Data Appendix.

3.4 Suggestive Evidence

Before proceeding to the formal analysis, we provide some descriptive evidence to help put the findings into context. Figure 4 shows the distribution of rebellions over time. It clearly shows that the frequency of rebellions significantly increased following the abandonment of the canal: from 1.37 annually before 1825 to 10.47 annually afterwards. The number kept increasing until the peak was reached in 1861, when a total of 66 rebellions took place. The number of rebellions did not fall until the 1870s. The spatial distribution of rebellions also reveals a potential relationship between the canal's abandonment and social instability. The left panel of Figure 5 shows the distribution of rebellions in the pre-abandonment period, while the right panel shows the distribution in the post-abandonment period. The color intensity represents the number of rebellions reported. Before abandonment, the rebellions were less frequent but more dispersed. Afterwards, the total number of rebellions increased, and, more importantly, the relative change was greater in areas near the canal. This evidence of temporal as well as spatial distribution suggests that the abandonment of the canal should significantly contribute to the overall increase in rebellions in the mid-19th century.

Table 2 translates such intuition into a precise but naive calculation. We calculated the relative change in the number of rebellions before and after the canal's abandonment in both areas and performed the standard t test. We found that rebellions were more frequent in canalside counties and post-abandonment years: the frequency of rebellions increased 0.0240 and 0.0146, respectively, for canalside and non-canalside counties after the canal's abandonment in 1825. The relative change is 0.0094 higher at the 0.01 level of significance for counties along the canal, accounting for a 124% change relative to the sample mean of 0.0076.

4 Empirical Strategies and Results

This section estimates the impact of the abandonment of the Grand Canal on rebellions. Our baseline estimation follows the standard DID strategy, where we compare the relative change in the number of rebellions in counties along the canal relative to non-canalside counties. The identification strategy and results are presented in Section 4.1. As an extension of the analysis, Section 4.2 generalizes the standard DID estimation using continuous measures of intensity to explore finer spatial and chronological variations.

4.1 Baseline Specification and Results

We estimate the following equation as our baseline specification:

$$Y_{ct} = \beta Bordering_c \times Post_t + \delta_c + \sigma_t + \chi_{ct} + \varepsilon_{ct} \tag{1}$$

where c indexes counties and t indexes years. The outcome of interest, denoted Y_{ct}, is the number of rebellions recorded in county c in year t. $Bordering_c$ is a dummy variable that equals one if a county is located adjacent to the canal and zero otherwise. Hence, the treated group contains counties that bordered the canal, while the control group contains counties that did not. $Post_t$ is a dummy variable that equals one for the years after the abandonment. The equation also controls for county and year fixed effects, δ_i and σ_t; χ_{ct} denotes other controls. The coefficient of interest in equation (1) is β, the estimated impact of the canal's abandonment on the number of rebellions. The coefficient is expected to be positive, which would suggest a greater increase in the number of rebellions in canalside counties.

The results are reported in Table 3, where the dependent variables are the number of rebellions. All four columns adopted similar model specifications with different sets of controls. In Column (1), we control for county fixed effects and year fixed effects as the baseline. This allows us to rule out all time-invariant county features (e.g. location), and year shocks that unanimously affect all regions (e.g. overall state capacity). Column (2) further includes province-emperor fixed effects to account for unobservable factors associated with regimes, e.g., policy preferences of the emperors. Column (3) includes prefecture-specific year trends to account for differences in regional trends. Column (4) includes all previous controls simultaneously. For each column, the standard errors reported in the parentheses are clustered at the county level (as reported in parentheses) [7]. We also include Conley standard errors in the square brackets following the approaches suggested in Conley (1999) and Conley (2008) to adjust for spatial correlations.

The results obtained across all specifications are positive and significant, suggesting a higher number of rebellions associated with the canal's abandonment. As an example of interpretation, the point estimator in Column (1) represents 0.0094 more rebellions experienced by counties bordering the canal (compared to non-canalside counties) after the reform (relative to before). The effect corresponds to a 124% increase from the sample mean (0.0076), and is significant at the 95% confidence interval. The estimated coefficients from Columns (2) to (4) are very close to those in Column (1) in terms of magnitude as well as levels of significance.

The analysis is replicated in Appendix B using alternative outcome measures to account for potential measurement issues. First, to reduce the potentially biasing effects of extreme values, we use binary measures of outcomes, where the dependent variables are coded 1 if there are any cases of rebellion recorded, and 0 otherwise. The results are reported in Table B2. The estimated coefficients and standard errors are almost unchanged relative to those in Table 3. Second, Table B3 presents the results where the rebellions are normalized by population [8]. The estimated coefficients across all specifications suggest an additional 0.0004 rebellions per $10,000$ people. The scale accounts for a 133% increase relative to the sample mean, which is close to the non-normalized estimates.

[7] We have also clustered the standard errors at the prefecture level to account for within prefecture correlations. The results are reported in Table B1. The standard errors are much larger, but still significant.

[8] Prefecture-level population in 1660, 1776, 1820, 1851, 1880, and 1910 is compiled by Cao (2001). For our analysis, we construct annual county population measures assuming even distribution across counties and linear changes over time.

4.2 Generalized Estimates

One limitation of our empirical studies is the lack of well-defined treated and control groups. In the baseline we use a coarse specification that assumes binary treatment and two time periods, which may underestimate the true effects. To refine the identification, this section generalizes the specification by allowing continuous treatment measures across counties and years. We begin by exploring variations in treatment intensity across counties. We measure intensity both *internally* and *externally* [9]. The internal measure exploits variation in the length of the canal within a county, while the external one measures the distance from the county seat to the canal. For the time dimension, we use the number of years after the initial reform to account for the gradual abandonment process. Models that simultaneously allow for extensions in both dimensions are also estimated.

We start with models with continuous treatment intensity. For the internal measure of intensity, we conducted a regression analysis on the following specification:

$$Y_{ct} = \beta Length_c \times Post_t + \delta_c + \sigma_t + \chi + \varepsilon_{ct} \tag{2}$$

$$Y_{ct} = \sum_{\iota=0}^{80} \beta_\iota Post_t \times Length_\iota + \delta_c + \sigma_t + \chi + \varepsilon_{ct} \tag{3}$$

where Equation (2) assumes a linear function of canal length, while Equation (3) uses a more flexible specification to estimate a separate coefficient for each length interval. The coefficient β estimated from Equation (2) represents the relative change in the number of rebellions per kilometer length of the canal. It is expected to be positive, since the impact of the canal should be greater in counties containing longer segments. As a further extension, the coefficients β_ιs in Equation (3) estimate the treatment effects for each of the 10-km intervals with counties away from the canal (i.e., the baseline control group) as the reference group. Accordingly, we would expect these estimates to be increasing with ι's.

The coefficients estimated from Equation (2) with county, year and province-emperor fixed effects are reported in Column (2) of Table 4; the first column is taken from Table 3, Column (2) for comparison. As expected, the estimated coefficient β suggests an increase of 0.0003 rebellions per kilometer length of the canal, which is significant at the 99% confidence interval. This means that counties with an additional 25 km of canal experienced a 100% increase in rebellions relative to the sample mean [10]. For further illustration, Figure 6 plots the coefficients along with the 95% confidence intervals estimated from Equation (3). The coefficients kept increasing with the length of the canal, but did not reach statistical significance until a length of 40 km. Therefore, counties that marginally intersect the canal are not statistically different from those away from the canal in rebellions. In other words, the treatment effects we have observed in the baseline primarily come

[9] We use the term *internal measure* to represent intensity measures within the baseline treated group,i.e., counties along the canal. *External measure* refers to variations in intensity among all sample regions.

[10] For robustness, we also analyzed models in which the length of the canal is normalized by the size of the county (i.e., a density measure). The results, available from the authors, are consistent with our non-normalized estimates.

from counties that are intensively treated by the canal.

Alternatively, the external measure of intensity exploits variations in the distance to the canal, following similar specifications:

$$Y_{ct} = \beta Distance_c \times Post_t + \delta_c + \sigma_t + \chi + \varepsilon_{ct} \tag{4}$$

$$Y_{ct} = \sum_{\rho=0}^{400} \beta_\rho Post_t \times Distance_\rho + \delta_c + \sigma_t + \chi + \varepsilon_{ct} \tag{5}$$

where $Post_t$ is interacted with $Distance_c$, the distance to the canal, and each of the 25-km distance intervals, respectively [11]. The estimated coefficient β from Equation (4) represents the relative change in rebellions per kilometer away from the canal, which is expected to be negative as the impact diminishes. Equation (5) estimates the treatment effects for each of the 25-km distance intervals; counties 400 km away from the canal serve as the reference group. We expect their estimates to be smaller for intervals with larger distances.

Column (3) of Table 4 presents the estimated coefficients from Equation (4). Consistent with our expectations, it suggests 0.01 fewer rebellions per 100 km away, which is significant at the 1% level. Figure 7 plots the estimated coefficients from Equation (5) for each of the distance intervals. The coefficients keep decreasing, and remain significant within a distance of 150 km. Counties located more than 150 km from the canal did not experience more rebellions than those that are farther away. Therefore, we interpret 150 km as the range of the canal's impact.

Extensions in the time dimension are motivated by the gradual process of the reform. While the first experiment was launched in 1826, the canal was not officially abandoned until 1901. This raises concerns about our two-period baseline model with 1826 as the cutoff. Therefore, we extend our analysis using continuous measures of reform progress:

$$Y_{ct} = \beta Bordering_c \times PostYears_t + \delta_c + \sigma_t + \chi + \varepsilon_{ct} \tag{6}$$

$$Y_{ct} = \sum_{\tau=-40}^{60} \beta_\tau Bordering_c \times Period_\tau + \delta_c + \sigma_t + \chi + \varepsilon_{ct} \tag{7}$$

where the treatment indicator is interacted with $PostYears_t$, the number of years after the initial reform. As such, a later year represents a higher degree of reform completion. The result is reported in Column (4) of Table 4 with all previous controls. The estimated coefficient β measures the difference in the slopes of post-reform trends. The difference between treated and control counties per decade later is 0.001 larger, suggesting yearly expanding trends. Figure 8 plots the coefficients of Equation (7) to estimate the treatment effects by decade. The pre-reform pattern unveiled in the figure verifies the common trends assumption, which is critical in a DID context. The close-to-zero and insignificant estimated coefficients in the pre-periods suggest no evidence for

[11] Distance is measured from the county seat to the canal. The results are robust to using the least distance between county boundary and the canal as well (available upon request).

diverging trends prior to the reform. This establishes the validity of our DID design. Meanwhile, the figure reveals the rebelling dynamics after the implementation of the reform. The canal's impact on rebellions arose immediately after 1826 and kept increasing over the next 30 years. After that the gap between the two groups started to converge, yet remained significant at the 5% level. This justifies our choice of 1826 as the cutoff.

An alternative measure of the progress of the reform is the amount of grain shipped via the canal: a smaller amount represents a higher intensity. However, the shipping data is only available for some of the years between 1724 and 1849 and is very noisy. Nevertheless, we estimate the treatment effects using the amount of grain shipped to proxy for reform progress and summarize the results in Table B4. The first column estimates the treatment effects using the actual amount of grain shipped, while the following two columns use the amount simulated with moving-average and four-degree polynomials, respectively. The results are consistent with our expectation that a smaller amount of grain shipped is associated with more canalside rebellions.

Finally, we combine Equation (2) and Equation (6) to allow continuous treatment intensity in both dimensions simultaneously. Column (5) is interacted $PostYears_t$ with $Length_c$, whereas Column (6) is interacted with $Distance_c$. An intuitive way to interpret the results is to refer to the relative difference in the post-reform trends. The positive coefficient in Column (5) indicates a steeper trend in counties with longer stretches of the canal, whereas the negative coefficient in Column (6) indicates a milder effect in counties farther from the canal. Taken together, the results in Table 4 reveal that the impact of the abandonment was larger in places that were more intensively affected by (i.e., closer to) the canal, and diverged over time. This reinforced our baseline findings that the reform was associated with the subsequent wave of rebellions.

5 Robustness

5.1 Including More Controls

To address concerns that our results suffer from omitted variable bias — i.e., that other factors affecting social conflict may also be correlated with the canal — we include several controls associated with conflict in the literature.

Section 3.3 summarized the choice and sources of the control variables. We included time-variant variables like climate shocks directly into our model, and interacted time-invariant variables (such as terrain ruggedness) with the post-reform indicator to account for potential structural changes. The results are reported in Table 5. Columns (1) – (8) add the set of controls one at a time, while Column (9) includes all of them simultaneously. Our main coefficient of interest, $Bordering_c \times Post_t$, preserves its significance across all specifications. The magnitude of the effects is also stable. It ranges from 0.0075 to 0.0100, around 100% to 144% of the sample mean.

As for the control variables, the correlations discovered in our data are consistent with the conflict literature. For example, extreme weather, in all sorts of measures, is associated with a higher rate of rebellions. Land ruggedness, however, reduced the frequency of rebellions during the post-reform periods [12]. Distance to the Yellow River also contributed to the rise of rebellions, as suggested by the historical context, yet it does not negate the effects of the canal. We find no evidence that agricultural technology or culture plays a significant role in our context.

5.2 Truncated Sample Periods

Another threat to our identification strategy is the relatively long sample periods after the reform. While the launching of the reform in 1826 was not due to previous conflict around the canal, the social unrest that took place afterwards might reinforce and accelerate the reform process in subsequent years, raising concerns about reverse causality in later periods [13]. Therefore we restrict our analysis to truncated sample periods to mitigate the potential biasing effects.

Figure 9 depicts the estimated coefficients and 95% confidence intervals from Equation (1) based on various sample periods. The x-axis labels the last year included in the analysis. The first sample contains all years prior to 1840, while every subsequent one adds another 10 years. The estimated coefficients are positive and significant across all samples, suggesting that our analysis is robust to excluding potentially endogenous periods. Specifically, the estimates from the pre-1840 sample represent the effects of the reform in the first 25 years, which provides the finest identification. However, we interpret its coefficient as a lower bound since the reform was in its initial stage during this period.

5.3 Falsification Test

Because the number of treated observations is relatively small in our sample (73 out of 575), there might be concerns of spurious correlations due to noise. To address this concern, we compare the treatment effects we have estimated to the distribution of placebo treatment effects when county locations are randomly assigned. Specifically, we randomly assign counties to the polygons in our sample map representing county locations, without replacement. Thus the number of placebo counties bordering the canal was the same as the number of actual counties, but the selection of counties was random. Then we estimated the placebo treatment effects using Equation (1) and compare them to those in Column (1), Table 3.

Figure 10 plots the distribution of t-statistics from the placebo treatment effects for $1,000$, $3,000$, $5,000$ and $10,000$ times. The vertical lines mark the location of the t-statistic of the actual treatment effect (as in Column (1), Table 3). The share of the placebo t-statistics that is larger than the actual statistic ($P(t \leq T)$) can be interpreted as analogous to a p-value. It suggests the probability that a randomly assigned treated group will present an effect at the same or higher level of significance as the actual treated group. As such, we can reject the null that our result is indifferent to the placebo treatment effects at about the 1% level of significance.

[12] This is consistent with the findings in Nunn and Puga (2012) that terrain ruggedness benefited African countries by avoiding the slave trade.

[13] For instance, the capture of Jiangning (now Nanking) by the Taiping Rebellion in 1853 is believed to accelerate the reform by many historians as it blocked the source of grain transportation.

6 Discussion of Mechanisms

In previous sections we presented evidence that relates the abandonment of the Grand Canal to the subsequent emergence of rebellions. Now we discuss the mechanisms behind this correlation. The conflict literature has highlighted two distinct mechanisms that may explain our findings. First, the reform might have reduced state capacity, and hence increased the probability that the rebels would win (Besley and Persson, 2010, 2011; Michalopoulos and Papaioannou, 2013). Second, it might have lowered the opportunity cost, and thus increased the relative benefit, if it succeeded (Becker, 1968, 1974; Ehrlich, 1973; Hirshleifer, 1995; Grossman, 1991; Acemoglu and Robinson, 2001). Either way, the reform would increase the expected payoff of participating in rebellions and hence produce instability. In this section, we compare the relative explanatory power of the alternative mechanisms by testing the validity of their predictions.

6.1 Decline in State Capacity

While county-level measures of state capacity are not available in our data, we employ two indirect approaches to examine the role of state capacity. The first approach explores variations in the importance of political control. If state capacity is the primary driving force behind our results, we would expect a stronger effect in regions that are more important to the government. Therefore we interact our treatment indicator with two measures of importance — the number of imperial soldiers assigned and the presence of prefectural capitals. The results are reported in the first two columns of Table 6. The importance of political control, measured either way, does not exhibit a higher rate of rebellion in the post-reform period. Furthermore, we find no evidence that the reform produced more rebellions in regions that are more important to the government (suggested by the triple interaction terms). The insignificance of these estimates suggests that state capacity played a very limited (if any) role in these rebellions.

The second approach is to check the placebo effect on other types of social unrest that are closely related to a decline in state capacity. Specifically, we test the impact of the abandonment on the frequency of being attacked or retreated into by enemies, based on the rationale that weak counties are vulnerable to attack and secure to retreat into. If abandoning the canal reduced state capacity more dramatically in counties it passed through than in others, we should also expect increases in their chances of being attacked or retreated into. The results are summarized in the next two columns of Table 6. Column (3) tests the placebo treatment effect on the frequency of being attacked, whereas Column (4) tests the placebo treatment effect on the frequency that defeated enemies retreated into the county. Both coefficients are relatively small compared to the sample mean, and are not significantly different from zero. Thus while the abandonment of the canal increased the local onset of rebellions, there is no evidence of increases in any other types. Therefore, the data does not support the decline of state capacity as a potential mechanism.

6.2 Reduction of Opportunity Costs

An alternative hypothesis is that the reform might have triggered rebellions by reducing the rebels' opportunity costs. In rural sectors, this could happen if abandoning the canal adversely affected agricultural productivity. In urban areas, where people worked in commercial sectors, rebellions could have been induced by the decline in trade accessibility. We examine both possibilities in this section.

We first check, both directly and indirectly, whether abandoning the canal induced rebellions because it reduced agricultural productivity. The direct approach exploits variation in grain prices compiled by Chen and Kung (2016). If agricultural productivity deteriorated after the canal was abandoned, we would observe inflation in grain prices. The first column of Table 7 regresses grain prices on the abandonment of the canal. The positive but insignificant estimated coefficient suggests little evidence that grain price inflation was associated with the reform. As an indirect test, the next two columns examine whether the impact of the reform was stronger in agricultural regions. We multiply the baseline interaction with the suitability indicator for wheat and wetland rice, the two main crops in our sample area (Talhelm et al., 2014). While the main effects of the reform remain significant, we find no heterogeneity across various levels of crop suitability. Therefore, the deterioration in agricultural productivity was not supported by the data.

We next turn to the urban sector, where we discovered considerable evidence to support the channel of declined trade. The first piece of evidence comes from the underdevelopment of local markets around the canal. In the first column of Table 8, we regress the number of towns and markets reported in 1820 and 1911 on the reform. The relative change was significantly lower in regions that were more intensively affected by the canal. This reveals that the reform had strong adverse impacts on the development of the local market. Second, we find that the impact of the reform was stronger in more urbanized regions. To see this, we multiply our baseline interaction by the share of urban areas in 1776 and summarize the result in the second column of Table 8. In this specification, the baseline interaction $Canal \times Post$ represents the treatment effect in the absence of urbanization, while the triple interaction $Canal \times Post \times 1776\ Urbanshare$ estimates the upward trend as urbanization increased. The result suggests that the impact of the reform was not present in rural areas, and was stronger in highly urbanized regions. The final test compares the impact of the reform in places with and without alternative trade routes. Specifically, we interact the reform indicator with the county's access to courier roads, the major routes for north-south transportation by land. In Column (3) of Table 8, the interaction between $Canal \times Post$ estimates the treatment effects for canalside counties without access to the courier roads, while the triple interaction represents the relative change in the treatment effects in counties with such access. We observe from the estimated coefficients that access to alternative trade routes offset half of the impact induced by the reform. [14] In summary, this evidence is consistent with the channel of

[14] We also verified the canal's role in mitigating risk, the role that trade usually plays in the course of climate shocks, as suggested by Dube and Vargas (2013). Consistent with their argument, we find that the canal helped reduce conflict during extreme weather, but such effect was absent after its abandonment. The results are available upon request.

declined access to trade which reduced rebels' opportunity cost in urban sectors [15].

6.3 Discussion

Our finding that the reform triggered rebellions in urban areas has significant implications. Unlike their rural counterparts, the labor force in densely populated urban areas has more collective consciousness and organized politics. During the era of canal transportation, the grain transport boatmen formed various societies and associations all over the canal [16]. Where there was a lack of socio-economic opportunities, such organizations were likely to transform into gangs, and become a long-lasting hotbed of secret societies and organized violence. This transformation, while not well documented in the conflict literature, is consistent with the evolution of gangsters in Chicago (Haller, 1971), the rise of the mafia in New York city (Critchley, 2008), and many other violent events around the world.

We further explore this idea using three cross-sectional exercises [17]. The first exploits variation in the emergence of the Green Gang, one of China's largest and most powerful organized crime groups in the early 20^{th} century. We obtained a list of Green Gang high-ranking members and correlated their distribution with the location of the canal. The results, presented in the first column of Table 9, demonstrate a high concentration around the canal. The second evaluation regards the rise of communism in southern China during the 1920s. We compiled the year when the first Communist Party group was founded for each county in Anhui, Jiangsu and Zhejiang, the provinces with the earliest communist activities in our sample. Column (2) of Table 9 presents the correlations between the canal and the spread of communism. On average, the Communist Party emerged earlier in counties that were more intensively affected by the canal. Finally, Column (3) of Table 9 estimates the correlation between the canal's intensity and the presence of armed conflict (with deaths > 0) in the 5 five years after the onset of the Chinese Cultural Revolution $(1966 - 71)$ [18]. It shows that the regions around the canal experienced much more violence than the others during Cultural Revolution [19]. All these results, while not necessarily causal, suggest that pre-reform labor organizations in urban regions transformed into gangs, secret societies and organized violence as a result of the reform.

[15] An alternative interpretation of our findings on urban areas is that they reflect some sort of political grievance (blaming the government for the abandonment) rather than a decline in opportunity costs. To account for this possibility, we identify a set of regions that experienced mass killing when the Qing military took over their territory in the 1640s. We would expect stronger effects at the site of mass killing if the impact we have observed is due to such grievances. The result, while not reported, is inconsistent with this argument. We do not find a significant difference between places with and without a history of mass killing.

[16] According to historical records, these associations took control of tens of thousands of grain junks and over $50,000$ registered members by the late 18^{th} century.

[17] In all analyses, we restrict our sample to counties within $150km$ from the canal, the effective regions according to our estimation in Section 4.2.

[18] We thank Andrew Walder for generously sharing his data.

[19] Walder (2014) estimated that the political upheaval resulted in 1.1 to 1.6 million deaths and 22 to 30 million direct victims of political persecution

7 Conclusion

In this paper, we use the abandonment of China's Grand Canal as a natural experiment to study the link between economic shocks and social conflicts. This setting is ideal for our research purpose because the reform was generally unexpected, and was driven by political rather than economic considerations. Using a dataset covering 575 counties from 1650 to 1911, we find that the negative economic shock generated significant social instability: compared to counties away from the canal, counties bordering the canal on average experienced 0.0094 more rebellions after the canal's abandonment. The effect represents a 124% increase relative to the sample mean, and is significant at the 95% confidence interval. Extensions to the specification further show that the effects spread over a range of 150 km, and kept increasing over the next 30 years. We found considerable evidence to support our opportunity cost hypothesis. In particular, the increase in rebellions in counties bordering the canal seems to have been due to the interruption of trade in urban sectors. We briefly discuss the possible implications for the underlying social structure in urban regions, and tentatively attempt to relate this to the evolution of organized crime and communism in the early 20^{th} century.

This paper makes a significant contribution to the conflict literature by examining a permanent shock to the urban sector that was initiated by the government. Given that the existing literature primarily focuses on shocks associated with commodity prices and weather volatility, our study broadens the set of causal evidence that links economic shocks to violent conflict. It can also be linked to the impact of transportation infrastructure, the persistence of historical events, and the wave of social unrest in historical China.

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Figures

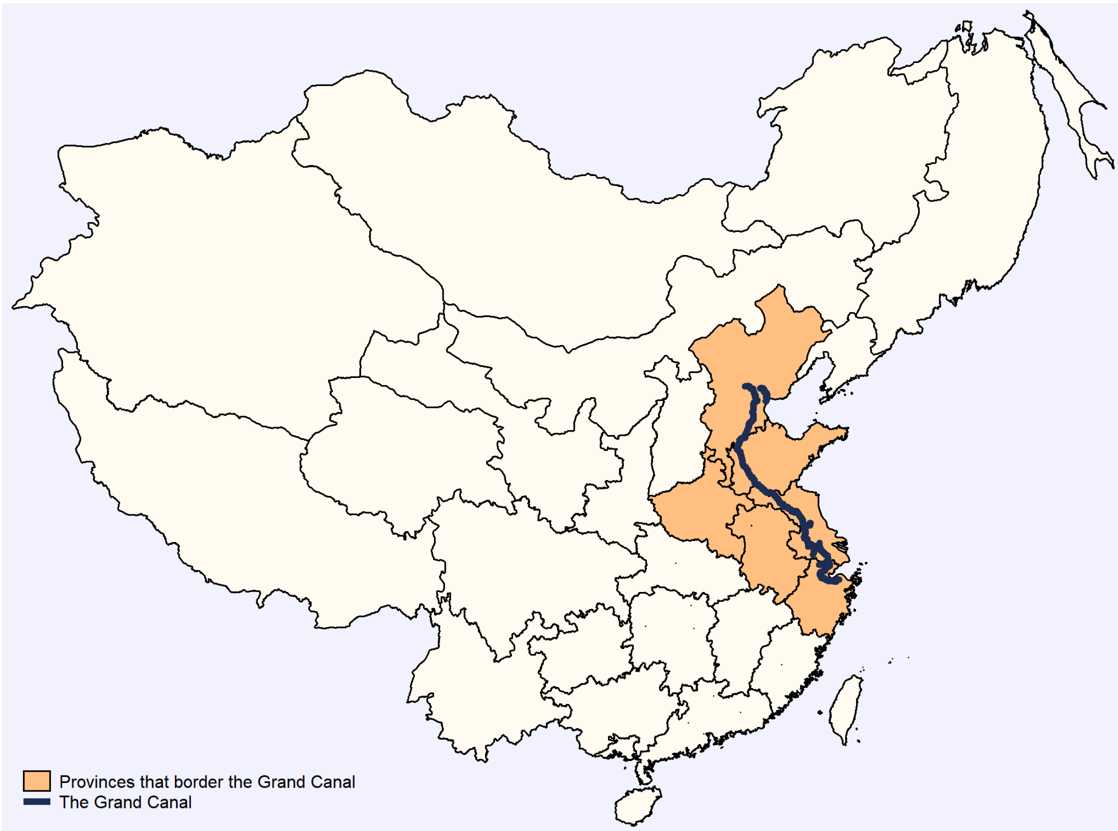

Figure 1: Location of the Grand Canal

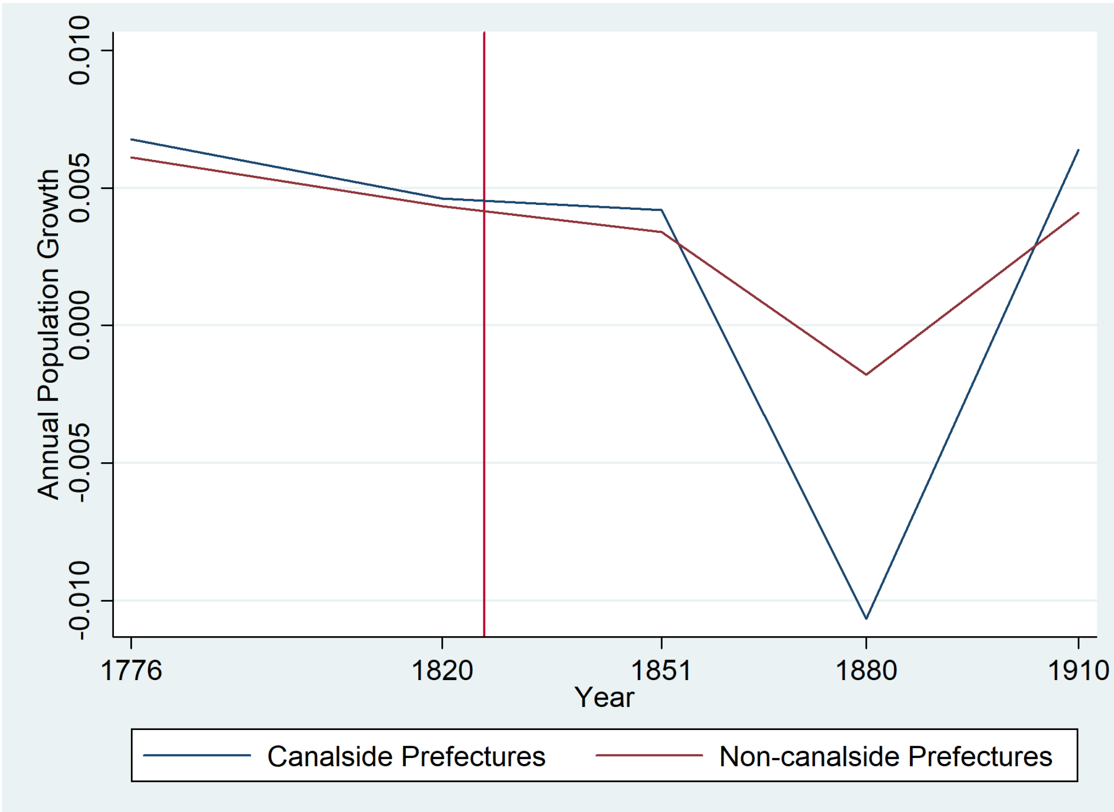

Figure 2: Annual Population Growth at the Prefecture Level

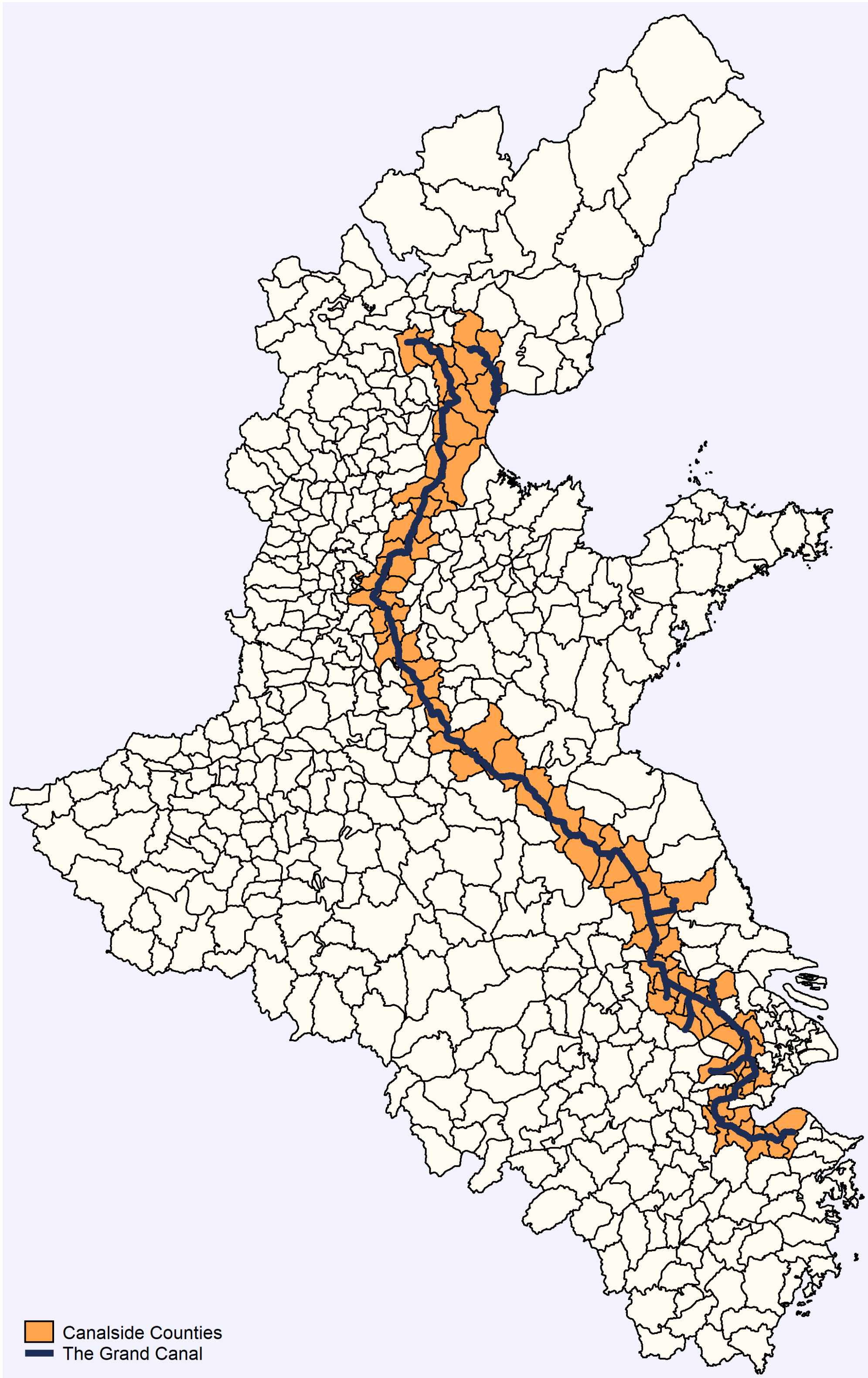

Figure 3: Counties Contained in the Sample

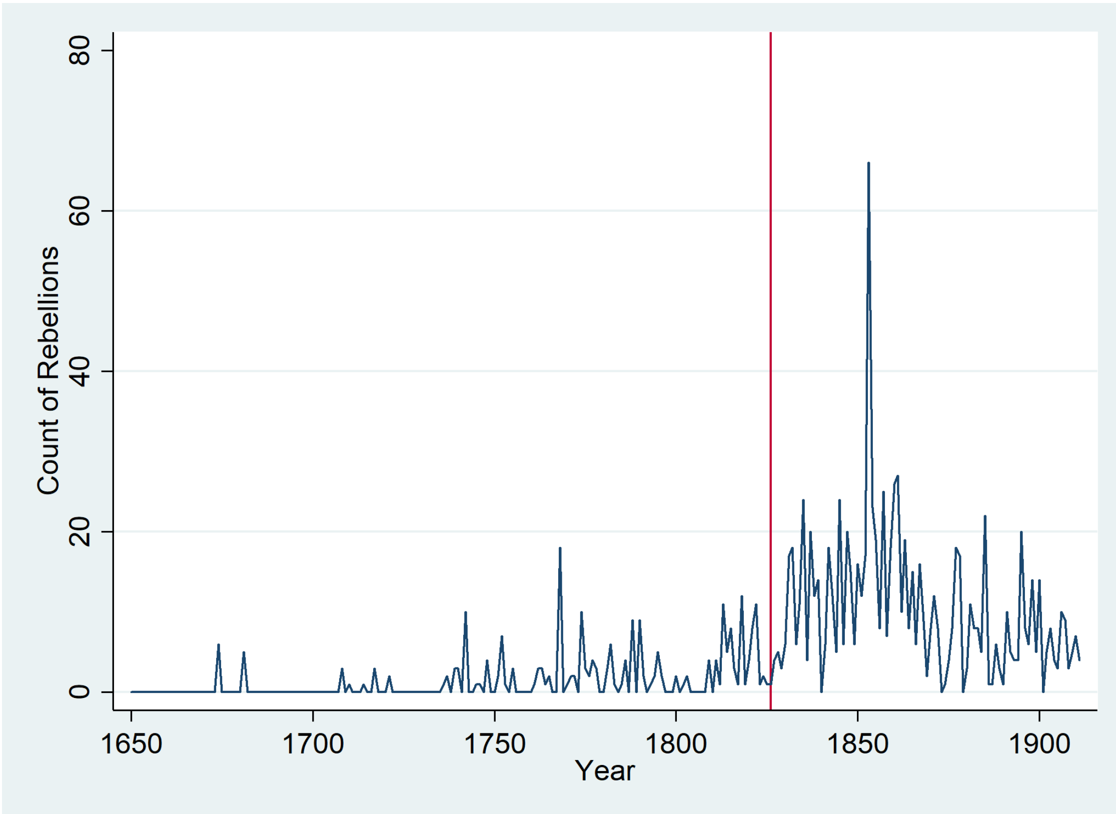

Figure 4: The Dynamics of Rebellions over Time

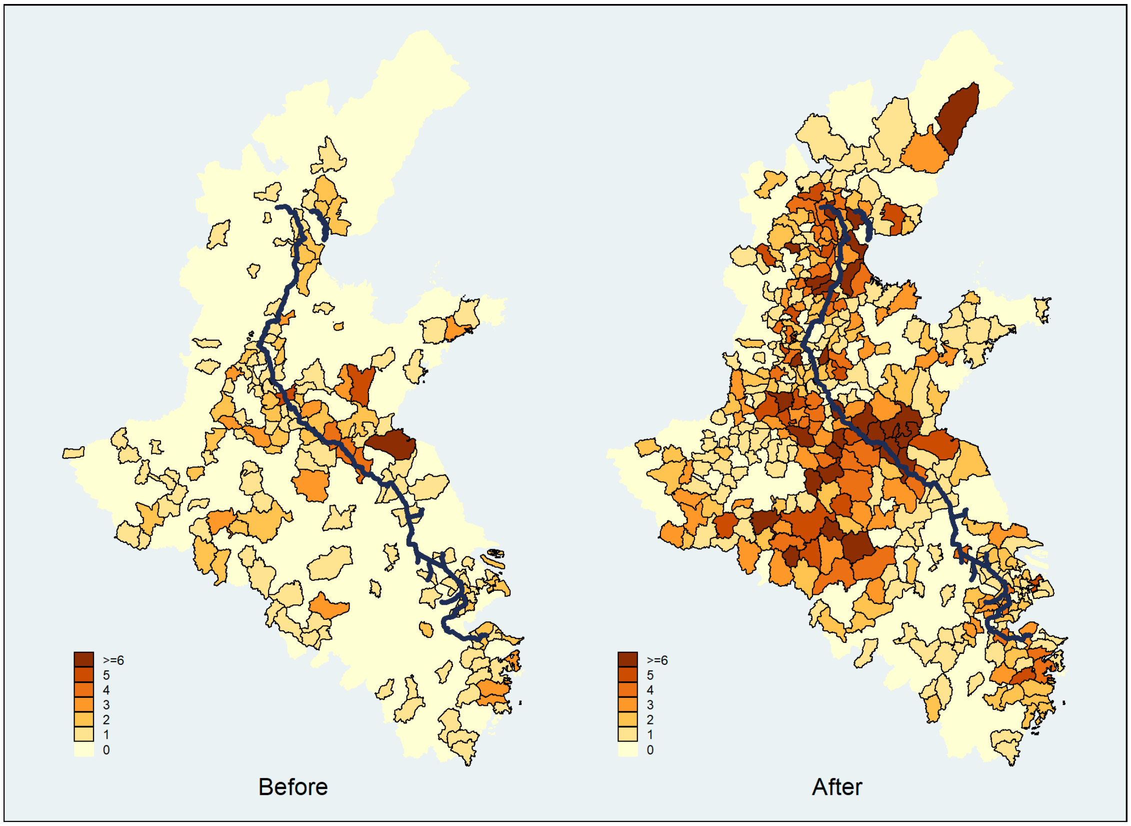

Figure 5: The Spatial Distribution of Rebellions before and after the Abandonment

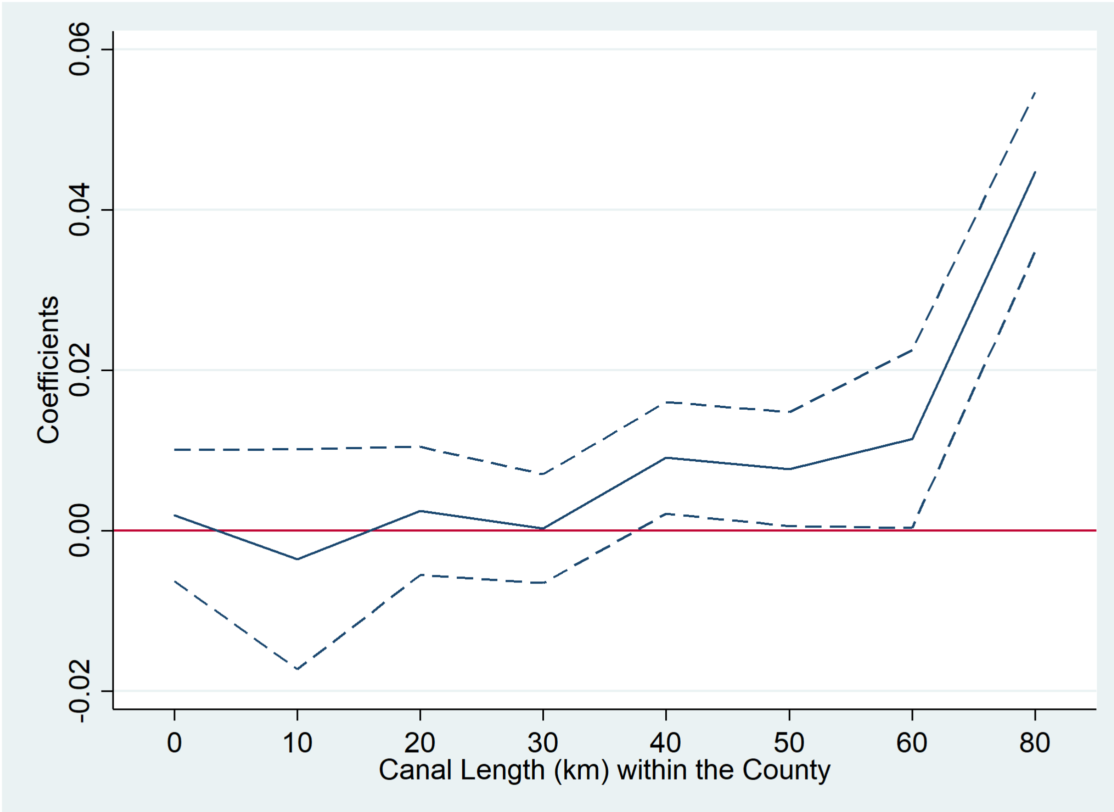

Figure 6: More Flexible Estimation of the Treatment Effects by Canal Length

Figure 7: More Flexible Estimation of the Treatment Effects by Distance to the Canal

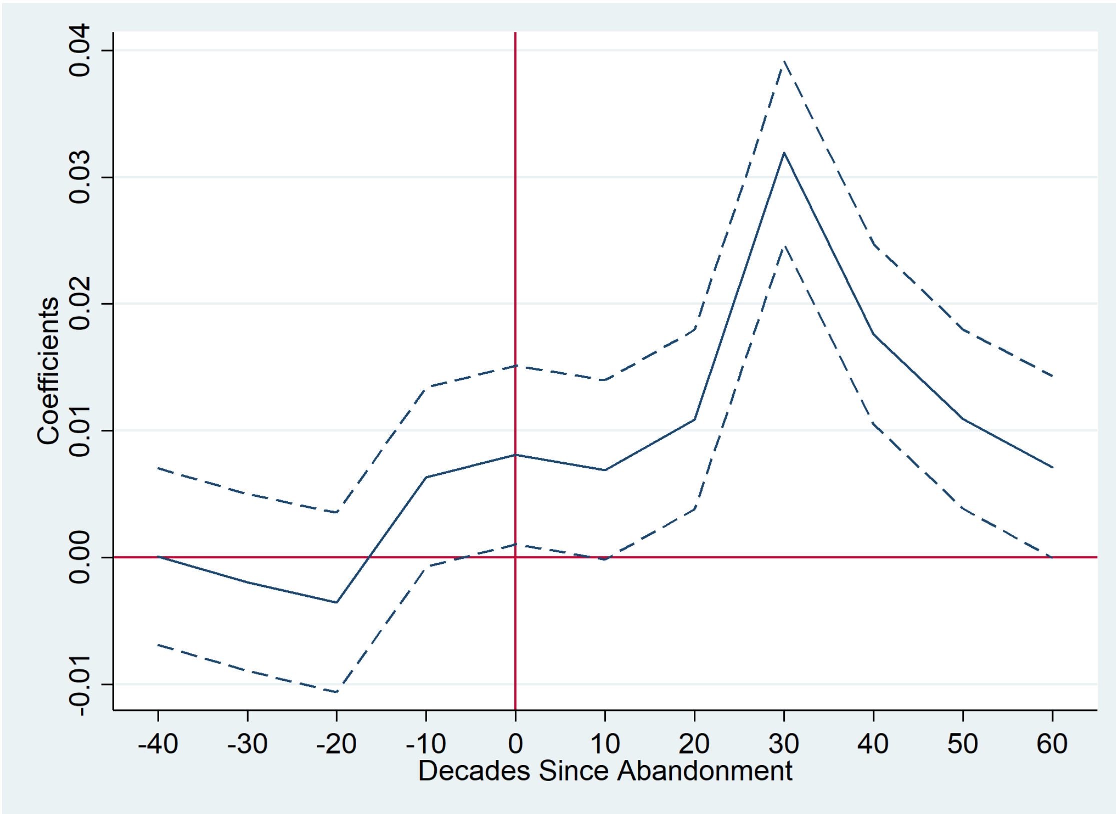

Figure 8: More Flexible Estimation of the Treatment Effects by Decades

Figure 9: Treatment Effects with Gradually Expanding Years of Analysis

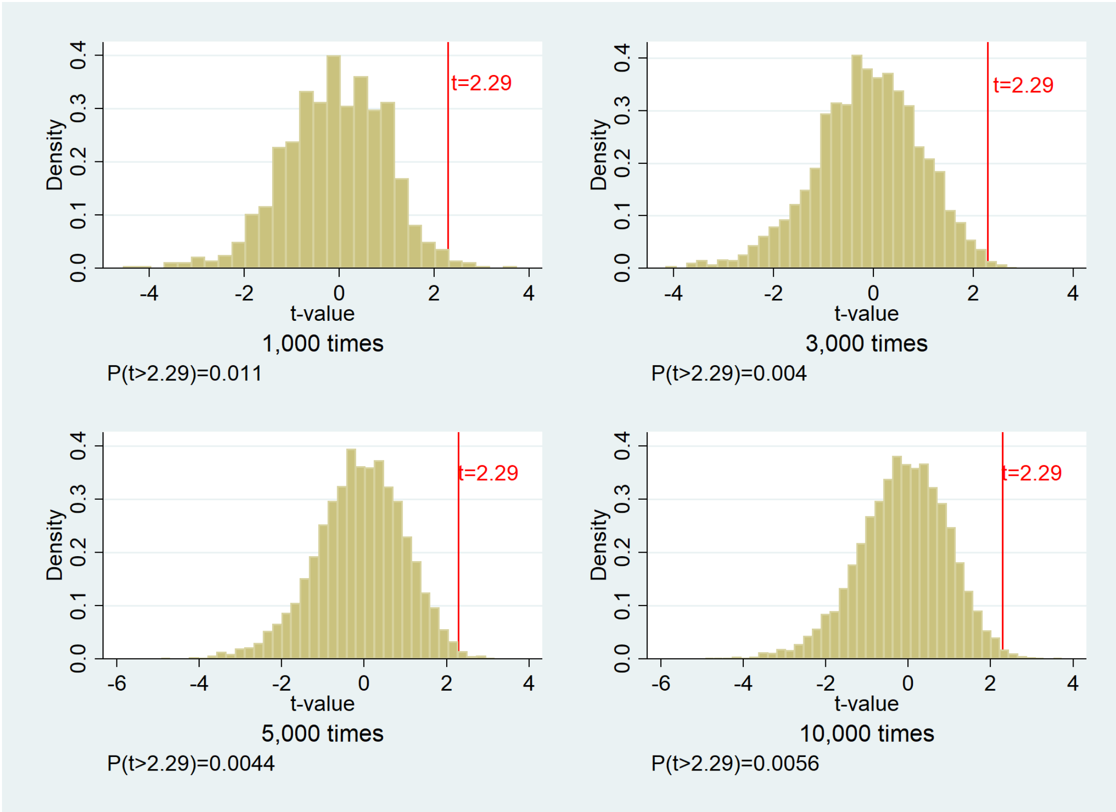

Figure 10: The Distribution of t-statistics from Randomly Assigned Placebo Treatment Effects

Tables

Table 1: Descriptive Statistics

	Source	Obs.	Mean	S.D
Outcomes				
Presence of Rebellions (Onset)	1	150,650	0.0073	0.0854
Number of Rebellions (Onset)	1	150,650	0.0076	0.0894
Treatments				
Being Along the Grand Canal	2	575	0.1270	0.3332
Length of Canal within Boundary (km)	2	575	4.1196	13.3217
Distance from the Grand Canal (km)	2	575	118.0353	113.4459
Controls				
Temperature Deviated from 1961-2006 Mean	3	143,838	-0.1954	0.3343
Drought	4	150,650	0.0976	0.2968
Flood	4	150,650	0.0743	0.2623
Ruggedness Index	5	575	72.7510	97.6787
Distance from the Yellow River (km)	2	575	296.8347	267.3429
Year of Maize Adoption	4	563	1,718.4050	95.6149
Year of Sweet Potato Adoption	4	231	1,755.0130	51.2365
jinshi	6	150,650	0.1563	0.8558
Supplements				
Imperial Soldiers Stationed	7	575	154.2104	345.8505
Prefecture Capital	2	575	0.1391	0.3464
Number of Attacking Cases	1	150,650	0.0054	0.0822
Number of Retreating Cases	1	150,650	0.0036	0.0690
Average Grain Price (Liang/KCal)	4	91,110	0.5980	0.1856
Suitability Index for Wheat (Irrigation, M Input)	8	575	4,793.0057	1,836.9174
Suitability Index for Wetland Rice (Irrigation, M Input)	8	575	3,758.3572	1,231.6994
Number of Towns and Local Markets	2	1,150	12.4957	10.7650
1776 urbanshare	4	563	8.6055	3.7947
Along the Qing Courier Routes	2	575	0.2800	0.4494
Mass Kill during the Qing Invasion	9	575	0.0226	0.1488
Senior Green Gang Members	10	575	0.2435	1.0592
Year of First Communist Party Branch	11	569	1,928.2583	5.2102
Armed conflict with non-zero death toll, 1966 - 1971	12	569	0.6432	0.4795

Data Sources:

1. Veritable Records of the Qing Emperors (*Qing Shilu*)
2. Harvard Yenching Institution (2007), CHGIS, Version 4.
3. Mann et al. (2009)
4. Chen and Kung (2016)
5. Nunn and Puga (2012)
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10. Encyclopedia of the Green Gang (*Qingbang Tongcao Huihai*)
11. Local gazettes
12. Walder (2014)

Table 2: Comparing the Number of Rebellions between the Treatment and the Controls

	Before 1825	After 1825	Difference
Counties Along the Grand Canal	0.0048	0.0288	0.0240***
	(0.0704)	(0.1730)	(0.0018)
Counties not Along the Grand Canal	0.0020	0.0166	0.0146***
	(0.0462)	(0.1322)	(0.0004)
Difference	0.0028***	0.0122***	0.0094***
	(0.0005)	(0.0019)	(0.0015)

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels respectively.

Table 3: The Effects of the Canal's Abandonment on the Number of Rebellions

	Dependent Variable: Number of Rebellions			
	(1)	(2)	(3)	(4)
Along Canal × After Abandonment	0.0094**	0.0100***	0.0076**	0.0076**
	(0.0037)	(0.0038)	(0.0037)	(0.0037)
	[0.0026]	[0.0026]	[0.0027]	[0.0026]
Constant	0.0119***	-0.0066***	-0.0026	-0.4522**
	(0.0004)	(0.0011)	(0.0749)	(0.1814)
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province × Emperor FE	No	Yes	No	Yes
Prefecture Year Trend	No	No	Yes	Yes
Mean of the Dependent Variable	0.0076	0.0076	0.0076	0.0076
No. of Observations	150,650	150,650	150,650	150,650
No. of Counties	575	575	575	575
No. of Clusters	575	575	575	575
Adjusted R-squared	0.0250	0.0263	0.0277	0.0290

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels, respectively. Standard errors in parentheses are clustered at the county level. Standard errors in square brackets are Conley standard errors robust for spatial correlation.

Table 4: Continuous Treatment Effects of the Abandonment of the Canal on the Number of Rebellions

Measure of Treatment Intensity:	*Dependent Variable:* Number of Rebellions					
	(1)	(2)	(3)	(4)	(5)	(6)
Binary (Baseline):						
Along Canal × After Abandonment	0.0100***					
	(0.0038)					
Continuous intensity:						
Canal Length × After Abandonment		0.0034***				
		(0.0013)				
Distance to Canal × After Abandonment			-0.0005***			
			(0.0001)			
Continuous progress						
Along Canal × Years after Abandonment				0.0011*		
				(0.0006)		
Continuous in both						
Canal Length × Years after Abandonment					0.0004**	
					(0.0002)	
Distance to the Canal × Years after Abandonment						-0.0001***
						(0.0000)
Constant	-0.0066***	-0.0066***	-0.0091***	-0.0066***	-0.0066***	-0.0079***
	(0.0011)	(0.0011)	(0.0013)	(0.0011)	(0.0011)	(0.0012)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Province × Emperor FE	Yes	Yes	Yes	Yes	Yes	Yes
Mean of the Dependent Variable	0.0076	0.0076	0.0073	0.0076	0.0076	0.0073
No. of Observations	150,650	150,650	139,384	150,650	150,650	139,384
No. of Counties	575	575	532	575	575	532
No. of Clusters	575	575	532	575	575	532
Adjusted R-squared	0.0263	0.0266	0.0265	0.0261	0.0263	0.0262

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels respectively. Standard errors are clustered at the county level. The length and distance measures are rescaled to 10 km. Number of years since the reform is measured in decades.

Table 5: The Effects of the Canal's Abandonment with Multiple Controls

	Dependent Variable: Number of Rebellions								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Canal × Post	0.0097**	0.0100***	0.0100***	0.0076**	0.0091**	0.0099***	0.0100***	0.0100***	0.0075*
	(0.0038)	(0.0038)	(0.0037)	(0.0038)	(0.0038)	(0.0038)	(0.0037)	(0.0038)	(0.0039)
Climate:									
Temperature Deviation	0.0072**								0.0063**
	(0.0029)								(0.0030)
Drought		0.0019**							0.0024***
		(0.0009)							(0.0009)
Flooding			0.0023**						0.0026**
			(0.0010)						(0.0011)
Geography:									
Ruggedness × After				-0.0000***					-0.0000***
				(0.0000)					(0.0000)
Distance to Yellow River × After					-0.0000***				-0.0000**
					(0.0000)				(0.0000)
Technology:									
Maize Adopted						0.0017			0.0020*
						(0.0011)			(0.0011)
Sweet Potato Adopted							-0.0002		-0.0004
							(0.0013)		(0.0013)
Culture:									
jinshi								0.0002	0.0003
								(0.0002)	(0.0003)
Constant	-0.0042***	-0.0066***	-0.0067***	-0.0002	-0.0045***	-0.0063***	-0.0066***	0.0125***	0.0012
	(0.0014)	(0.0011)	(0.0011)	(0.0012)	(0.0010)	(0.0012)	(0.0011)	(0.0011)	(0.0022)
County FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province × Emperor FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean of the Dependent Variable	0.0075	0.0073	0.0073	0.0073	0.0073	0.0074	0.0074	0.0073	0.0077
No. of Observations	143,838	150,650	150,650	150,650	150,650	147,506	147,506	150,650	141,218
No. of Counties	549	575	575	575	575	563	563	575	539
No. of Clusters	549	575	575	575	575	563	563	575	539
Adjusted R-squared	0.0274	0.0263	0.0263	0.0266	0.0266	0.0267	0.0267	0.0263	0.0282

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels respectively. The treatment is measured by along canal indicator. Standard errors are clustered at the county level.

Table 6: Testing the Shocks to State Capacity

	Dependent Variable:			
	Baseline Outcome		Placebo Outcome	
	Rebellions (Onset Case)		Attack Case	Retreat Case
	(1)	(2)	(3)	(4)
Canal × Post	0.0003**	0.0003***	0.0000	0.0000
	(0.0001)	(0.0001)	(0.0001)	(0.0000)
Soldiers × Post	-0.0003			
	(0.0002)			
Canal × Post × Soldiers	0.0000			
	(0.0000)			
Prefecture Capital × Post		0.0047		
		(0.0029)		
Canal × Post × Capital		-0.0003		
		(0.0002)		
Constant	0.0120***	0.0123***	0.0137***	0.0040***
	(0.0004)	(0.0004)	(0.0003)	(0.0002)
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Mean of the Dependent Variable	0.0076	0.0073	0.0054	0.0036
No. of Observations	150,650	143,052	150,650	150,650
No. of Counties	575	546	575	575
Adjusted R-squared	0.0253	0.0245	0.0959	0.0785

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels respectively. The treatment is measured by the length of the canal within a county. Standard errors are clustered at the county level.

Table 7: Testing the Shocks to Agricultural Productivity

	Dependent Variable:		
	Grain Price	Number of Rebellions	
	(1)	(2)	(3)
Canal × Post	0.0003	0.0003***	0.0003***
	(0.0004)	(0.0000)	(0.0001)
Canal × Post × Wetland Rice Suitability		0.0001	
		(0.0002)	
Canal × Post × Wheat Suitability			0.0001
			(0.0001)
Constant	0.4372***	0.0119*	0.0129**
	(0.0321)	(0.0066)	(0.0066)
Dual Interactions	No	Yes	Yes
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Mean of the Dependent Variable	0.5980	0.0076	0.0076
No. of Observations	91,110	150,650	150,650
No. of Counties	560	575	575
Adjusted R-squared	0.7062	0.0252	0.0256

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels respectively. The treatment is measured by the length of the canal within a county.

Table 8: Testing the Shocks to Trade Accessibility

	Dependent Variable:		
	Town Number	Number of Rebellions	
	(1)	(2)	(3)
Canal × Post	-0.1234***	-0.0023*	0.0028***
	(0.0389)	(0.0012)	(0.0006)
Canal × Post × 1776 Urbanshare		0.0004***	
		(0.0001)	
Canal × Post × Courier			-0.0015**
			(0.0008)
Constant	1.2222***	0.0117*	0.0116*
	(0.0292)	(0.0066)	(0.0066)
Dual Interactions	No	Yes	Yes
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Mean of the Dependent Variable	2.1228	0.0076	0.0076
No. of Observations	1,104	147,506	150,650
No. of Counties	575	563	575
Adjusted R-squared	0.6523	0.0253	0.0249

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels respectively. The treatment is measured by the length of canal within the boundary normalized by the sizes of the counties.

Table 9: Testing the Persistent Effects of the Reform

	Dependent variable:		
	Green Gang High-ranking Members (early 20^{th} century)	Year of Communism Emergence (1920 – 1949)	Armed conflict (1966 – 1971)
	(1)	(2)	(3)
Canal	0.0305***	-0.0327*	0.0027*
	(0.0098)	(0.0189)	(0.0015)
Prefecture FE	Yes	Yes	Yes
Mean of the Dependent Variable	0.3533	1926.7339	0.6603
No. of Observations	317	109	312
Adjusted R-squared	0.1712	0.0597	0.1450

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels respectively. The treatment is measured by the length of the canal within the boundary.

A Additional Data Description

A.1 Coding Method

This section summarizes the coding method of our dependent variable: the number of rebellions. We start by describing the structure and content of *Qing Shilu* (The Veritable Records of Qing Emperors). Then the detailed steps taken to locate and code the relevant records are described with illustrative examples.

Qing Shilu is a collection of 13 books (See Figure A1 for a photo of its appearance), each corresponding to one of the 13 emperors in Qing China. The books consist of the words, orders and activities of the emperors documented by the court on a daily basis. According to many historians, they provide the most detailed information on social instability (among many others) throughout the Qing Dynasty.

We collected and digitalized the information in the *Qing Shilu* in two steps. In the first step, we identified the items related to rebellions from the books by searching for the keyword "fei" (bandits), which is the most common term used by the Qing government to refer to rebels [20]. We document a separate record for each county mentioned in the identified items, which gives us $3,041$ mentions of rebellions after dropping the duplications.

In the second step, we categorized the mentions through a close reading of the text. We defined five collectively exhaustive and mutually exclusive groups of actions taken by the rebels: *onset*, *attacking*, *defending*, *stationing* and *retreating*. Specifically, *onset* refers to cases where the rebelling group did not exist previously and started to rebel locally. This is often identified by phases such as "hu you" (suddenly there is), "shu qi" (raise their flag), "qi shi" (starts rebelling), etc. *Attacking* refers to cases where the rebelling group already exists and is trying to attack **another** county. *Defending* refers to cases where the rebelling group already exists and is being repressed by the government. *Stationing* refers to cases where the rebelling group already exists and is staying in one county without other military action. Finally, *Retreating* refers to cases where the rebelling group already exists and is retreating to a county (often after being defeated by the government).

For illustration, Figure A2 demonstrates a typical record obtained from the *Qing Shilu*. The report one of the emperor's orders in July 1900, saying that a group of rebels formed in Jiangshan County and Pucheng County and that they have conquered Jiangshan County and Changshan County. In this example, we identify two cases of onset events in 1900, one in Jiangshan County and the other in Pucheng County. Changshan County, however, is coded with one attacking event in the data. Our categorization is mutually exclusive in the sense that Jiangshan County is no longer coded with an attacking event in this record once it has been coded as onset (i.e., it is the place where the rebellion starts).

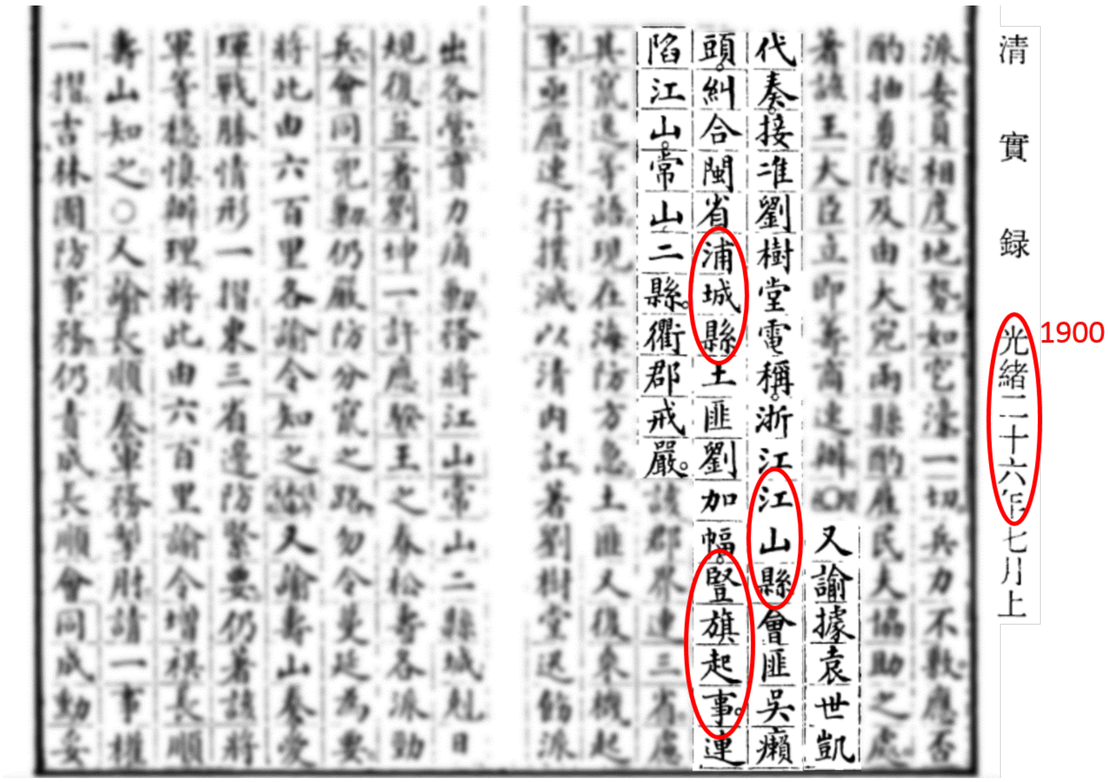
The number of rebellions (by category) in each county year is defined as the total number of **separate** events in each category [21] . For the purposes of this paper, we restrict our analysis to the cases of local onsets to avoid the complexity of military considerations. Yet we use the attacking and retreating cases as placebos in the discussion of mechanisms.

[20]The Qing government often referred to rebel groups according to their identity (usually the location or the leader's surname) followed by the keyword "fei". For example, "yue fei" refers to rebelling groups originating from Guangdong and Guangxi (also named "yue"); "cuan fei" refers to rebels moving around ("cuan").

[21]By the term **separate** we mean events that are not obviously connected according to the text record. For example, if the county reports two onset cases in one year, the number of onset events in that county year will be coded as 2 as long as there is no explicit connection between these two events implied in the text (e.g. one is a continuation of the other, or initiated by the same leader, or there is some sort of collusion between the rebels, etc.). It is possible that the two events are implicitly connected in an unobservable manner that is not recorded. We address this concern by using the presence of rebellion as a robustness check in our analysis.

A.Figures

Figure A1: The Photo of *Qing Shilu*


清實録
光緒二十六年七月上
1900

又諭據袁世凱
代奏接准劉樹堂電稱浙江江山縣會匪吳瀨
頭糾合閩省浦城縣土匪劉加幅竪旗起事連
陷江山常山二縣衢郡戒嚴

Figure A2: Coding Method

July, Guangxu 26 (1900):

> *A telegraph report from Shutang Liu suggests that a rebel group led by Laitou Wu and Jiafu Liu has formed in Jiangshan County and Pucheng County. They have captured Jiangshan County and Changshan County. Keep alert!*

Guangxu Shilu (vol. 266)

B Supplementary Results

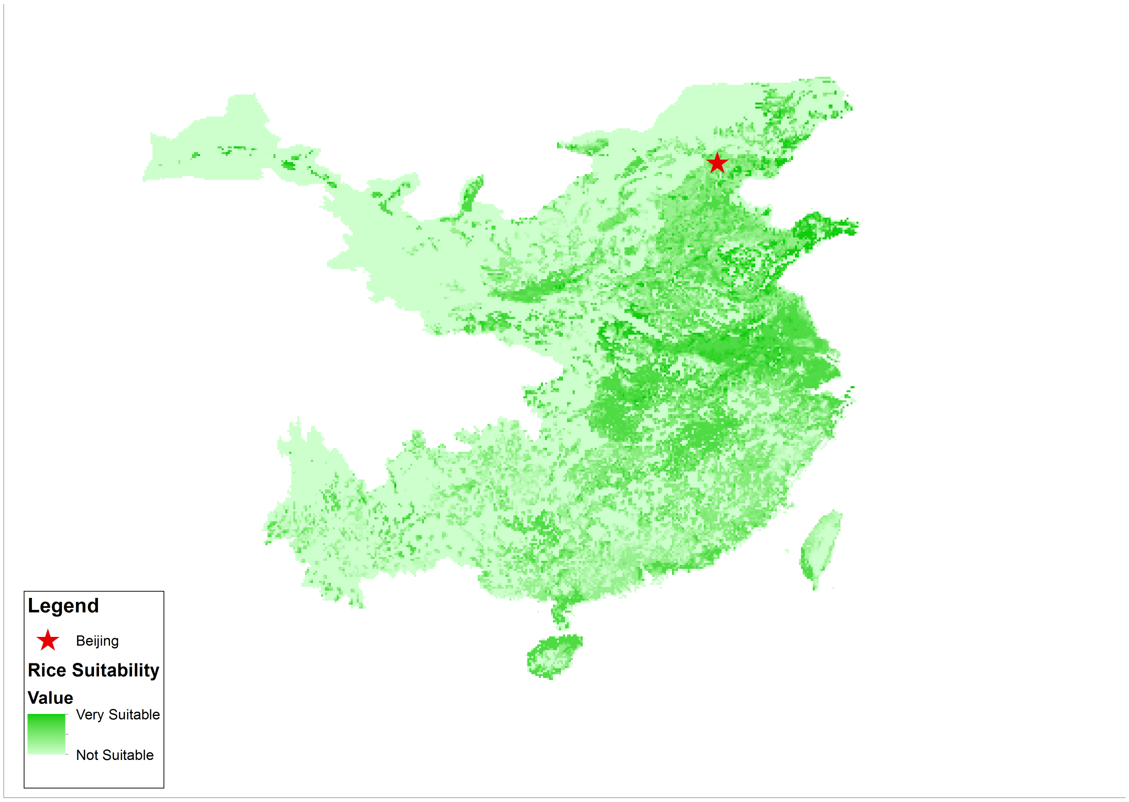


Figure B1: Suitability Index for Wetland Rice (irrigation, medium input)

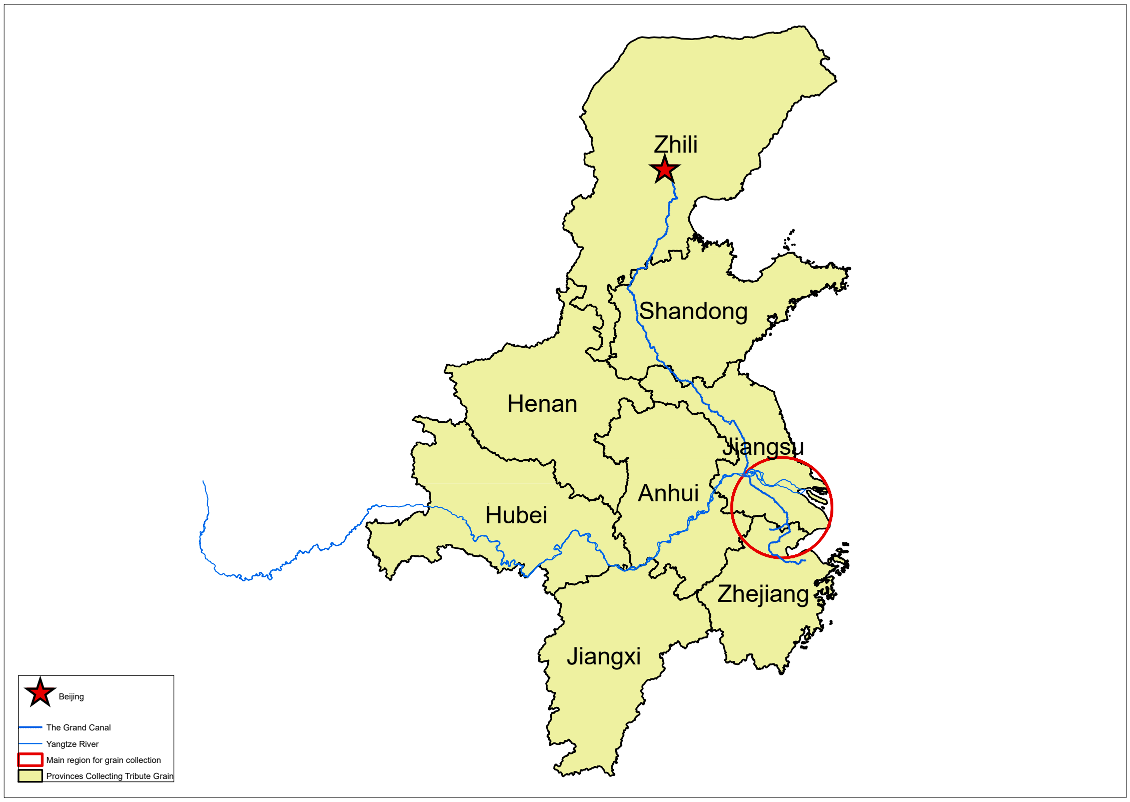


Figure B2: Sources and Shipping Routes of tribute rice in the Qing Dynasty

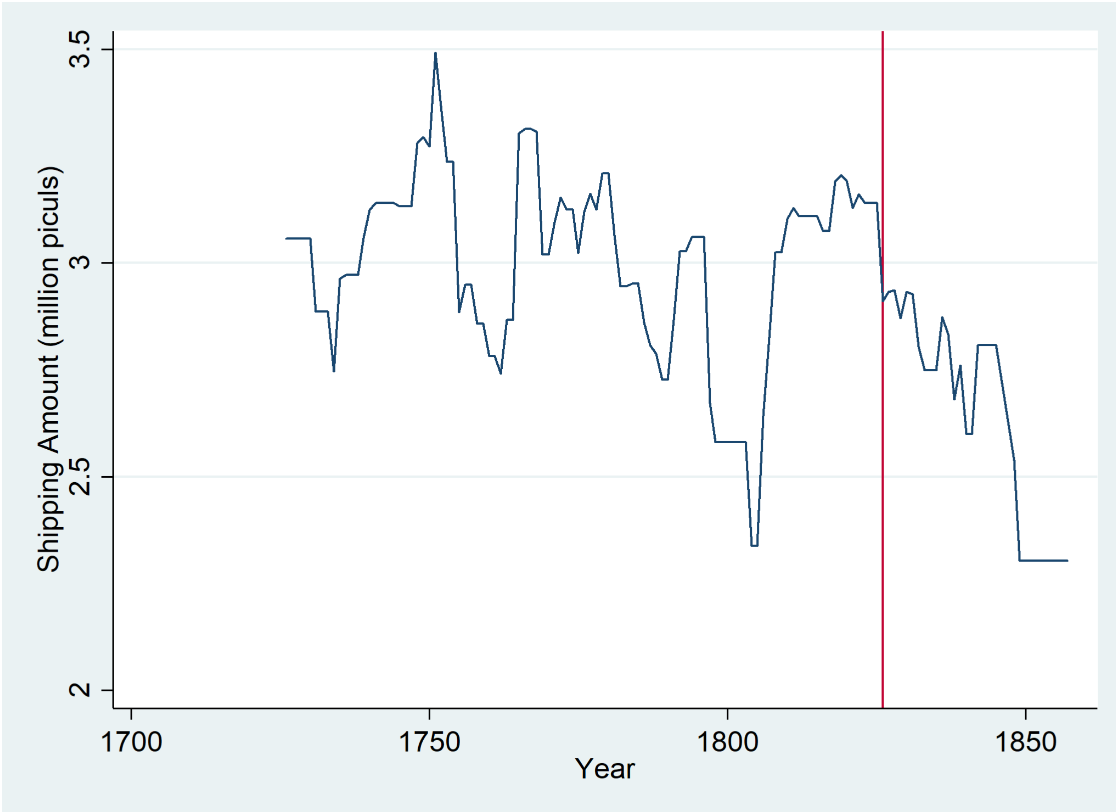
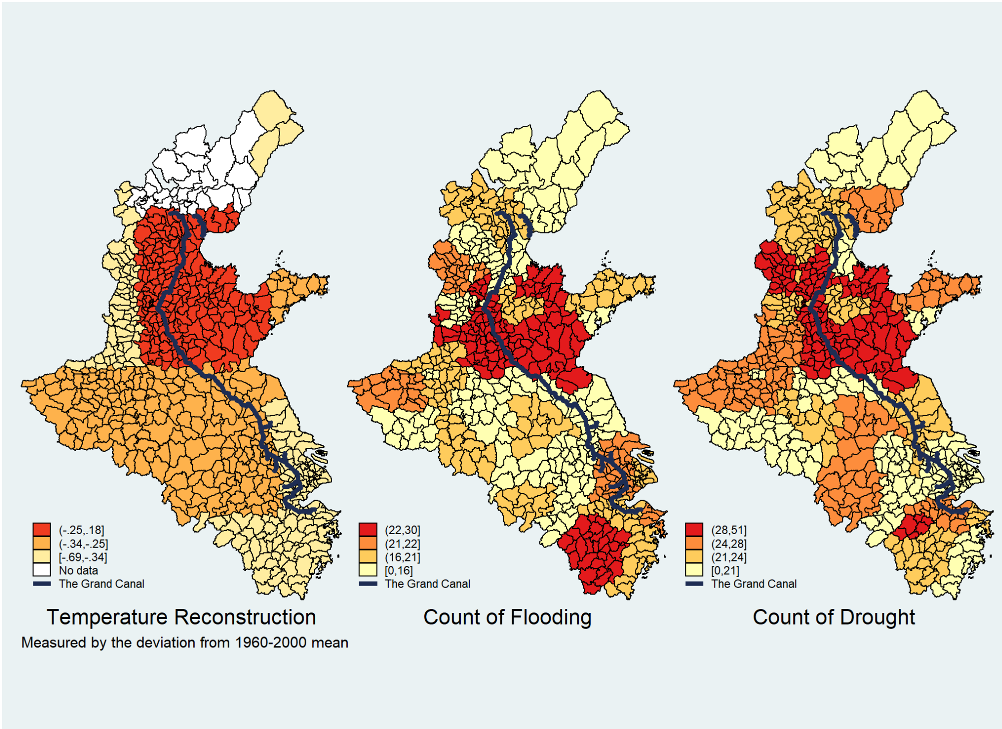
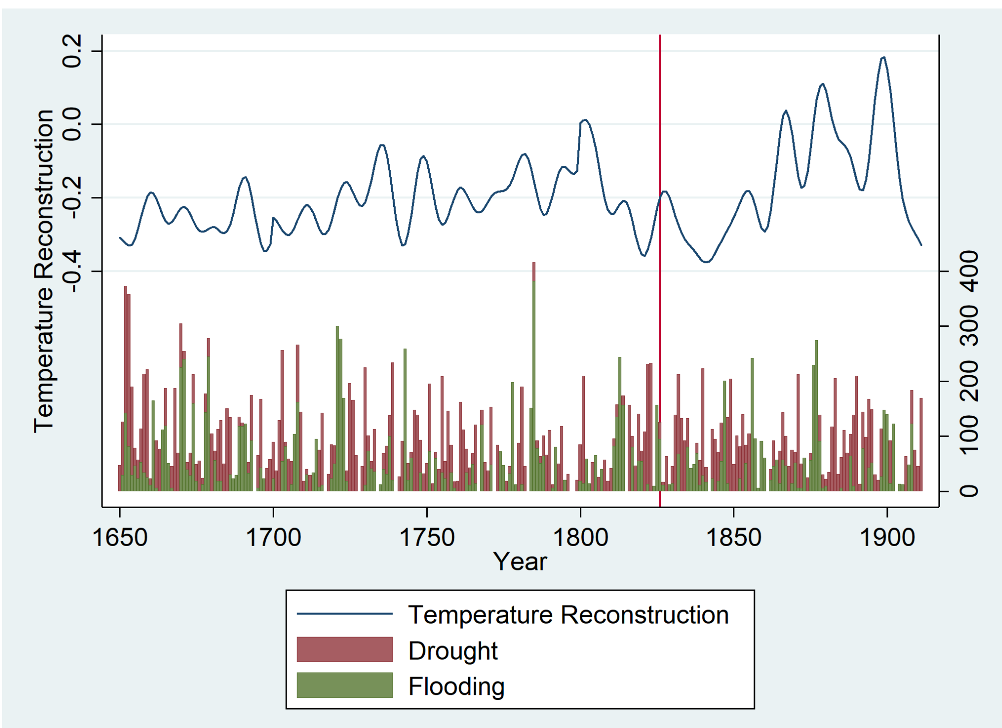


Figure B3: Shipping Amount of Grains



(a) Across Regions



(b) Over Time

Figure B4: Distribution of Climate Measures

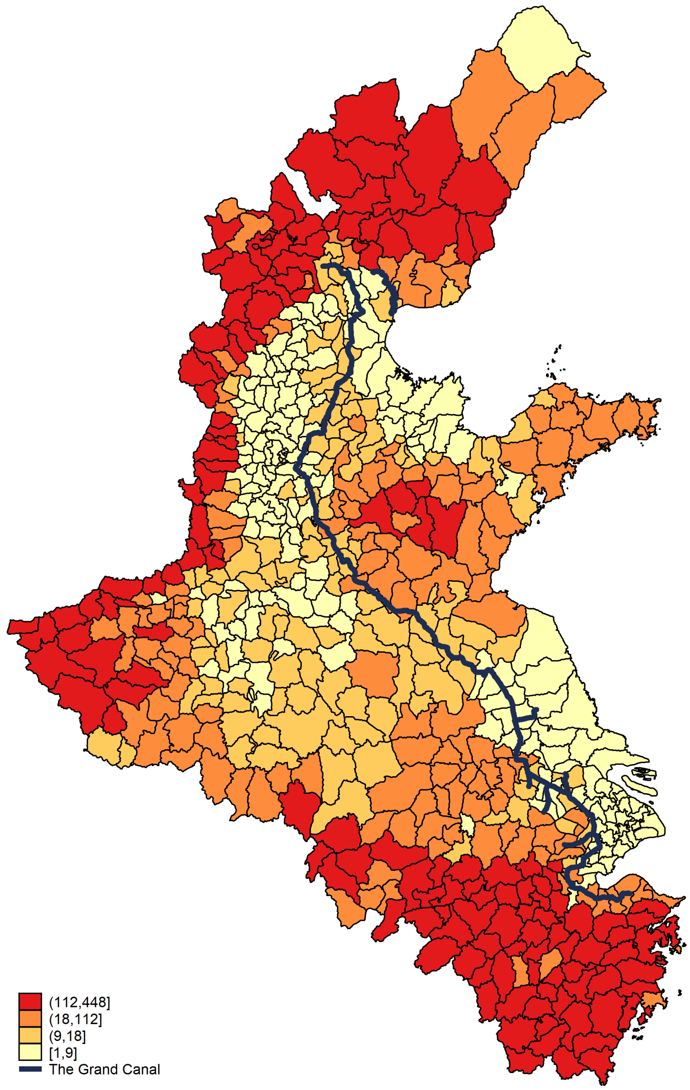
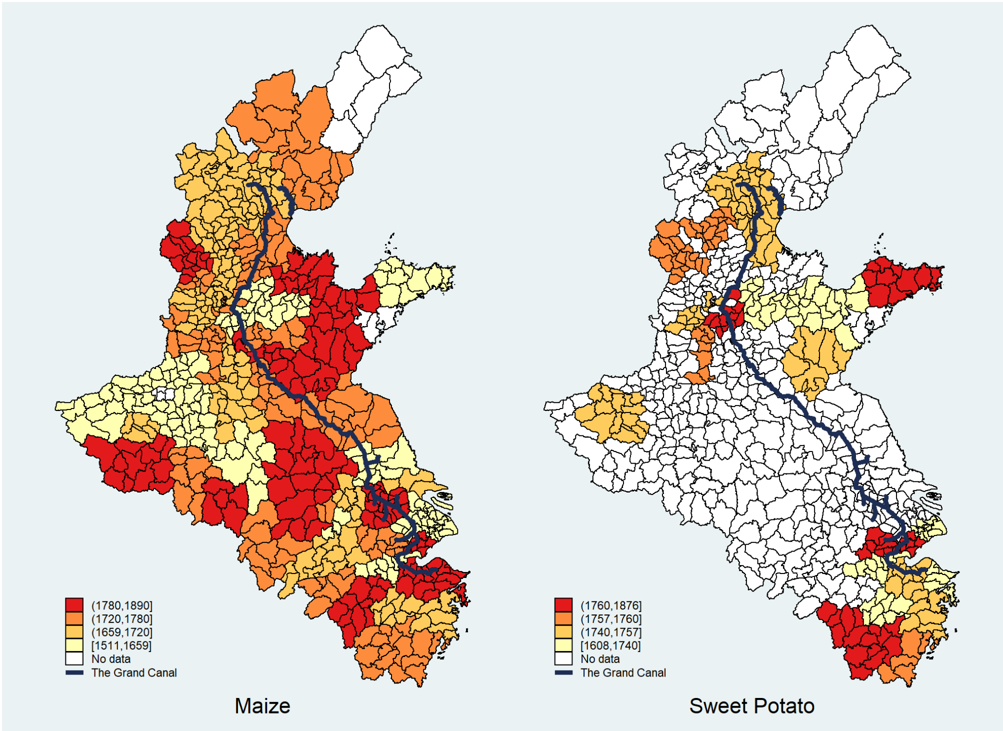
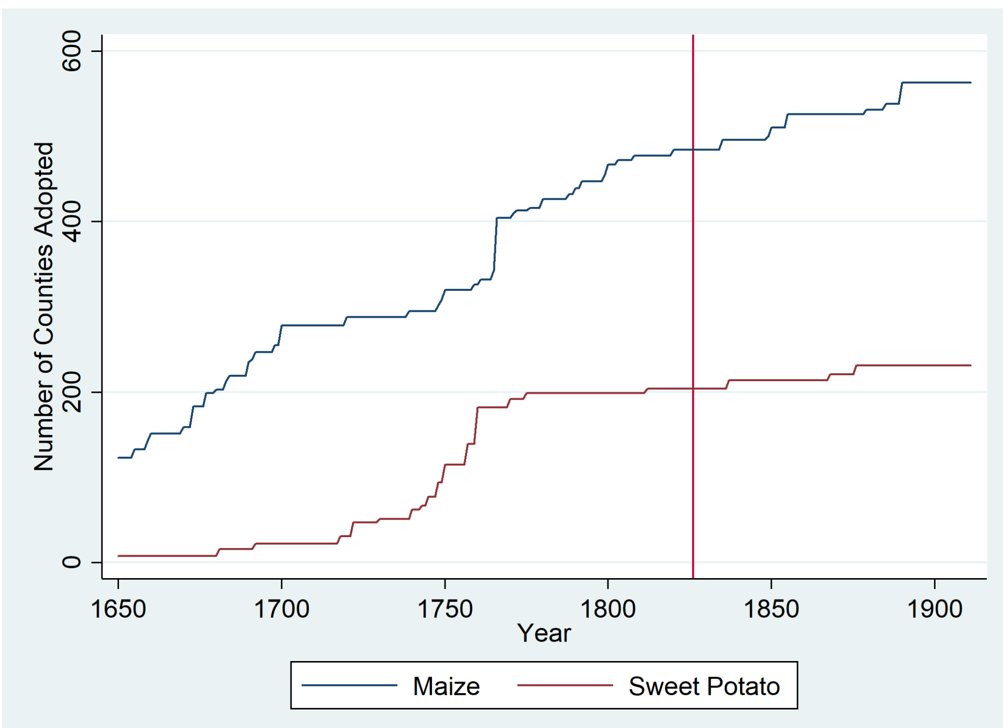


Figure B5: Spatial Distribution of the Ruggedness Index

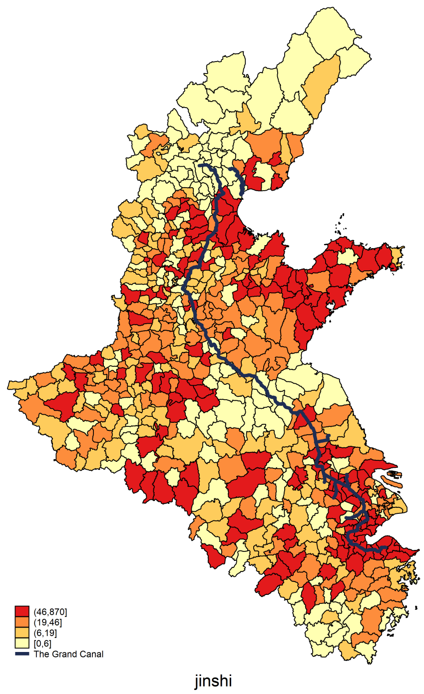


(a) Year of Adoption

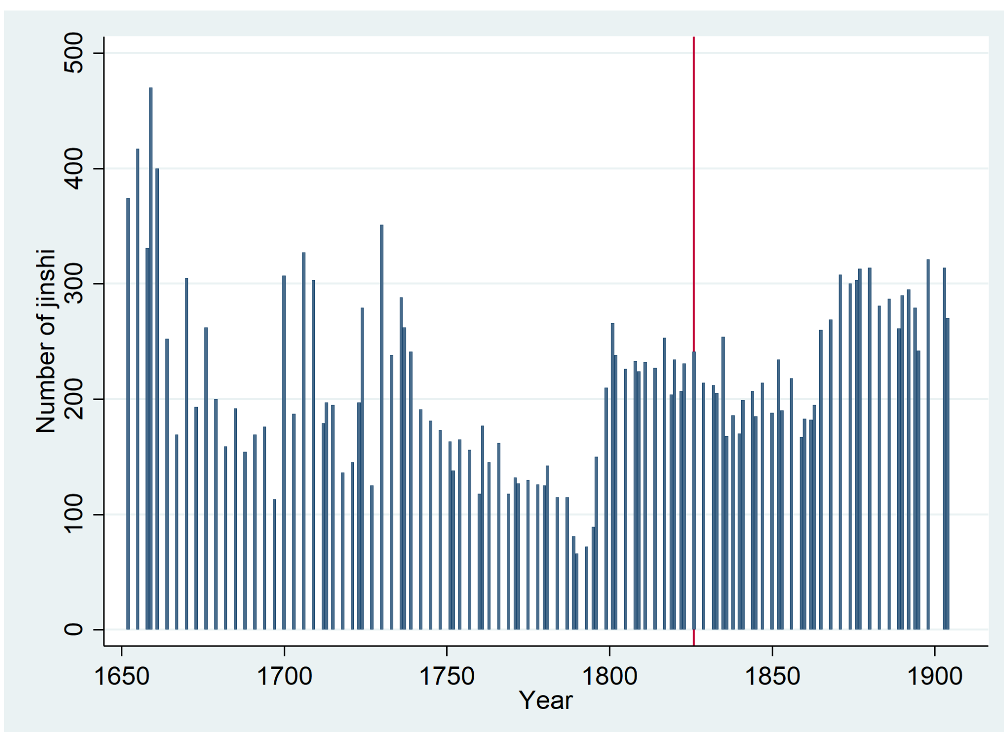


(b) Number of Counties Adopted

Figure B6: The Spread of New World Crops



(a) Across Regions



(b) Over Time

Figure B7: The Distribution of *jinshi*

Table B1: The Effects of the Canal's Abandonment on the Number of Rebellions Clustered at the Prefecture Level

	Dependent Variable: Number of Rebellions			
	(1)	(2)	(3)	(4)
Along Canal × After Abandonment	0.0094**	0.0100**	0.0076*	0.0076*
	(0.0044)	(0.0040)	(0.0042)	(0.0040)
	[0.0026]	[0.0026]	[0.0027]	[0.0026]
Constant	0.0119***	-0.0066***	-0.0026	-0.4522***
	(0.0007)	(0.0020)	(0.0290)	(0.1576)
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province × Emperor FE	No	Yes	No	Yes
Prefecture Year Trend	No	No	Yes	Yes
Mean of the Dependent Variable	0.0076	0.0076	0.0076	0.0076
No. of Observations	150,650	150,650	150,650	150,650
No. of Counties	575	575	575	575
No. of Clusters	79	79	79	79
Adjusted R-squared	0.0250	0.0263	0.0277	0.0290

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels respectively. Standard errors in parentheses are clustered at the prefecture level. Standard errors in square brackets are Conley standard errors robust for spatial correlation.

Table B2: The Effects of the Canal's Abandonment on the Presence of Rebellions

	Dependent Variable: Presence of Rebellions			
	(1)	(2)	(3)	(4)
Along Canal × After Abandonment	0.0090**	0.0097***	0.0071**	0.0071**
	(0.0035)	(0.0035)	(0.0035)	(0.0035)
	[0.0025]	[0.0025]	[0.0025]	[0.0025]
Constant	0.0121***	-0.0062***	-0.0074	-0.4471**
	(0.0004)	(0.0010)	(0.0749)	(0.1803)
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province × Emperor FE	No	Yes	No	Yes
Prefecture Year Trend	No	No	Yes	Yes
Mean of the Dependent Variable	0.0073	0.0073	0.0073	0.0073
No. of Observations	150,650	150,650	150,650	150,650
No. of Counties	575	575	575	575
No. of Clusters	575	575	575	575
Adjusted R-squared	0.0239	0.0253	0.0265	0.0278

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels, respectively. Standard errors in parentheses are clustered at the county level. Standard errors in square brackets are Conley standard errors robust for spatial correlation.

Table B3: The Effects of the Canal's Abandonment on Rebellions Normalized by Population

	Dependent Variable:			
	Number of Rebellions		Presence of Rebellions	
	(1)	(2)	(3)	(4)
Along Canal × After Abandonment	0.0004*	0.0004**	0.0003*	0.0004**
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
	[0.0002]	[0.0001]	[0.0001]	[0.0001]
Constant	0.0001***	-0.0001***	0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Province × Emperor FE	No	Yes	No	Yes
Mean of the Dependent Variable	0.0003	0.0003	0.0003	0.0003
No. of Observations	129,854	129,854	129,854	129,854
No. of Counties	575	575	575	575
No. of Clusters	563	563	563	563
Adjusted R-squared	0.0145	0.0171	0.0139	0.0165

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels, respectively. The dependent variables are normalized by population. Standard errors in parentheses are clustered at the county level. Standard errors in square brackets are Conley standard errors robust for spatial correlation.

Table B4: Continuous Treatment Effects using the Amount of Grain Shipped via Canal

	Dependent Variable: Number of Rebellions		
	(1)	(2)	(3)
Canal Length × Shipping Amount (Actual)	-0.0017**		
	(0.0008)		
Canal Length × Shipping Amount (Moving Average)		-0.0005**	
		(0.0002)	
Canal Length × Shipping Amount (Simulated)			-0.0103***
			(0.0032)
Constant	-0.0033	-0.0077***	-0.0049***
	(0.0116)	(0.0009)	(0.0010)
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Province × Emperor FE	Yes	Yes	Yes
Mean of the Dependent Variable	0.0055	0.0083	0.0075
No. of Observations	25,750	66,950	81,885
No. of Counties	515	515	515
Adjusted R-squared	0.0111	0.0266	0.0280

Note: *, **, and *** denote significance at the 90%, 95%, and 99% levels respectively. Canal length is measured per 10 km, and shipping amount is measured per million dan. Standard errors in Columns (2) and (3) are clustered at the county level.