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Does the Granary County Subsidy Program Lead to manipulation of grain production data in China?

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ABSTRACT

Manipulation of food production data could lead to catastrophic social and economic consequences. The accuracy of official agricultural statistics has long been questioned in China. This paper studies the linkage between agricultural production data manipulation and the Granary County Subsidy Program (GCSP). Since 2005, Chinese government gave subsidies to those counties with five-year average grain production between 1998 and 2002 more than 200 thousand tons to encourage these local governments to give priority to grain production. The prospective counties with grain production slightly below the threshold may have incentives to over-report their grain production. Based on the McCrary (2008)'s density test, this paper provides suggestive evidence of over-reporting grain production caused by the GCSP in 2005, 2006 and 2008, though the over-reporting rates are only 3%, 2%, and 1.7% respectively. The policy implication would be that fiscal distribution rules of a central government should avoid data manipulation incentives in local governments, particularly should cut the linkage to the data which are self-reported by the local governments.

1. Introduction

Ensuring grain self-sufficiency has always been a priority of Chinese agricultural policies. Chinese grain production experienced decreasing trend since 1998 and the production in 2003 returned to the level in 1990. Therefore, China has taken a series of policy measures since the early 2000s in response to the rising concerns on food security. Most of measures, such as the abolition of agricultural tax, direct grain subsidy program and price intervention program, are directly targeting at farmers based on their contracted land area (Huang & Yang, 2017). The Granary County Subsidy Program (GCSP) was announced in April 2005 to reward the contributions of local governments to national food security. This subsidy mainly relies on whether the counties' 5-year arithmetic average grain production is > 200 thousand tons on average[1] between 1998 and 2002, and the commodity grain[2] is > 5 thousand tons. The key statistics for the policy is 200 thousand tons of grain output, as 5 thousand tons of commodity grains could be easily

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[1] The original document from the Ministry of Finance of China can be found at: http://www.mof.gov.cn/zhengwuxinxi/caizhengwengao/caizhengbuwengao2005/caizhengbuwengao20056/200805/t20080525_42774.html

[2] Commodity grain is the total grain production minus ration grain, feed grain and seeds grain. Feed grain and seeds grain for each people in North China and South China are 175 kg and 225 kg per year, respectively. On average, ration grain for each people is 222 kg in 2003.

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reached when the total production is over 200 thousand tons.[3]

To get more fiscal distributions from the central government, it is rational for local governments to over-report their statistical data to fawn the central government's distributional rules because the grain production data is from the self-reported county level statistical yearbook. China reformed its fiscal system, and carried out the so-called revenue-sharing system in 1994, in which the central government controlled most of the revenues (Chen, 2004; Lee, 2000; Parker & Thornton, 2007). The granary counties have high incentive to "effortlessly" get the fiscal coffer even by manipulating grain data. However, exaggerating grain production may threaten food security with over-estimating grain self-sufficiency rate, and distort China's agricultural policy. Data manipulation may also undermine the government's credibility (Ghanem & Zhang, 2014). This paper aims at investigating whether the Granary County Subsidy Program (GCSP) implemented in 2005 causes a dubious grain production data around the cut-off (200 thousand tons). This paper will also shed some lights on the proportion of manipulation and the characteristics of which the county is likely to manipulate data.

The accuracy of China's major statistics data generally has long been questioned. Some literature finds that (1) China's GDP is often over-reported, though the evidence is not solid (Holz, 2014). Recently, Liaoning, Inner Mongolia admitted that their GDP figures could have been inflated by up to 40% and such fake data mask economic rebound[4]; (2) China's CPI is often slightly under-reported (Chamon & de Carvalho Filho, 2014; Nakamura, Steinsson, & Liu, 2016); (3) Food production is often over-reported, but the consumption under-reported (Fuller, Hayes, & Smith, 2000; Yu & Abler, 2014, 2016); (4) Environmental pollution data are often under-reported (Chen, Jin, Kumar, & Shi, 2013; Ghanem & Zhang, 2014). Manipulation of food production data has led to catastrophic social and economic consequences. It is known that the big famine at the beginning of 1960s in China which caused > 30 million unusual deaths was linked to manipulation of food production data in the period of the Great Leap Forward (Bernstein, 2006; Lin, 1990). Due to the exaggeration of grain output, state grain procurements experienced a devastating increase and grain sown areas were also cut (Bernstein, 2006). These led to the decline in food availability and furtherly results in the big famine.

In China, many policies are made based on the data reported by local governments in modern society, and the statistical data are linked to their performance review and future possible promotion (Yu & Abler, 2014). It is comprehensible that the GCSP may lead to data manipulation. The GCSP contains three important regulations:

First, although grain includes rice, wheat, corn, beans and tubers based on the definition of Chinese government, subsiding criteria only concern over the total grain production rather than each kind of grain.

Second, the program states that the subsidies were based on the grain production data which are collected from county-level statistical yearbooks published by local government. That is to say, the GCSP depends on the self-reported grain production data. Obviously local governments cannot change the past data. However, the document also stated that the list of subsidizing counties would not change in 3 years (Clause 12). Implicitly, the county list would be adjusted in 2008 when the GCSP continues. In other words, prospective counties with grain production slightly below the threshold of 200 thousand tons would expect their production to exceed the threshold in every year from 2005 because they don't know which period would be choose as evaluating period for subsidy. On the other hand, prospective counties are able to respond in 2005 because they had known the GCSP in April and would publish their grain production data of 2005 in 2006.

Third, the subsidy funding sources include central fiscal and provincial fiscal. For the most developed provinces, Zhejiang and Guangdong, central fiscal only undertakes 20% of total subsidies. For Liaoning, Jiangsu, Fujian and Shandong provinces, central fiscal accounts for half share. The subsidies for the other provinces are totally undertaken by central fiscal excluding Beijing, Shanghai and Tianjin. The subsidies are required to distribute to counties and can be budget for a large scale except for building offices, buying cars and some other image projects. After determining the eligible county list, central government will allocate the subsidy based on the quantity of commodity grain, grain production and grain sown areas with the corresponding weights of 50%, 25% and 25%.

The subsidy did increase the fiscal coffer of the granary counties. In 2005, 958 counties shared a total amount of RMB5.5 billion subsidies from central government. The subsidy amount is capped at RMB20 million with an average of RMB 5.7 million, accounting for about 2.6% of their fiscal revenues and about 13% (a few counties are 55%) of their total subsidy increment.[5] The amount of subsidy from central government increased to RMB39.3 billion in 2016, with an annual growth rate of 20%.

The central government changed the subsidy rules in 2008, perhaps realizing that the subsidy rules in 2005 might have incentivized local governments to over-reporting their grain production. In 2008, the central government declared that the subsidizing counties, in principle, remained the same as those in 2007,[6] viz. the eligible counties in 2008 are the same as that in 2005–2007. The increased subsidies mainly went to the top 100 super granary counties, which are based on the five-year average production between 2002 and 2006. As mentioned before, three years later, the grain production data in 2005 and 2006 is actually used to distribute subsidies. Manipulating grain production data would be paid off if subsidy rules were not changed. As the list of granary counties which would receive subsidies were fixed since then, the incentives of data manipulation may disappear.

The GCSP offers us a good choice to conduct a study to see if local counties (particularly those are slightly below the threshold of 200 thousand tons) cooked their grain production data in reaction to the GCSP between 2005 and 2007. Furthermore, we can use the

[3] In 2005, the eligible counties provided 80% of China's commodity grain.

[4] https://www.ft.com/video/c9d9ee7f-c2c7-4265-b46f-1665ab56b062

[5] Data is from the following source: http://www.mof.gov.cn/zhuantihuigu/czrdwt/xxcz/200805/t20080519_25500.html

[6] The Granary County Subsidy Program in 2008 from the Ministry of Finance could be seen in: http://www.mof.gov.cn/preview/gp/jingjijianshesi/200806/t20080625_52829.html

data after 2008 as a robust check because the subsidy rules changed.

This paper has three contributions. First, although "forensic economics" has been applied to many fields, this paper firstly applies the detection techniques on Chinese grain production data to investigate whether the GCSP results in data manipulation. Given the central role of food security in Chinese agricultural policy, this paper will provide valuable implications for policymakers. Second, the discontinuity at cut-off can attribute to data manipulation as well as many other factors. Besides McCrary (2008)'s density test, we furtherly use the regression discontinuity model based on the grain harvest areas collected from third-party to provide suggestive evidence of data manipulation. Third, we also adopt the censored MLE strategy developed by Ghanem, Shen, and Zhang (2017) to quantify the proportion of manipulation.

The remainder of this paper is organized as follows. We first provide more background on data manipulation and economic theory behind it. Section 3 describes the data. Section 4 presents the density test developed by McCrary (2008). In Section 5, we will report our empirical results. We conclude with a summary and some policy implications in the last section.

2. Theoretical background and economic mechanism

Data manipulation is widely studied in many sub-fields of economics. Driven by a variety of motivations, agents are likely to hide some information to meet with the particular standards due to asymmetric information. Zitzewitz (2012) refers to this research topic as "forensic economics". Though the questions differ in different sub-fields, the detection techniques are quite similar. Comparing the reported data with other source is the simplest approach to detect manipulation. By comparing the self-reported data to official data, Zinman and Zitzewitz (2016) found that ski resorts over-report substantially more snowfalls on weekends for greater benefits. Fisman and Wei (2004) compared Chinese Mainland's official reported imports from Hong Kong with Hong Kong's official reported exports to Chinese Mainland, and found that higher tariff products were misclassified into lower tariff categories for tax break.

Econometric and statistical tests can be used to detect the manipulation when there is no alternative data source. Burgstahler and Dichev (1997) developed a pooled cross-sectional distribution approach and revealed that firms are likely to manipulate their reported earnings to avoid earnings decreases and losses. In order to avoid tax, Saez (2010) found substantial evidence of discontinuity in the density of income. McCrary (2008) developed a density test and found strong evidence of manipulation of the roll call votes in the House through representatives' repeated game, but no evidence of manipulation in the popular elections to the United States House of Representatives. Chen et al. (2013) and Ghanem and Zhang (2014) adopted Burgstahler and Dichev (1997)'s distribution test and McCrary (2008)'s density test to detect the manipulation of the self-reported daily air pollution concentrations, and they found that some Chinese cities under-report the data in response to the requirement of air pollution abatement and to increase the number of "blue-sky days".

The simplest way to detect manipulation is to use independent statistics to validate the self-reported data. Unfortunately, the grain production data from the alternative sources is unavailable. Therefore, this paper turns to econometric methods to uncover the suggestive evidence of manipulation. We will adopt the density test developed by McCrary (2008) to detect whether or not the prospective counties over-report their grain production at 200 thousand tons to achieve subsidy.

Increase in one county's grain production could be finally attributed to productivity increase or sown areas expansion. First, both artificial factors (encouraging farmers to input more labor, capital,[7] and technological progress) and the natural factors (weather and geography) could affect grain productivity. The natural factors are random shocks and cannot be precisely controlled by a farmer. Although artificial factors could result in increase in productivity by inputting more labor, capital, and technological progress, it is also not necessary to lead to a discontinuity in grain production distribution. Chinese government always put food security in a prior position of their policy agenda. There are a lot of policies, such as the investment in land improvement, agricultural technology, rural roads, market infrastructure, "Machinery subsidy", "Direct grain subsidy", "Quality seed subsidy", "Aggregate input subsidy" and so on, aiming at increasing grain production. Therefore, the potential for increasing grain production through more input factors and technological progress has been exploited.

Moreover, technological progress has spillover effects not only across counties but also across farmers within counties. This will result in a shift of grain production distribution rather than discontinuity. Technological spillover effect has been widely proved in the literature. Compared with the high cost of productivity enhancement, the "effortless" data manipulation is basically costless for the prospective counties slightly below the threshold. The interaction effect between artificial factors and the natural factors will contribute to an uncertain grain production. Thus, it is almost impossible that these factors lead to a discontinuity at 200 thousand tons.

Second, the prospective county can encourage farmers to expand the grain sown areas. This is not an easy measure because the arable land has been taken full use of and even shows a decrease trend in China (Chen, 2009). Structural adjustment in crops by replacing low-yield crops with high-yield crops may increase grain sown areas, as well as average productivity of grain. Ideally, based on both grain production and yield of last year, prospective counties approximately know to what extent they can exceed the threshold by encouraging farmers to adjust their crop structure. Adjustment costs faced by farmers may discourage them from action. In addition, grain production may depend on some uncontrollable factors (e.g. weather condition, technological progress). Thus, it is possible for prospective counties to adjust grain harvest area to achieve the grain production of 200 thousand tons, but this not necessarily results in a discontinuity at 200 thousand tons. We have no enough evidence to rule out this possibility. This paper will furtherly test whether the grain harvest areas (rice, wheat and corn harvest areas) of prospective counties experience a significant increase after introducing the GCSP. If the grain harvest areas increase insignificantly, we will more confidently consider as the discontinuity as suggestive evidence consistent with data manipulation.

In the absence of manipulation, the improved productivity usually involved in a large number of counties with different grain

[7] Inputting more land belongs to harvest expansion, and we will further analyze this possibility.

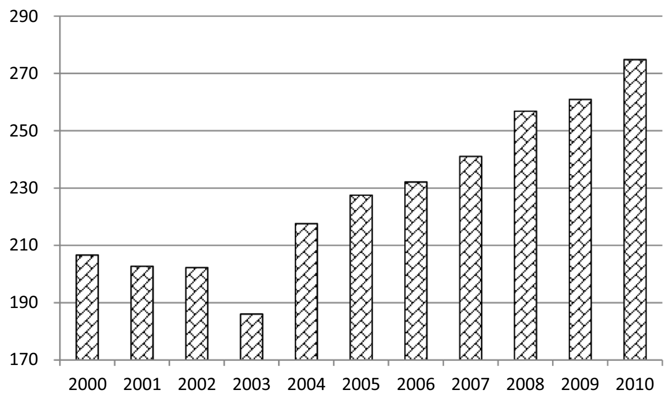

Fig. 1. the average grain production from 2000 to 2010.
Note: the unit is thousand tons. Source: county level statistical yearbooks in each year.

production, is almost impossible to result in the discontinuity of grain production distribution. In addition, this paper will furtherly analyze the change in harvest areas to rule out the slim possibility of discontinuity due to sown areas expansion. In this context, data manipulation is an effortless way to increase grain production to be above 200 thousand tons. Manipulating the grain production by a small amount is less likely to be detected and thus may not be doubt by central government. The mechanism here is that if most of prospective counties over-report its grain production, it will result in a discontinuity of grain production around the cut-off. Theoretically, it is possible that manipulation would not lead to a discontinuity, but the manipulators must have knowledge of the distribution of all the prospective counties which is unlikely. Therefore, we will conduct the density test at different intervals and different breakpoints to confirm that the discontinuity only occur at 200 thousand tons rather than other values. Thereafter, we will furtherly classify the prospective counties according to both economic development level and location to investigate the characteristics of which the county is likely to manipulate data.

3. Data sources

The data used in this paper are collected from the county level statistical yearbooks from 2000 to 2010. There are > 2000 counties in our dataset. Fig. 1 shows that the average grain production per county increases from 210 thousand tons in 2000 to 270 thousand tons in 2010, with an annual growth rate of 2.9%. In 2005, the average grain production is 230 thousand tons, which is higher than the subsidizing threshold. The grain production of 1220 counties, accounting for 59.8% of the number of counties, are < 200 thousand tons which is the threshold of the GCSP in 2005.

We are interested in whether the GCSP results in data manipulation. Fig. 2 depicts that the discontinuity is clear for the year of 2006 but not clear for other years at 200 thousand tons. More specifically, after the GCSP being introduced in 2005, the proportion of counties with grain production between 180 and 200 thousand tons remains the same in 2005, and decrease sharply to 3.3% in 2006. At the same time, the proportion of counties with grain production between 200 and 220 thousand tons had a moderate increase from 3.1% in 2004 to 3.2% in 2005, and jumped to 4.5% in 2006. Furthermore, the proportion of counties with grain production between 180 and 200 thousand tons reached its lowest level in 2006 and 2007, but the proportion of counties with grain production between 200 and 220 thousand tons reached its peak level in 2006 (Appendix A). The descriptive statistics have shown some suggestive evidence of data manipulation, particularly for the counties with grain production between 180 and 200 thousand tons. The diagram is clear but is not able to precisely identify the data manipulation. It is thus necessary for us to detect the data manipulation with the statistical tests developed by McCrary (2008).

In addition, our dataset also includes the harvest areas of rice, wheat and corn in research period. These data come from the Ministry of Agriculture and the Chinese Academy of Agriculture Science (CAAS). The harvest areas data is from a third-party and cannot be manipulated by local government.

4. Methodology

Due to lack of an alternative data source, an empirical method with the density test developed by McCrary (2008) will be adopted in this paper. The prospective counties are likely to over-report their grain production and cause bunching of grain production counties above the cut-off. Estimating a density function is thus a simple and straightforward method to identify the discontinuity. Both traditional histogram techniques and kernel density estimates have been used in previous studies (DiNardo & Lee, 2004; Jacob & Lefgren, 2004). However, it is well known that the kernel density estimator is badly biased at the boundary (McCrary, 2008). The local linear density estimator developed by Cheng (1994) and Cheng (1997) can overcome boundary bias and has theoretical and practical advantages (McCrary, 2008). As a simply extension of Cheng (1997)'s local linear density estimator, McCrary (2008) developed a more general density test to employ all the data on either side of the cut-off and make the results visual (Chen et al., 2013).

The density test developed by McCrary (2008) is informative when the existence of the program induces agents to adjust the data in one direction only. The GCSP creates an incentive for the prospective counties slightly below the threshold to “effortlessly” draw

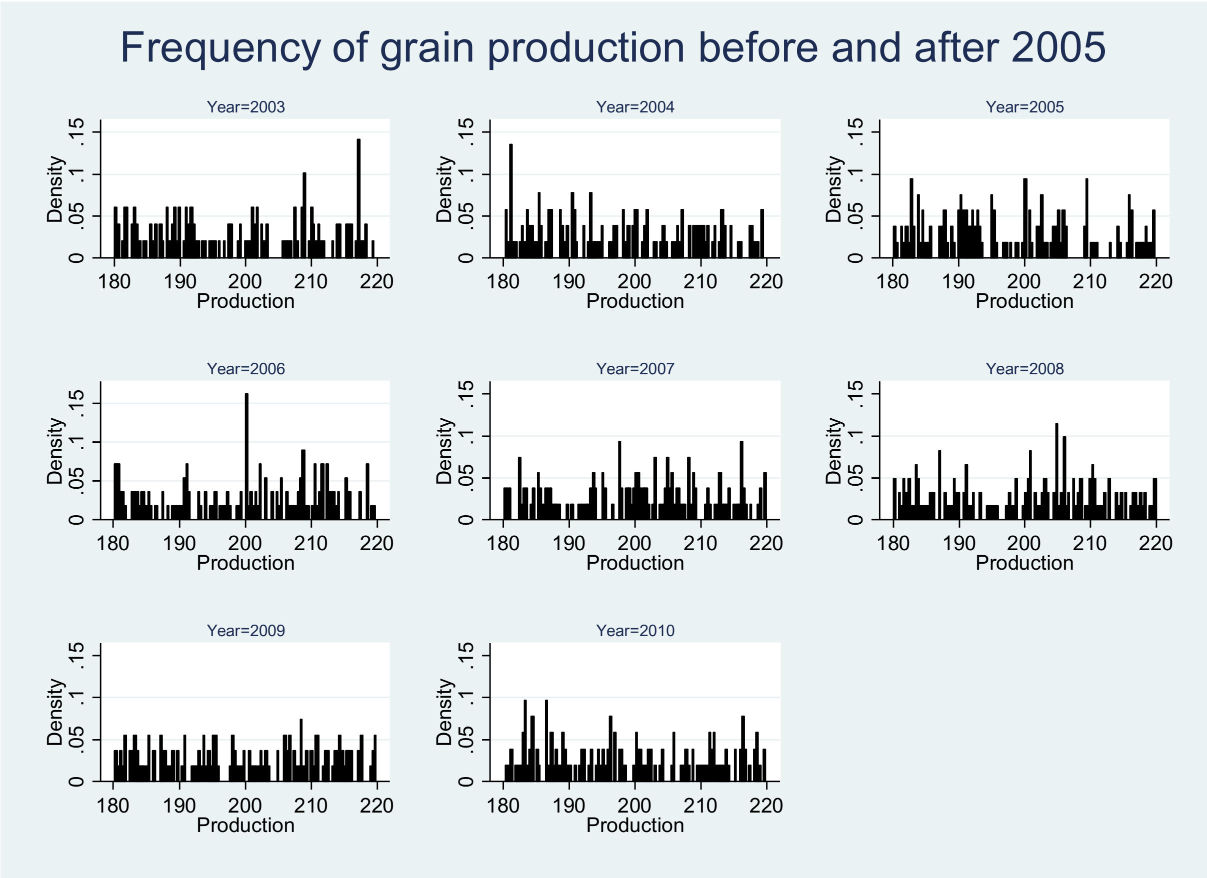

Fig. 2. Frequency of Grain Production before and after 2005.
Note: (1) X-axis denotes grain production; the unit is thousand tons; (2) grain production larger than 220 thousand tons and < 180 tons is not illustrated.

their grain production data just above the cut-off of 200 thousand tons. Therefore, the manipulation of grain production is expected to be monotonic and the McCrary (2008)'s density test is appropriate. The McCrary (2008)'s density test is a Wald test and the null hypothesis is that the discontinuity is zero. It is expected that prospective counties are likely to draw their grain production just above the cut-off of 200 thousand tons. It will result in the right limit to be higher than the left limit.

A caveat to the McCrary (2008)'s density test is that it would not detect the manipulation if all of the counties with grain production slightly below the 200 thousand tons manipulate the data by increasing a fixed number (Ghanem & Zhang, 2014).

5. Empirical results

In order to detect the data manipulation, we will first conduct McCrary (2008)'s density test at different break points and different intervals to confirm the existence of discontinuity at 200 thousand tons. As mentioned above, both manipulation and expanding harvest areas can lead to discontinuity. Based on regression discontinuity model, we will investigate whether the GCSP cause significant increase in grain harvest areas. If the grain harvest area increases insignificantly in 2005, 2006 and 2007, we can partly rule out the possibility that the discontinuity of grain production is caused by harvest area expanding. Therefore, we can attribute the discontinuity of grain production to suggestive evidence consistent with manipulation. In addition, the central government changed the subsidy rules that the subsidy candidates, in principle, remained unchanged after 2008. This change provides us with a chance to conduct a robustness check. We will also conduct McCrary (2008)'s density test for 2008, 2009 and 2010, and our expectation is that there is no evidence of discontinuity in these years.

There are no incentives for counties with true grain production far > 200 thousand tons to over-report their data, only the counties with grain production slightly below 200 thousand tons are likely to manipulate the data. If the data are over-reported by large amounts, the central government may doubt the grain production reported by local governments. Based on this mechanism, this paper will conduct McCrary (2008)'s density test around the cut-off value (200 thousand tons). Three different intervals are defined, and they are grain production between 170 and 230 thousand tons, 180–220 thousand tons, and 190–210 thousand tons. Fig. 3 shows that the grain production has discontinuity at 200 thousand tons in 2005, 2006 and 2008 for the interval of 180–220 thousand tons, but it is continuous for other years.

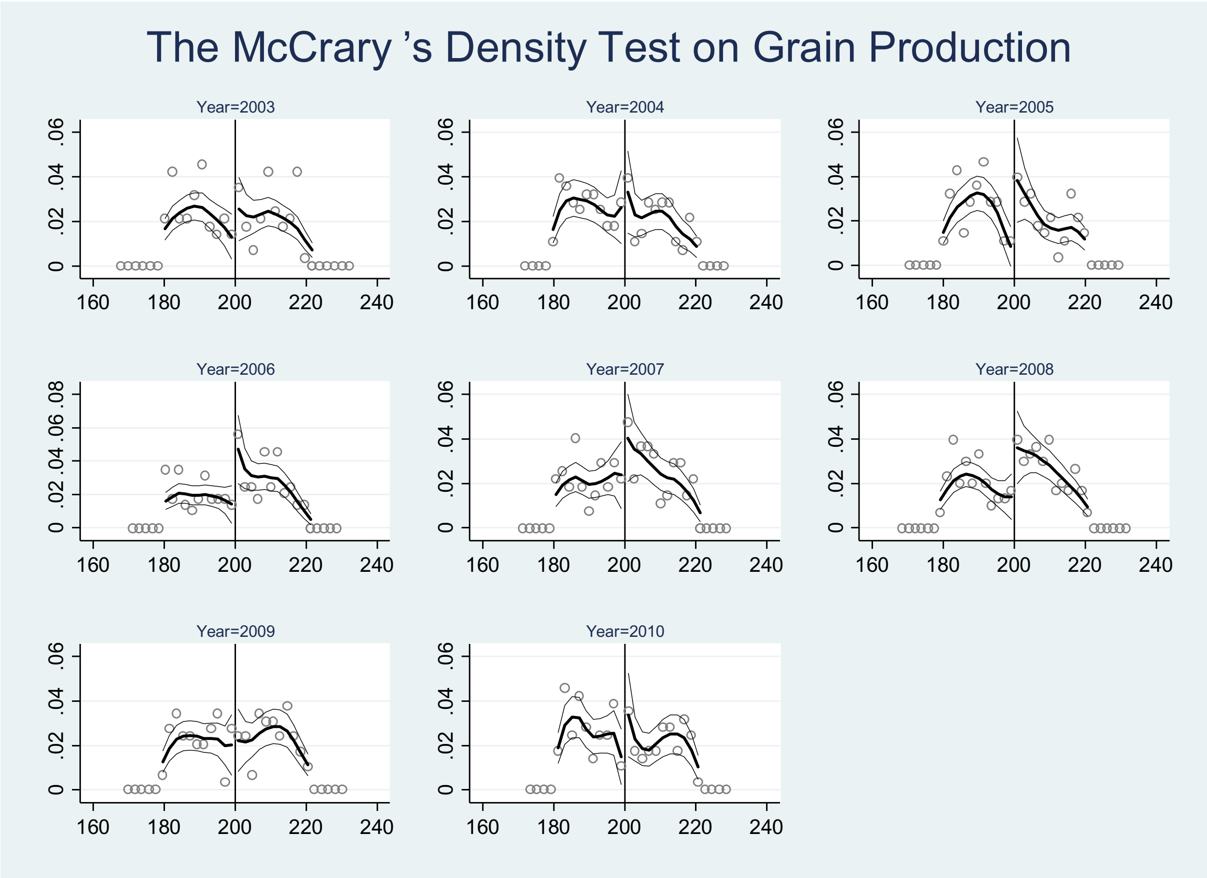

Fig. 3. The McCrary (2008)'s Density Test on Grain Production for 2003–2007.
Note: (1) X-axis denotes grain production; the unit is thousand tons; (2) The McCrary (2008) density test was conducted in the interval of 180–220 thousand tons.

Although the graph is more visual, *t*-statistic is more precise because it is normalized by its variance. This paper uses a 5% critical *t*-statistic to detect data manipulation (Ghanem & Zhang, 2014). We will focus on the behavior of over-reporting the grain production, thus the test is one-side and *t*-statistic is expected to be > 1.66.[8] It is worth emphasizing that a larger *t*-statistic just implies a higher level of confidence to reject the null hypotheses of continuity at cut-off. It does not mean a higher level of manipulation.

Table 1 presents the results of McCrary (2008)'s density test for different intervals. We reported two results for each interval because the estimator is robust to different bin size for a fixed bandwidth if the ratio of bandwidth and bin size is > 10 (Ghanem & Zhang, 2014). The bandwidth and bin size in first row of each interval is from the automatic procedure recommended by McCrary (2008). Bandwidth in third row of each interval is also from the automatic procedure, but the bin size is subjectively adjusted to guarantee the value of $h/b > 10$. The *t*-statistics indicate that the null hypothesis of the discontinuity being zero cannot be rejected at the 5% significance level for all of the intervals and different h/b values before the GCSP being implemented. However, the null hypotheses for all of the intervals excluding the interval of 190–210 are significantly rejected at the 5% significance level when the GCSP introduced in 2005. The results imply that grain production has an evidence of discontinuity at 200 thousand tons. The results in 2006 are similar with the results in 2005, but all of the *t*-statistics become insignificant at the 5% significance level in 2007. This result indicates that the implementation of the GCSP may result in a short term discontinuity on grain production. In addition, we have found that the results are similar for the different h/b values (smaller and > 10). Therefore, in the following test, we will only report the results using the bandwidth and bin size recommended by the automatic procedure.

Based on the results conducted on different intervals, this paper also investigates whether the grain production is continuous at different break points. Table 2 presents the *t*-statistics for the break point at 190, 195, 200, 205 and 210 thousand tons, and the McCrary (2008) density test is conducted in the interval of 180–220 thousand tons. The null hypothesis that the discontinuity is zero at 200 thousand tons in 2005 and 2006 is rejected at 5% significance level. The results are consistent with our expectation and furtherly demonstrate that the grain production has and only has one discontinuity at 200 thousand tons. The empirical results

[8] Due to different intervals, the test has different degree of freedom. For interval of 190–210 thousand tons, the *t*-statistic shall be > 1.66. For interval 180–220 thousand tons, the *t*-statistic shall be > 1.66. For intervals 170–230 thousand tons, the *t*-statistic shall be > 1.65.

Table 1
t-Statistics of McCrary density test for different intervals: break point 200 thousand tons.

Year		2003	2004	2005	2006	2007
170–230 thousand tons	h/b	4.55	5.56	4.90	5.22	4.24
	t-Statistics	1.07	0.76	2.46***	2.36***	0.54
	h/b	22.39	23.28	16.50	15.42	20.42
	t-Statistics	1.23	0.59	2.67***	2.56***	1.09
180–220 thousand tons	h/b	5.60	3.47	4.27	4.48	4.27
	t-Statistics	1.44	0.69	2.21**	2.45***	1.22
	h/b	14.64	11.62	18.17	9.50	14.60
	t-Statistics	0.96	0.60	2.58***	2.55***	1.01
190–210 thousand tons	h/b	1.27	2.12	3.15	2.43	4.65
	t-Statistics	0.46	0.45	1.55	1.89**	0.84
	h/b	9.72	17.91	14.99	13.84	14.78
	t-Statistics	0.06	0.88	1.65	2.44***	1.24

Notes: (1) ***, ** indicate statistically significant at the 1 and 5% for one-side critical *t*-statistic; (2) h denotes bandwidth, and b is bin size. Bandwidth and bin size in first row of each interval are from the automatic procedure suggested by McCrary (2008). Bandwidth in third row of each interval is also from the automatic procedure, but the bin size is subjectively adjusted to guarantee the value of h/b > 10.

Table 2
t-Statistics of McCrary density test for different break points.

Break points	190	195	200	205	210
2003	−0.01	0.90	1.44	0.78	−0.45
2004	0.34	−0.76	0.69	−0.23	0.06
2005	2.24**	0.67	2.21**	−0.21	−1.32
2006	1.86**	−0.13	2.45***	0.69	0.44
2007	−0.14	−0.65	1.22	0.56	−1.29

Notes: (1) ***, ** indicates statistically significant at the 1 and 5% for one-side critical *t*-statistic; (2) Bandwidth and bin size are from the automatic procedure suggested by McCrary (2008); (3) The McCrary (2008) density test was conducted in the interval of 180–220 thousand tons.

provide suggestive evidence consistent with data manipulation at 200 thousand tons in 2005 and 2006. In addition, it is worth noting that the null hypotheses of discontinuity being zero at 190 thousand tons are significantly rejected at 5% significance level in 2005 and 2006. One possible explanation is that data manipulation may occur gradually. The county with grain production smaller than 190 thousand tons may firstly draw their grain production above 190 thousand tons and then draw the data above 200 thousand tons in the next years because small adjustment is difficult to discern.[9]

Based on the results in Tables 1 and 2, we have suggestive evidences that county level grain production has a discontinuity at 200 thousand tons in 2005 and 2006. However, as mentioned above, we cannot simply attribute the discontinuity to the evidence consistent with manipulation. The prospective counties can encourage farmers to expand their harvest areas by replacing low-yield crops with high-yield crops to exceed the grain production threshold, and they know to what extent the grain production should be increased according to the grain yield and grain production of last year. Although it is very difficult to achieve this target precisely, we should take this possibility into consideration. Therefore, we will furtherly investigate whether or not the grain harvest areas of prospective counties increase significantly in 2005 or 2006.

Fortunately, our dataset includes rice, wheat and corn harvest areas which are collected by the third-party. We assume that prospective counties mainly expand their rice, wheat or corn harvest areas to increase their grain production to exceed the threshold because the yield of rice, wheat and maize are higher than that of beans and tubers (NBSC, 2011). Based on regression discontinuity method, this paper will furtherly estimate the impact of the GCSP on rice, wheat and corn harvest areas of prospective counties.

Table 3 presents the results of the regression discontinuity method for rice, wheat and corn harvest areas. The regression discontinuity method is conducted in the interval of 180–220 thousand tons. The estimates are sensitive to the choice of bandwidth. This paper mainly focuses on the results using the default bandwidth of 100, and we will also take the results using the twice bandwidth of 200 as references.

The results show that in 2005, the average corn harvest areas of prospective counties increase significantly, but the average rice harvest areas and the average wheat harvest areas have no significant increase. In 2006, we don't find any significant increase for rice, wheat and corn harvest areas. This result indicates that we cannot rule out the possibility that the discontinuity in 2005 may attribute to corn harvest areas expansion. It is important to note that harvested areas expansion is not necessarily lead to discontinuity. If counties whose grain production increase from slightly below 200 thousand tons in 2004 to moderately above 200 thousand tons in 2005, don't significantly expand their harvest areas at the same time, we may attribute the discontinuity to the suggestive evidence consistent with manipulation.

Furthermore, we calculate the Pearson's correlation coefficient between the proportion of corn harvest areas increase and the proportion of grain production increase in the interval of 180–220 thousand tons by limiting the grain production in the previous

[9] It is also a possible explanation that counties with production below 190 attempted to improve their productivity though failed to pass the threshold due to other uncertainty factors. However, as mentioned before, it is difficult to cause discontinuity by improving productivity.

Table 3
the results of regression discontinuity for grain harvest area.

Variables	Rice harvest area: hectare		Wheat harvest area: hectare		Corn harvest area: hectare	
	2005	2006	2005	2006	2005	2006
Lwald100	6620	NA	NA	NA	7842*	NA
	(4676)				(4165)	
Lwald200	−1847	6590	66.69	497.3	−1826	2564
	(2165)	(4030)	(1078)	(2850)	(1662)	(2306)
Observations	1304	1304	1318	1318	1356	1356

Notes: (1) standard errors in parentheses, *, **, *** indicate statistically significant at the 10%, 5%, and 1%, respectively; (2) Lwald100 means Local Wald Estimator with the bandwidth of 100; (3) 2005 and 2006 mean the cut-off in regression discontinuity model; (4) the regression discontinuity model was conducted in the interval of 180–220 thousand tons; (5) The variation in observations mainly attribute to the different grain planting structure for counties.

Table 4
The Pearson's correlation coefficient across years.

	2005	2006	2007	2008	2009	2010
Rice	0.18	0.24	0.79***	0.40	0.27	0.87***
Wheat	0.37	0.53	0.54**	0.04	−0.19	0.40
Corn	0.34	−0.34	−0.19	0.19	0.34*	0.18

Notes: The Pearson's correlation coefficients are calculated in the interval of 180–220 thousand tons by limiting the grain production in the previous year < 200 thousand tons.

year < 200 thousand tons. Although the corn harvest areas increase significantly in 2005, the Pearson's correlation coefficient reported in Table 4 is 0.34 but not statistically significant. It implies that the prospective counties raise their grain productions above 200 thousand tons but do not simultaneously expand their harvest areas. Thus, the discontinuity in both 2005 and 2006 may be considered as evidence consistent with manipulation. Furthermore, we add some control variables including employment in agriculture, total power of agricultural machinery, agriculture value added, cotton harvest areas and oil harvest areas in the regression discontinuity model. The results are consistent with the results in Table 3 and are reported in Appendix B.

6. Robustness checks

In 2008, the central government changed the subsidy rules that the subsidy candidates, in principle, remained the same as before in 2008. There may be thus a lack of incentive for prospective counties to over-report their grain production. This change provides us with a perfect chance to conduct a robustness check. This paper conducts McCrary (2008)'s density test for 2008, 2009 and 2010 in different intervals and at different break points. Table 5 presents the *t*-statistics for different intervals, and the results show that *t*-statistics in 2008 and 2010 are significant at 5% significance level. In addition, Table 6 shows that all of the *t*-statistics are insignificant at different break points except for 200 thousand tons in 2008 and 2010. The results in Tables 5 and 6 imply that there also exists discontinuity in grain production in 2008 and 2010. Table 7 also shows that the harvest areas experience significant variation in 2008.[10]

As mentioned before, the discontinuities may result from harvest areas expansion. Thus, the Pearson's correlation coefficients are also calculated and presented in Table 4. In 2008, the discontinuity cannot attribute to harvest areas expansion because the grain production and harvest areas don't jump at the same time. On the contrary, the Pearson's correlation coefficient between rice harvest areas and grain production is statistically significant and indicates that the discontinuity in 2010 may result from harvest areas expansion. In addition, Table 7 shows that that the grain harvest areas of prospective counties experience significant increase in 2009 but the distribution of grain production is continuous. This result confirms that the variation in grain harvest areas will not necessarily lead to discontinuity. Based on all of the above results, we may conclude that the grain production discontinuity in 2005, 2006 and 2008 may provide suggestive evidence consistent with data manipulation.

Although the central government states to remain the candidate list constant in principle, it is an uncertain statement and may not totally eliminate the incentive of data manipulation. Moreover, the GCSP announced in 2008 releases two important information: The GCSP is continuous and the evaluating period for subsidy would be updated. This may be one possible explanation for finding suggestive evidence consistent with manipulation in 2008.

7. The proportion of manipulation

The McCrary density test only provides suggestive evidence consistent with manipulation. This paper furtherly quantifies the

[10] We cannot conduct the regression discontinuity model in 2010 because our data ends in 2010.

Table 5

t-Statistics of McCrary density test for different intervals: a robustness check.

Intervals		2008	2009	2010
170–230 thousand tons	h/b	4.59	7.45	6.42
	t-Statistics	1.42	−0.04	0.51
	h/b	16.10	22.34	21.15
	t-Statistics	1.88**	0.08	0.78
180–220 thousand tons	h/b	5.53	4.23	3.02
	t-Statistics	1.74**	0.33	1.80**
	h/b	15.29	14.38	10.11
	t-Statistics	1.59	0.58	1.98**
190–210 thousand tons	h/b	3.07	2.61	NA
	t-Statistics	1.68**	0.56	
	h/b	12.45	14.13	15.96
	t-Statistics	1.54	0.43	1.69**

Notes: (1) ***, ** indicates statistically significant at the 1 and 5% for one-side critical *t*-statistic; (2) h denotes bandwidth, and b is bin size. Bandwidth and bin size in first row of each interval are from the automatic procedure suggested by McCrary (2008). Bandwidth in third row of each interval is also from the automatic procedure, but the bin size is subjectively adjusted to guarantee the value of h/b > 10.

Table 6

t-Statistics of McCrary density test for different break points: a robustness check.

Break points	190	195	200	205	210
2008	−0.04	0.15	1.74**	0.92	1.37
2009	−0.46	−0.30	0.33	1.26	−0.49
2010	−0.62	1.44	1.80**	−0.23	0.60

Notes: (1) ***, ** indicates statistically significant at the 1 and 5% for one-side critical *t*-statistic; (2) Bandwidth and bin size are from the automatic procedure suggested by McCrary (2008); (3) The McCrary (2008) density test was conducted in the interval of 180–220 thousand tons.

Table 7

the results of regression discontinuity for grain harvest area.

Variables	Rice harvest area: hectare		Wheat harvest area: hectare		Corn harvest area: hectare	
	2008	2009	2008	2009	2008	2009
Lwald100	8873	−25,679	−3037**	4676**	−2942**	4039**
	(7971)	(16353)	(1217)	(2173)	(1153)	(1947)
Lwald200	15954**	−13,045	−9671***	4007	−5373***	5839**
	(7462)	(9044)	(1922)	(2470)	(1607)	(2465)
Observations	1443	1443	1457	1457	1495	1495

Notes: (1) standard errors in parentheses, *, **, *** indicate statistically significant at the 10%, 5%, and 1%, respectively; (2) Lwald100 means Local Wald Estimator with the bandwidth of 100; (3) 2008 and 2009 mean the cut-off in regression discontinuity model; (4) the regression discontinuity model was conducted in the interval of 180–220 thousand tons; (5) The variation in observations mainly attribute to the different grain planting structure for counties.

proportion of manipulation following the censored MLE strategy developed by Ghanem, Shen and Zhang (2017). Based on a set of assumptions, the total proportion of grain production manipulation is measured as the Cumulative Distribution Function $F_X(c)$ of observed grain production minus the cdf of true grain production $G(c;\theta)$ at the cut-off of c. The generalized beta distribution of the second kind nesting a wide range of common distributions is used to estimate $G(c;\theta)$. Fig. 4 depicts both the reported and MLE Cumulative Distribution Functions. Based on the results, the manipulation proportions of prospective counties are approximately 3% in 2005, 2% in 2006 and 1.7% in 2008. It is worth noting that the degree of manipulation is small, thus the impact of the GCSP on the policies related to food security is greater than food security itself.

8. The characteristics of manipulator

After confirming the suggestive evidence consistent with manipulation in grain production, we now shed some light on the characteristics of manipulators. First, we classify the counties as mid-western counties and eastern counties according to geographical location,[11] and the results of McCrary (2008) density test in Table 8 suggest evidence consistent with manipulation for mid-western

[11] Eastern provinces (A county from eastern province is defined as eastern county) include Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi and Hainan. And the rest provinces are mid-western provinces.

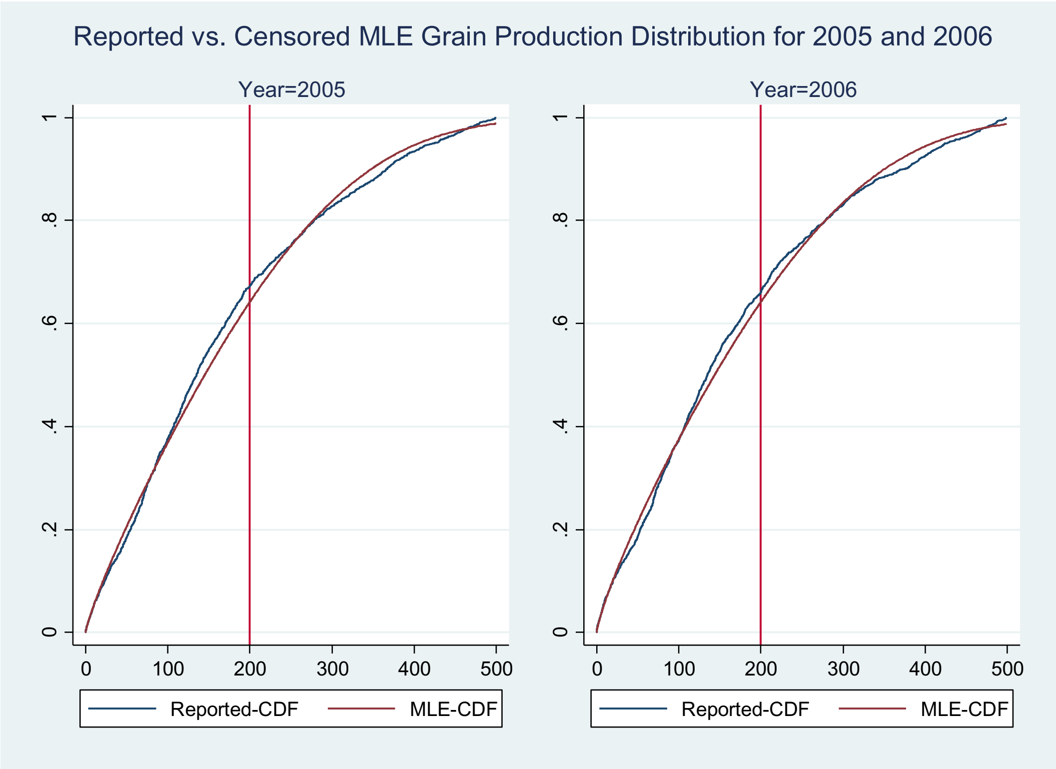

Fig. 4. Reported vs. Censored MLE Grain Production Distribution for 2005 and 2006.
Notes: The MLE-CDF is estimated using the censored MLE procedure. The reference line marks the cut-off for subsidy (200 thousand tons).

counties, but no evidence for eastern counties. Second, we classify the counties as the major grain production regions and non-major grain production regions.[12] Based on the results in Table 8, we find suggestive evidence consistent with manipulation for the major grain production regions, but no evidence for non-major grain production regions. Last but not least, according to the criterion set by World Bank, we classify the counties with GDP per capital less than USD906 as low income counties and the others as middle and high income counties.[13] The *t*-statistics indicate that the null hypothesis is rejected at 5% significance level for all counties regardless of income. Therefore, we can conclude that there is more incentive for mid-western counties in the major grain production regions to manipulate grain production data.

9. Conclusions

Manipulation of food production data could lead to catastrophic social and economic consequences, as many policies are made based on the data in modern society. The data manipulation of local officials could be driven by better performance reviews and promotion. The fiscal system in China also plays important rules for local governmental data manipulation. In this context, we propose two research questions. First, whether the GCSP causes the prospective county to manipulate the grain production data to get subsidy? Second, which counties are likely to manipulate data?

Based on McCrary (2008)'s density test, we have suggestive evidences that county level grain production has a discontinuity at 200 thousand tons in 2005, 2006, 2008 and 2010. Furthermore, we use the regression discontinuity method and the Pearson's correlation coefficient to rule out the possibility that the grain harvest area expanding contributes to the grain production discontinuity. Finally, we consider the grain production discontinuity as suggestive evidence consistent with data manipulation in 2005, 2006 and 2008. The proportion of manipulation is also quantified to be approximately 3% in 2005, 2% in 2006 and 1.7% in 2008. In addition, we found that suggestive evidence consistent with manipulation is more likely to occur in the major grain production regions and mid-western counties.

Developing and implementing a food policy program is complex. The externalities from a program are hard to envision in the beginning. Our current study clearly shows that the fiscal distribution rules of a central government should avoid data manipulation

[12] China has thirteen major grain producing provinces, including Hebei, Henan, Heilongjiang, Jilin, Liaoning, Hubei, Hunan, Jiangsu, Inner Mongolia, Shandong, Sichuan, and Anhui.

[13] China is a developing country. GDP per capital of most of counties are less than USD 906. Therefore, we only classify the counties as two groups. In addition, we only have the data of GDP and population, thus we use GDP instead of GNI.

Table 8
t-Statistics of McCrary density test for different characteristics.

Characteristics		*t*-Statistics
Regions	Central and western regions	3.010***
	Eastern regions	1.512
Major grain production region or not	Non-major grain production region	1.586
	Major grain production region	2.366***
Income	Low income	2.238**
	Middle and high income	1.890**

Note: (1) ***, ** indicates statistically significant at the 1 and 5% for one-side critical *t*-statistic; (2) Bandwidth and bin size are from the automatic procedure suggested by McCrary (2008); (3) The McCrary (2008) density test was conducted in the interval of 180–220 thousand tons for both 2005 and 2006.

incentives in local governments, particularly should cut the linkage to the data which are self-reported by the local governments. Fortunately, Chinese central government realized the shortcoming of the program and could quickly take measures to correct the problems. The implied policy implication is that we need to make policy program flexible and adaptable and could be corrected quickly to avoid further damage.

Cautions should be warranted in interpreting the results concluded in this paper. First, the empirical results are suggestive. We have no enough evidence to completely rule out the discontinuity caused by replacing low productivity grains with high ones. This is because that adjusting grain planting structure with small magnitude might result in grain production discontinuity at 200 thousand tons but not necessarily lead to significantly increase in harvest areas. Second, the McCrary (2008)'s density test has limitation. If all of counties with grain production slightly below 200 thousand tons manipulate the data by increasing a fixed number, we cannot detect the manipulation by using this method.

Declaration of Competing Interest

None.

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Appendix A

A.1. The number and proportion of counties with grain production above and below the threshold

Year	Total number	< 200 thousand tons		160–240 thousand tons		> 200 thousand tons		200–240 thousand tons	
		Number	proportion	Number	proportion	Number	proportion	Number	proportion
2000	2045	1224	59.9	72	3.5	821	40.1	80	3.9
2001	1966	1210	61.5	77	3.9	756	38.5	75	3.8
2002	2045	1286	62.9	84	4.1	759	37.1	82	4.0
2003	2046	1345	65.7	71	3.5	701	34.3	66	3.2
2004	2042	1245	61.0	82	4.0	797	39.0	63	3.1
2005	2041	1220	59.8	81	4.0	821	40.2	66	3.2
2006	1960	1146	58.5	65	3.3	814	41.5	89	4.5
2007	2043	1185	58.0	67	3.3	858	42.0	81	4.0
2008	2040	1157	56.7	74	3.6	883	43.3	94	4.6
2009	2037	1141	56.0	73	3.6	896	44.0	77	3.8
2010	2041	1125	55.1	77	3.8	916	44.9	67	3.3

Appendix B

B.1. The results of regression discontinuity for grain harvest area with some control variables

Variables	Rice harvest area: hectare		Wheat harvest area: hectare		Corn harvest area: hectare	
	2005	2006	2005	2006	2005	2006
Lwald100	13500**	NA	NA	NA	8994*	NA
	(6300)				(5381)	
Lwald200	438.3	5139	−603.0	2040	−3228*	4551
	(2474)	(3397)	(1286)	(3360)	(1908)	(2834)
Observations	1304	1304	1318	1318	1356	1356

Notes: (1) standard errors in parentheses, *, **, *** indicate statistically significant at the 10%, 5%, and 1%, respectively; (2) Lwald100 means Local Wald Estimator with the bandwidth of 100; (3) 2005 and 2006 mean the cut-off in regression discontinuity model; (4) the control variables include employment in agriculture, total power of agricultural machinery, agriculture value added, cotton harvest area and oil harvest area; (5) the regression discontinuity model was conducted in the interval of 180–220 thousand tons; (6) The variation in observations mainly attribute to the different grain planting structure for counties.

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