Reaping What You Sow: Historical Rice Farming and Contemporary Cooperative Behavior in China*

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Abstract

This paper investigates how China's long tradition of wetland rice farming affects contemporary cooperative behavior. We exploit a discontinuity in rice farming generated by a natural geographic boundary in China and find a significant positive impact on cooperative behavior today. In particular, an increase in the percentage of farmland devoted to rice farming significantly increases the frequency of mutual help in terms of borrowing and lending money, caring for each other's family members, and helping each other with job seeking and house construction. We identify cultural transmission, labor exchange and irrigation networks as the likely driving forces behind this phenomenon.

Keywords: rice farming, cooperative behavior, culture, irrigation, labor exchange, China

JEL Codes: D90, N55, Z10

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"As man sows, so shall he reap. In works of fiction, such men are sometimes converted. More often, in real life, they do not change their natures until they are converted into dust."

– Charles W. Chesnutt

1 Introduction

Economists, psychologists, anthropologists and evolutionary biologists alike have long been working towards an understanding of human cooperative behavior. Effective cooperation contributes to socially desirable outcomes, such as economic growth and development (Hicks and Kenworthy, 1998; Algan and Cahuc, 2010; Litina, 2016), global environmental agreements (Asheim et al., 2006), international trade (Maggi, 1999; Jackson and Nei, 2015), and public health (Bollyky and Bown, 2020; Brown and Susskind, 2020). Yet there is substantial evidence that cooperation varies widely across societies, as shown by the variation in economic preferences for reciprocity, altruism and trust in the Global Preference Survey (Falk et al., 2018), the disparity in indicators of trust and civic norms from the World Value Surveys (Knack and Keefer, 1997; Litina, 2016), and the diversity of responses in controlled lab experiments on public goods (Zhou et al., 2016; Butler and Fehr, 2018) across countries and across regions within countries.

Our goal is to explain the origins of the differences in cooperative behavior. Specifically, we test the hypothesis that differences in contemporary cooperative behavior have their origins in historical agricultural practices. The influential rice theory of culture, put forth by Talhelm et al. (2014), identifies important differences between rice farming and wheat farming. Paddy rice grows best in standing water, therefore farmers in rice regions build elaborate irrigation networks.[1] In comparison, wheat farmers can rely on rainfall and do not need to irrigate wheat. Growing paddy rice also requires at least twice the number of hours as growing wheat (Buck, 1937). It is difficult for a single family to grow paddy rice independently due to these differences in irrigation and labor requirements. These features of rice farming made rice communities more interdependent, encouraged rice farmers to cooperate intensely, and resulted in relationships requiring greater reciprocation. Societies characterized by rice farming, therefore, developed interdependent, collectivist and cooperative cultures (Talhelm et al., 2014; Talhelm and English, 2020).[2] In fact, people from rice growing regions inherit these cultures, which continue to influence their behavior towards others even after they put

[1] Rice farming refers to paddy rice farming unless otherwise stated throughout this paper.

[2] Alesina and Giuliano (2015) have an extended discussion on the definition and measurement of culture. Following most of the empirical literature, we include values, preferences and beliefs in our notion of culture. Butler and Fehr (2018) suggest that culture influences cooperation through both preferences and beliefs.

down their plows and move out of traditional farming.

To test the hypothesis that historical rice farming affects cooperative behavior today, we combine historical data on rice farming with contemporary measures of individual behaviors on borrowing and lending, caring and helping each other from China. As argued by Talhelm et al. (2014), China is a natural test case because it has traditionally grown both rice and other crops, and has been ethnically and politically unified for most of the past few thousands of years. Moreover, given the complex interaction between culture and institutions (Alesina and Giuliano, 2015), the focus on individuals within the same country can help isolate the effect of culture from institutions as compared to a cross-country analysis.

A critical challenge to identifying the effects of historical rice farming on contemporary cooperative behavior is that we would observe the same relationship between rice farming and cooperative behavior if societies with more collectivist and cooperative culture and behavior were more likely to adopt rice farming historically, and these norms transmit from generation to generation. We address this identification problem by exploiting the variations in rice farming generated by a geographical boundary between southern and northern China – the Qinling-Huaihe line and implementing a regression discontinuity (RD) design.

The line formed by the Huai River in the east and Qinling Mountain range in the west defines the border between northern and southern China, corresponding roughly to the 33rd parallel north.[3] Regions on the two sides of the boundary differ significantly in weather conditions such as temperature, humidity, precipitation, wind speed and sunshine. Overall the South is warmer with abundant water whereas the North is cooler, dry and chronically short of water, which results in a sharp difference in rice farming suitability (Figure 1) and rice farming (Figure 2) between the two regions. Our empirical strategy compares the cooperative behavior of individuals from regions just north of the Qinling-Huaihe line to those just south of the line. In our empirical specifications, we also control for a large set of observed individual and regional characteristics.

We find that historical rice farming has a significant positive impact on cooperative behavior today. The results show evidence for higher frequencies of cooperative behavior in a wide range of monetary and non-monetary activities. In particular, as the percentage of farmland devoted to rice farming increases, we find higher incidences of mutual help in terms of borrowing and lending money, caring for each other's family members, and helping each other with job seeking and house construction. These results are robust to a variety of alternative RD specifications, alternative measures for rice farming and a series of falsification

[3]The Qinling-Huaihe line was first drawn as the natural geographical boundary between southern and northern China by Chinese geographer Xiangwen Zhang in 1908 (Zhang, 1908). The Chinese government also used the line to separate northern and southern China to create a subsidized indoor heating system in the colder north during the 1950-1980 period (Almond et al., 2009; Chen et al., 2013).

tests consisting of moving the true boundary northward or southward and using the Yangtze River as the placebo boundary.

To test for the importance of cultural persistence, we examine the impacts of historical rice farming on individuals directly involved in farming and those that either have off-farm jobs or do not work. We find that even among non-farm workers and non-workers, those with a legacy of traditional rice farming exhibit more cooperative behavior. These results provide evidence that part of the importance of historical rice farming arises through its impact on internal beliefs and values. We also use the data from Talhelm et al. (2014) on psychological measures of culture and confirm their finding that people from historical rice growing regions think more holistically and have more interdependent cultures. Furthermore, rice farming is found to increase the possibility of existence of irrigation networks in a rural village and the possibility of labor exchange during planting and harvesting seasons. These results suggest that irrigation network and labor exchange are likely driving forces that have produced cultural preferences for cooperation in rice farming regions.

This paper contributes to the growing literature on the determinants and origins of human cooperation. Traditional socio-biological theories of human cooperation emphasize the importance of kinship (Hamilton, 1964), reciprocal altruism (Trivers, 1971), or costly signaling (Zahavi and Zahavi, 1999). More recent literature highlights culture as a key factor that affects and regulates cooperation (e.g., Alvard, 2003; Boyd and Richerson, 2009; Gächter and Herrmann, 2009; Gächter et al., 2010; Berigan and Irwin, 2011; Padró i Miquel et al., 2015; He et al., 2018; Enke, 2019), and several studies emphasize the role of trust in cooperation (e.g., Anderson et al., 2004; Carpenter et al., 2004; Gächter et al., 2004). Our paper is most closely related to the studies that investigate the historical origins of cooperative culture. Talhelm et al. (2014), Zhou et al. (2016) and Talhelm et al. (2018) show that historically rice-farming southern China has a more interdependent and cooperative culture compared to wheat-farming northern China. Litina (2016) advances the hypothesis that historical land productivity affected cooperation in the agriculture sector and had a persistent effect on culture. Buggle (2020) show that societies that historically practiced irrigation agriculture have stronger collectivist norms today.[4] We add to this line of inquiry by providing new evidence that traditional farming practices have shaped not only preferences and beliefs on cooperation, but also various cooperative behaviors in natural (instead of experimental) settings today. We explore a natural geographic boundary and implement an RD strategy to identify the causal effects of historical rice farming on contemporary cooperative behavior.

[4] This study is also related to the literature on the stickiness and persistence in culture transmission (e.g., Guiso et al., 2006; Tabellini, 2008; Fernandez and Fogli, 2009; Nunn and Wantchekon, 2011; Voigtländer and Voth, 2012; Alesina et al., 2013; Becker et al., 2016).

We obtain empirical evidence on the underlying mechanisms driving the observed relationship between historical farming and contemporary cooperative behavior. We also show that this type of cooperative behavior has mattered in terms of socioeconomic outcomes such as trust, household income, and public spending.

The remainder of the paper is organized as follows. Section 2 discusses the conceptual framework underlying the hypothesis tested in the paper. Section 3 provides some background on rice farming in China. Section 4 describes our data and empirical strategy. Section 5 presents the main results. We test for underlying mechanisms and discuss alternative explanations in Sections 6 and 7. Section 8 provides some concluding remarks on the economic implications of historical rice farming.

2 Conceptual Framework

The scale of human cooperation is an evolutionary puzzle (Boyd and Richerson, 2009), and its origins have been the subject of considerable research (e.g., Fowler, 2005; Pennisi, 2009). The term cooperation is often loosely defined. It may refer to cooperative behaviors, that is, engaging with others in a mutually beneficial activity (Bowles and Gintis, 2011). It may also refer to cooperative culture, that is, a set of values, preferences and beliefs regarding reciprocity, altruism, and trust, among others. Cooperative culture is also sometimes used to describe interdependence and collectivism.[5]

For thousands of years, agriculture was central to the vast majority of people's lives. The possibility that modern culture has been shaped by traditional agriculture practices has long been recognized. The rice theory of culture, proposed by Talhelm et al. (2014), examines the relationship between historical farming practices (rice versus wheat farming) and psychological differences in collectivism today. There are two important differences between rice farming and wheat farming.[6] The first difference is that rice grows best in standing water whereas wheat can rely on rainfall. Paddy rice is extremely sensitive to water shortage. Continuous flooding of the soil is needed to ensure sufficient water supply and better nutrient availability. In many rice regions, paddy rice can be flooded with seasonal rainfall or waterway flooding without active irrigation. However, natural flooding is irregular. Moreover active irrigation can help precisely control the amount of water, as well as the time

[5]Some argue that collectivism does not always require cooperation (Talhelm and English, 2020).

[6]Following Talhelm et al. (2014), we focus our discussion on the differences between rice and wheat farming while keeping in mind that there are many other important crops grown in China and around the world (e.g., millet, corn, and potatoes) and there are also many other subsistence styles (e.g., hunting, herding, and fishing).

of flooding and draining.[7]

The second important difference between rice and wheat farming is that rice cultivation is significantly more labor intensive. The best yielding method for paddy rice is transplantation wherein pre-germinated seedlings are transferred from a seedbed to the main wet field once they show three to four leaves. Transplanting requires heavy labor input but fewer seeds and is more effective (Elvin, 2004). Typically rice farmers also have to prepare the land in advance to create the best conditions for crop growth. For irrigating rice, farmers need to construct separate field channels to deliver water to individual seed beds. Several additional practices are taken to increase productivity. For example, deep cracks in the soil must be filled before soaking; plowing and leveling increase grain quality and reduce the amount of water wasted by uneven fields; bunds are constructed to conserve water and avoid overflowing water in case of heavy rains. Harvesting is another time-consuming task for rice farming. Apart from cutting the mature rice crop, other harvesting activities, such as stacking, handling, threshing, cleaning and hauling, are conducted to minimize grain damage and maximize productivity. As a result, growing paddy rice requires at least twice the number of hours as growing wheat (Buck, 1937).[8]

Construction and maintenance of irrigation facilities are usually large projects, which can only be completed through the coordinated efforts of different families in the whole village. Rice farmers also need to decide how to use water from the irrigation facilities collectively. Thus, irrigation likely fostered coordination and cooperation among rice farmers. Moreover, the high labor demand of paddy rice implies that it is often out of the scope of a single family to farm rice independently. Cooperative labor exchanges were common, especially during the planting and harvesting season. Different from kindhearted help, the exchanges of labor in rice areas were more binding and acted as a form of implicit contract that said, *"I help you today because I expect you to help me tomorrow"* (Posner, 1980). For example, several villagers would work together to offer help on one villager's paddy rice plot today in exchange for receiving favors on their plots later. Therefore, the cooperation required by irrigation networks and labor exchanges constitute potential underlying mechanisms for societies characterized by rice farming to develop a more cooperative culture (Buck, 1937; Fei, 1992; Bray, 1994; Khush, 1997).

The classic work by Boyd and Richerson (1985) argues that culture evolves and adapts

[7]Although some varieties of dryland rice can grow without being flooded, flooded rice can generate much higher yields (Khush, 1997).

[8]Despite of the high labor demand, farmers choose to grow rice because it has an extraordinary productivity per acre. Historically rice plant could yield three to five times more than wheat (Perkins, 1969). A very limited supply of arable land, with a rapidly expanding population in China, made it necessary to farm land intensively. The high productivity of paddy rice made the traditional Chinese respond to this problem by choosing to grow rice.

based on evolutionary principles determined by relative payoffs. This framework suggests that in societies that engaged in rice farming, collectivist and cooperative culture norms and beliefs were relatively more valuable. Therefore, these norms and beliefs may have evolved in rice farming societies but not in wheat farming societies. Boyd and Richerson (1985) and Boyd and Richerson (2005) also argue that cultural beliefs are sticky and passed along from generation to generation, and hence the cooperative culture may persist even after the economy moves out of rice farming. Finally, socially transmitted norms, beliefs and values heavily influence our behavior. Therefore, the cooperative culture originating in rice farming may affect human cooperative behaviors today.

3 Rice farming in China

According to the archaeological literature, the cultivation of rice in China originated in the Yangtze River valley and then spread to the Yellow River valley in the late Neolithic period (Normile, 1997; Zhao, 1998; Fuller et al., 2007). Rice farming played a crucial role in the Yellow River valley to meet the food needs of the political centers until the late Tang Dynasty (755-907 CE), because the capital cities of that time, Chang'an and Luoyang, were located in the lower Yellow River valley (He et al., 2017). After the Tang Dynasty, the cultivated areas of paddy rice in the Yellow River valley shrank dramatically. There are several explanations for the shift. First, climate in the Yellow River valley had changed over thousands of years so that it could no longer provide a friendly environment for rice farming. The government had to spend significant resources in mitigating chronically disastrous floods in the Yellow River valley. In the meantime, the government forbade farmers to irrigate from the water course to ensure cargo transportation, which greatly discouraged rice farming in the Yellow River valley (Yue, 2017). Second, during the Northern Song Dynasty (960-1127 CE), due to wars and natural hazards, the irrigation systems for rice farming in the Yellow River valley were severely damaged. After the Northern Song Dynasty was defeated and lost control of its northern half, the Song court retreated to the south and established its capital at Lin'an (now Hangzhou), which is known as the Southern Song Dynasty (1127-1279 CE). The economic center moved to the south during this time. Ever since then, the subsequent rulers had encouraged people to build irrigation systems and cultivate rice in the Yangtze River valley.

Ecological factors also play an important role in the geographic distribution of rice farming in China. The Qinling-Huaihe line, formed by the Huai River in the east and Qinling Mountain range in the west, defines the geographical boundary between southern and northern China. The Yangtze River valley is located to the south of the Qinling-Huaihe line whereas the Yellow River valley is located to the north. The climate of China is dominated by the southeast monsoon. The summer monsoon brings abundant rainfall to southeastern China. As the monsoon moves northwest, it loses strength and delivers less rain. In good years, the monsoons push over the belt of mountains between the Yangtze and Yellow River valleys and provide moderate summer rains in northern China. However, the monsoons are often too weak to cross over the central mountain ranges, and as a result, northern China is struck by drought while southern China has heavy rainfall. This central mountain range thus creates a fundamental dividing line between southern and northern China, with the South being warmer with abundant water whereas the North being cooler, dry and chronically short of water (Naughton, 2006).

In Figure 1, we compare the ecological conditions for rice farming between southern and northern China using an agro-ecological suitability index for wetland rice developed by the Food and Agriculture Organization of the United Nations and the International Institute for Applied Systems Analysis. The rice suitability index is calculated using average climatic data from 1961 and 1990 and taken from the Global Agro-Ecological Zones (GAEZ) database.[9] The index takes values ranging from 0 to 100, where larger numbers indicate higher agro-ecological suitability for rice farming. In Figure 1, the light gray color corresponds to a rice suitability index close to 0, the dark gray color corresponds to an index below 10, and the orange color indicates that the rice suitability index in the region is between 30 and 60. The black line illustrates the position of the Qinling-Huaihe line, which is close to the 33rd parallel north. According to the GAEZ database, areas to the south of the Qinling-Huaihe line are much more environmentally suitable for rice farming.

Given the large differences in ecological conditions, it is not surprising that there is a marked difference in rice farming between southern and northern China. More than 90 percent of paddy rice is produced south of the Qinling-Huaihe line today, while only around 2 to 3 percent is produced in the Yellow River valley. To measure rice farming, we use the percentage of farmland devoted to rice farming in a region, as in prior research (Talhelm et al., 2014; Talhelm and English, 2020). To represent historical rice farming, we use data from 1957 which is the earliest county-level data we could find on rice farming from China's Ministry of Agriculture (Planning Department of the Agricultural Ministry, 1959). These data have a correlation of 0.90 with 1918 data available for a subset of 22 provinces collected by Buck (1937). Thus, the 1957 data seem to adequately represent the patterns of historical rice farming in China. Figure 2 displays the distribution of historical rice farming across

[9] Complex models that take into account the growing requirements of wetland rice, local temperature, rainfall, evaporation, humidity, soil qualities and slope are used to assign a suitability index for each land area of roughly 56 kilometers by 56 kilometers. More details on the GAEZ database can be found at http://www.fao.org/nr/gaez.

Chinese prefectures.[10] The darker color corresponds to a higher intensity of rice farming. As is in Figure 1, the black line highlights the Qinling-Huaihe line. A discernible decline in rice cultivation is evident to the north of the boundary.[11] This discontinuous change in rice farming across the Qinling-Huaihe line motivates the usage of an RD design to estimate the impact of rice farming on cooperative behavior.

4 Data and Empirical Strategy

4.1 Data

The data that we use come from the 2002 wave of the Chinese Household Income Project (CHIP). The CHIP surveys were initiated by a group of international scholars and scholars who at the time were based at the Institute of Economics, Chinese Academy of Social Science, with assistance from China's National Bureau of Statistics (NBS).[12] All CHIP waves contain a subsample of urban household and a subsample of rural households. The survey has included an additional subsample of rural-to-urban migrants since 2002. We focus on the rural sample in CHIP 2002 because this is the only subsample with a social network questionnaire that provides detailed information on individual collaborative behavior. In this portion of the survey, 9,200 randomly-selected households from 961 villages in 22 provinces were interviewed.[13] Our analysis is based on three questionnaires – the household level main rural questionnaire, the questionnaire on social network, village affairs and living quality for rural households, and the village level questionnaire. Individual-level questions were

[10] Prefecture is an administrative division in China that is below province and above county. There are 333 prefecture-level divisions in China that are under 34 province-level divisions and above 2,844 county-level divisions.

[11] Some regions in northern China have relatively high rice farming intensity because of their unique geographic and weather conditions. For example, part of the Northeast China grow rice as several primary rivers (e.g., the Songhua River, the Amur River, and the Ussuri River) flow through the region, significantly compensating for rainfall shortage (Jin, 2007). However, paddy rice in the North is usually harvested in only one season due to the less suitable climate conditions whereas paddy rice in the South can be harvested in two or three different seasons. In our empirical analysis, almost all of the rice regions in the North are excluded from our effective sample because they are far away from the Qingling-Huaihe boundary.

[12] The CHIP has conducted five waves of household surveys in 1988, 1995, 2002, 2007 and 2013. A detailed description of the 2002 survey can be found in Li et al. (2008). Although the main purpose of the CHIP is to track the dynamics of income distribution in China, the data set has been widely used to study various economic issues in China (e.g., Sicular et al., 2008; Wei and Zhang, 2011; Kanbur et al., 2021).

[13] Although there are 34 province-level administrative units in China, the 22 provinces in the CHIP 2002 data set provide a nationally representative sample (Li et al., 2008). More specifically, Beijing represented three large metropolitan cities (the other two being Shanghai and Tianjin); Hebei, Liaoning, Jiangsu, Zhejiang, Shandong and Guangdong the eastern region; Shanxi, Jilin, Anhui, Jiangxi, Henan, Hubei, and Hunan the central region; and Sichuan, Guizhou, Yunnan, Guangxi, Shaanxi, Xinjiang and Gansu the western region. Counties and villages were selected to reflect variations in economic development and geography.

answered mainly by heads of households, or other household members when household heads were not available. These include questions about both the individuals and their families. For each village, the village-level questions were answered by a village representative who was familiar with the geographic, demographic and economic characteristics of the village.[14] In each village, around 10–15 randomly chosen families were surveyed. We exclude observations from Xinjiang province and those with missing data for the measures of cooperative behavior, which leaves 8,043 households from 759 villages in our full sample.[15] Among all households in the sample, 4,544 of them live in villages south of the Qinling-Huaihe line and 3,499 live in villages north of the line. There are 430 southern villages and 329 northern villages in our sample of analysis.

We use the percentage of farmland devoted to rice farming in the respondent's county in 1957 to construct a historical measure that captures traditional rice farming activities, *RICE*. The 759 villages in the sample are located in 113 different counties.[16] In 1957, on average 27.2% of farmland was devoted to rice farming in the survey counties. The intensity of rice farming varied significantly across counties, with a standard deviation of 0.279. Figure 3 provides a visual presentation of the variations in rice farming. The darker color corresponds to higher percentage of farmland devoted to rice farming in a county in 1957. The county of Gaoyao from Guangdong province had the highest rice farming intensity in the sample, with 83.4% of farmland devoted to rice farming whereas several counties in Gansu and Hebei province had no farmland devoted to rice farming. Those regions to the south of the Qinling-Huaihe line generally had much higher percentages of farmland devoted to rice farming.

In the social network questionnaire of the CHIP 2002, we rely on the following questions to construct different measures of cooperative behaviors: "How often do you offer the following types of mutual help to your relatives and neighbors?" The types of mutual help include (i) borrowing and lending money (*loan*), (ii) caring for the elderly, the sick, and babies (*care*), (iii) helping with job seeking (*job*), (iv) helping with house building (*house*). Each response is a binary variable that takes the value one if the respondent answered often or very often, and zero if the respondent stated that this mutual help occurs rarely or never. Among the

[14] A village representative could be the party branch secretary, the head of the village committee, or the village treasurer, whoever was available during the survey.

[15] We exclude Xinjiang from our sample because Xinjiang is a historically herding region and has different language, culture and religion from other provinces in China (Talhelm et al., 2014). Our empirical results are robust if we include observations from Xinjiang province in the sample. Moreover, there are no significant differences between the excluded respondents and the remaining respondents in terms of individual characteristics such as age, gender, marital status, years of education, household income and household size.

[16] In rural China, an administrative village is the lowest administrative division underneath four higher-administrative divisions–township, county, prefecture and province. Due to privacy concerns, the CHIP data set does not disclose village names. However, we are able to identify the county that a village belongs to using the administrative codes recorded in the data set.

four types of cooperative behaviors, individuals in the sample most frequently helped each other with house building (63.5%), followed by borrowing and lending money (59.2%), and helping with job seeking (46.6%). Caring for non-family members was the activity people least likely to provide mutual help, with a 36.5% average frequency.

We also collect information on individual characteristics including age, gender, marital status, years of education, household income and household size and information on village characteristics, such as the population of the village, net income per capita (in Chinese yuan) of the village, and planting area per capita for the village (total planting area of the village in mu divided by village population) in 2002.[17] Summary statistics of our full sample are presented in Table 1. On average, the respondents were 45 years of age, and 26% of them were female because the majority of household heads were male. More than 95% of the respondents were married, and their average years of schooling was about 7. The average household income was slightly above 10,000 yuan in 2002, and the average household size was around 4. In terms of village characteristics, the villages in the sample had an average population of 1,843, net income per capita of 2,623 yuan and planting area per capita of around 1.9 mu in 2002.

4.2 Empirical Strategy and Econometric Specification

Our goal is to identify the effects of historical rice farming on cooperative behavior. We begin by presenting the following empirical model,

$$Y_{ijc} = \beta_0 + \beta_1 RICE_{jc} + X'_{ijc}\beta_2 + Z'_{jc}\beta_3 + \epsilon_{ijc}, \tag{1}$$

where the outcome variable Y_{ijc} considers measures of cooperative behavior for individual i in village j of county c. The variable of interest, $RICE_{jc}$, indicates the percentage of farmland devoted to paddy rice in county c that village j belonged to in 1957. We control for a vector of individual characteristics in X_{ijc} and a vector of village characteristics in Z_{jc}. The covariates in X_{ijc} include gender, age, marital status, education, family income and family size, whereas the covariates in Z_{jc} include the village's population size, net income per capita and planting area per capita. ϵ_{ijc} is an unobserved error term.

In Equation (1), the coefficient β_1 measures the effect of rice farming on cooperative behavior under the assumption that the distribution of rice farming is random across different villages. The estimation of this specification poses a number of challenges. The main challenge is the possibility of the problem of reverse causality. Suppose that different regions

[17] At the end of 2002, one Chinese Yuan was approximately 0.121 US dollars, and one mu is approximately 0.165 acres.

in China had the right environment to grow rice, but only some areas chose rice farming. This would imply that it is people who had a cooperative culture and like to work together also chose to grow rice, not the other way around. In China, environmental suitability of rice strongly predicts the distribution of rice farming. Most of the places that can grow rice do so because of its high productivity. Therefore, the reverse causality problem may not be very serious. Another concern is that there may exist some unobserved regional differences, for example, differences in preferences and social norms, that are correlated with both rice farming and cooperative behavior. Any of these possibilities would bias our results if we conduct ordinary least squares (OLS) regression analysis.

As is shown in Figure 1, areas to the south of the Qinling-Huaihe line are much more environmentally suitable for rice farming compared to areas to the north of the boundary. As a result, southern China has a much higher percentage of farmland devoted to rice farming than northern China (Figure 2). To the extent that the respondents who grew up around the Qinling-Huaihe line are similar in observed and unobserved dimensions, we take advantage of this change in rice farming intensity due to the natural boundary of the Qinling-Huaihe line to identify the causal effect of historical rice farming on cooperative behavior through an RD framework. We first consider a reduced form version in Equation (2) to evaluate the regional differences between the South and the North:

$$Y_{ijc} = \alpha_0 + \alpha_1 SOUTH_c + h(d_c) + X'_{ijc}\alpha_2 + Z'_{jc}\alpha_3 + \epsilon_{ijc}. \tag{2}$$

In this equation, $SOUTH_c$ is an indicator variable that is equal to one if county c is located to the south of the Qinling-Huaihe line. $h(d_c)$ is a polynomial in d_c, which is county c's location measured in degrees in latitude south to the Qinling-Huaihe line. Recall that while we know which county each village belongs to, we are unable to identify the exact geographic location of the village. Thus, we construct d_c, which is the difference in latitude degrees between county c that the surveyed village j belongs to and the Qinling-Huaihe boundary.[18] $h(d_c)$ may include linear and polynomial terms of the running variable d_c and the interactions of these terms with $SOUTH_c$ and ϵ_{ijc} is the error term. The coefficient α_1 provides an estimate of the difference in cooperative behavior between the southern and northern counties.

Needless to say it is impossible for all areas around the boundary to grow rice only or grow no rice, making a fuzzy RD design a more appropriate approach for this study. The RD design exploits the discrete increase in rice farming as one crosses the Qinling-Huaihe

[18] The latitude degree of a county is determined by the location of the county government. The Qinling-Huaihe line runs through one county in our sample. There are 7 villages that are located in the county on the Qinling-Huaihe boundary. It is possible that the South or North designations of these villages based on the county latitude degree are not precise. We have tried to re-estimate our models excluding households from these 7 villages and found that the results are very similar.

line into southern China. Specifically, we separately test whether there is a discontinuous change in the percentage of farmland devoted to paddy rice as well as discontinuous changes in the measures of cooperative behavior. The fuzzy RD design has the interpretation of an instrumental variable (IV) estimation (Hahn et al., 2001; Lee and Lemieux, 2010).

Based on the empirical strategy outlined above, we use locating south of the Qinling-Huaihe line as an instrument for rice farming and implement a two-stage least square (2SLS) regression. More specifically, we use a parametric fuzzy RD design as following:

$$RICE_{jc} = \pi_0 + \pi_1 SOUTH_c + g(d_c) + Z'_{jc}\pi_2 + v_{jc}, \tag{3}$$

$$Y_{ijc} = \gamma_0 + \gamma_1 RICE_{jc} + f(d_c) + X'_{ijc}\gamma_2 + Z'_{jc}\gamma_3 + u_{ijc}, \tag{4}$$

where $g(d_c)$ and $f(d_c)$ are polynomials in d_c. π_1 provides an estimate of whether there is a discontinuous change in the percentage of farmland devoted to paddy rice for counties located just to the south of the boundary relative to regions located to the north. The parameter of interest, the 2SLS estimate of γ_1, produces a consistent estimate of the impact of rice farming on cooperative behavior provided that the identifying assumptions underlying the RD design are satisfied. For robustness checks we show additional results using varying orders of polynomials. Following Imbens and Kalyanaraman (2012) and Calonico et al. (2014), in our main analysis we employ a bandwidth of 4 degrees in latitude around the cutoff and then check the sensitivity of our estimates to different bandwidths. We are able to mitigate concerns regarding unobserved historical, geographic and economic differences between the South and the North by focusing on the areas around the Qinling-Huaihe line. We cluster standard errors at the county level.

4.3 Validity of the RD Design

We use the discontinuity around the Qinling-Huaihe line to identify the effect of rice farming on cooperative behavior. The key identifying assumption of the RD design is that the assignment of households is as good as random around the boundary. One potential concern is that people may migrate in response to differences in rice farming. China enacted its household registration system in 1958, which inhibits free migration and essentially ties people to the land where they were born. Although the household registration system has been gradually relaxed since the 1980s, internal migration remains heavily regulated and controlled by the state (Chan, 2009; Colas and Ge, 2019). The purpose of internal migration in China is primarily to seek greater economic opportunity and a better life (Davin, 1998). There has been an increasing number of rural migrants pour into cities in search of non-agricultural jobs, but rural to rural migration is rare and often occurs because of marriage and family reunion

(Poncet, 2006).[19] One potential concern is that seasonal farm workers may move across the Qinling-Huaihe line in a systematic pattern. Therefore, we conduct a formal validity check. If migration in response to rice farming were a problem, we would expect a discontinuity in the population density at the boundary. Appendix Table A1 implements several tests proposed by McCrary (2008) using the populations in surveyed villages included in CHIP 2002 (columns 1 and 2) as well as the populations in all counties in China's 2000 Census (columns 3 and 4) around the boundary. We fail to detect a discontinuity in population density at the cutoff. The estimates tend to indicate that the villages or counties to the south of the boundary have smaller populations but none of these estimates is statistically significant.

We also examine the validity of the RD design by checking whether the predetermined variables are smoothly distributed around the boundary. We run RD regressions by using the predetermined individual and village characteristics as dependent variables to test whether the instrument predicts their changes around the boundary:

$$X_{ijc} = a_0 + a_1 SOUTH_c + m(d_c) + \phi_{ijc}, \quad (5)$$

$$Z_{jc} = b_0 + b_1 SOUTH_c + n(d_c) + \omega_{jc}. \quad (6)$$

Equation (5) conducts tests for individual controls whereas Equation (6) conducts tests for village-level controls. $m(.)$ and $n(.)$ are polynomial functions that vary on each side of the boundary, and ϕ_{ijc} and ω_{jc} are error terms. Table 2 presents the covariate balance tests. The sample includes respondents from the CHIP 2002 around the Qinling-Huaihe boundary. We use a bandwidth of 4 degrees in latitude on each side; this sample includes 4,017 individuals, with 1,905 respondents from 206 southern villages and 2,112 respondents from 232 northern villages. In the first two columns of Table 2, we present the summary statistics on individual, household and village characteristics for those to the south and the north of the boundary, respectively. In the last two columns, we report the coefficients on the dummy variable, $SOUTH_c$, in Equations (5) and (6) under the linear and quadratic specifications. As shown in Table 2, all covariates are balanced at the boundary under both specifications. Figure 4 provides a visual inspection of the distributions of the predetermined variables and plots their unconditional means on each side of the Qinling-Huaihe line. Fitted values from a quadratic polynomials are pre-imposed over these means, and the dashed lines are the 95 percent confidence intervals. As is evident from these figures, there is no clear breaks around

[19] According to a survey conducted by Lohmar et al. (2001) in over two hundred villages from nine representative provinces, about 0.5% of the rural labor force were rural-to-rural migrants in 1988 and about 3% were rural-to-rural migrants in 1995.

the cutoff.

5 Effects of Rice Farming on Cooperative Behavior

5.1 Main Results

We estimate Equation (4) on the sample that lives within 4 degrees in latitude of the Qinling-Huaihe boundary. We use a quadratic polynomial function of the running variable d_c and allow the curvature of the polynomial to vary across the boundary. We instrument the variable on rice farming by $SOUTH_c$, a dummy for south of the boundary. Figure 5 provides a visual presentation of our first-stage results. The figure plots a county's percentage of farmland devoted to rice farming in 1957 against its latitude relative to the Qinling-Huaihe line, with a vertical line at the boundary. The scatter plots are averages within 0.5 degree bins, and the solid lines are the quadratic fits for each side of the boundary. The figure shows that while regions to the north of the boundary had a percentage of farmland devoted to rice farming close to zero, around 40 percent of the farmland in the regions to the south of the boundary were used for rice farming in 1957. The boundary generates a discontinuity of about 30 percentage points in the percentage of farmland devoted to rice farming. In line with the observations in Figure 5, there is also a significant jump in the rice farming suitability index at the boundary as presented in Figure 6. Corresponding to the jump in rice farming, Figure 7 repeats the graphical exercises by plotting cooperative behaviors against latitude degrees south of the Qinling-Huaihe line and reveals an increase in each one of the four types of cooperative behavior moving from north to south.

We now turn to the discussion of our main regression results, which are reported in Table 3. For comparison purposes, Appendix Table A2 reports the naïve OLS estimates of the association between rice farming and cooperative behavior using Equation (1). The top panel of Table 3 reports the reduced form RD estimates for four types of cooperative behavior, including mutual help in borrowing and lending money (*loan*), caring for the elderly, the sick, and babies (*care*), helping with job seeking (*job*), and helping with house building (*house*), using Equation (2). The coefficients are all positive and statistically significant in columns (1)-(4). In the last four columns of the table, we include additional controls on individual and village characteristics, and find that all the estimates remain robust. We find that individuals from villages to the south of Qinling-Huaihe line exhibit more frequent cooperation than those who live to the north of the boundary. In particular, our estimates show that individuals from the south are 14.3 percentage points more likely to borrow or lend money to their relatives or neighbors, 19.0 percentage points more likely to take care of others, 22.8 percentage points more likely to help with job seeking, and 40.6 percentage points more likely to offer help with house construction.

The bottom two panels of Table 3 report the 2SLS estimates from the fuzzy RD design using Equations (3) and (4). According to the first-stage estimates, regions to the south of the Qingling-Huaihe boundary devoted 29.5 percentage points more farmland to rice farming. The difference in rice farming intensity between the south and north remains large and statistically significant at 23.8 percentage points after we control for a set of village characteristics, as shown in columns (5)-(8). The coefficients on rice farming in the second-stage are all positive and statistically significant, and the estimates are insensitive to the inclusion of individual and village control variables. They suggest that more rice farming increases the frequency of cooperative behaviors. According to the estimates in columns (5) to (8), a 10 percentage points increase in the farmland devoted to rice farming increases the possibility of frequent mutual help in borrowing and lending, caring for others, job seeking, and house construction by 5.83 percentage points, 7.99 percentage points, 9.71 percentage points, and 17.0 percentage points, respectively.

Appendix Tables A3 to A6 show that our main results are robust to a wide range of robustness checks with respect to alternative empirical specifications and choice of sample. The set of robustness checks includes (i) using different polynomial orders for the function of the running variable, (ii) implementing nonparametric estimation, (iii) using different bandwidths, and (iv) implementing a donut regression discontinuity design by excluding observations near the boundary. Appendix A provides more details on these robustness checks.

5.2 Alternative Measures of Rice Farming

Farming was based on individual, small-scale households for thousands of years in China and the agriculture system underwent little change before the communist revolution. However, Chinese rural society was swept by two dramatic revolutions during the second half of the twentieth century (Naughton, 2006). The first revolution, the collectivization movement in the 1950s, mobilized hundreds of millions of farmers to pool resources and work together in large rural communes.[20] The second revolution, the economic reform initiated in 1978, restored the traditional household-based agriculture production. We have used the baseline rice farming measure from 1957 to capture traditional rice farming activities in China. In this section we consider two alternative measures of rice farming to check the robustness of our estimates.

[20] Although the collectivization movement started in the mid 1950s, the large-scale communal movement was not imposed until 1958 as a part of the Great Leap Forward (Lin, 1990).

The first alternative measure of rice farming is the percentage of farmland devoted to rice farming in each county in 1980. These data were collected by the Institute of Geographic Sciences and Natural Resources Research of Chinese Academy of Sciences and available from China Agriculture Yearbooks. They are the second earliest county-level rice farming statistics we could find. To check the robustness of our estimates, we rerun Equations (3) and (4) and replace the county-level percentage of farmland devoted to rice farming in 1957 used in our main analysis with the 1980 rice statistics. The IV estimation results using the alternative 1980 rice statistics are reported in Panel A of Table 4. According to the first-stage estimates, the boundary generates a large and significant discontinuity in rice farming as the sample moves from the north to the south of the boundary. The estimates on the effects of rice farming on cooperative behaviors are generally larger in magnitude than those using historical rice data in 1957, and they remain statistically significant.

The second alternative measure of rice farming is at village level. The 2002 wave of rural CHIP survey includes the required information to calculate the percentage of farmland devoted to rice farming for each village in 1998. We re-estimate our empirical model by replacing the county-level percentage of farmland devoted to rice farming in 1957 with the 1998 village-level rice statistics and report the corresponding estimation results in Panel B of Table 4. The first-stage estimated effects of the boundary on rice farming intensity remains statistically significant and the estimates on the effects of rice farming on cooperative behaviors are similar to those in Panel A, which are somewhat larger than the baseline estimates in Table 3. Although the contemporary rice farming could be affected by institutional change and modernization of agriculture, the estimated effects of rice farming on cooperative behaviors are remarkably stable using alternative measures of rice farming.[21]

5.3 Placebo Tests

The validity of our RD strategy relies on the smoothness of all factors besides rice farming at the boundary. While our covariate balance tests confirm the smoothness of most observable pre-determined individual, household and village characteristics, other confounding factors may still exist. To check this possibility, we perform a placebo test by artificially moving the boundary 4 degrees in latitude southward and replicating our estimation procedure. This process keeps all counties within the 4 degrees bandwidth to the falsified boundary. Rice farming intensity is high on both sides of the falsified boundary. Therefore, we should not

[21] One explanation is that to support the large and growing population, most of the places that could grow rice did grow rice in China, at least before the early 2000s when the rapid urbanization and agricultural mechanization started. As a result, the rice statistics from different years are highly correlated. The pairwise correlation between 1957 rice farming and 1980 rice farming is 0.910, and that between 1957 rice farming and 1998 rice farming is 0.864.

observe a discontinuous change in cooperative behaviors if there are no other confounding factors. Panel A of Table 5 presents the results. The first-stage estimates are small and statistically insignificant, indicating no visible difference in rice farming across the falsified boundary. The reduced form estimates suggest no difference in frequencies of cooperative behavior around the falsified boundary. The second-stage estimates on the effects of rice farming on cooperative behaviors are likewise not statistically different from zero. Panel B presents the results of moving the boundary 4 degrees northward; thus, all counties within the 4 degrees bandwidth to the falsified boundary on both sides have low rice farming intensity. The results also reveal no statistically significant differences in rice farming or cooperative behavior across the falsified boundary.

As a further placebo test, we use the Yangtze River as a placebo boundary. The Yangtze River flows 3,900 miles from the Tibetan Plateau in the west in a generally easterly direction to the East China Sea. The Yangtze has played a major role in the history, culture and economy of China and is another important natural geographic boundary in China besides the Qingling-Huaihe line. In Panel C of Table 5, we use the Yangtze River as an alternative boundary and replicate our estimation procedure. Since the Yangtze is located to the south of the Qingling-Huaihe line, rice farming intensity is relatively high on both sides of it. We find no discontinuous change in the four measures of cooperative behaviors across the Yangtze River. The first-stage estimates also find no statistically significant difference in rice farming across the Yangtze. These placebo tests ensure that our findings are not due to chance but are due to the distinct impact of the discontinuity in rice farming across the Qingling-Huaihe boundary.

6 Testing for Underlying Mechanisms

6.1 Culture Transmission as Part of the Mechanism

In this section, we conduct a deeper analysis of the mechanisms underlying our results. We argue that the long-term impacts of traditional rice farming on contemporary cooperative behavior are due to the persistence of cultural norms. It is likely that part of the impact of historical rice farming on cooperative behavior today may come from the contemporaneous experience of rice farming as we focus on a rural sample.[22] We compare individuals directly involved in farming with those that either have off-farm jobs or do not work to better isolate the causal impact of historical rice farming on cultural beliefs and values. If culture trans-

[22]We are not able to use the urban or migrant samples from CHIP 2002 to examine the impact of historical rice farming because the questions on cooperative behaviors are unavailable for them.

mission is the main mechanism underlying the impact of historical farming on contemporary cooperative behaviors, everyone from rice regions, including those who do farm work and those who have moved out of traditional farming, are expected to inherit the cooperative culture and behave more cooperatively today.

We use a question on individual occupation to divide our sample into two groups. The first group includes farm labor only, whereas the other group includes all workers with off-farm jobs and non workers. As documented by Ge and Yang (2011), a large number of rural workers began to seek employment in rural off-farm work starting in the mid-1980s, and the percentage of rural employment in agriculture dropped below 70% by 2002 based on aggregate statistics. In our sample, approximately 60.5% (2,429 out of 4,017) of the full sample had farm jobs in 2002 and the rest had off-farm jobs such as working in rural township village enterprises, private and individual enterprises, or local government agencies. Table 6 reports the regression discontinuity estimates of the effects of rice farming on cooperative behaviors for farm workers (Panel A) and for workers on non-farm jobs and non-workers (Panel B), respectively. The results show that historical rice farming increases cooperative behaviors for both types of individuals. For those workers on non-farm jobs and non-workers from rice regions, their cooperative behaviors are affected by historical rice farming as much as those who work in farming. Thus our results are consistent with the hypothesis that people from rice regions have inherited the same culture.

We also test whether traditional rice farming leads to more cooperative culture by using the triad data from Talhelm et al. (2014), which collects information on psychological measures of culture thought, individual characteristics such as gender, city where people grew up, and provincial characteristics. We extend their analysis and implement RD specifications similar to those in Equations (2) to (4) using the Qinling-Huaihe line as the boundary and prefecture level rice farming in 1957 as a measure for historical rice farming. We confirm the findings from Talhelm et al. (2014) that people from historical rice regions think more holistically and have more interdependent cultures.[23]

6.2 Irrigation and Labor Exchange as Underlying Driving Forces

Two potential underlying forces may drive the relationship between historical rice farming and contemporary collaborative behavior. First, irrigation is a vital part of paddy rice cultivation, and it requires collective effort. Therefore, the existence of an irrigation system could serve as one underlying driving force for how rice farming affects collaborative behavior. Second, the high labor demand for paddy rice makes labor exchanges a common

[23] Appendix B provides more details on our replication of Talhelm et al. (2014) using an RD design.

practice, especially during the planting and harvesting season. Thus, reciprocal labor exchange may serve as another driving force for the positive relationship between rice farming and cooperative behavior. Talhelm et al. (2014) suggest the above two potential channels in their study on rice farming and cooperative culture, but they do not provide empirical tests for them. In this section, we directly test these two potential underlying channels.

We first examine whether historical rice farming increases the probability of having an irrigation network in a village today.[24] We use a similar RD specification as before:

$$irrigation_{jc} = \rho_0 + \rho_1 RICE_{jc} + l(d_c) + \omega_{jc}, \quad (7)$$

where the variable $irrigation_{jc}$ is equal to one if village j in county c had an irrigation system in 1998 and zero otherwise, and $RICE_{jc}$ is the percentage of farmland devoted to paddy rice in county c that village j belonged to in 1957.

Column (1) of Panel A in Table 7 reports estimated effect of rice farming on the existence of an irrigation system in a village. We find significant positive and sizable effect of rice farming on the likelihood of having an irrigation system. A 10 percentage points increase in the farmland devoted to rice farming increases the likelihood of having an irrigation system in the village by 11.9 percentage points.

In the next four columns of the same panel, we report the direct effect of irrigation on cooperative behaviors and find significant positive effects. In the last four columns, we explore how the estimated effects of rice farming on cooperative behaviors are mediated by irrigation. We do this by adding an interaction term between an indicator for irrigation and the rice farming variable. We find statistically significant interaction terms that show significantly greater impact of rice farming on cooperative behaviors in villages with an irrigation system. The estimated effects of rice farming on cooperative behaviors in the omitted group, who live in villages without an irrigation system, are also positive, sizable, and statistically significant except for the outcome variable on mutual help in borrowing and lending. The positive effects of rice farming for people from villages without irrigation can be interpreted as consistent with rice farming having an independent effect on cooperative behaviors regardless of irrigation.[25] The significant positive interaction term between rice farming and irrigation support the importance of irrigation as a key driver for how rice farming affects cooperative behaviors.

Next, we examine the effect of labor exchange. We construct a variable *labor exchange*

[24] CHIP 2002 has information on whether a village had an irrigation system in 1998 but has no information on the age of the irrigation system.

[25] Several recent studies, such as Buggle (2020) and Fredriksson and Gupta (2020), emphasize the importance of irrigation on culture. We show that irrigation reinforces the effect of rice farming on cooperation but the rice farming effect persists regardless of irrigation.

from CHIP 2002, which equals one if the respondents exchange labor frequently or very frequently during planting and harvesting seasons and zero if such labor exchange occurs rarely or never.[26] We use $\textit{labor exchange}_{ijc}$ as the outcome variable in Equation (7) and examine whether historical rice farming increases the frequency of labor exchange today. We then explore the direct effects of labor exchange on cooperative behaviors and the heterogeneous effects of rice farming on cooperative behaviors for people that exchange labor frequently and not frequently. The results are presented in Panel B of Table 7.

When we treat labor exchange as an outcome variable, we find a striking effect of rice farming: a 10 percentage points increase in the farmland devoted to rice farming increases the possibility of frequent labor exchange during planting and harvesting seasons by 17.9 percentage points. This finding that rice farming increases labor exchange indicates that labor exchange is an important part of the story for why cooperation increases with rice farming. We explore this channel more directly in the rest of columns in Panel B of Table 7. Columns (2)-(5) show that labor exchange has significantly positive effects on cooperative behaviors. In columns (6)-(9), we add interaction terms between the labor exchange indicator variable and the measure of rice farming. Here we find statistically significant interaction terms that show significantly greater rice farming effects on cooperative behaviors for individuals who exchange labor frequently. In fact, the estimated effects of rice farming on cooperation for those in the omitted group, who do not exchange labor frequently, are all statistically insignificant. The lack of an effect for individuals who do not exchange labor frequently can be interpreted as labor exchange being a critical channel through which rice farming affects cooperative behaviors.

7 Alternative Interpretations

This section discusses competing stories that may also generate a positive link between historical rice farming and contemporary cooperative behavior. Possible confounding factors include: population density, rural to urban migration, religious belief, ethnicity, Huai River heating policy and its impact on health, and historical migration. We find no evidence that any of the potential confounding factors drives the positive effects of rice farming on cooperative behaviors.

[26] Generally, the planting and harvesting seasons include May, June and October.

7.1 Population Density

The first possible confounding factor in our main specification is population density. In regions with higher population density, it is possible that there are more opportunities for people to interact with each other, promoting cooperative behavior. One may argue that population density in the South is higher and thus drives the differences in our measures of cooperative behaviors between the South and the North. Although we have controlled for village-level total population in our baseline specification, we further explore the potential influence of population density by collecting county-level information on population density in 2002. Dividing the total population size of each county in our sample by its land area in square kilometer yields population density.

We include the logarithm of county-level population density as an additional variable in our baseline specification and report the estimated coefficients on rice farming and population density in Column (1) of Table 8. Panels A to D present the estimated effects on our four measures of cooperative behaviors (*loan, care, job, house*), respectively. The results show that population density has no statistically significant association with the first three variables and is negatively associated with the last variable. However, the effects of rice farming on the four measures of cooperative behaviors remain highly similar to the baseline estimates after considering the impact of population density.

7.2 Rural Migration

Since the inception of economic reforms in the early 1980s, a large number of rural migrants have moved into cities in search of non-agricultural jobs. It is well documented that late teens and young adults have the highest probability to migrate (Colas and Ge, 2019). If more young people in the South migrate out of their villages and cause a shortage of farm labor, labor exchange in farming and other cooperative behaviors may become necessary in the South. To formally test this possibility, we utilize two pieces of information on migrants from the CHIP 2002: (i) the number of migrants in each household, where a migrant is defined as someone who resides in the household for less than 6 months in a year, and (ii) the number of households that have migrated out of the village permanently since 1999.

Columns (2) and (3) of Table 8 report the results after controlling for rural out migration using household-level number of migrants and village-level number of migrant households, respectively. The estimated coefficients on both household and village migration are positive and statistically significant in Panel A, indicating that rural out migration is positively associated with financial mutual help. Neither household or village migration is associated with cooperative behaviors in caring for others' family members (Panel B) or helping with job seeking (Panel C). Households with more migrants are also more likely to help each other with household construction but the village-level migration does not matter for cooperative behavior measured by house construction (Panel D). After controlling for the household and village out migration, the estimated coefficients of rice farming remain positive, statistically significant, and similar to the baseline estimates. These results suggest that the positive effects of rice farming on cooperative behaviors are unlikely to be driven by variations in rural migration.

7.3 Religious Belief

There is a large literature relating cooperation with religion (Anderson and Mellor, 2009; Chuah et al., 2014; Fernández, 2014). To examine the impact of the regional distribution of religious belief on our results, we construct an individual indicator variable which is equal to one if the respondent thought religious belief is very import, fairly important or important and zero otherwise. Column (4) of Table 8 reports the results including the religious belief indicator as an additional control. Religious belief is found to be positively associated with cooperative behavior in taking care others' family members (Panel B) and its associations with other measures of cooperative behaviors in our data are small and not statistically different from zero. We find no evidence that religious belief contributes to the positive effects of rice farming on cooperative behavior.

7.4 Ethnicity

China officially recognizes 55 ethnic minority groups in addition to the Han majority. Ethnic minorities are concentrated in different regions in China. They often have different cultures, languages and life styles that could potentially confound our main results. To evaluate the impact of ethnic minorities, we control for an additional dummy variable that equals one if the respondent belongs to a minority group and zero otherwise in Column (5) of Table 8. The minority indicator is generally negatively associated with our measures of cooperative behaviors, but the effects of rice farming on cooperative behaviors remain positive and statistically significant.

7.5 Huai River Heating Policy and Health

Our RD specification can be invalid if there is a confounding change around the boundary that had a discontinuous effect on people living on different sides of the cutoff. Chen et al. (2013) and Ebenstein et al. (2017) suggest that China's Huai River policy, which had the laudable goal of providing indoor heating, has led to reductions in life expectancy in the North of the Qinling-Huaihe line. To test whether the differences in health between the South and the North around the boundary may confound our results, we control for self-reported health from CHIP 2002 in Column (6) of Table 8. Health is measured by a dummy variable which is equal to one if the respondent is reported to be very healthy or healthy and zero otherwise. The results show that better health conditions are negatively associated with financial mutual help but positively associated with mutual help in job seeking. Despite some significant effects of health on cooperative behaviors, the estimated effects of rice farming are very similar to our baseline specification, suggesting that our results are robust to the inclusion of the impact of the Huai River heating policy on health.

7.6 Historical Migration

One could argue that historical migration may have generated spurious positive relationships between rice farming and cooperative behavior. For example, if more collaborative people were more likely to migrate when China's economic center moved from the north to the south during the 11th century, their offspring in the south may also be more cooperative today. The large scale north to south migration in the 11th century was mostly driven by wars and natural hazards, so there is no strong reason to believe that this type of selective historical migration would dominate our results. Nevertheless, we conduct some tests on this possibility.

Data on historical migration are generally sparse. Even though there is some information on historical migration patterns, we do not have any information on individual characteristics such as their cooperative behaviors. Therefore, we take an indirect approach to investigate the sensitivity of our main results with respect to historical migration by focusing on the Hakka population in China. The Hakka are a Han Chinese subgroup that are thought to have originated from northern China but moved and settled in southern China in a series of migration due to social unrest and natural hazards in the north (Lee and Zee, 2009).[27] Many Hakka people today still maintain their ancestral traditions and speak the Hakka language. We use the Hakka population to test the potential impact of historical migration. If the Hakka are more cooperative compared to other Chinese subgroups, their historical migration from the north to the south may be a confounding factor for the effects of rice farming on cooperative behavior. In our data, we do not have information on whether an individual belongs to Hakka. However, it is well documented that the Hakka population are

[27] Hakka in Chinese, "*Kejia*", literally means "guest families." The Hakka are not considered an ethnic minority in China. Li et al. (2003) find that genetically the majority of Hakka gene pool comes from the northern Han Chinese.

concentrated in certain areas in southern China. Constable (2005) identifies 185 counties from 19 provinces that have high concentration of Hakka communities. In Column (7) of Table 8, we exclude the Hakka counties from our sample and re-estimate our model. The positive effects of rice farming on cooperative behaviors remain robust, suggesting that our results are unlikely to be driven by historical Hakka migration.

8 Concluding Remarks

This paper exploits plausible exogenous variation in rice farming induced by a natural geographic boundary between northern and southern China and finds a positive effect of historical rice farming on contemporary cooperative behavior. Moreover, this positive relation is driven by the persistence of cultural norms and by two driving forces that are largely required to cultivate paddy rice – irrigation and binding labor exchange – which makes paddy rice fundamentally different from other crops.

Throughout this paper we have argued that rice farming leads to a more cooperative culture. A cooperative culture is generally viewed as being beneficial to society. Next, we explore whether societies that have had this culture of cooperation differ from others in terms of their socioeconomic outcomes. Previous studies by Talhelm et al. (2014) and Talhelm and English (2020) have found evidence that rice cultures are more collectivistic with tighter norms. Although we do not have data available on norm tightness, we link norm tightness with trust measured by two survey questions in CHIP 2002 at individual level. One measures general trust, which is a binary variable that is equal to one if the respondent agrees or strongly agrees that generally speaking most people can be trusted and zero if the respondent disagrees or strongly disagrees. Our second measure is about out-group trust, and is a binary variable that is equal to one if the respondent disagrees or strongly disagrees that only relatives and friends can be trusted and zero if the respondent agrees or strongly agrees. In a tight society, people should be trusted more by others since behaviors are more regulated and predictable (Chua et al., 2019). Columns (1) and (2) in Table 9 report the regression discontinuity estimates using the two trust measurements as the outcome variables for Equation (4). We find that rice farming increases both general trust and out-group trust.

We have presented evidence on the positive effect of rice farming on cooperation. Effective cooperation may contribute to economic growth and development (Hicks and Kenworthy, 1998; Algan and Cahuc, 2010; Litina, 2016). Therefore we further explore how rice farming affects a set of economic outcomes both at individual level and at village level.[28] First,

[28]In a related recent paper by Fan et al. (2021), the emergence of family firms is attributed to rice farming

we examine the impact of rice farming on households' agricultural income and resilience in response to disasters. In particular, we construct a variable on the logarithm of households' annual agricultural income in 2002 and another variable on the percentage points of the loss in income if the households were hit by natural hazards in 2002 from the same CHIP sample as before and use them as the outcome variables in Equation (4). Columns (3) to (4) of Table 9 show the RD estimates of the impact of rice farming on these two household economic outcomes. We find that a 10 percentage points increase in the farmland devoted to rice farming increases agricultural income by 10 percentage points and reduces income loss during natural disasters by 2.1 percentage points. Then, we examine the impact of rice farming on a village level outcomes. We construct a variable on the share of village budget spent on education, the medical system, and other common expenditures (i.e., expenditures for environmental protection and public safety).[29] The estimate in columns (5) of Table 9 demonstrates that rice farming also has significant impact on village-level economic outcomes. A 10 percentage points increase in the farmland devoted to rice farming increases the share of village budget spent on education, medical and other public expenditure by 14.2 percentage points.

It is argued that differences in ability to cooperate may affect economic development, as illustrated by the sharp gap between the North and the South of Italy (Bigoni et al., 2019). The economic gap between the north and the south of China has been widening in recent years. All cities in northern China, except Beijing, are in relative decline currently. One explanation for the growing North-South divide in China is that the two regions appear to have different economic structures: state-owned enterprises in heavy industries account for the bulk of the north's economy whereas the south's economy is primarily composed of the export-oriented private sector. In addition, the two regions differ greatly from each other in climate and access to ports. Based on the evidence provided in this study, southern China may have more cooperative culture and cooperative behavior because of traditional rice farming. An important topic for future research is the extent to which China's North-South divide can be explained by the differences in cooperative culture and cooperative behavior identified in this paper.

and collectivist cultures.

[29]In CHIP 2002, public goods include education, infrastructure, health and other common expenditures but we exclude infrastructure investment here. In contrast to other public goods, infrastructure needs both money and labor investment from rural villagers due to the fact that funds from the upper echelons of government are usually not sufficient to cover the total costs of these public projects. Thus, the results would be biased if we included infrastructure while ignoring the labor contribution to it.

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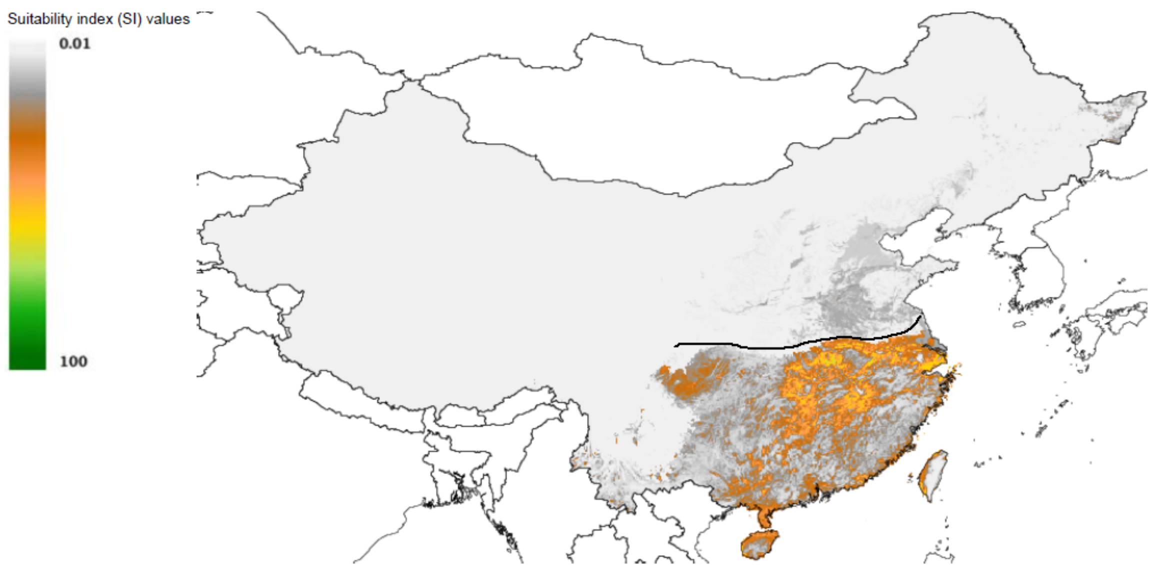
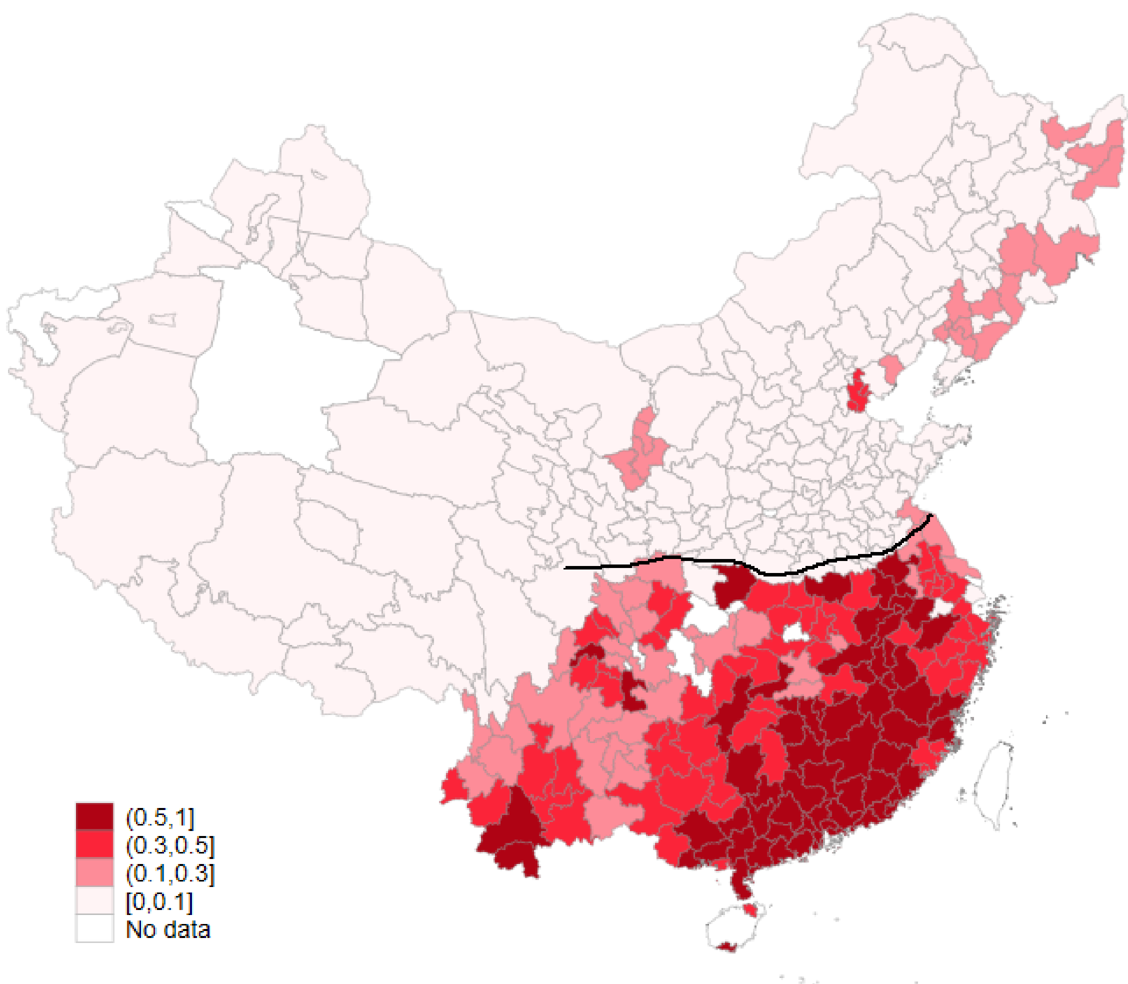
Figure 1: Suitability for Wetland Rice in China



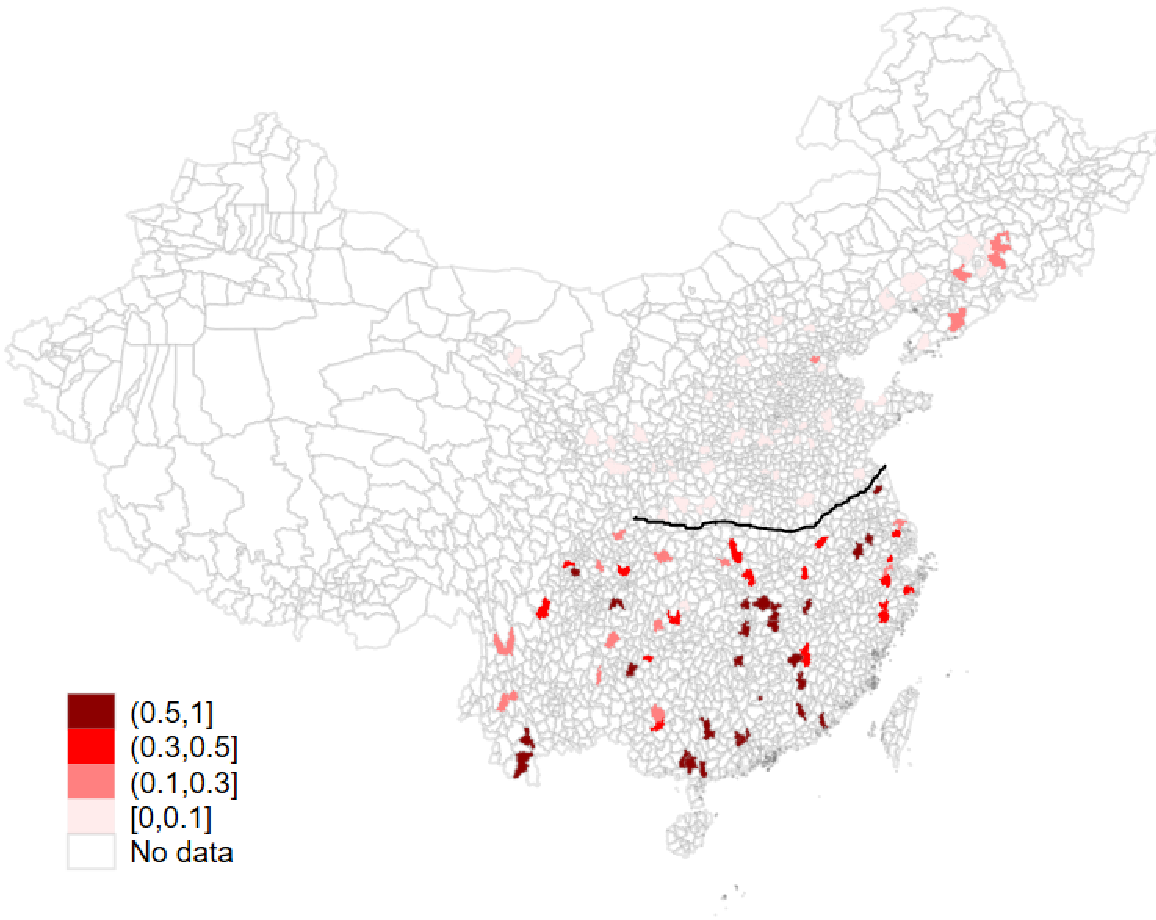
Notes: The rice suitability index is calculated using average climatic data from 1961 and 1990 and taken from the Global Agro-Ecological Zones (GAEZ) database. The index takes values ranging from 0 to 100 where larger numbers indicate higher agro-ecological suitability. The light gray color corresponds to a rice suitability index close to 0, the dark gray color corresponds to an index below 10, and the orange color indicates that the rice suitability index in the region is between 30 and 60. The black line illustrates the position of the Qinling-Huaihe line.

Figure 2: Rice Farming in China



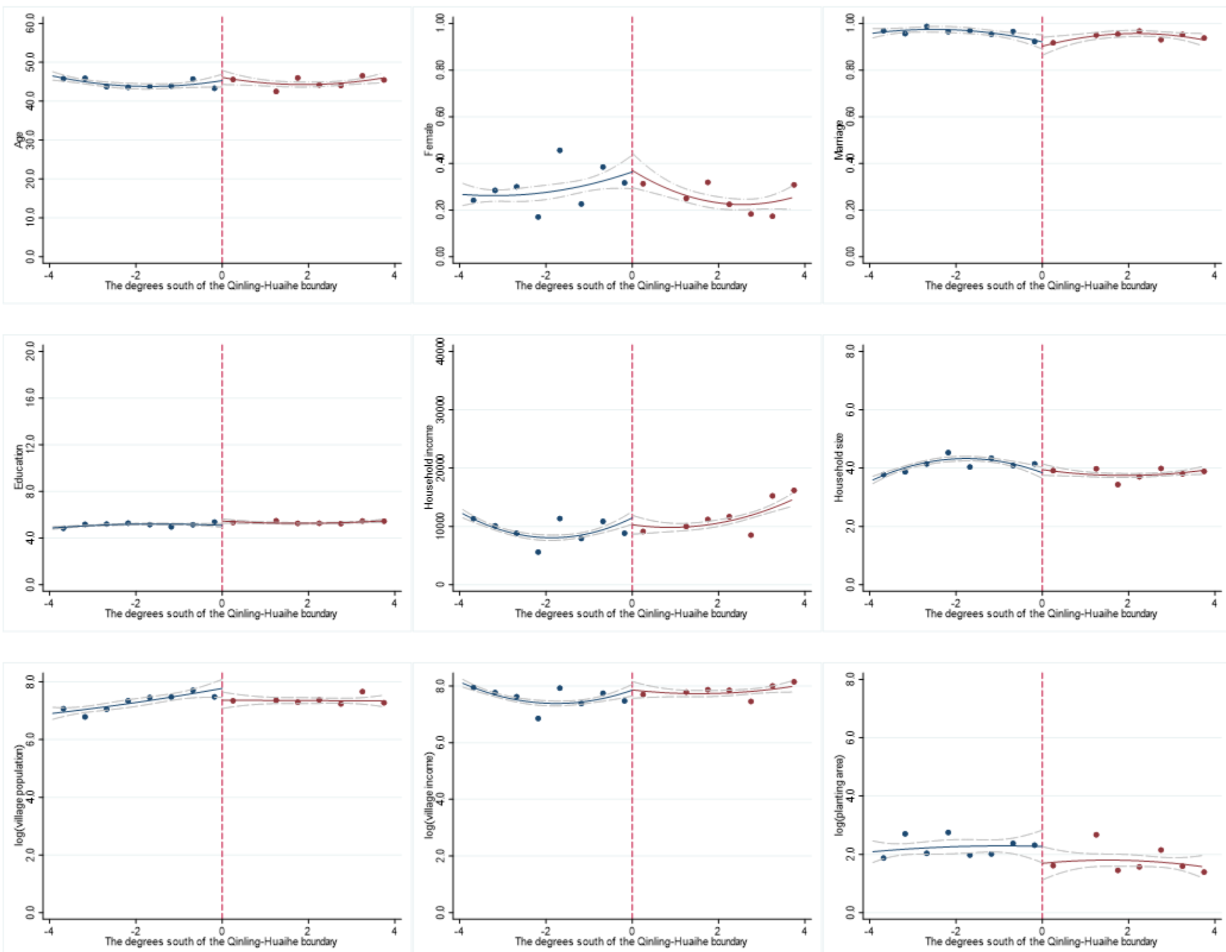
Notes: The data come from China's Ministry of Agriculture and measure the percentage of farmland devoted to rice farming in each prefecture in 1957. The darker red color corresponds to a higher intensity of rice farming in the prefecture. The black line highlights the Qinling-Huaihe line.

Figure 3: Rice Farming in Surveyed Counties in CHIP 2002



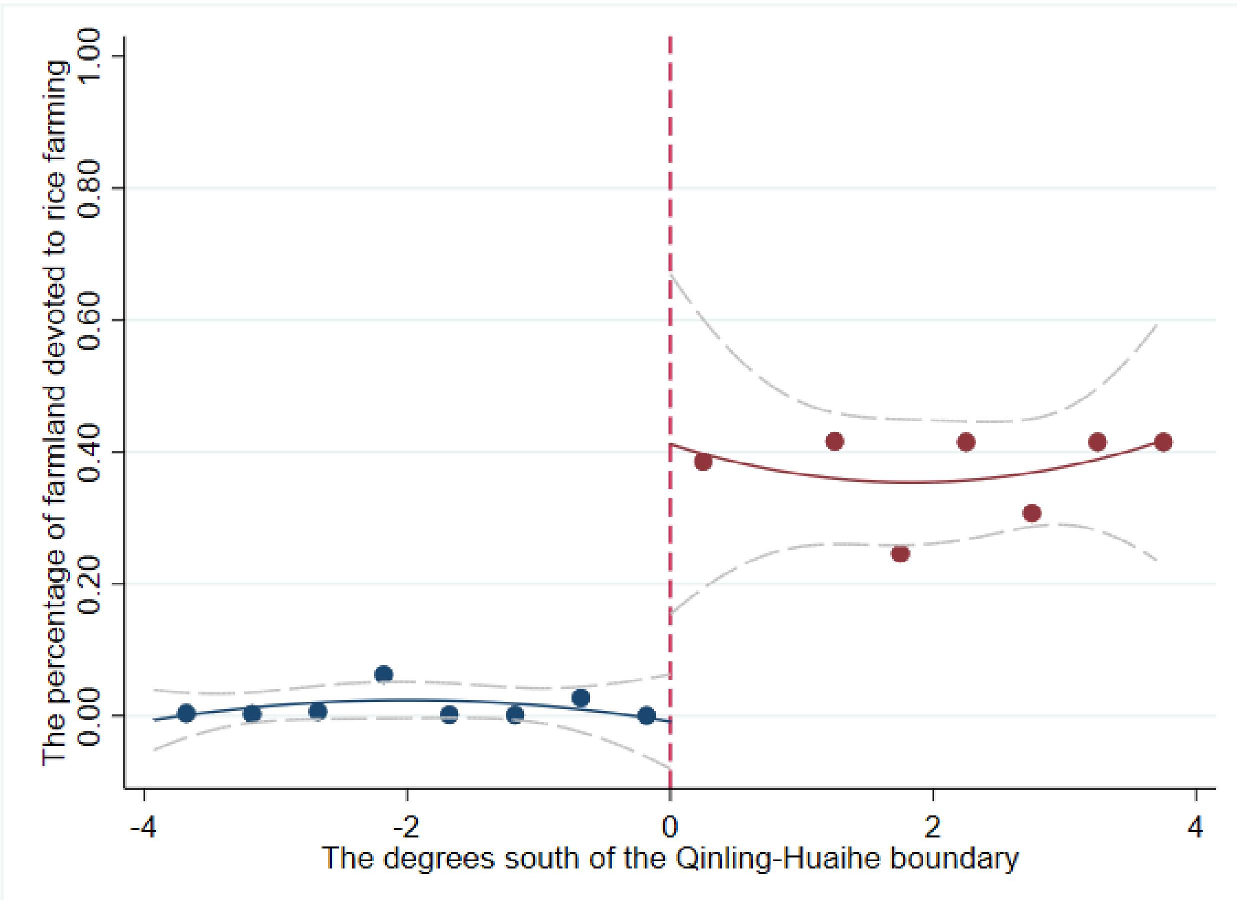
Notes: The data come from China's Ministry of Agriculture and measure the percentage of farmland devoted to rice farming in each county in 1957. The darker red color corresponds to a higher intensity of rice farming in the county. The black line highlights the Qinling-Huaihe line.

Figure 4: Distribution of Predetermined Variables



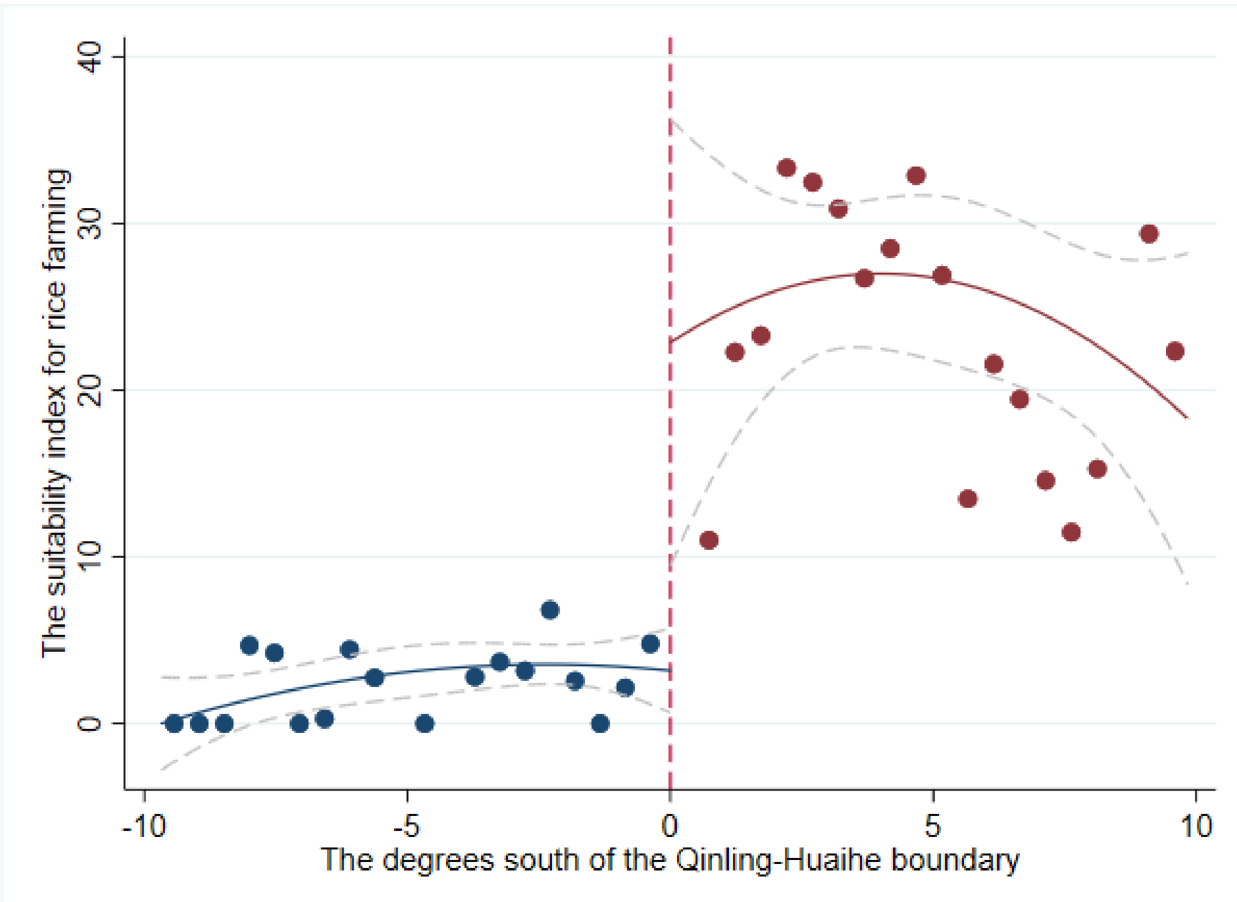
Notes: The vertical line in each figure indicates the Qingling-Huaihe boundary, which is used as the South/North divide and normalized to 0. We use a 4 degrees bandwidth on each side. The dots represent the means of predetermined variables for individuals/villages within half of a degree in the CHIP 2002 sample. The solid lines are fitted values using quadratic regressions. The dashed lines are the 95 percent confidence intervals.

Figure 5: Rice Farming in 1957 by the Degree South of Qingling-Huaihe Line



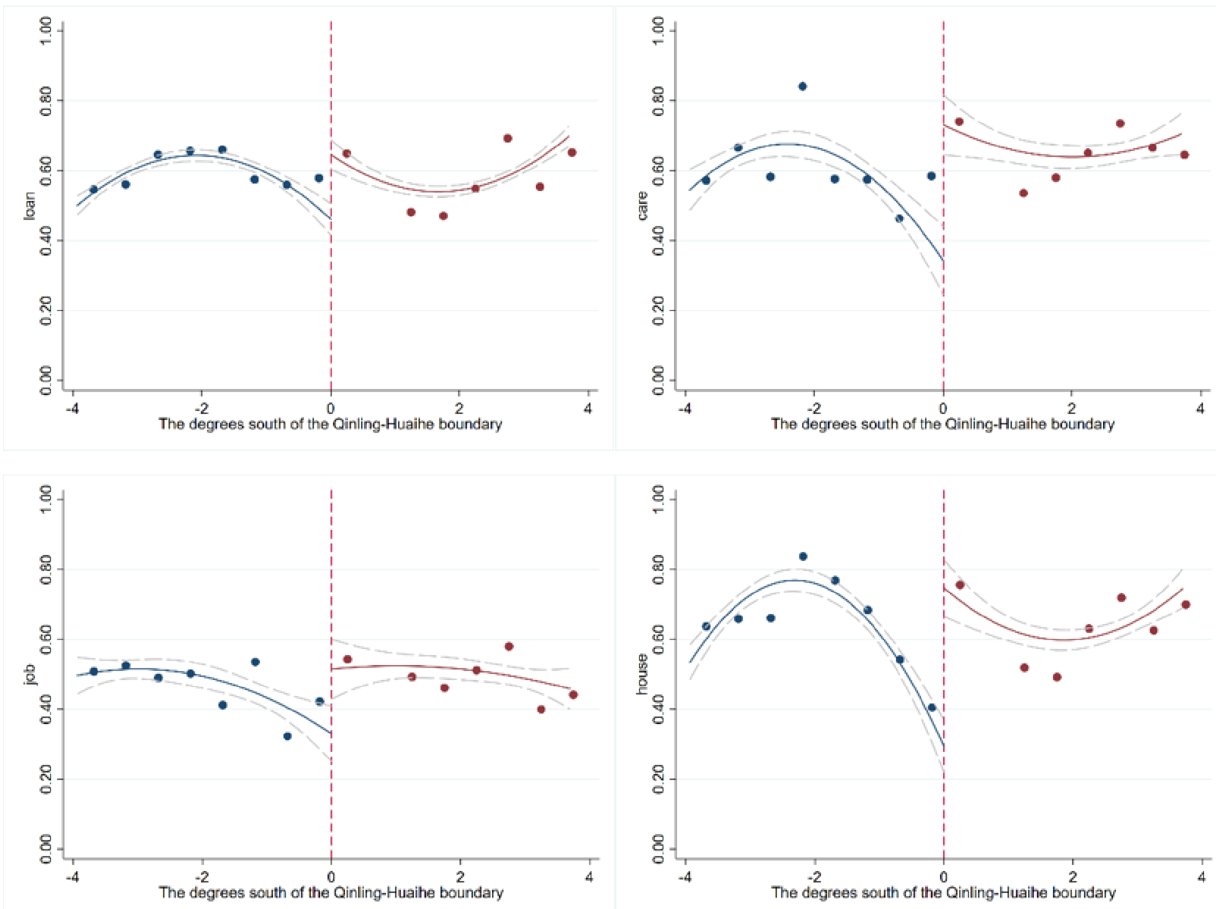
Notes: The vertical line indicates the Qingling-Huaihe boundary, which is used as the South/North divide and normalized to 0. We use a 4 degrees bandwidth on each side. The dots represent the means of percentage of farmland devoted to rice farming in 1957 in counties within half of a degree. The solid lines are fitted values using quadratic regressions. The dashed lines are the 95 percent confidence intervals.

Figure 6: Rice Suitability by the Degree South of Qingling-Huaihe Line



Notes: The vertical line indicates the Qingling-Huaihe boundary, which is used as the South/North divide and normalized to 0. The dots represent the average rice suitability index from the GAEZ database in regions within each degree. The solid lines are fitted values using quadratic regressions. The dashed lines are the 95 percent confidence intervals.

Figure 7: Cooperative Behaviors by the Degree South of Qingling-Huaihe Line



Notes: The vertical line in each figure indicates the Qingling-Huaihe boundary, which is used as the South/North divide and normalized to 0. We use a 4 degrees bandwidth on each side. The dots represent the means of the variables on cooperative behaviors in villages within half of a degree. The solid lines are fitted values using quadratic regressions. The dashed lines are the 95 percent confidence intervals.

Table 1: Summary Statistics

Variables	Definition	Mean (1)	Std. (2)
Rice Farming			
RICE	% of farmland devoted to rice farming in the respondent's county in 1957	0.272	0.279
Cooperation			
loan	borrowing and lending money =0 if none/few or sometimes; =1 if often or very often	0.592	0.492
care	caring for the elderly, the sick, and babies =0 if none/few or sometimes; =1 if often or very often	0.365	0.481
job	helping with job seeking =0 if none/few or sometimes; =1 if often or very often	0.466	0.499
house	helping with house building =0 if none/few or sometimes; =1 if often or very often	0.635	0.481
Individual and Household Controls			
Age	Age of the respondent	45.319	10.605
Female	=1 if female; =0 if male	0.259	0.438
Married	=1 if married; =0 otherwise	0.953	0.211
Education	The respondent's years of schooling	7.075	2.681
Household income	Net household income (in yuan)	10,705	8,651
Household size	Total number of residents living in household for 6 months or more	4.044	1.255
Village Controls			
Population	Population of the village	1,843	1,191
Income	Net income per capita (in yuan)	2,623	1,616
Planting area	Planting area per capita (in mu)	1.947	1.226

Notes: The data come from the 2002 wave of the Chinese Household Income Project (CHIP). The statistics above are for our analysis sample, which includes 8,043 individuals from 759 rural villages located in 113 Chinese counties. One Chinese Yuan was approximately 0.121 dollars at the end of 2002, and one mu is approximately 0.165 acres.

Table 2: Covariate Balance Tests

Variables	South	North	Adjusted Difference	
			Linear	Quadratic
	(1)	(2)	(3)	(4)
Individual and Household Controls				
Age	44.788	44.595	0.637	2.223
	(10.586)	(10.278)	(1.773)	(2.723)
Female	0.246	0.285	-0.013	0.045
	(0.431)	(0.452)	(0.073)	(0.084)
Married	0.947	0.963	-0.014	-0.043
	(0.224)	(0.189)	(0.022)	(0.036)
Education	6.863	7.365	-1.087	-0.103
	(2.799)	(2.600)	(0.877)	(0.513)
Household income	11449.43	9413.898	-475.281	520.198
	(9508.735)	(6833.716)	(2840.826)	(4054.335)
Household size	3.798	4.085	-0.252	-0.036
	(1.141)	(1.211)	(0.175)	(0.400)
Village Controls				
Population	1770.362	1678.94	-419.158	-315.862
	(899.540)	(995.250)	(497.029)	(925.420)
Income	2830.075	2216.722	380.215	1088.789
	(1881.455)	(988.032)	(966.599)	(1404.782)
Planting area	1.735	2.199	-0.517	-0.56
	(1.045)	(1.101)	(0.466)	(0.596)
Observations	1,905	2,112	4,017	4,017

Notes: The Qinling-Huaihe line is used as the South/North divide, and we use a 4 degrees bandwidth on each side. The discontinuity estimates in columns (3) and (4) are adjusted for a linear and a quadratic polynomial, respectively, in degrees south of the Qinling-Huaihe line. Standard deviations are reported in parentheses in columns (1) and (2). Standard errors clustered by county are reported in parentheses in columns (3) and (4). ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table 3: Regression Discontinuity Estimates of Rice Farming on Cooperative Behaviors

	Dependent variables: Frequency of cooperative behavior							
	loan	*care*	*job*	*house*	*loan*	*care*	*job*	*house*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Reduced-form estimates								
SOUTH	0.209***	0.179***	0.268***	0.440***	0.143**	0.190***	0.228***	0.406***
	(0.066)	(0.063)	(0.067)	(0.061)	(0.067)	(0.065)	(0.068)	(0.062)
First-stage estimates (dependent variable: *RICE*)								
SOUTH	0.295***	0.295***	0.295***	0.295***	0.238***	0.238***	0.238***	0.238***
	(0.032)	(0.032)	(0.032)	(0.032)	(0.035)	(0.035)	(0.035)	(0.035)
2SLS estimates								
RICE	0.418**	0.381**	0.566**	1.394***	0.583**	0.799***	0.971***	1.700***
	(0.209)	(0.205)	(0.213)	(0.394)	(0.295)	(0.286)	(0.312)	(0.368)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	4,017	4,017	4,017	4,017	4,017	4,017	4,017	4,017

Notes: This table reports reduced form and 2SLS estimates of rice farming on cooperative behaviors. Robust standard errors clustered by county are reported in the parentheses. All specifications include separate quadratic trends in the degrees south of the Qinling-Huaihe line. The bandwidth size is 4 degrees. *SOUTH* is an indicator for the respondents whose county is located south of the Qinling-Huaihe line. *RICE* is the percentage of farmland devoted to rice farming in each county in 1957. Controls include all those listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table 4: Regression Discontinuity Estimates Using Alternative Rice Farming Statistics

	Dependent variables: Frequency of cooperative behavior							
	loan	*care*	*job*	*house*	*loan*	*care*	*job*	*house*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. 1980 county-level rice farming							
Reduced-form estimates								
SOUTH	0.209***	0.179***	0.268***	0.440***	0.143**	0.190***	0.228***	0.406***
	(0.066)	(0.063)	(0.067)	(0.061)	(0.067)	(0.065)	(0.068)	(0.062)
First-stage estimates (dependent variable: *RICE1980*)								
SOUTH	0.188***	0.188***	0.188***	0.188***	0.191***	0.191***	0.191***	0.191***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.017)	(0.017)	(0.017)	(0.017)
2SLS estimates								
RICE1980	0.973**	1.212***	1.687***	2.143***	0.735*	1.342***	1.581***	2.123***
	(0.402)	(0.378)	(0.416)	(0.435)	(0.389)	(0.383)	(0.400)	(0.416)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	4,017	4,017	4,017	4,017	4,017	4,017	4,017	4,017
	Panel B. 1998 village-level rice farming							
Reduced-form estimates								
SOUTH	0.209***	0.179***	0.268***	0.440***	0.143**	0.190***	0.228***	0.406***
	(0.066)	(0.063)	(0.067)	(0.061)	(0.067)	(0.065)	(0.068)	(0.062)
First-stage estimates (dependent variable: *RICE1998*)								
SOUTH	0.127***	0.127***	0.127***	0.127***	0.090***	0.090***	0.090***	0.090***
	(0.037)	(0.037)	(0.037)	(0.037)	(0.032)	(0.032)	(0.032)	(0.032)
2SLS estimates								
RICE1998	0.988**	1.426***	1.625***	2.138***	0.829**	1.445***	1.618***	2.086***
	(0.409)	(0.441)	(0.472)	(0.560)	(0.406)	(0.456)	(0.480)	(0.555)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	4,017	4,017	4,017	4,017	4,017	4,017	4,017	4,017

Notes: This table reports 2SLS estimates of rice farming on cooperative behaviors using alternative rice farming statistics. Robust standard errors clustered by county are reported in the parentheses. All specifications include separate quadratic trends in the degrees south of the Qinling-Huaihe line. The bandwidth size is 4 degrees. *SOUTH* is an indicator for the respondents whose county is located south of the Qinling-Huaihe line. *RICE1980* is the percentage of farmland devoted to rice farming in each county in 1980. *RICE1998* is the percentage of farmland devoted to rice farming in each village in 1998. Controls include all those listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table 5: Placebo Tests

	Dependent variables: Frequency of cooperative behavior							
	loan	*care*	*job*	*house*	*loan*	*care*	*job*	*house*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Move the true boundary 4 degrees southward								
Reduced-form estimates								
SOUTH	0.202	-0.296	-0.135	0.294	0.218	-0.253	-0.132	0.109
	(0.186)	(0.220)	(0.297)	(0.303)	(0.127)	(0.245)	(0.244)	(0.253)
First-stage estimates (dependent variable: *RICE*)								
SOUTH	0.048	0.048	0.048	0.048	0.055	0.055	0.055	0.055
	(0.081)	(0.081)	(0.081)	(0.081)	(0.070)	(0.070)	(0.070)	(0.070)
2SLS estimates								
RICE	4.427	7.770	-2.810	6.288	4.384	8.290	-2.476	7.158
	(9.120)	(12.726)	(4.413)	(14.407)	(4.942)	(10.587)	(3.863)	(10.740)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	3,276	3,276	3,276	3,276	3,276	3,276	3,276	3,276
Panel B. Move the true boundary 4 degrees northward								
Reduced-form estimates								
SOUTH	-0.030	-0.016	0.021	-0.116	-0.014	0.016	0.047	-0.096
	(0.062)	(0.091)	(0.065)	(0.097)	(0.051)	(0.127)	(0.099)	(0.088)
First-stage estimates (dependent variable: *RICE*)								
SOUTH	0.235	0.235	0.235	0.235	0.113	0.113	0.113	0.113
	(0.162)	(0.162)	(0.162)	(0.162)	(0.090)	(0.090)	(0.090)	(0.090)
2SLS estimates								
RICE	-0.126	-0.691	0.720	-0.497	0.007	-2.222	1.355	-1.468
	(0.220)	(0.570)	(0.532)	(0.424)	(0.372)	(1.417)	(1.118)	(1.250)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	3,834	3,834	3,834	3,834	3,834	3,834	3,834	3,834

Continued: Placebo Tests

	Dependent variables: Frequency of cooperative behavior							
	loan	*care*	*job*	*house*	*loan*	*care*	*job*	*house*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel C. Use Yangtze River as the boundary							
Reduced-form estimates								
SOUTH	0.007	0.06	0.028	0.009	-0.059	-0.046	-0.090	-0.066
	(0.043)	(0.042)	(0.044)	(0.042)	(0.081)	(0.163)	(0.094)	(0.101)
First-stage estimates (dependent variable: *RICE*)								
SOUTH	-0.208	-0.208	-0.208	-0.208	-0.212	-0.212	-0.212	-0.212
	(0.161)	(0.161)	(0.161)	(0.161)	(0.164)	(0.164)	(0.164)	(0.164)
2SLS estimates								
RICE	0.076	0.385	0.371	0.195	0.215	0.223	0.452	0.264
	(0.571)	(0.872)	(0.394)	(0.484)	(0.424)	(0.980)	(0.369)	(0.364)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	4,235	4,235	4,235	4,235	4,235	4,235	4,235	4,235

Notes: This table reports 2SLS estimates of rice farming on cooperative behaviors using alternative boundaries. Robust standard errors clustered by county are reported in the parentheses. All specifications include separate quadratic trends in the degrees south of the boundary. The bandwidth size is 4 degrees. *SOUTH* is an indicator for the respondents whose county is located south of the boundary. *RICE* is the percentage of farmland devoted to rice farming in each county in 1957. Controls include all those listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table 6: The Impact of Rice Farming on Cooperative Behaviors for Farm Workers and Others

	Dependent variables: Frequency of cooperative behavior							
	loan (1)	*care* (2)	*job* (3)	*house* (4)	*loan* (5)	*care* (6)	*job* (7)	*house* (8)
Panel A. Farm workers								
Reduced-form estimates								
SOUTH	0.194**	0.149*	0.267***	0.371***	0.192**	0.205**	0.241***	0.340***
	(0.087)	(0.080)	(0.086)	(0.079)	(0.089)	(0.083)	(0.088)	(0.081)
First-stage estimates (dependent variable: *RICE*)								
SOUTH	0.217***	0.217***	0.217***	0.217***	0.187***	0.187***	0.187***	0.187***
	(0.045)	(0.045)	(0.045)	(0.045)	(0.051)	(0.051)	(0.051)	(0.051)
2SLS estimates								
RICE	0.487*	1.147***	0.713**	1.436***	0.588*	1.004**	1.191**	1.762***
	(0.282)	(0.385)	(0.328)	(0.490)	(0.340)	(0.510)	(0.563)	(0.665)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	2,429	2,429	2,429	2,429	2,429	2,429	2,429	2,429
Panel B. Workers on off-farm jobs and non-workers								
Reduced-form estimates								
SOUTH	0.368***	0.245**	0.277**	0.573***	0.293***	0.215**	0.214*	0.521***
	(0.105)	(0.106)	(0.112)	(0.098)	(0.106)	(0.109)	(0.113)	(0.099)
First-stage estimates (dependent variable: *RICE*)								
SOUTH	0.243***	0.243***	0.243***	0.243***	0.326***	0.326***	0.326***	0.326***
	(0.054)	(0.054)	(0.054)	(0.054)	(0.049)	(0.049)	(0.049)	(0.049)
2SLS estimates								
RICE	0.596**	0.760*	0.810*	1.238***	0.877**	0.664**	0.675*	1.603***
	(0.247)	(0.403)	(0.448)	(0.276)	(0.346)	(0.330)	(0.348)	(0.382)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	1,588	1,588	1,588	1,588	1,588	1,588	1,588	1,588

Notes: This table reports reduced form and 2SLS estimates of rice farming on cooperative behaviors for farm workers and others (including both workers on off-farm jobs and non-workers). Robust standard errors clustered by county are reported in the parentheses. All specifications include separate quadratic trends in the degrees south of the Qinling-Huaihe line. The bandwidth size is 4 degrees. *SOUTH* is an indicator for the respondents whose county is located south of the Qinling-Huaihe line. *RICE* is the percentage of farmland devoted to rice farming in each county in 1957. Controls include all those listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table 7: Potential Channels: Irrigation and Labor Exchange

	Panel A: Existence of irrigation as potential channel for cooperative behavior								
	irrigation (1)	*loan* (2)	*care* (3)	*job* (4)	*house* (5)	*loan* (6)	*care* (7)	*job* (8)	*house* (9)
RICE	1.192**					0.336	0.730***	1.039***	1.095***
	(0.604)					(0.268)	(0.261)	(0.301)	(0.343)
irrigation		0.386*	0.704***	0.784***	1.076***				
		(0.201)	(0.208)	(0.219)	(0.226)				
RICE × *irrigation*						0.447***	0.356**	0.283*	0.640***
						(0.128)	(0.141)	(0.162)	(0.274)
Obs.	409	4,007	4,007	4,007	4,007	4,007	4,007	4,007	4,007
	Panel B: Frequency of labor exchange as potential channel for cooperative behavior								
	labor exchange (1)	*loan* (2)	*care* (3)	*job* (4)	*house* (5)	*loan* (6)	*care* (7)	*job* (8)	*house* (9)
RICE	1.791***					-0.087	0.248	-0.064	0.836
	(0.362)					(0.274)	(0.268)	(0.277)	(1.583)
labor exchange		0.331**	0.440***	0.527***	0.939***				
		(0.151)	(0.155)	(0.150)	(0.167)				
RICE × *labor exchange*						0.489***	0.402***	0.755***	0.630***
						(0.053)	(0.050)	(0.052)	(0.066)
Obs.	4,007	4,007	4,007	4,007	4,007	4,007	4,007	4,007	4,007

Notes: This table examines irrigation (Panel A) and labor exchange (Panel B) as potential channels through which rice farming affects cooperative behaviors. Column (1) reports the effect of rice farming on the existence of an irrigation system in a village in Panel A and on frequency of labor exchange in Panel B. Columns (2)-(5) report the direct effects of irrigation and labor exchange on cooperative behaviors. Columns (6)-(9) investigate how the estimated effects of rice farming on cooperative behaviors are mediated by the existence of irrigation and labor exchange. Robust standard errors clustered by county are reported in the parentheses. All specifications include separate quadratic trends in the degrees south of the Qinling-Huaihe line. The bandwidth size is 4 degrees. *RICE* is the percentage of farmland devoted to rice farming in each county in 1957. *irrigation* indicates whether the village has an irrigation network since 1998. *labor exchange* indicates whether the respondent exchanged labor frequently or very frequently during busy farming seasons. All specifications include controls that are listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table 8: Addressing Various Confounding Factors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Panel A. Dependent variable: *loan*						
RICE	0.424*	0.593**	0.501**	0.589**	0.631**	0.576**	0.704**
	(0.245)	(0.279)	(0.216)	(0.281)	(0.288)	(0.279)	(0.326)
Population density	-0.023						
	(0.017)						
Household migrants		0.046**					
		(0.023)					
Village migrants			0.020***				
			(0.007)				
Religious belief				0.003			
				(0.018)			
Minority					-0.337**		
					(0.164)		
Health						-0.051**	
						(0.021)	
Hakka							
	Panel B. Dependent variable: *care*						
RICE	0.932***	0.801***	0.467**	0.747***	0.808***	0.813***	0.784**
	(0.237)	(0.269)	(0.207)	(0.269)	(0.277)	(0.271)	(0.309)
Population density	0.018						
	(0.018)						
Household migrants		-0.010					
		(0.022)					
Village migrants			0.009				
			(0.007)				
Religious belief				0.072***			
				(0.019)			
Minority					-0.102		
					(0.117)		
Health						0.007	
						(0.021)	
Hakka							

Continued: Addressing Various Confounding Factors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Panel C. Dependent variable: *job*						
RICE	1.071***	0.967***	0.900***	0.950***	1.008***	0.998***	1.055***
	(0.251)	(0.292)	(0.227)	(0.295)	(0.303)	(0.295)	(0.345)
Population density	0.014						
	(0.020)						
Household migrants		-0.010					
		(0.023)					
Village migrants			0.002				
			(0.007)				
Religious belief				0.023			
				(0.020)			
Minority					-0.364**		
					(0.180)		
Health						0.053**	
						(0.023)	
Hakka							
	Panel D. Dependent variable: *house*						
RICE	1.014***	1.601***	1.053***	1.611***	1.644***	1.608***	1.886***
	(0.241)	(0.330)	(0.227)	(0.335)	(0.345)	(0.122)	(0.419)
Population density	-0.079***						
	(0.019)						
Household migrants		0.053**					
		(0.021)					
Village migrants			-0.001				
			(0.007)				
Religious belief				-0.017			
				(0.023)			
Minority					-0.465***		
					(0.131)		
Health						0.019	
						(0.027)	
Hakka							
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Effective obs.	4,017	4,017	4,017	4,017	4,017	4,017	3,887

Notes: This table reports 2SLS estimates of rice farming on cooperative behaviors addressing various confounding factors. In Columns (1)-(6), one potential confounding factor is included as an additional control variable, and in Column (7), villages from counties with Hakka population are excluded from the sample. Robust standard errors clustered by county are reported in the parentheses. All specifications include separate quadratic trends in the degrees south of the Qinling-Huaihe line. The bandwidth size is 4 degrees. *RICE* is the percentage of farmland devoted to rice farming in each county in 1957. See Section 7 for the detailed definitions of the confounding factors considered in the table. Controls include all those listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table 9: The Effects of Rice Farming on Other Outcomes

	Trust		Household outcomes		Village outcomes
	General trust	*Out-group trust*	*Agricultural income*	*Income loss in disasters*	*Public spending*
	(1)	(2)	(3)	(4)	(5)
RICE	0.303**	0.225**	1.005***	-0.216***	1.416***
	(0.129)	(0.098)	(0.182)	(0.078)	(0.427)
Observations	3,523	3,451	3,985	3,106	377

Notes: This table shows the regression discontinuity estimates of rice farming on trust and other household and village outcomes. Robust standard errors clustered by county are reported in the parentheses. All specifications include separate quadratic trends in the degrees south of the Qinling-Huaihe line. The bandwidth size is 4 degrees. *RICE* is the percentage of farmland devoted to rice farming in each county in 1957. All specifications include controls that are listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

A Appendix: Robustness Checks on RD Specifications

In this subsection, we present several robustness checks regarding RD specifications. Specially, we check sensitivity of our estimates to different polynomial orders, nonparametric estimation, different bandwidths, and a donut RD design.

First, our parametric estimates, if credible, should remain consistent to different choices regarding the polynomial order (Lee and Lemieux, 2010). In the benchmark regression, we adopt the second-order polynomial function. In Table A3, we explore the robustness of the estimation results to alternative polynomial orders. Panel A reports the 2SLS estimates with a linear polynomial whereas Panel B reports the 2SLS estimates with a cubic polynomial. Again, we consider both specifications with and without individual and village control variables. The positive effects of rice farming on cooperative behaviors are insensitive to these alternative specifications.

Second, we use nonparametric methods to confirm our findings considering that specific functional forms may affect parametric estimates. Gelman and Imbens (2019) suggest that low-order local polynomials are preferred in RD designs because global high-order polynomials may lead to noisy estimates, sensitivity to the degree of the polynomial, and poor coverage of confidence intervals. Thus, we estimate Equations (3) and (4) by assuming local linear and quadratic polynomial functional forms for both $g(d_c)$ and $f(d_c)$. Table A4 shows the results of 2SLS kernel local polynomial regressions.[30] The estimates are quite similar when we adopt different specifications of nonparametric methods.

Third, we use alternative bandwidths to check if our estimates are sensitive to the choice of bandwidth. In our baseline regressions, the bandwidth size is 4 degrees. In Panel A of Table A5, we reduce the bandwidth size to 2 degrees and we follow the mean square error (MSE)-optimal method proposed by Imbens and Kalyanaraman (2012) and Calonico et al. (2014) to choose optimal bandwidth in Panel B. The numbers of observations within the bandwidth are reported. We find that the estimates are very similar in specifications with and without additional control variables and the positive effects of rice farming on cooperative behaviors are robust to alternative bandwidth choices.

We also apply a donut regression discontinuity design and investigate the sensitivity of the estimates to excluding observations near the Qinling-Huaihe line. One concern could be that cooperation in villages near the cutoff may be correlated with each other. One approach to deal with this is to apply a donut regression discontinuity model and drop the observations near the cutoff (Barreca et al., 2016). We re-estimate Equations (2) to

[30] This table reports regression results using a triangular kernel function. The results are robust to the alternative epanechnikov and uniform kernel functions, which are not reported but available upon request.

(4), excluding observations near the threshold. The results are reported in Table A6. To investigate sensitivity, we first drop the observations within 0.3 degree in each direction of the boundary, as shown in columns (1) to (4), and then drop the observations within 0.6 degree in each direction of the boundary, as shown in columns (5) to (8).[31] Both the reduced-form and 2SLS estimates are generally consistent with the main specifications. This provides additional evidence supporting the validity of our discontinuity estimates.

B Appendix: Replication of Talhelm et al. (2014) Using an RD Design

Talhelm et al. (2014) conduct an experiment to test 1,162 Han Chinese students from universities in Beijing, Fujian, Guangdong, Yunnan, Sichuan and Liaoning in 2011. They use the triad approach to measure cultural thought. In the triad task, participants decide which two items from lists of three should be paired. For instance, a list includes train, bus and tracks. Some people may pair train and bus because they are both vehicles whereas some may pair train and tracks because they share a functional relationship. People that choose more abstract pairings are believed to have more individualistic and analytic cultures, whereas those that choose more relational pairings have more holistic and collectivistic cultures. In particular, the triad task is a series of binary choices, in which there are eight key questions as well as twelve filler questions to keep participants from guessing the intention of the task. The dataset also contains information on participants' gender, city where they grew up, and other provincial characteristics. Talhelm et al. (2014) show that people from provinces with a higher percentage of farmland devoted to rice paddies in 1996 think more holistically.

We test whether historical rice farming leads to more cooperative culture by using the same triad data. We implement RD specifications similar to those in Equations (2) to (4) to identify the causal effect of historical rice farming in 1957 by using the Qinling-Huaihe line as the boundary. We focus on the sample that grew up in prefectures within 4 degrees in latitude of the boundary. Table A7 reports the estimation results. The outcome variable is the percentage of holistic choices in the triad task, where 0% is completely analytic or individualistic and 100% is completely holistic or collectivistic. Column (1) shows that students that grew up in prefectures to the south of Qinling-Huaihe line are more likely to make holistic choices in the triad task than those that grew up in the north of the boundary. Prefectures to the south of the boundary in the sample devote significantly more farmland to rice farming. The coefficient on rice farming in the second-stage is positive and

[31] We choose donut sizes of 0.6 and 1.2 degree based on available observations. If the increment is too small, we are not able to drop observations effectively.

statistically significant, indicating that historical rice farming promotes holistic thought. In Column (2) we include additional controls of an indicator on individual gender and prefecture level characteristics on the percentage of minorities, GDP per capita and death rate from infectious diseases as in Talhelm et al. (2014). The estimated effect of rice farming on cultural thoughts is very similar to the one in column (1). The first two columns of Table A7 use linear functions of the degree to the boundary in the RD specifications. In the rest of the columns, we consider both quadratic and cubic polynomials for the functions of the running variable and find very similar results.

C Appendix: Additional Tables

Table A1: Test for Discontinuity in Log Population at the Qingling-Huaihe Boundary

	Dependent variable: Log(population)			
	CHIP	CHIP	Census	Census
	(1)	(2)	(3)	(4)
SOUTH	-0.031	-0.109	-0.131	-0.125
	(0.226)	(0.236)	(0.187)	(0.198)
Observations	144	406	496	1,123
Polynomial	Linear	Quadratic	Linear	Quadratic
Bandwidth	2 degrees	4 degrees	2 degrees	4 degrees

Notes: The Qinling-Huaihe line is used as the South/North divide. The regression discontinuity estimates in columns (1) and (2) use village population from the CHIP 2002, and those in columns (3) and (4) use county population from the 2000 Chinese census. Different orders of polynomials and bandwidths are considered. Robust standard errors are presented in the parentheses. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table A2: Naïve OLS Estimates

	Dependent variables: Frequency of cooperative behavior			
	loan	*care*	*job*	*house*
	(1)	(2)	(3)	(4)
RICE	0.002	0.032	0.089	0.043
	(0.064)	(0.056)	(0.056)	(0.071)
Controls	Yes	Yes	Yes	Yes
Observations	4,017	4,017	4,017	4,017
R-squared	0.027	0.030	0.045	0.041

Notes: Robust standard errors clustered at county level are reported in the parentheses. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table A3: Alternative Polynomial Orders

	Dependent variables: Frequency of cooperative behavior							
	loan	*care*	*job*	*house*	*loan*	*care*	*job*	*house*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. Linear polynomial							
RICE	0.122**	0.187**	0.278***	0.523***	0.137***	0.344***	0.278**	0.530***
	(0.059)	(0.078)	(0.126)	(0.117)	(0.058)	(0.083)	(0.121)	(0.112)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	4,017	4,017	4,017	4,017	4,017	4,017	4,017	4,017
	Panel B. Cubic polynomial							
RICE	0.716***	0.916***	0.660***	1.297***	0.538***	0.665***	0.589***	1.293***
	(0.147)	(0.143)	(0.181)	(0.201)	(0.147)	(0.144)	(0.176)	(0.189)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	4,017	4,017	4,017	4,017	4,017	4,017	4,017	4,017

Notes: This table explores the sensitivity of the main RD fuzzy IV estimates to different orders of polynomial. Robust standard errors clustered by county are reported in the parentheses. All specifications include separate trends in the degrees south of the Qinling-Huaihe line. The bandwidth size is 4 degrees. *RICE* is the percentage of farmland devoted to rice farming in each county in 1957. Controls include all those listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table A4: Nonparametric Estimates

	Dependent variables: Frequency of cooperative behavior							
	loan	*care*	*job*	*house*	*loan*	*care*	*job*	*house*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. Local linear regressions							
RICE	0.184*	0.381***	0.325***	0.387***	0.203*	0.359***	0.374***	0.613***
	(0.104)	(0.104)	(0.105)	(0.096)	(0.110)	(0.107)	(0.108)	(0.098)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	4,017	4,017	4,017	4,017	4,017	4,017	4,017	4,017
	Panel B. Local quadratic regressions							
RICE	0.721**	1.359***	0.893***	2.106***	0.496**	1.090***	0.641***	1.586***
	(0.279)	(0.264)	(0.283)	(0.258)	(0.202)	(0.282)	(0.203)	(0.188)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	4,017	4,017	4,017	4,017	4,017	4,017	4,017	4,017

Notes: This table reports non-parametric local estimators using a triangular kernel function. Robust standard errors clustered by county are reported in the parentheses. All specifications include separate trends in the degrees south of the Qinling-Huaihe line. The bandwidth size is 4 degrees. *RICE* is the percentage of farmland devoted to rice farming in each county in 1957. Controls include all those listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table A5: Alternative Bandwidths

	Dependent variables: Frequency of cooperative behavior							
	loan (1)	*care* (2)	*job* (3)	*house* (4)	*loan* (5)	*care* (6)	*job* (7)	*house* (8)
	Panel A. Two degrees bandwidth							
RICE	0.607**	0.932***	0.922***	1.264***	0.854***	1.169***	1.116***	1.699***
	(0.294)	(0.261)	(0.292)	(0.318)	(0.286)	(0.262)	(0.279)	(0.287)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	1,420	1,420	1,420	1,420	1,420	1,420	1,420	1,420
	Panel B. MSE optimal bandwidth							
RICE	0.589***	0.795***	0.948***	1.237***	0.410**	1.003***	0.831***	1.149***
	(0.140)	(0.157)	(0.268)	(0.311)	(0.200)	(0.265)	(0.233)	(0.166)
Controls	No	No	No	No	Yes	Yes	Yes	Yes
Effective Obs.	2,658	1,153	2,561	1,341	4,528	2,588	4,415	3,244

Notes: This table explores the sensitivity of the main RD fuzzy IV estimates to different bandwidths. The bandwidth size in Panel A is 2 degrees. The bandwidths size in Panel B is selected by the MSE-optimal bandwidth selector proposed by Calonico et al. (2014). Robust standard errors clustered by county are reported in the parentheses. All specifications include separate trends in the degrees south of the Qinling-Huaihe line. *RICE* is the percentage of farmland devoted to rice farming in each county in 1957. Controls include all those listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table A6: Donut Regression Discontinuity Estimates

	Dependent variables: Frequency of cooperative behavior							
	loan	*care*	*job*	*house*	*loan*	*care*	*job*	*house*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Reduced-form estimates								
SOUTH	0.247***	0.290***	0.191**	0.399***	0.267***	0.290***	0.191**	0.405***
	(0.081)	(0.080)	(0.083)	(0.074)	(0.095)	(0.080)	(0.083)	(0.085)
First-stage estimates (dependent variable: *RICE*)								
SOUTH	0.225***	0.225***	0.225***	0.225***	0.269***	0.269***	0.269***	0.269***
	(0.032)	(0.032)	(0.032)	(0.032)	(0.025)	(0.025)	(0.025)	(0.025)
2SLS estimates								
RICE	0.916**	1.260***	0.919**	1.669***	0.880**	0.709***	0.994***	1.422***
	(0.388)	(0.379)	(0.387)	(0.412)	(0.406)	(0.271)	(0.353)	(0.370)
Donut size	0.6	0.6	0.6	0.6	1.2	1.2	1.2	1.2
Effective Obs.	3,758	3,758	3,758	3,758	3,668	3,668	3,668	3,668

Notes: This table reports reduced form and 2SLS estimates of rice farming on cooperative behaviors from donut regression discontinuity models. Robust standard errors clustered by county are reported in the parentheses. All specifications include separate quadratic trends in the degrees south of the Qinling-Huaihe line. The bandwidth size is 4 degrees. Different donut widths are considered. *RICE* is the percentage of farmland devoted to rice farming in each county in 1957. *SOUTH* is an indicator for the respondents whose county is located in the south of the Qinling-Huaihe line. All specifications include controls that are listed in Table 2. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.

Table A7: Regression Discontinuity Estimates of Rice Farming on Holistic Thought

	Dependent variables: The percentage of holistic choices in triad task					
	Linear		Quadratic		Cubic	
	(1)	(2)	(3)	(4)	(5)	(6)
Reduced-form estimates						
SOUTH	0.111**	0.050*	0.205**	0.153***	0.210***	0.214***
	(0.042)	(0.023)	(0.075)	(0.044)	(0.052)	(0.062)
First stage estimates (dependent variable: *RICE*)						
SOUTH	0.445***	0.337***	0.506***	0.370***	0.360***	0.342***
	(0.073)	(0.101)	(0.071)	(0.073)	(0.109)	(0.097)
2SLS estimates						
RICE	0.248***	0.148**	0.405**	0.413***	0.583**	0.627**
	(0.088)	(0.075)	(0.168)	(0.146)	(0.233)	(0.292)
Controls	No	Yes	No	Yes	No	Yes
Effective Obs.	297	297	297	297	297	297

Notes: This table reports reduced form and 2SLS estimates of rice farming on the percentage of holistic choices in triad task. Robust standard errors clustered by province are reported in the parentheses. All specifications include separate trends in the degrees south of the Qinling-Huaihe line. The bandwidth size is 4 degrees. *SOUTH* is an indicator for the respondents who grew up in prefectures located to the south of the Qinling-Huaihe line. *RICE* is the percentage of farmland devoted to rice farming in each prefecture in 1957. Controls include a gender indicator, the percentage of ethnic minorities, GDP per capita, and death rate from infectious diseases. ***, **, and * stand for significance at the 1%, 5%, and 10% level, respectively.