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Weather Shocks, Sweet Potatoes and Peasant Revolts in Historical China

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Abstract

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1 Introduction

Does production technology adoption affect conflict? Research such as the literature on Green Revolution has documented the effects of technology adoption on economic outcomes. However, there is little empirical evidence on the impacts of technology adoption on political outcomes. If technology adoption stabilizes or destabilizes a society, it will affect people's welfare economically and politically. The answer to this question will also shed some light on the discussion of development policy and conflict in developing countries (Collier 2003).

To study this general question, I focus on a specific technology adoption in the Columbian Exchange: the adoption of sweet potatoes in historical China. Like many agrarian economies today, historical China was very vulnerable to weather shocks for a long history. Sweet potatoes have been known to survive bad weather much better than rice and wheat, two traditional staple crops in China. Besides, they also provide more calories per unit of land. Hence it is interesting to examine whether the adoption of sweet potatoes mitigated the effects of weather shocks on peasant revolts.

I collect and combine yearly historical data on weather and peasant revolts between 1470 and 1900 as well as data on the diffusion of sweet potatoes across China. Consistent with existing qualitative discussions by historians, this paper finds that droughts increased peasant revolts significantly whereas the effect of floods on revolts is not significant. More interestingly, by exploring the timing differences in the adoption of sweet potatoes, I find that the adoption of sweet potatoes mitigated the effect of droughts on revolts. Therefore, the adoption of a certain technology mitigated the effects of shocks on conflict in this context.

This study is clearly related to a few lines of literature. First, existing conflict theories have focused on greed versus grievance to explain rebel motivation. Collier and Hoeffler (2004) discuss models for greed and grievance and their empirical evidences show that greed dominates grievance from the cross-country data. Similarly, Fearon and Laitin (2003) find religious or political grievances don't account for civil war using cross-country data. Different from these studies, peasant revolts within China in this paper were more related to grievance[1]. Peasants were motivated to start these revolts when it was difficult to obtain enough food for their families. The purpose of these revolts was usually to rob the rich and redistribute their wealth.

Second, recent research has shown that weather shocks affected conflict (Miguel, Satyanath, and Sergenti 2004) and other political outcomes such as democratic transition (Brückner and Ciccone 2011). Despite sometimes opposite findings, this line of literature shares a similar idea: bad weather shocks lead to bad harvests in agrarian economies and hence affect conflict and political change. Now suppose some new technology is adopted that makes agriculture less affected by shocks, will the effect of weather shocks be changed? This is the question this paper attempts to answer.

Third, there is a large literature on the economic effects of technology adoption such as the Green Revolution. This paper is more particularly related to renewed interest among economists on the historical exchange of crops, diseases and ideas between the New World and the Old World, known as the Columbian Exchange. Nunn and Qian (2010a) provide a qualitative discussion of the exchange and emphasize the importance of botanical exchange. Hersh and Voth (2009) calculate the welfare increase for the average Englishman from the availability of sugar and coffee. Nunn and Qian (2010b) show that the introduction of potatoes has significant impacts on population growth and urbanization. As Nunn and Qian (2010a) suggest, there are many other crops that were introduced but have not been examined. This paper studies sweet potatoes, which played an important role in Chinese history. Different from existing studies, the outcome of interest is conflict rather than economic proxies.

[1] However, even dominated by grievance, opportunity costs might also play a role. The opportunity costs of revolts were lower when there were bad weather shocks.

This paper contributes to the existing literature by using an example in history to combine the literature of weather shocks and conflict and the impacts of technology adoption. The historical data used in this paper have two advantages. First, it is not easy to find clean evidences about the effects of technology adoption on political outcomes since the adoption may be endogenous to institutions. As explained in the background section, sweet potatoes were first adopted in the South of China by accident and were later promoted in the North by the central government. The regional adoption timing is closely correlated with geographical locations rather than provincial economic development. Further, the adoption timing is not correlated with previous revolts of a place. Besides, the adoption of another foreign crop, maize, can be used as a placebo test for this concern. Second, the causes of peasant revolts within a country are closely related to agricultural harvests. Hence, the conflicts considered in this paper are more homogeneous compared with existing cross-country studies.

Along with these advantages, I should be cautious about the external validity of the main conclusion that the adoption of new technology mitigates conflict. The technology considered in this study is very simple and the entry costs are very low. Hence, even the very poor could adopt it easily, which helped stabilize the society. To the best of my knowledge, there are no existing quantitative studies on the effects of technology adoption on conflict. However, political scientists have mentioned that technology adoption affects violence. For example, Shiva (1991) argues that the Green Revolution in India led to more violence in the 1980s as the new technology mainly helped the rich while the poor could not afford it. Therefore, the general effect of technology adoption on conflict might depend on what type of technology, especially who get benefited from its adoption. This implication also sheds some light on the discussion of development policy and conflict in developing countries (Collier 2003).

The rest of the paper is organized as follows. Section 2 provides a discussion of the historical background, including the existing literature by historians on weather shocks and peasant revolts as well as the diffusion of sweet potatoes. Section 3 describes the data and the methodology of data collection. Section 4 presents the empirical strategy and the baseline results. Section 5 reports robustness checks. Section 6 concludes with a conjecture of the long-run effects of sweet potatoes.

2 Historical Background

Although the effect of sweet potatoes on peasant revolts has never been explicitly studied, there have been many studies on two related aspects of this paper. First, the effect of weather shocks on general warfare has been quantitatively documented. Second, there is a large, mainly qualitative, literature on the impact of sweet potatoes in Chinese history. In the historical background, I review some of the existing studies and discuss potential concerns that might confound the main results.

2.1 Weather Shocks and Peasant Revolts

During its long history as an agrarian society, China was very vulnerable to weather shocks. The effects of climate shocks on social unrest have been well recognized by both historians and ecologists. Historians keep detailed records of weather and wars. Historical studies such as Chesneaux (1973) and Feuerwerker (1975) provide an overview of peasant revolts in China. Ecologists pay more attention to the effects of long-run climate changes such as cooling phases versus warming phases. Combining data on the two aspects, Zhang et al. (2007) show that almost all peaks of warfare frequency and dynastic changes occurred in cooling phases in China over the last millennium.

Existing studies by ecologists usually count all the wars together and study the correlation of climate change and the number of wars. Different from ecologists' research, Bai and Kung (2010) focus on Sino-Nomadic wars.

I have not noticed existing empirical studies that focus on peasant revolts except some case studies by scientists such as Yancheva et al. (2007). However, peasant revolts were not rare in China's history. Table 1 lists a few large-scale peasant revolts that directly led to the demise of dynasties in China and the causes of these revolts were all related to droughts.

[Table 1 here]

2.2 Sweet Potatoes in China and Their Impacts

In this section, first I summarize research by historians on the virtues, impacts and diffusion of sweet potatoes in China. Then I discuss why sweet potatoes might affect the effects of weather shocks on peasant revolts.

Sweet potatoes are native to the tropical parts of South America. They were introduced to China in the mid-17th century from Burma, Philippine and Vietnam and became widely spread in the mid-18th century. The spread moved gradually from the South to the North. "The sweet potato did not take long to become the third most important food crop in China after rice and wheat" (Bray 1984). In the 1920s, China produced over one fourth of sweet potatoes in the world and today the share is over 80 percent (FAO 2010).

The advantages of sweet potatoes over, wheat and rice, the traditional staple food in China have been realized and mentioned in historical archives. Bray (1984) summarize these virtues from the important historical agricultural works in the 17th century such as Complete Treatise on Agriculture[2]. First, compared with rice and wheat, sweet potatoes are less vulnerable to droughts and floods. Second, the yields per unit of land are much higher for sweet potatoes than rice and wheat, hence the saying "one season of sweet potatoes accounts for half a year's food". Third, the requirement for land

[2]It was written during 1625 to 1628 by a scholar-official, Xu Guangqi, who advocated the spread of sweet potatoes.

quality is not so high for the cultivation of sweet potatoes, which survive well even in poor sandy soil. Forth, sweet potatoes do not compete for land with wheat and rice as they are usually cultivated between different seasons of rice and wheat.

The impacts of sweet potatoes have been discussed a lot among population historians in China, as the diffusion timing coincided well with population growth. Estimates of China's population increase between 1368 and 1800 vary a bit, but there is no doubt that immense growth of population took place. Ho (1959) and Perkins (1969) estimate China's population in 1398 to be in the vicinity of 65 million people growing to around 430 million by 1850, indicating an approximate five fold increase in China's population during the 450 years. Unfortunately, there was no consistent measure of population sizes before the mid-18th century. Sometimes only the number of households was registered for the Ming dynasty (1368-1644) whereas only the number of men aged between 16 and 60 were officially recorded during the early Qing dynasty (1644-1911). This inconsistency makes it difficult to get consistent estimates of population. Hence, there is no definite quantitative conclusion about how much sweet potatoes contributed to China's dramatic population growth.

Studies about the diffusion paths of sweet potatoes in China by historians include the sources of data I use from Guo (1979) and Wu (1983). Besides, studies such as Ho (1979) have discussed the drives of the diffusion. These studies show that the diffusion of sweet potatoes started by accident: Chinese businessmen working in Southeast Asia brought sweet potatoes to China as they realized this crop survived droughts. When people moved from a region with sweet potatoes to another region, they spread the information. The central government promotion played an important role only since the mid-18th century.

Despite their widespread use as food, sweet potatoes have been considered poor man's food in China both in history and today (Simoons 1991).

Hence, sweet potatoes mainly worked as subsistence food. Complete Treatise on Agriculture (1628) praises that sweet potatoes can help people survive in years of crop failure whereas they can be made into alcohol in years of good harvest. Anderson (1990) writes of sweet potatoes as pig feed among well-off families and of people consuming them only when their food situation is hopeless. Buck (1937) provides the earliest quantitative document of sweet potatoes consumption in China. Buck conducted a detailed survey of 16786 farms in rural villages across China in the 1920s. Sweet potatoes were mentioned in the 84% of the farm families in his survey. When people were asked why they decreased the consumption of sweet potatoes compared with the previous year, 100% answered that they switched to rice or wheat. Meanwhile, the change of rice or wheat consumption was more related to harvest or price volatility. This finding also reflects the role of sweet potatoes as subsistence food.

The virtues of sweet potatoes and their role as subsistence food explain why they might matter for peasant revolts. After the adoption of sweet potatoes, peasants could depend on them when rice and wheat were affected by bad weather shocks. Therefore, peasants were less motivated to start or join revolts.

As pointed by Hersh and Voth (2009), the adoption of high calorie crops did not necessarily imply improved quality of life. First, in a Malthusian world, population increased with the availability of high calorie crops and hence calorie availability per capita might not necessarily be increased. Meanwhile, more labor force developed more arable land. Besides, the virtues of sweet potatoes helped utilizing low-quality land such as salty or sandy soils and steep slopes (Pomeranz 2000). Therefore, sweet potatoes made a difference out of equilibrium.

2.3 Other historical concerns

In this section, I discuss other historical concerns and explain why they will not confound the main results in this paper.

2.3.1 The Adoption of Other American Crops

Besides sweet potatoes, there are a few other American crops that was introduced to historical China, including white potatoes, maize, peanuts and tobacco. Below I present their role discussed by historians briefly, which will explain why sweet potatoes have been paid the most attention both by population historians and this paper.

Peanuts and tobacco have never been food crops in China. Their adoption increased the consumption variety but generally did not play an important role in solving the food problem.

As studied in Nunn and Qian (2010b), white potatoes played an important role in population growth in Europe. However, "the Irish potato was not introduced to China until the late 19th century and has not been successful" (Bray 1984).

Maize was introduced to China in the 16th century, which was similar to sweet potatoes. The role of maize in historical China is controversial. On the one hand, Laufer (1907) studies the introduction of maize to East Asia and his Spanish sources indicate that maize became an important economic crop in China after its introduction. On the other hand, the important Chinese historical agricultural works paid little attention to maize (Bray 1984). Generally maize has not been as important in Chinese food as sweet potatoes and they do not survive weather shocks so well. Guo (1979) and Wu (1983) also present the diffusion timing of maize along with the information for sweet potatoes. I use this information as a robustness check.

2.3.2 The State Disaster Relief Institution

Another concern with the idea of this paper is that there might be some government disaster relief policies that confound the effect of sweet potatoes. In particular, a prominent institution that has been discussed by economic historians for disaster relief is the system of state granaries in the Qing dynasty (1644-1911). Many granaries were created to help smooth harvest shocks. This policy did not exist before the Qing dynasty. Li (2007) provides a general description of the institutional background. Shiue (2004) quantitatively examines the relationship between weather shocks and grain storage. She finds that the frequency of disaster relief in the Qing dynasty is not correlated with weather patterns. Hence this policy will not confound the main results of this paper as I am mainly interested in whether the adoption of sweet potatoes mitigated the effects of weather shocks.

3 Data

Table 2 presents some summary statistics. Below, I describe my data sources for weather shocks, peasant revolts and diffusion of sweet potatoes.

The data on weather shocks is collected at prefecture level. Prefecture was the administrative level below the province level and there were about 240 prefectures in the 18 provinces. The location of peasant revolts can be identified at both prefecture and provincial level. However, the adoption timing of sweet potatoes available is at provincial level. Therefore, I mainly employ provincial level information in my estimation. As a robustness check, I also use prefecture level data by year and by decade. In Table 2, panel A presents the summary statistics for province level by year, panel B for prefecture level by year and panel C for prefecture by decade.

[Table 2 here]

3.1 Weather Shocks

Historical weather data come from the State Meteorological Society (1981), which gives annual information on weather for locations throughout China back to 1470. A variable denoted dryness is a discrete indicator of the degree of "wetness and aridity", from floods, droughts, monsoons, or rainfall. Bad weather ranks are 1 and 5 (exceptional drought and flood), fair weather ranks are 2 and 4 (limited drought and flood), and good weather is rank 3 (favorable conditions). The indicators are assigned based on the average weather in different locations.

This data source has been used in Keller and Shiue (2007). To get a provincial level measure, I take the average of prefectures in a province. Similarly to Keller and Shiue (2007), I use the deviation of the average from 3 to measure the size of shocks.

As pointed out by Keller and Shiue (2007), systematic rainfall recording began as early as the Tang Dynasty (618-907 A.D.), and from at least the 17th century the collection of rainfall and weather reports at the county level had become standard government practice. The sources of weather indicators for historical period in the State Meteorological Society (1981) include reports from more than 2200 local gazetteers[3].

As shown in Table 2, the average of weather deviation at provincial level is about -0.06 and the standard deviation is about 0.78. In my benchmark estimation below, I divide the deviation into two groups: deviation from above (larger than or equal to 3) and deviation from below (smaller than 3). The purpose is to separate the effects of droughts and floods. Besides using the shocks information linearly, I also use dummies for droughts and floods as a robustness check. For example, a province is coded as having a drought in a year if any prefecture in this province had exceptional drought in that

[3]Local gazetteers in China dated back to Han Dynasty (202 BC–220 AD) and became more common in the Song Dynasty (960–1279 AD). The information in the gazetteers focused on geography, local products, botany, topography, natural disasters etc.

year.

3.2 Diffusion of Sweet Potatoes

Guo (1979) presents the information on the adoption time of sweet potatoes and maize in different provinces as well as their cultivation in the mid-18th century. The methodology behind this data is to go back to chapters on "plants and crops" in local gazetteers and recorded the year when sweet potatoes were first mentioned. I also use a second source for adoption timing to double check the consistency, namely Wu (1983). The two sources provide consistent information on sweet potatoes and maize except for the adoption time of sweet potatoes in Yunnan Province. I only present the results using the information from Guo (1979) and the results presented below are robust to the exclusion of Yunnan Province.

As Ho (1955) pointed out, however, it may be a bit risky to fix a single date for the introduction. Therefore, I do some robustness checks in the estimation in two ways, slightly varying the introduction year by bringing forward the adoption time five years and using the nearest decennial year. The two variations do not change the basic results.

Figure 1 illustrates the diffusion timing. I divide the timing into four waves based on the introduction year: Wave I from the 1570s to the 1600s; Wave II from the 1600s to the 1630s; Wave III from the 1730s to the 1760s; Wave IV for the single province with no record of sweet potatoes by the 1760s.

[Figure 1 here]

Roughly speaking, provinces in the South had adopted sweet potatoes by the mid-17th century (the late Ming dynasty) and provinces in the North adopted sweet potatoes by the mid-18th century (the mid-Qing dynasty). Unfortunately, I cannot provide a spatial model about technology adoption due to limited historical data available. However, dynasty replacement should have played a role in understanding the time lag between the South and the North. The Qing dynasty replaced the Ming dynasty in 1644. The adoption of sweet potatoes might have been interrupted during the chaotic period of the dynasty change.

Figure 2 shows the relationship between adoption timing and average previous revolts in the province. Clearly, there is no significant correlation between the adoption timing and previous revolts.

[Figure 2a here]

Ideally it would be good to know more about the relationships between the adoption timing and provincial economic development as well as governance. The information on China's regional development in the 16th century is very limited and often only available for a certain year. Liang (1981) provide provincial population sizes and population density in 1578. Figure 2b presents the relationship between adoption timing and population density in 1578 and shows that there is no significant correlation between the two variables.

[Figure 2b here]

Huang (1974) is one of the most influential historical works on government finance and taxation in this period. He cited data from the official governmental records on land area and land tax revenues in 1578. Combining data from Huang (1974) and Liang (1981), Figure 2c illustrates the relationship between adoption timing and land tax per capita[4] in 1578 while Figure 2d for land tax rate. Again, there is no significant correlation between the adoption timing and land tax per capita or land tax rate in that year.

[4]The land data were presented in traditional Chinese units of measure. The land area was measured in *Mu.* One *Mu* is about 667 square meters. The land revenue was measured by *Dan* of grains. One *Dan* is about 90 kilograms in this period. The tax rate is also calculated in terms of these traditional units.

[Figure 2c-2d here]

Table 2 also gives the cultivation area information for the 1920s and the suitability information from Global Agro-Ecological Zones (GAEZ) data from the Food and Agriculture Organization. This information will be used for robustness check.

3.3 Peasant Revolts

The data source for peasant revolts is a multi-volume book entitled "Chronology of Warfare in Dynastic China" (The Editing Committee of China's Military History 1985). This is believed to be the most comprehensive existing documentation in listing the warfare in China. It has been used in existing studies on climate shocks and wars such as Zhang et al. (2007) and Bai and Kung (2010). Zhang et al. (2007) counted all the warfare together whereas Bai and Kung (2010) focus on Sino-Nomadic wars. Different from their research, this paper focuses on civil conflict, particularly peasant revolts.

The Editing Committee of China's Military History (1985) listed the revolts by year and gave information on where a revolt took place, who were the leaders, as well as a brief summary of the spread and result of the revolt. There is no information about the size of revolts such as the number of casualties[5]. There are 227 revolts registered in the period between 1470 and 1900. Most of these revolts were local and suppressed very quickly by the central government. The total number of revolts in each province is also presented in the map in Figure 1.

[5]However, implicitly the influence of these revolts was above certain threshold to be registered by historians.

4 Empirical Strategy and Main Results

The estimation methodology is generalized differences-in-differences. The main specification is as follows.

$$\begin{aligned} R_{it} &= \alpha_i + \gamma_t + \beta_1 |Deviation_{it}| * Sweetpotatoes_{it} + \beta_2 |Deviation_{it}| \\ &\quad + \beta_3 Sweetpotatoes_{it} + \sum_{i=2}^{18} \delta_i province_i * trend + \varepsilon_{it} \qquad (1) \end{aligned}$$

where α_i and γ_t are the the prefecture fixed effects and the year fixed effects.

R_{it} takes two types of values: (1) a dummy indicating whether there is a revolt or (2) the number of revolts in province i and year t.

$Deviation_{it} = weather_{it} - 3$ and $|Deviation_{it}|$ is the absolute value. First, I take deviations from above and below symmetrically. Second, to separate the effects of droughts and floods, I run regressions for the deviation from above and deviation from below respectively.

$Sweetpotatoes = 1$ if year is after the adoption time in province i. The variable $trend$ is defined as $t - 1470$. Besides, provincial time trends are included to capture possible different time trends.

The coefficient of interest is β_1, the interaction effect of sweet potatoes and weather shocks. β_2 measures the effect of weather shocks. To see whether the adoption of sweet potatoes relieved the effect of weather shocks, I test whether $\beta_1 + \beta_2 = 0$.

The main results taking droughts and floods together are presented in Table 3. Column 1 presents the OLS results for whether there is a revolt, column 2 and column presents the fixed effects results without and with time trends. Similarly column (4) to (6) give the results for the number of revolts. Standard errors are clustered at provincial level.

The results are stable across different specifications. For the specification using whether there is a revolt as the dependent variable, the coefficient of weather shocks is around 0.02. Given the standard deviation of weather shocks is 0.78, one standard deviation of weather shocks increased the likelihood of revolts by 0.016, which is about 10% of the standard deviation of the dependent variable.

Similarly, for specification using number of revolts as the dependent variable, the coefficient of weather shocks is around 0.03. Hence one standard deviation of weather shocks increased the likelihood of revolts by 0.023, which is also about 10% of the standard deviation of the dependent variable.

More interestingly, as the F test result presented in Table 3 show, I cannot reject $\beta_1 + \beta_2 = 0$.Therefore, the effects of weather shocks are cancelled out by the adoption of sweet potatoes.

[Table 3 here]

Table 4 gives the results for droughts and floods separately. Panel A shows the results for droughts and Panel B for floods. As in Table 3, Column 1 presents the OLS results for whether there is a revolt, column 2 and column presents the fixed effects results without and with time trends. Similarly, column (4) to (6) give the results for the number of revolts.

[Table 4 here]

First, the results show that the effect of weather shocks on peasant revolts mainly comes from droughts rather than floods. This finding is consistent with qualitative historical studies. It is argued that droughts had much significant influence than floods on peasant revolts because the length of droughts was usually longer than floods and the affected areas by droughts were generally larger compared with those affected by floods. Besides, it was more difficult to carry out revolts when there were floods.

Second, consistent with the results in Table 3, for the specification using whether there is a revolt as the dependent variable, the coefficient of weather shocks is around 0.03 whereas the standard deviation of weather shocks from above is 0.54. Hence, a standard deviation of weather shocks increased the likelihood of revolts by 0.016, which is about 10% of the standard deviation of the dependent variable. Similarly, for the specification using number of revolts as the dependent variable, the coefficient of weather shocks is around 0.05. Hence, a standard deviation of weather shocks increased the likelihood of revolts by 0.027, which is also about 10% of the standard deviation of the dependent variable.

Besides, the F test results presented in Table 4 also show that $\beta_1 + \beta_2 = 0$ cannot be rejected for both droughts and floods. However, the reasons for the non-rejections are different. In the case of droughts, I cannot reject that the effect of droughts on revolts were cancelled out by the adoption of sweet potatoes. In the case of floods, I cannot reject $\beta_1 + \beta_2 = 0$ because the coefficients are not precisely estimated.

5 Robustness Check

5.1 Using cultivation areas information

In the benchmark model, how many sweet potatoes were produced is not taken into consideration. It's conceivable that not only the mere adoption of sweet potatoes matters but also the amount of cultivation matters. Generally it is not easy to find a good proxy for historical cultivation areas. Nunn and Qian (2010b) use suitability data from FAO-GAEZ (FAO and IIASA 2002). However, in the case of sweet potatoes, suitability data from FAO-GAEZ differs greatly from real cultivation both in the mid-18th century based on the maps of Guo (1979) and later the yields data in the 1920s. Figure 3a-3c give the information on suitable area for sweet potatoes from FAO-GAEZ and the data for sweet potatoes cultivation areas in the 1920s presented in Xu (1983). The unit of area is in square kilometers. The data for the 1920s in Xu (1983) is also consistent with the map provided in Buck (1937).

[Figure 3a-3c here]

The relationship between values of suitability area in Figure 3b and the values of cultivation areas in Figure 3c can be evaluated by a linear regression, $Cultivation_i = \phi Suitability_i + \varepsilon_i$. The estimated ϕ is around 0.03.

Here I use the area data from the 1920s and run regression (2) as below. This may be not a perfect proxy for the exact cultivation areas in history but is better than using suitability data directly. Xu (1983) provides both areas and yields information, from which there is no significant difference in terms of productivity measured by yield per square kilometers across provinces.

$$\begin{aligned} R_{it} &= \alpha_i + \gamma_t + \beta_1 |Deviation_{it}| * Sweetpotatoes_{it} * Normlized(\ln\_Area_i) \\ &\quad + \beta_2 |Deviation_{it}| + \beta_3 Sweetpotatoes_{it} * Normlized(\ln\_Area_i) \\ &\quad + \sum_{i=2}^{18} \delta_i province_i * trend + \varepsilon_{it} \end{aligned} \tag{2}$$

I define $\log\_Area_i = \log(1 + area_i)$ to take care of the observation 0. The transformation will not change the results. Moreover, I normalized $\log\_Area_i$ by its mean across provinces and hence $Normlized(\ln\_Area_i) = \frac{\ln\_Area_i}{mean(\ln\_Area)}$. The purpose is to make the results comparable with the benchmark results. Now β_1 measures the effect of adoption if the adoption area was the mean of the cultivation areas for the 1920s, i.e., 6.53.

The results are presented in Table 5. The estimates are consistent with the results from the benchmark estimation and the magnitudes are also similar.

[Table 5 here]

5.2 Using maize as a placebo test

Another concern is about omitted variables. For example, provinces that adopt sweet potatoes are more liberal and hence also adopt other technologies earlier. These provinces might have fewer peasant revolts because they are more liberal rather than because sweet potatoes relieve the weather shocks. To test this concern, I run a placebo test using information on the introduction of maize also presented in Guo (1979) and Wu (1983).

$$R_{it} = \alpha_i + \gamma_t + \beta_1|Deviation_{it}| * Maize_{it} + \beta_2|Deviation_{it}| + \beta_3 Maize_{it} + \sum_{i=2}^{18} \delta_i province_i * trend + \varepsilon_{it} \quad (3)$$

The results are presented in Table 6. It shows that the coefficient of the interaction is not significant. Hence, the introduction of maize itself does not relieve the effects of weather shocks on peasant revolts. Here I cannot reject $\beta_1 + \beta_2 = 0$ in column (1) for droughts and the results for floods, because the coefficients are not precisely estimated.

[Table 6 here]

There are two potential reasons that might explain the differences between sweet potatoes and maize. First, maize cannot not survive droughts so well as sweet potatoes for droughts. Second, maize provide fewer calories than sweet potatoes per unit of land.

5.3 Defining weather shocks by dummies

I use the deviation linearly in the benchmark estimation. Here I define $Drought_{it} = 1$ if any prefecture in a province i and year t had exceptional drought, otherwise $Drought_{it} = 0$. The motivation behind this indicator is that peasant revolts were generally very local and hence local weather might have mattered more for revolts.

The specification for droughts is as follows.

$$R_{it} = \alpha_i + \gamma_t + \beta_1 Drought_{it} * Sweetpotatoes_{it} + \beta_2 Drought_{it} + \beta_3 Sweetpotatoes_{it} + \sum_{i=2}^{18} \delta_i province_i * trend + \varepsilon_{it} \quad (4)$$

Similarly, $Flood_{it} = 1$ if any prefecture in a province i and year t had exceptional flood, otherwise $Flood_{it} = 0$. And the specification for floods is as follows.

$$\begin{aligned} R_{it} &= \alpha_i + \gamma_t + \beta_1 Flood_{it} * Sweetpotatoes_{it} + \beta_2 Flood_{it} \\ &\quad + \beta_3 Sweetpotatoes_{it} + \sum_{i=2}^{18} \delta_i province_i * trend + \varepsilon_{it} \end{aligned} \quad (5)$$

The estimations results are presented in Table 7. Clearly, the conclusion is consistent with the benchmark specification. For instance, in the specification for whether there was a revolt, the coefficient for droughts is about 0.016, which is comparable to the effect of one standard deviation of shocks from above in the benchmark estimation.

[Table 7 here]

5.4 Slightly varying the introduction year

To be more cautious about the precise year of introduction of sweet potatoes, I vary the adoption year in two ways. First, the adoption year is brought forward five years. Second, I use the nearest decennial year to substitute for the introduction year. For example, the adoption year is changed to be 1710 if it is originally in 1707.

The rest of the regression is the same as in (2) and the results are presented in Table 8. The basic results are not changed. Of course, this finding is not very surprising considering that the revolts were rare events and not continuously distributed.

[Table 8 here]

5.5 Allowing for time-variant effects

I also allow for time-variant effects to test whether the effect of sweet potatoes varies a lot over time. The regression is as follow.

$$\begin{aligned} R_{it} &= \alpha_i + \gamma_t + \beta_1^1 |Deviation_{it}| * Firstperiod_{it} + \beta_1^2 |Deviation_{it}| * Secondperiod_{it} \\ &+ \beta_2 |Deviation_{it}| + \beta_3^1 Firstperiod_{it} + \beta_3^2 Secondperiod_{it} \\ &+ \sum_{+i=2}^{18} \delta_i province_i * trend + \varepsilon_{it} \end{aligned} \quad (6)$$

where $Firstperiod_{it}$ refers to the period within 50 years or within 100 years after the adoption time. $Secondperiod_{it}$ refers to the period after 50 years or 100 years after adoption respectively. The estimation results are presented in Table 9.

[Table 9 here]

According to Table 9, I do not find the effect varies significantly over time. The F test result presented in Table 9 shows that $\beta_1^1 = \beta_1^2$ cannot be rejected.

5.6 Using prefecture-year data

As mentioned above, both the revolt and weather data are available at prefecture level. Since most of the revolts were very local, it is reasonable to employ prefecture-level data. The disadvantage is that the adoption time of sweet potatoes is only available at provincial level. However, as I have already shown above, the main results are not very sensitive to the exact year. Hence, provincial adoption timing is employed for each prefecture as a robustness check. The regression is as follows.

$$R_{it} = \alpha_i + \gamma_t + \beta_1|Deviation_{it}| * Sweetpotatoes_{it} + \beta_2|Deviation_{it}| + \beta_3 Sweetpotatoes_{id} + \sum_{i=2}^{263} \delta_i prefecture_i * trend + \varepsilon_{it} \quad (7)$$

Now α_i is the prefecture fixed effects. The estimation results are presented in Table 10. In the specifications for droughts, a standard deviation of weather shocks increased the likelihood of revolts by about 0.3%, which is about 7% of the standard deviation of prefecture-level revolts. And $\beta_1 + \beta_2 = 0$ cannot be rejected. In the specifications for floods, the effects of floods on revolts are not significant. $\beta_1 + \beta_2 = 0$ cannot be rejected either. As explained above, this is because the standard errors are large in the latter case.

[Table 10 here]

5.7 Using prefecture-decade data

Another way to look at the question is to use prefecture-decade data by aggregating the revolts and weather shocks by decade. The disadvantage of doing so is obvious. The precise year information on when there were droughts or floods and peasant revolts is sacrificed. However, compared with using yearly data in the benchmark model, using decade information might deal with the critique on potential autocorrelation better (Bertrand, Duflo, and Mullainathan 2004).

$$R_{id} = \alpha_i + \gamma_d + \beta_1 Droughts_d * Sweetpotatoes_{id} + \beta_2 Drought_d + \beta_3 Sweetpotatoes_{id} + \sum_{i=2}^{263} \delta_i prefecture_i * trend + \varepsilon_{it} \quad (8)$$

where R_{id} indicates whether there was a revolt in prefecture i within a decade d. $Drought_d$ indicates whether there was any serious drought in prefecture i within a decade d. α_i, γ_d are prefecture fixed effects and decade fixed effects.

The specification for floods is similar. $Flood_d$ indicates whether there was any big negative deviation, i.e. -2, in a prefecture within a decade. The estimation results are presented in Table 11.

[Table 11 here]

The implication of the results is similar to the main conclusion of this paper. Droughts led to more peasant revolts and the magnitude is about 10% of the standard deviation of the revolt indicator. The diffusion of sweet potatoes mitigated the effects of droughts since $\beta_1 + \beta_2 = 0$ cannot be rejected. The effect of floods is not significant. $\beta_1 + \beta_2 = 0$ cannot be rejected either in this case since the coefficients are not precisely estimated.

6 Discussion

This paper shows that droughts led to more peasants' revolts and the adoption of sweet potatoes relieved the effects of droughts on the revolts in an agrarian society like historical China. Hence, the adoption of a certain production technology stabilizes the society. As mentioned in the introduction, the technology of sweet potatoes required low entry costs and hence even the very poor could adopt it. The general implication of technology adoption's effects on conflict might depend on the type of technology, especially who get benefit from the adoption.

The long-run effect of sweet potatoes on urbanization is not as clear as the results in Nunn and Qian (2010). On the one hand, sweet potatoes stabilize the society and increase population growth. On the other hand, peasants in the places with sweet potatoes might lack the incentives to move to urban areas since they can survive well when there are serious weather shocks. The popularity of sweet potatoes is negatively correlated with urbanization rates in modern China. However, this negative correlation might be due to the role sweet potatoes as subsistence food. More detailed information on population sizes and urban population sizes is needed to test this conjecture. This will be the future work.

References

Anderson, E. (1990). *The Food of China*. Yale University Press: New Haven.

Bai, Y. and J. Kung (2010). Climate Shocks and Sino-nomadic Conflict. *The Review of Economics and Statistics*.

Bertrand, M., E. Duflo, and S. Mullainathan (2004). How Much Should We Trust Differences-in-Differences Estimates? *Quarterly Journal of Economics 119*(1), 249–275.

Bray, F. (1984). *Science and Civilization in China, Volume 6; Biology and Biological Technology. Part II: Agriculture*. Cambridge University Press: Cambridge.

Brückner, M. and A. Ciccone (2011). Rainfall and the Democratic Window of Opportunity. *Econometrica*.

Buck, J. (1937). *Land Utilization in China*. Commercial Press: Shanghai.

Chesneaux, J. (1973). *Peasant Revolts in China, 1840–1949*, Volume 2. Thames & Hudson Ltd: London.

Collier, P. (2003). *Breaking the Conflict Trap: Civil War and Development Policy*. A World Bank Publication.

Collier, P. and A. Hoeffler (2004). Greed and Grievance in Civil War. *Oxford Economic Papers 56*(4), 563.

FAO (2010). http://faostat.fao.org/default.aspx.

FAO and IIASA (2002). http://www.iiasa.ac.at/research/luc/gaez/index.html.

Fearon, J. and D. Laitin (2003). Ethnicity, Insurgency, and Civil War. *American Political Science Review 97*(01), 75–90.

Feuerwerker, A. (1975). *Rebellion in Nineteenth-Century China*. Center for Chinese Studies, University of Michigan.

Guo, M. (Ed.) (1979). *Zhongguo lishi dituji (Historical Atlas of China)*. Ditu Press: Beijing.

Hersh, J. and H. Voth (2009). Sweet Diversity: Overseas Trade and Gains from Variety after 1492. *Working Paper*.

Ho, P. (1955). The Introduction of American Food Plants into China. *American Anthropologist 57*(2), 191–201.

Ho, P. (1959). *Studies on the Population of China, 1368-1953*. Harvard Univ Press: Cambridge.

Ho, P. (1979). The Introduction, Diffusion of American Crops and Their Impacts on Crop Production in China. *Shi Jie Nong Ye(World Agriculture) 6*, 25–31.

Huang, R. (1974). *Taxation and Government Finance in Sixteenth-Century China*. Cambridge University Press: Cambridge.

Keller, W. and C. Shiue (2007). Markets in China and Europe on the Eve of the Industrial Revolution. *The American Economic Review 97*(4), 1189–1216.

Laufer, B. (1907). The Introduction of Maize Into Eastern Asia. *Proc. 15th Int. Congr. Americanists 1*, 223–257.

Li, L. (2007). *Fighting Famine in North China: State, Market, and Environmental Decline, 1690s-1990s*. Stanford Univ Press: Stanford.

Liang, F. (1981). *Zhongguo lidai hukou tiandi tianfu tongji (Statistics on China's Historical Population, Cultivated Land and Land Tax)*. Shanghai Renmin Press: Shanghai.

Miguel, E., S. Satyanath, and E. Sergenti (2004). Economic shocks and civil conflict: An instrumental variables approach. *Journal of Political Economy 112*(4), 725–753.

Nunn, N. and N. Qian (2010a). The Columbian Exchange: A History of Disease, Food, and Ideas. *The Journal of Economic Perspectives 24*(2), 163–188.

Nunn, N. and N. Qian (2010b). The Potato's Contribution to Population and Urbanization: Evidence from an Historical Experiment. *Quarterly Journal of Economics*.

Perkins, D. (1969). *Agricultural Development in China, 1368-1968*. Edinburgh University Press: Edinburgh.

Pomeranz, K. (2000). *The Great Divergence*. Princeton University Press: Princeton.

Shiue, C. (2004). Local Granaries and Central Government Disaster Relief: Moral Hazard and Intergovernmental Finance in Eighteenth-and Nineteenth-Century China. *The Journal of Economic History 64*(01), 100–124.

Shiva, V. (1991). *The Violence of the Green Revolution: Third World Agriculture, Ecology, and Politics*. Zed Books: New York.

Simoons, F. (1991). *Food in China: a Cultural and Historical Inquiry*. CRC Press: Boston.

State Meteorological Society (1981). *Zhongguo jin wu bai nian han lao fen bu tu ji (Yearly Charts of Dryness/Wetness in China for the Last 500-Year Period)*. Di tu Press: Beijing.

The Editing Committee of China's Military History (Ed.) (1985). *Zhongguo lidai zhanzheng nianbiao (Chronology of Warfare in Dynastic China)*. People's Liberation Army Press: Beijing.

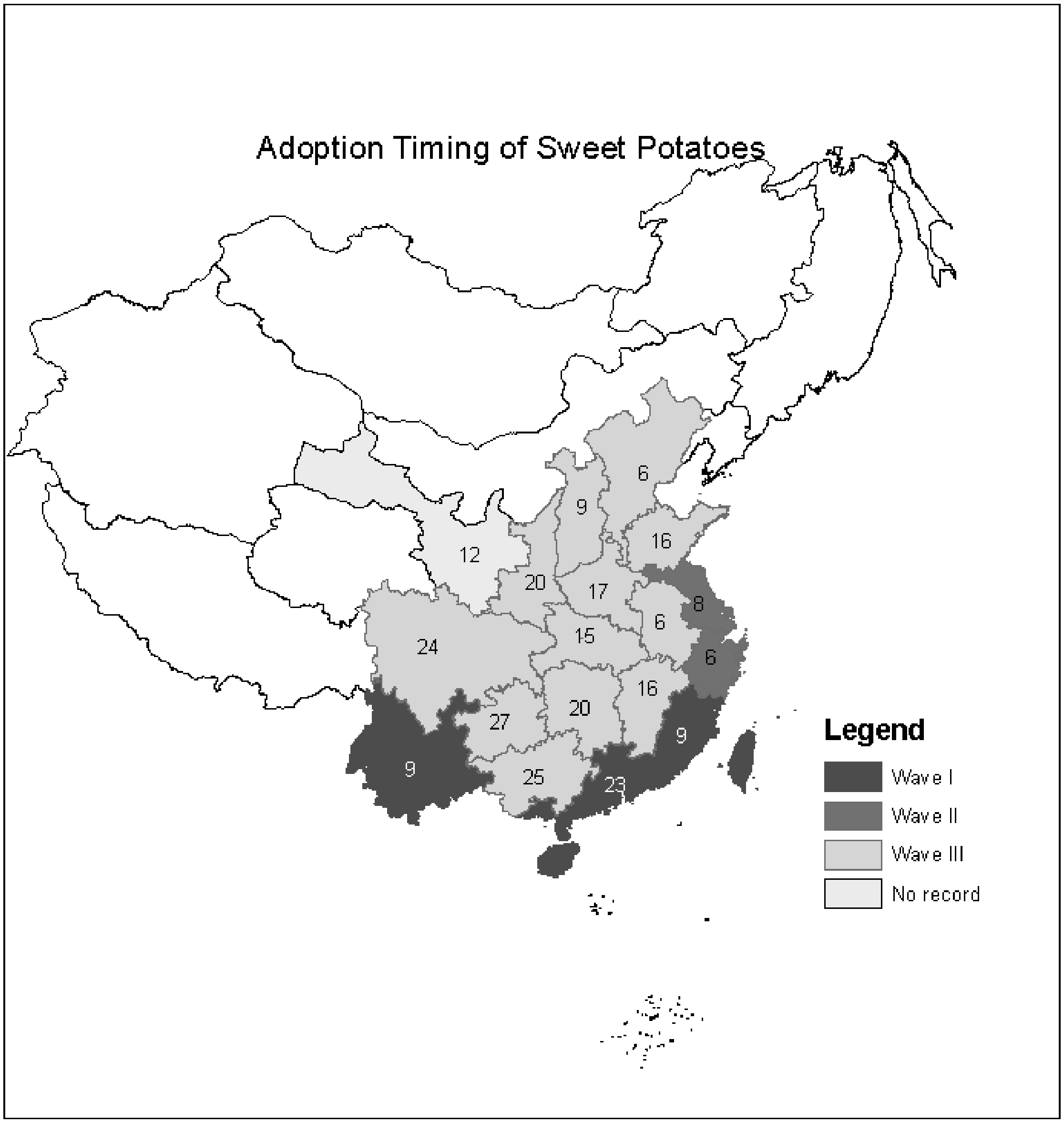
Wu, H. (Ed.) (1983). *"Gudai Jingji Zhuanti Shihua (Topics in Chinese Economic History)"*. Zhonghua Shuju: Beijing.

Xu, D. (1983). *Zhongguo Jindai Nongye Shengchan He Maoyi Tongji Ziliao (Statistical Data of Agricultural Production and Trade in Premodern China)*. Shanghai People's Press: Shanghai.

Yancheva et al. (2007). Influence of the Intertropical Convergence Zone on the East Asian Monsoon. *Nature 445*(7123), 74–77.

Zhang et al. (2007). Climate Change and War Frequency in Eastern China Over the Last Millennium. *Human Ecology 35*(4), 403–414.

Figure 1: Adoption Timing of Sweet Potatoes



Note: In the first wave, Yunnan in the southwest adopted sweet potatoes from Burma whereas provinces in the southeast adopted them from Vietnam and Malaysia. Source: Guo (1979).

The numbers represent the total number of revolts in each province during 1470-1900.

Figure 2a: Adoption timing and previous revolts

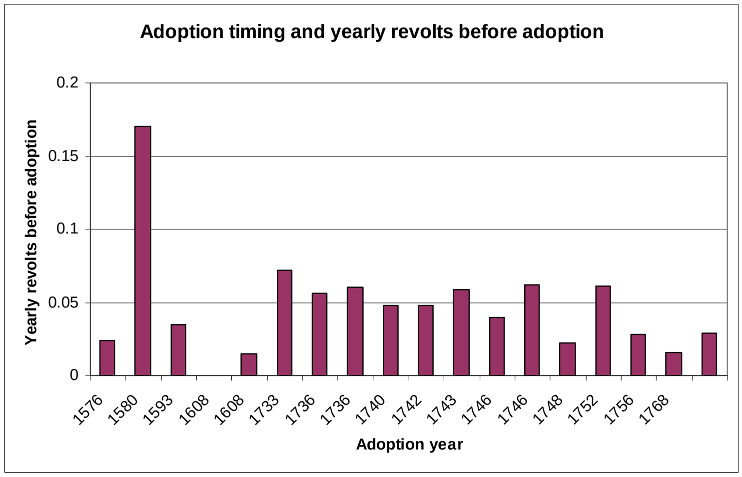
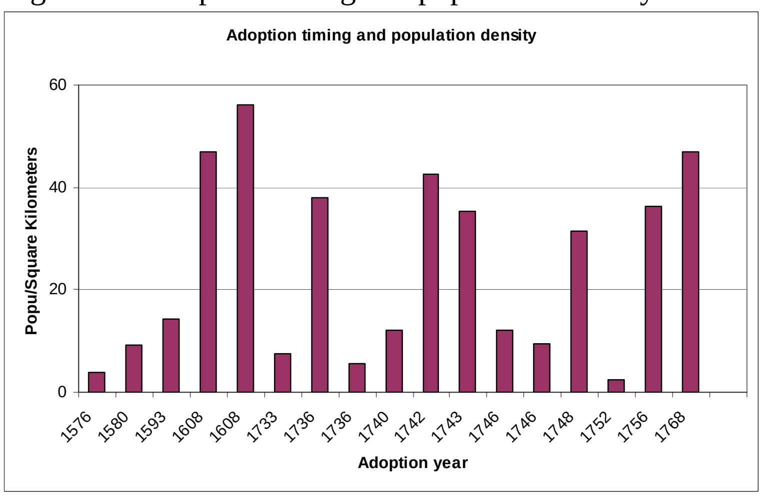
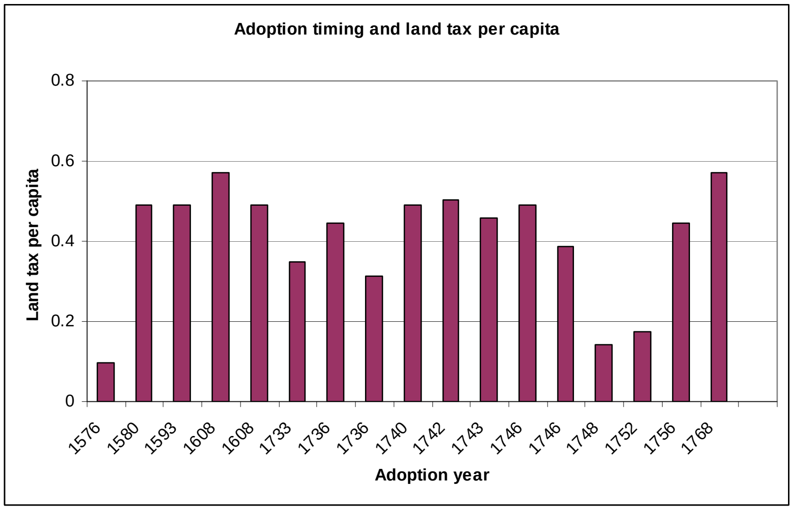


Figure 2b: Adoption timing and population density in 1578



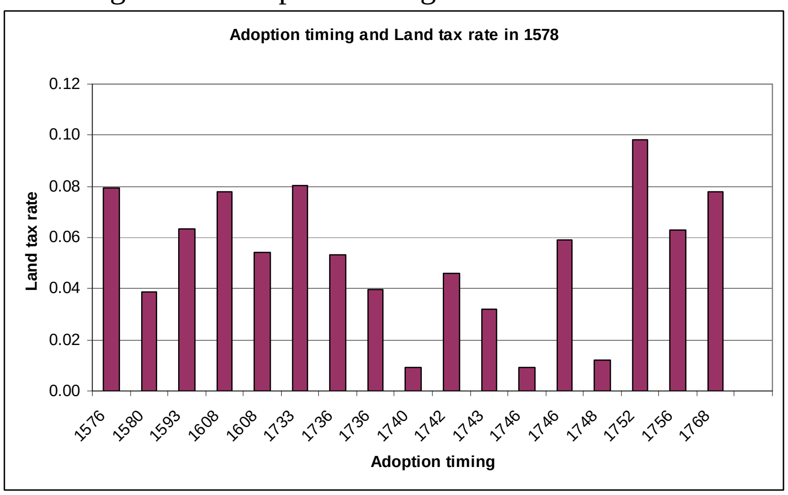
Note: Population density is measured in number of population per square kilometers.
Source: Liang (1981)

Figure 2c: Adoption timing and land tax per capita in1578



Note: Land tax is measured in traditional Chinese units, *Dan* of grains. One *Dan* is about 90 kilograms in this period. Source: Huang (1974) and Liang (1981).

Figure 2d: Adoption timing and land rate in1578



Note: Land tax rate is measured in traditional Chinese units, *Dan* of grains/*Mu*. One *Mu* is about 667 square meters whereas one *Dan* is about 90 kilograms in this period. Source: Huang (1974).

Figure 3a: Suitable areas for Sweet Potatoes

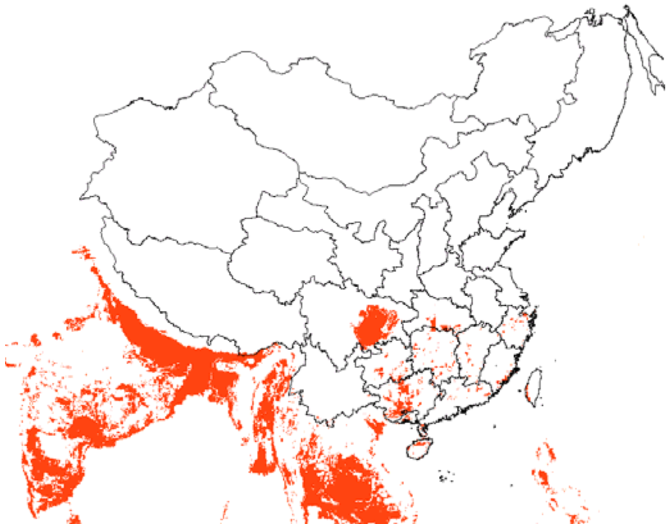
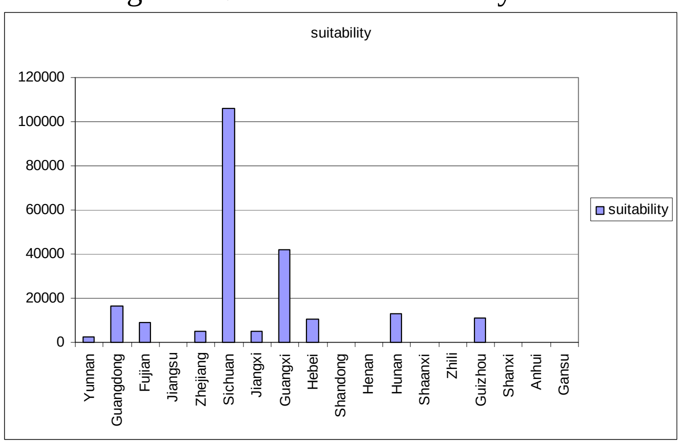
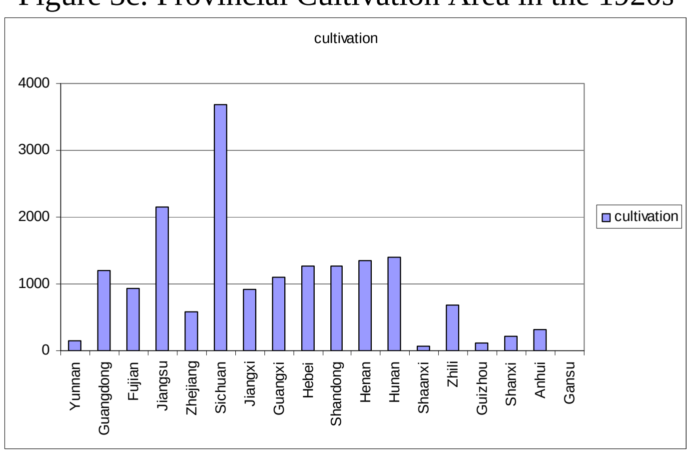


Figure 3b: Provincial Suitability Area



Note: the area is measured in square kilometers. Source: FAO (2002)

Figure 3c: Provincial Cultivation Area in the 1920s



Note: the area is measured in square kilometers. Source: Xu (1983) and Buck (1937).

Table 1: Rebellions that led to demise of dynasties

Period	Causes of Rebellions	Demise of Dynasties
184-192	Droughts, Locust plague	East Han Dynasty
611-622	Droughts	Sui Dynasty
1120-1122	Droughts	North Song Dynasty
1351-1368	Droughts, Locust plague	Yuan Dynasty
1628-1644	Droughts	Ming Dynasty

Table 2: Summary Statistics

Panel A: Province by year data (18 provinces*430 years)				
	Mean	Standard Dev.	Min	Max
Number of revolts	0.036	0.236	0	6
Whether there was a revolt	0.030	0.170	0	1
Average weather deviation from 3 in a province	-0.057	0.780	-2	2
Average weather deviation from above (only >=3)	0.530	0.535	0	2
Average weather deviation from above (only <3)	-0.670	0.457	-2	-0.03
Sweet Potatoes Dummies	0.439	0.496	0	1
Log (1+Sweet Potatoes Area in the 1920s) (unit: km^2)	6.532	1.876	0	8.6
Log(1+Suitable Area) (unit: km^2)	5.468	4.700	0	11.6
Panel B: Prefecture by year data (263 prefectures*430 years)				
	Mean	Standard Dev.	Min	Max
Number of revolts	0.002	0.047	0	1
Average weather deviation from 3 in a prefecture	-0.042	1.063	-2	2
Sweet Potatoes Dummies	0.431	0.495	0	1
Panel C: Prefecture by decade data (263 prefectures*43 decades)				
	Mean	Standard Dev.	Min	Max
Whether is there was a revolt	0.020	0.141	0	1
Average of weather deviation in a decade	-0.005	1.037	-2	2
Sweet Potatoes Dummies	0.433	0.496	0	1

Table 3. Main Estimation Results

Dependent Var.	Revolt=0/1			Number of revolts		
	OLS	Fixed Effects	Fixed Effects	OLS	Fixed Effects	Fixed Effects
	(1)	(2)	(3)	(4)	(5)	(6)
|Deviation|*Sweetpotatoes	-0.016**	-0.020**	-0.021**	-0.025**	-0.032***	-0.033***
	(0.008)	(0.009)	(0.009)	(0.011)	(0.012)	(0.012)
|Deviation|	0.017***	0.020***	0.021***	0.026***	0.032***	0.032***
	(0.005)	(0.007)	(0.007)	(0.007)	(0.010)	(0.010)
Sweetpotatoes	-0.010	-0.005	0.002	-0.008	-0.004	0.002
	(0.006)	(0.009)	(0.010)	(0.008)	(0.012)	(0.013)
Province fixed effects		Y	Y		Y	Y
Year fixed effects		Y	Y		Y	Y
Time trends			Y			Y
Mean of dependent Var.	0.030	0.030	0.030	0.036	0.036	0.036
S.d. of dependent Var.	(0.170)	(0.170)	(0.170)	(0.236)	(0.236)	(0.236)
Observations	7,636	7,636	7,636	7,636	7,636	7,636
R-squared	0.005	0.103	0.110	0.004	0.097	0.100
F-test for $\beta_1 + \beta_2 = 0$	0.89	0.98	0.99	0.93	0.92	0.97

Note: standard errors are clustered at province level. *** denotes significance at 1% and ** at 5%. β_1 and β_2 are the coefficients of |Deviation|*Sweetpotatoes and |Deviation| respectively. The reported results for F-tests are the p-values.

Table 4. Main Estimation Results: separating droughts from floods

Panel A: Droughts (deviation from above)						
Dependent Var.	Revolt=0/1			Number of revolts		
	OLS	Fixed Effects	Fixed Effects	OLS	Fixed Effects	Fixed Effects
	(1)	(2)	(3)	(4)	(5)	(6)
|Deviation|*Sweetpotatoes	-0.017	-0.028**	-0.033**	-0.036**	-0.052***	-0.058***
	(0.011)	(0.013)	(0.014)	(0.016)	(0.020)	(0.020)
|Deviation|	0.020***	0.027***	0.029***	0.040***	0.050***	0.052***
	(0.007)	(0.009)	(0.010)	(0.010)	(0.016)	(0.017)
Sweetpotatoes	-0.014	0.007	0.020	-0.013	0.006	0.018
	(0.009)	(0.014)	(0.016)	(0.012)	(0.016)	(0.018)
Province fixed effects		Y	Y		Y	Y
Year fixed effects		Y	Y		Y	Y
Time trends			Y			Y
Mean of dependent Var.	0.036	0.036	0.036	0.043	0.043	0.043
S.d. of dependent Var.	(0.187)	(0.187)	(0.187)	(0.257)	(0.257)	(0.257)
Observations	3,893	3,893	3,893	3,893	3,893	3,893
R-squared	0.006	0.155	0.164	0.008	0.152	0.158
F-test for $\beta_1 + \beta_2 = 0$	0.73	0.94	0.71	0.75	0.83	0.62

Panel B: Floods (deviation from below)						
Dependent Var.	Revolt=0/1			Number of revolts		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Fixed Effects	Fixed Effects	OLS	Fixed Effects	Fixed Effects
|Deviation|*Sweetpotatoes	-0.016	-0.016	-0.012	-0.013	-0.015	-0.010
	(0.011)	(0.013)	(0.013)	(0.015)	(0.016)	(0.016)
|Deviation|	0.016**	0.016	0.015	0.010	0.012	0.010
	(0.007)	(0.011)	(0.011)	(0.011)	(0.013)	(0.012)
Sweetpotatoes	-0.003	-0.013	-0.015	-0.003	-0.011	-0.015
	(0.009)	(0.012)	(0.013)	(0.012)	(0.019)	(0.020)
Province fixed effects		Y	Y		Y	Y
Year fixed effects		Y	Y		Y	Y
Time trends			Y			Y
Mean of dependent Var.	0.023	0.023	0.023	0.028	0.028	0.028
S.d. of dependent Var.	(0.150)	(0.150)	(0.150)	(0.211)	(0.211)	(0.211)
Observations	3,743	3,743	3,743	3,743	3,743	3,743
R-squared	0.003	0.165	0.171	0.001	0.152	0.160
F-test for $\beta_1 + \beta_2 = 0$	0.98	0.97	0.72	0.81	0.74	0.99

Note: standard errors are clustered at province level. *** denotes significance at 1% and ** at 5%. β_1 and β_2 are the coefficients of |Deviation|*Sweetpotatoes and |Deviation| respectively. The reported results for F-tests are the p-values.

Table 5. Using Area Information

Panel A: Droughts				
Dependent Var.	Revolt=0/1		Number of revolts	
	(1)	(2)	(3)	(4)
|Deviation|*Sweetpotatoes* Normalized ln_Area	-0.031**	-0.036***	-0.058***	-0.064***
	(0.014)	(0.014)	(0.020)	(0.021)
|Deviation|	0.027***	0.029***	0.050***	0.052***
	(0.009)	(0.010)	(0.016)	(0.016)
Sweetpotatoes* Normalized ln_Area	0.003	0.020	0.003	0.020
	(0.014)	(0.016)	(0.016)	(0.019)
Province fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
Time trends		Y		Y
Observations	3,893	3,893	3,893	3,893
R-squared	0.156	0.164	0.152	0.158
F-test for $\beta_1 + \beta_2 = 0$	0.74	0.51	0.54	0.35

Panel B: Floods				
Dependent Var.	Revolt=0/1		Number of revolts	
	(1)	(2)	(3)	(4)
|Deviation|*Sweetpotatoes* Normalized ln_Area	-0.017	-0.013	-0.016	-0.011
	(0.014)	(0.014)	(0.017)	(0.017)
|Deviation|	0.016	0.015	0.012	0.010
	(0.011)	(0.011)	(0.012)	(0.012)
Sweetpotatoes* Normalized ln_Area	-0.009	-0.013	-0.006	-0.012
	(0.012)	(0.013)	(0.020)	(0.022)
Province fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
Time trends		Y		Y
Observations	3,743	3,743	3,743	3,743
R-squared	0.164	0.171	0.152	0.159
F-test for $\beta_1 + \beta_2 = 0$	0.93	0.80	0.69	0.94

Note: To compare with the results from Table 2, the area information is normalized by the mean of ln_area, 6.53.

Standard errors are clustered at province level. *** denotes significance at 1% and ** at 5%. β_1 and β_2 are the coefficients of |Deviation|*Sweetpotatoes*（Normalized ln_Area) and |Deviation| respectively. The reported results for F-tests are the p-values.

Table 6. Using Maize as Placebo Tests

Panel A: Droughts		
Dependent Var.	Revolt=0/1	Number of revolts
	(1)	(2)
|Deviation|*Maize	-0.024	-0.018
	(0.014)	(0.022)
|Deviation|	0.030**	0.040**
	(0.012)	(0.019)
Maize	0.023	0.032
	(0.016)	(0.022)
Province fixed effects	Y	Y
Year fixed effects	Y	Y
Observations	3,893	3,893
R-squared	0.155	0.150
F-test for $\beta_1 + \beta_2 = 0$	0.43	0.08

Panel B: Floods		
Dependent Var.	Revolt=0/1	Number of revolts
	(1)	(2)
|Deviation|*Maize	-0.013	-0.016
	(0.016)	(0.018)
|Deviation|	0.018	0.016
	(0.015)	(0.016)
Maize	0.008	0.019
	(0.015)	(0.018)
Province fixed effects	Y	Y
Year fixed effects	Y	Y
Observations	3,743	3,743
R-squared	0.170	0.159
F-test for $\beta_1 + \beta_2 = 0$	0.65	0.87

Note: Standard errors are clustered at province level. *** denotes significance at 1% and ** at 5%. β_1 and β_2 are the coefficients of |Deviation|*Maize and |Deviation| respectively. The reported results for F-tests are the p-values.

Table 7. Defining Weather Shocks by Dummies

Panel A: Droughts		
Dependent Var.	Revolt=0/1	Number of revolts
	(1)	(2)
Drought*Sweetpotatoes	-0.016	-0.031**
	(0.010)	(0.014)
Drought	0.022***	0.035***
	(0.008)	(0.012)
Sweetpotatoes	-0.008	-0.013
	(0.008)	(0.011)
Province fixed effects	Y	Y
Year fixed effects	Y	Y
Time trends	Y	Y
Observations	7,575	7,575
R-squared	0.109	0.100
F-test for $\beta_1 + \beta_2 = 0$	0.35	0.62
Panel B: Floods		
	Revolt=0/1	Number of revolts
Flood*Sweetpotatoes	-0.002	0.003
	(0.009)	(0.011)
Flood	0.004	-0.002
	(0.007)	(0.008)
Sweetpotatoes	-0.011	-0.020
	(0.008)	(0.011)
Province fixed effects	Y	Y
Year fixed effects	Y	Y
Time trends	Y	Y
Observations	7,575	7,575
R-squared	0.108	0.098
F-test for $\beta_1 + \beta_2 = 0$	0.67	0.82

Note: Standard errors are clustered at province level. *** denotes significance at 1% and ** at 5%. β_1 and β_2 are the coefficients of Drought*Sweetpotatoes (or Flood*Sweetpotatoes) and Drought (or Flood) respectively. The reported results for F-tests are the p-values.

Table 8. Slightly Varying the Introduction Year

Panel A: Droughts				
Dependent Var.	Revolt=0/1	Number of revolts	Revolt=0/1	Number of revolts
Varying method	Bringing forward 5 years		Using nearest decennial year	
	(1)	(2)	(3)	(4)
|Deviation|*Sweetpotatoes	-0.030**	-0.055***	-0.027	-0.051**
	(0.014)	(0.020)	(0.014)	(0.020)
|Deviation|	0.028***	0.051***	0.026***	0.048***
	(0.010)	(0.017)	(0.009)	(0.016)
Sweetpotatoes	0.022	0.020	0.016	0.017
	(0.016)	(0.018)	(0.016)	(0.019)
Province fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
Time trends	Y	Y	Y	Y
Observations	3,893	3,893	3,743	3,743
R-squared	0.163	0.157	0.167	0.171
F-test for $\beta_1 + \beta_2 = 0$	0.86	0.75	0.96	0.81

Panel B: Floods				
Dependent Var.	Revolt=0/1	Number of revolts	Revolt=0/1	Number of revolts
Varying method	Bringing forward 5 years		Using nearest decennial year	
	(1)	(2)	(3)	(4)
|Deviation|*Sweetpotatoes	-0.015	-0.012	-0.022	-0.022
	(0.013)	(0.016)	(0.016)	(0.013)
|Deviation|	0.016	0.011	0.015	0.019
	(0.011)	(0.012)	(0.012)	(0.011)
Sweetpotatoes	-0.007	-0.007	-0.008	-0.009
	(0.013)	(0.020)	(0.020)	(0.013)
Province fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
Time trends	Y	Y	Y	Y
Observations	3,743	3,743	3,743	3,743
R-squared	0.171	0.160	0.160	0.172
F-test for $\beta_1 + \beta_2 = 0$	0.88	0.89	0.44	0.56

Note: Standard errors are clustered at province level. *** denotes significance at 1% and ** at 5%. β_1 and β_2 are the coefficients of |Deviation|*Sweetpotatoes and |Deviation| respectively. The reported results for F-tests are the p-values.

Table 9. Allowing Time-variant Effects for Droughts

Panel A: 50 years after adoption versus later		
Dependent Var.	Revolt=0/1	Number of revolts
	(1)	(2)
|Deviation|*50yearsafteradoption	-0.037	-0.069***
	(0.020)	(0.026)
|Deviation|*Later	-0.031**	-0.053**
	(0.015)	(0.021)
|Deviation|	0.029***	0.052***
	(0.010)	(0.017)
50yearsafteradoption	0.017	0.015
	(0.018)	(0.020)
Later	0.027	0.026
	(0.017)	(0.020)
Province fixed effects	Y	Y
Year fixed effects	Y	Y
Time trends	Y	Y
Observations	3,893	3,893
R-squared	0.164	0.158
F-test for $\beta_1^1 = \beta_1^2$	0.08	1.59

Panel B: 100 years after adoption versus later		
Dependent Var.	Revolt=0/1	Number of revolts
|Deviation|*100yearsafteradoption	-0.031	-0.058***
	(0.016)	(0.022)
|Deviation|*Later	-0.035**	-0.057**
	(0.017)	(0.023)
|Deviation|	0.029***	0.051***
	(0.010)	(0.017)
100yearsafteradoption	0.019	0.018
	(0.016)	(0.018)
Later	0.045**	0.050**
	(0.021)	(0.024)
Province fixed effects	Y	Y
Year fixed effects	Y	Y
Time trends	Y	Y
Observations	3,893	3,893
R-squared	0.164	0.158
F-test for $\beta_1^1 = \beta_1^2$	0.05	0.00

Note: Standard errors are clustered at province level. *** denotes significance at 1% and ** at 5%. β_1^1 and β_1^2 are the coefficients of |Deviation|*100yearsafteradoption and Deviation|*Late respectively.

Table 10. Using Prefecture by year Data

Panel A: Droughts			
Dependent Var.	Whether there is a revolt in a prefecture		
	OLS	Fixed effects	Fixed effects
	(1)	(2)	(3)
|Deviation|*Sweetpotatoes	-0.002**	-0.002***	-0.002**
	(0.001)	(0.001)	(0.001)
|Deviation|	0.002***	0.003***	0.003***
	(0.000)	(0.001)	(0.001)
Sweetpotatoes	-0.002***	-0.002**	-0.002
	(0.001)	(0.001)	(0.001)
Prefecture fixed effects		Y	Y
Decade fixed effects		Y	Y
Time trends			Y
Mean of dependent Var.	0.002	0.002	0.002
S.d. of dependent Var.	(0.047)	(0.047)	(0.047)
Observations	54,711	54,711	54,711
R-squared	0.001	0.025	0.040
F-test for $\beta_1 + \beta_2 = 0$	0.13	0.34	0.37

Panel B: Floods			
Dependent Var.	Whether there is a revolt in a prefecture		
	OLS	Fixed effects	Fixed effects
|Deviation|*Sweetpotatoes	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)
|Deviation|	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
Sweetpotatoes	-0.001	-0.002	-0.003
	(0.002)	(0.002)	(0.002)
Prefecture fixed effects		Y	Y
Decade fixed effects		Y	Y
Time trends			Y
Mean of dependent Var.	0.002	0.002	0.002
S.d. of dependent Var.	(0.047)	(0.047)	(0.047)
Observations	26,154	26,154	26,154
R-squared	0.000	0.037	0.050
F-test for $\beta_1 + \beta_2 = 0$	0.19	0.56	0.24

Note: standard errors are clustered at prefecture level. *** denotes significance at 1% and ** at 5%. β_1 and β_2 are the coefficients of |Deviation|*Sweetpotatoes and |Deviation| respectively. The reported results for F-tests are the p-values.

Table 11. Using Prefecture by Decade Data

Panel A: Droughts			
Dependent Var.	Whether there is a revolt in a prefecture		
	OLS	Fixed effects	Fixed effects
	(1)	(2)	(3)
Drought*Sweetpotatoes	-0.015***	-0.013**	-0.015**
	(0.005)	(0.006)	(0.006)
Drought	0.021***	0.017***	0.018***
	(0.004)	(0.005)	(0.005)
Sweetpotatoes	-0.007**	-0.013**	-0.008
	(0.003)	(0.005)	(0.006)
Prefecture fixed effects		Y	Y
Decade fixed effects		Y	Y
Time trends			Y
Mean of dependent Var.	0.020	0.020	0.020
S.d. of dependent Var.	(0.141)	(0.141)	(0.141)
Observations	11,528	11,528	11,528
R-squared	0.005	0.061	0.088
F-test for $\beta_1 + \beta_2 = 0$	0.17	0.27	0.49

Panel B: Floods			
Dependent Var.	Whether there is a revolt in a prefecture		
	OLS	Fixed effects	Fixed effects
Flood*Sweetpotatoes	-0.001	-0.002	-0.001
	(0.005)	(0.005)	(0.006)
Flood	0.004	0.005	0.005
	(0.004)	(0.004)	(0.005)
Sweetpotatoes	-0.013***	-0.017***	-0.014**
	(0.003)	(0.006)	(0.007)
Prefecture fixed effects		Y	Y
Decade fixed effects		Y	Y
Time trends			Y
Mean of dependent Var.	0.020	0.020	0.020
S.d. of dependent Var.	(0.141)	(0.141)	(0.141)
Observations	11,528	11,528	11,528
R-squared	0.002	0.060	0.086
F-test for $\beta_1 + \beta_2 = 0$	0.46	0.41	0.31

Note: Standard errors are clustered at prefecture level. *** denotes significance at 1% and ** at 5%. β_1 and β_2 are the coefficients of Drought*Sweetpotatoes (or Flood*Sweetpotatoes) and Drought (or Flood) respectively. The reported results for F-tests are the p-values.