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Impact of Grain Subsidy Reform on the Land Use of Smallholder Farms: Evidence from Huang-Huai-Hai Plain in China

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Abstract: Smallholder farms have played an essential role in agricultural production and food security. In order to increase farm size, the Chinese government announced a reform of the grain subsidy program in 2015. Under the reform, 20% of the aggregate input subsidy, as well as the pilot subsidy to large-scale farmers and the incremental part of the agricultural support and protection subsidy budget, were used to support increasing farm size. This study evaluated the impact of China's grain subsidy reform on the land use of smallholder farms to investigate whether the reform achieved its goal. Based on 2063 samples obtained from the 2013–2015 Survey for Agriculture and Village Economy data in Huang-Huai-Hai Plain, we conducted a difference-in-difference model to solve the problem of missing counterfactual states in policy evaluation. Farms from Henan and Shandong were assigned to the treatment group, and farms from Hebei were assigned to the control group. The results revealed that the average treatment effect on the treated of the impact of the grain subsidy reform on the wheat-sown area was −25% (0.10 ha). Furthermore, there was heterogeneity in regard to the subsidy reform effects in different sown-area groups. The reform had the most significant impact on the smallest farmers. We also found that China's grain subsidy reform had a significant and positive effect on the amount of outflow land area, while the impact of subsidy reform on land tenure was insignificant. Our findings suggest that while encouraging large-scale farms, it is necessary to take into account farmers' small-scale operations and gradually promote the transformation of small-scale operations to large-scale operations. The Chinese government should strengthen the supervision of land use to achieve the goal of ensuring food security.

Keywords: agriculture subsidy program; land use; farm size; difference-in-difference

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1. Introduction

Food security is the 2nd Sustainable Development Goal (SDG2) and a key objective of the Chinese agricultural policy [1,2]. Smallholder farms have played an essential role in agricultural production and food security, especially in Asian countries [3–5]. In China, the average farm size is only 0.52 ha, and nearly 98% of farms are smaller than 2 ha [3,6]. Recently, several efforts have been undertaken by the Chinese government to encourage the farms to expand to increase farm output efficiency, reduce production costs, and reduce the use of agricultural chemicals [7–11].

Previous studies have shown that subsidy programs, e.g., direct payments, are efficient tools to achieve policy goals [12–15]. Since the commencement of the country's first grain subsidy program in 2004, China's grain output has increased dramatically, reaching 663.84 million tons in 2019, with an annual growth rate of 2.3% [16]. Meanwhile, China's Producer Support Estimate (PSE) has increased from 170.9 billion CNY in 2004 to 1.4 trillion CNY in 2016 [17].

China launched its grain subsidy program in 2004 to increase grain production and farmers' incomes [18–20]. The program consisted of direct grain subsidy, quality seed subsidy, and machinery subsidy [18,21,22]. Later in 2006, the aggregate input subsidy was introduced to the grain subsidy program when fertilizer and fuel prices rose rapidly [18,19,21,23]. The direct grain subsidy, the quality seed subsidy, and the aggregate input subsidy (also known as the "three subsidies") were wired to farmers' bank accounts mainly based on the grain-sown areas [21,23]. This machinery subsidy was only available to those who purchased medium or large machines, and approximately 30–50% of the subsidy value was deducted from the cost of these machines [23]. The subsidy amount was 1425 CNY/ha in 2012, and an average Chinese farm could only receive 741 CNY/ha, about 6.7% of its annual income [23].

In 2015, the Ministry of Finance (MOF) and the Ministry of Agriculture (MOA) announced a reform of the grain subsidy program through combining the direct grain subsidy, the quality seed subsidy, and the aggregate input subsidy into an "agricultural support and protection subsidy". To actively and steadily promote the grain subsidy reform, the MOF and MOA selected Anhui, Shandong, Hunan, Sichuan, and Zhejiang as the reform pilot provinces in 2015 [24]. The Henan province, however, also reformed the grain subsidy based on the announcement issued by the MOF and MOA in 2015 [25]. Then, the reform has been implemented nationwide since 2016. The reform aims were set to improve the accuracy of subsidy, strengthen the protection of arable land, and increase farm size [24]. Furthermore, the agricultural support and protection subsidy is still a planted-area-based subsidy based on hectares planted to grain [26]. In particular, Shandong Province, one of the pilot provinces, addressed that the subsidy would be paid according to the area of wheat sown [27].

Under the reform, 20% of the aggregate input subsidy, as well as the pilot subsidy to large-scale farmers and the incremental part of the agricultural support and protection subsidy budget, were used to support increasing farm size. Furthermore, the subsidy targets included large-scale farms, large-scale family farms, farmer cooperatives, and agricultural socialization service organizations. The government also announced a slogan; whoever has a higher grain production would receive priority support of subsidy fund. Additionally, 80% of the aggregate input subsidy, as well as the direct grain subsidy and the quality seed subsidy were used to protect arable land and increase land productivity. In 2016, the total amount of "agricultural support and protection subsidy" reached 144.2 billion CNY, including 23.8 billion CNY to increase farm size [28].

Moreover, as designed by the policymakers, smallholder farms would receive fewer subsidies, while subsidy amounts for large-scale and cooperative farming would increase. Consequently, the reform may have two opposing impact pathways. Firstly, smallholder farms would increase their farm size to receive more subsidies. Secondly, smallholders might transfer their lands to large-scale farmers or cooperatives so as to decrease or terminate their grain production.

Previous studies on the China's grain subsidy effects mainly focused on production [29–32], migration [33,34], effectiveness [26,35], and welfare [18,29,32,36]. Some studies also shed light on the relationship between China's agricultural subsidy and land use. For instance, Yi et al. (2015) concluded that the grain subsidy program had a positive effect on grain-sown areas [23]. Zou et al. (2020) found that the grain subsidy had a significant and positive effect on both leasing out and leasing in farmland in rural China [37]. Guo et al. (2021) concluded that an increase in soybean producer subsidy would encourage farmers to allocate more land for soybean planting [38]. Additionally, since grain subsidies might increase land tenure [39], the grain subsidies were paid mostly to the land contractor instead of the operator [31,37], and farm size was found to have a significantly negative effect on land tenure [39]. Huang et al. (2011) demonstrated that the grain subsidy policy did not affect their grain production decisions [31]. However, to our knowledge, previous studies have rarely empirically explored whether China's grain subsidy reform achieved its goal to increase farm size. This study contributes to the literature by providing evidence on the relationship between the subsidy reform and the land use of smallholder farms and reveals the impact pathways of the reform. Our results also have important policy implications to further improve China's grain subsidy programs.

The main challenge in empirically evaluating policy impacts is to determine how to address missing counterfactual states, because we observe what happens to them with treatment, but we cannot observe what would have happened without treatment [40]. In practice, propensity score matching (PSM) [41–43], regression discontinuity designs (RDD) [44,45], and difference-in-difference (DID) [46–51] are the most common approaches used for counterfactual analysis. However, PSM is mainly used to correct selection bias [41], and RDD can be applied when policy leads to the cut-off for key explanatory variables [45]. In this study, since the subsidy reform was exogenously issued by the government and covered each farm in the pilot provinces, selection bias would not occur, and the reform would not bring any cut-offs. We thus adopted the DID approach to evaluate the impacts of China's grain subsidy reform on the land use of smallholder farms, the heterogeneity across different farm-size groups, and the potential impact pathways of the reform.

2. Materials and Methods

2.1. Study Area

Huang-Huai-Hai Plain is one of the most productive grain belts, especially winter wheat growing areas in China (Figure 1) [52,53]. In 2019, Huang-Huai-Hai Plain produced 23.8% of China's grain and 58.1% of China's wheat [16]. Furthermore, two pilot provinces implemented a subsidy reform in 2015, i.e., Shandong and Henan, located at the Huang-Huai-Hai Plain. To evaluate the impact of China's grain subsidy reform, farms should be assigned either to the treatment group or to the control group. First, farms from Henan and Shandong were subjected to the reform, and were therefore assigned to the treatment group. Second, we selected the farms in the Hebei Province as the control group since the province lies on the Huang-Huai-Hai Plain, but has not reformed the grain subsidy until 2016.

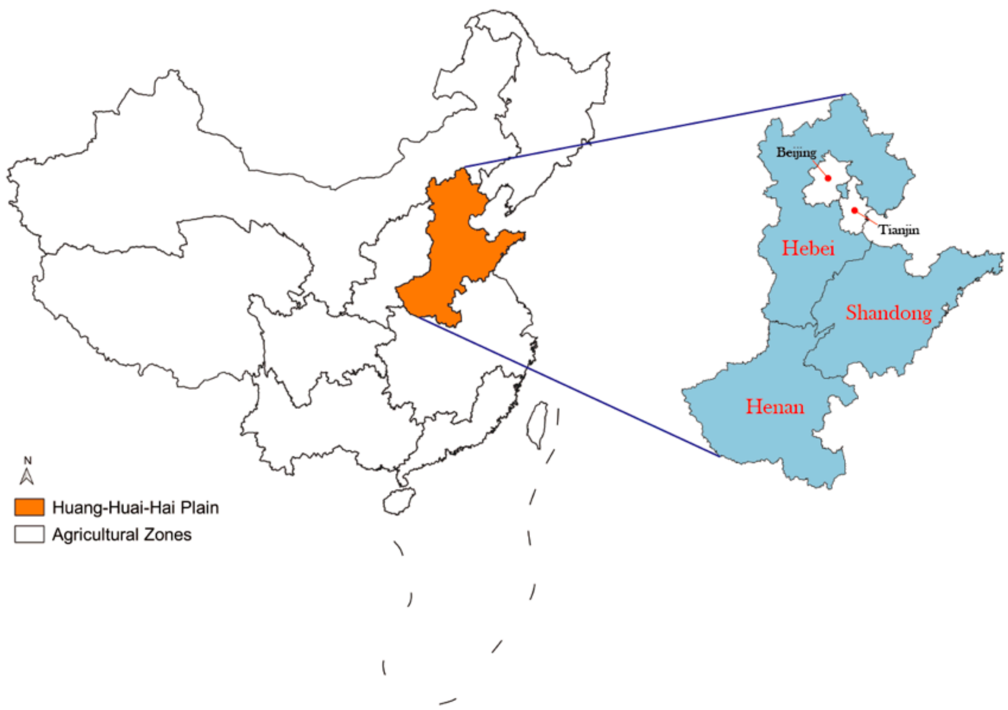

Figure 1. The geographical location of the study areas.

2.2. *Experimental Design*

2.2.1. Empirical Method

This study employs a difference-in-difference (DID) approach to evaluate the impacts of China's grain subsidy reform on the land use of smallholder farms. As shown in Figure 2, the first difference is the difference between post- and pre-treatment in the treatment group $(A2 - A1)$, and the second difference is the difference between post- and pre-treatment in the control group $(B2 - B1)$. The impact of treatment on the outcome of interest is $(A2 - A1) - (B2 - B1)$.

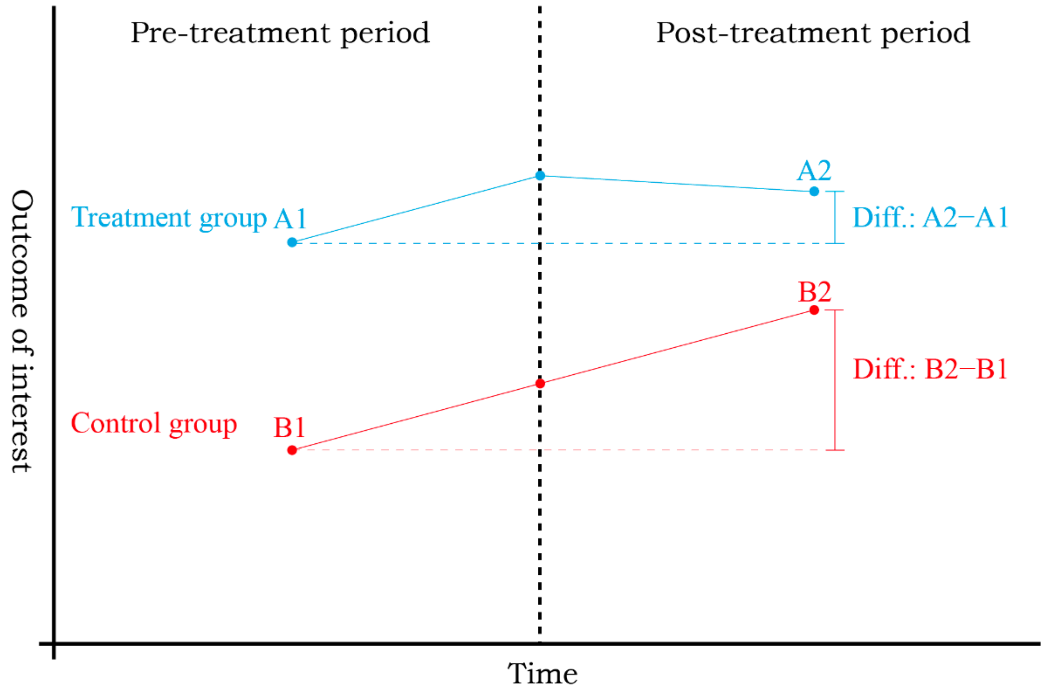

Figure 2. Conceptual illustration of the DID approach.

Let Y_{it} be the outcome of interest for farm i at time t. The naive difference-in-differences estimator is described as the following regression:

$$y_{it} = \alpha + \beta(D_i \times T_t) + \gamma D_i + \delta T_t + \varepsilon_{it} \quad (1)$$

where D_i is an indicator variable equal to 1 if farm i has been exposed to the treatment (e.g., policy reform) and 0 otherwise; T_t is a time-specific component; $t = 0$ if the population is observed in a pre-treatment period, and $t = 1$ in a post-treatment period; α is a constant; β captures the average treatment effect on the treated (ATET), which is $(A2 - A1) - (B2 - B1)$ in Figure 2 and the focus of policy evaluation; γ and δ are other parameters to be estimated; ε_{it} represents the random error item. Therefore, the DID procedure removed a large degree of the potential for biases attributable to unobservable heterogeneity and omitted variables [46,54].

In our study, the outcome variable is the wheat-sown areas (WA_{it}) due to the following two reasons. First, the subsidy was allocated based on the wheat-sown areas in the Shandong province [27], which indicated that farms could receive more subsidies if they enlarged their wheat-sown areas. Second, since the reform announcement was issued in May 2015 by the central government, in June 2015 by the Shandong province, and in August 2015 by the Henan province, respectively, only winter crops (i.e., winter wheat in the Huang-Huai-Hai Plain) could be affected by the reform [24,25,27]. Further, we used the logarithm form of wheat-sown areas to obtain the percentage changes in wheat-sown areas. Additionally, since the subsidy reform was piloted in 2015 and implemented nationwide in 2016, we denoted $t = 0$ if $T < 2015$, and $t = 1$ if $T = 2015$. We also added a group of control variables (x_{itj}) that affect wheat-sown area to Equation (1). Based on the previous literature, the x_{itj} include labor and tractor input, land tenure, and individual characteristics of the household heads (HHs), such as the age, years of education, and agricultural training. Thus, Equation (1) can be revealed as the following:

$$\ln WA_{it} = \alpha + \beta(D_i \times T_t) + \gamma D_i + \delta T_t + \Sigma_{j=1}^{n} \gamma_j x_{itj} + \varepsilon_{it} \quad (2)$$

where n is the number of the control variables and γ_j are the parameters to be estimated. One of the main assumptions to estimate the DID model is parallel trends [55]. Under the parallel trends assumption, trends in outcomes between the treatment and control groups are the same prior to the implementation of the subsidy reform [46].

2.2.2. Data Collection

Data used in this study were obtained from the 2013–2015 Survey for Agriculture and Village Economy (SAVE), which is an annual rural household survey conducted by the Institute of Agricultural Economics and Development (IAED), the Chinese Academy of Agricultural Sciences (CAAS) [43]. We select an unbalanced panel sample from 93 villages in 9 counties in Hebei (the counties of Pingshan, Luannan, and Qiu), Shandong (the counties of Qixia, Shouguang, and Gaotang), and Henan (the counties of Fan, Xuchang, and Queshan) provinces (Figure 3).

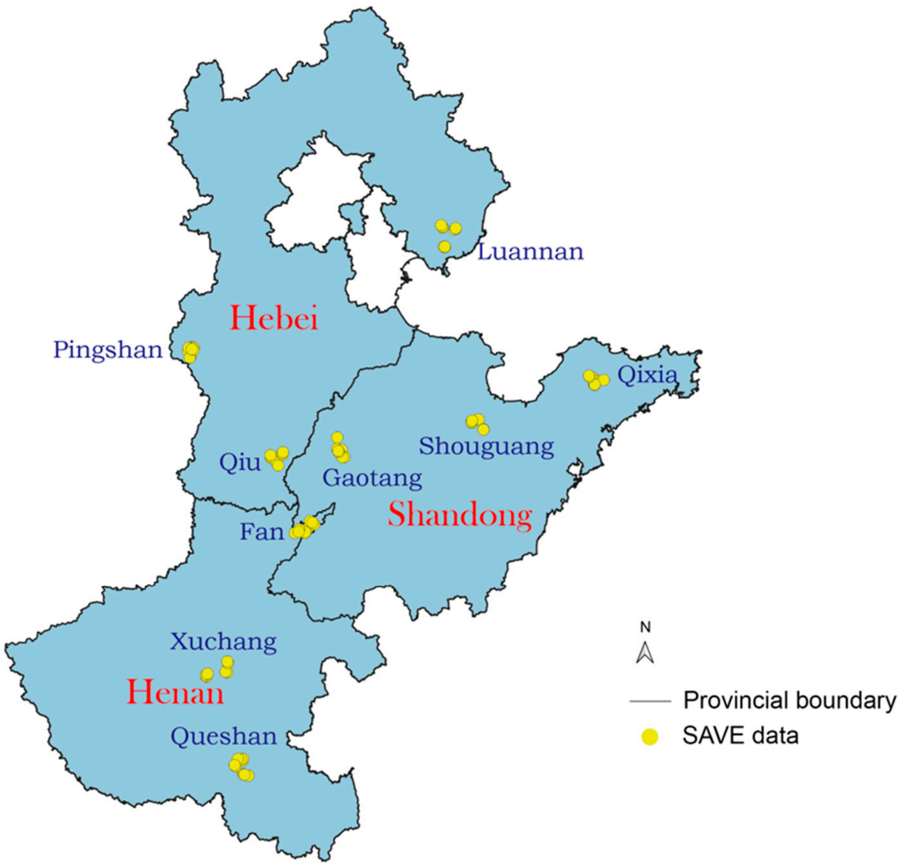

Figure 3. The geographical location of the samples.

Before estimation, the data were processed as follows. (1) The variables related to price were processed using the national Consumer Price Index (CPI, 2012 = 100) to eliminate the effect of inflation. (2) Only farms with a wheat-sown area greater than 0 and less than 2 ha (the threshold of smallholder farm) were kept. (3) To reflect the opportunity cost of land transfer, missing values for land tenure were replaced with the provincial median in the same year. (4) To exclude the effect of machinery subsidy, the households that purchased agricultural machinery in the survey year were removed. After data processing, 2063 valid samples were retained, and 1550 were treated (Table A1).

3. Results

3.1. Descriptive Analysis

As shown in Table 1, the average wheat-sown area in the sample regions was only 0.39 ha. The average subsidy farmer received and land tenure were 1847.28 CNY/ha and 2742.87 CNY/ha, respectively. Further, since labor is still essential in China's wheat production, the average labor input reached 71.38 days/ha, while only 34% of farms own at least one tractor. In terms of individual characteristics of the household heads (HHs), most wheat farmers were aged, less-educated, and none-trained. The average age reached 52.51, while the average years of education of wheat farmers were only 7.83. Lastly, only 34% of wheat farmers in the survey received agricultural training.

Table 1. Summary statistics of variables.

Variable	Mean	SD	MAX	MIN
Panel A: All farms				
WA: Wheat-sown area (ha)	0.39	0.24	2.00	0.03
SUB: Subsidy (CNY/ha)	1847.28	517.47	4425.00	719.82
LAND: Land tenure (CNY/ha)	2742.87	313.97	7037.30	718.09
LB: Labor input (Days/ha)	71.38	45.25	242.92	18.75
TRAC: Tractor ownership (1 = Y, 0 = N)	0.37	0.48	1.00	0.00
AGE: Age of HH	52.51	10.62	88.00	19.00
EDU: Education of HH (Years)	7.83	2.61	16.00	0.00
AGT: Agricultural training (1 = Y, 0 = N)	0.34	0.47	1.00	0.00
Number of observations (N)	2063			
Panel B: Farms in the treatment group (Henan and Shandong)				
WA: Wheat-sown area (ha)	0.40	0.25	2.00	0.03
SUB: Subsidy (CNY/ha)	1795.73	413.67	4125.00	720.00
LAND: Land tenure (CNY/ha)	2731.28	319.26	7037.30	718.09
LB: Labor input (Days/ha)	73.23	48.71	242.92	18.75
TRAC: Tractor ownership (1 = Y, 0 = N)	0.33	0.47	1.00	0.00
AGE: Age of HH	52.93	10.41	88.00	19.00
EDU: Education of HH (Years)	7.71	2.80	16.00	0.00
AGT: Agricultural training (1 = Y, 0 = N)	0.32	0.47	1.00	0.00
Number of observations (N)	1550			
Panel C: Farms in the control group (Hebei)				
WA: Wheat-sown area (ha)	0.34	0.20	1.67	0.04
SUB: Subsidy (CNY/ha)	2003.02	726.87	4425.00	719.82
LAND: Land tenure (CNY/ha)	2777.87	294.95	5654.27	807.75
LB: Labor input (Days/ha)	65.79	32.02	240.00	18.75
TRAC: Tractor ownership (1 = Y, 0 = N)	0.48	0.50	1.00	0.00
AGE: Age of HH	51.26	11.15	79.00	25.00
EDU: Education of HH (Years)	8.19	1.90	12.00	0.00
AGT: Agricultural training (1 = Y, 0 = N)	0.40	0.49	1.00	0.00
Number of observations (N)	513			

Compared with the control group, farms in the treatment group had significant characteristics (Table 2). First, the wheat-sown area of farms in the treatment group was 0.07 ha (or 19.5%) larger than that of the farms in the control group. Second, subsidy and land tenure per area in the treatment group were 207.29 CNY/ha (or 10.3%) and 46.59 CNY/ha (or 1.7%) less of that of the control group, respectively. Third, farms in the treatment group tended to input more labor other than buy tractors. Fourth, HHs in the treatment group were significantly older than those of the control group, while the education level and agricultural training participation of HHs was significantly less than those of the control group.

Table 2. Differences of variables between the treatment and control groups.

Variable	Diff. in Means $\text{Mean}_T - \text{Mean}_C$	Diff.% $(\text{Mean}_T - \text{Mean}_C)/\text{Mean}_T$
WA: Wheat-sown area (ha)	0.07 *	19.4%
SUB: Subsidy (CNY/ha)	−207.29 *	−10.3%
LAND: Land tenure (CNY/ha)	−46.59 *	−1.7%
LB: Labor input (Days/ha)	7.44 *	11.3%
TRAC: Tractor ownership (1 = Y, 0 = N)	−0.15 *	−31.3%
AGE: Age of HH	1.67 *	3.3%
EDU: Education of HH (Years)	−0.48 *	−5.9%
AGT: Agricultural training (1 = Y, 0 = N)	−0.08 *	−20.0%

Notes: Mean_T and Mean_C indicates means in the treatment group and control group, respectively; * $p < 0.05$ based on the *t* test.

After the subsidy reform (Table 3), wheat farms did not significantly change their wheat-sown area, although the subsidy was 62.96 CNY/ha (or 3.3%) less than before, and the land tenure per area was 343.95 CNY/ha (or 13.1%) more than before. Furthermore, compared with the pre-treatment group, farms significantly decreased their labor input but increased their machine input in wheat production.

Table 3. Differences of variables between the pre- and post-treatment groups.

Variable	Diff. in Means $\text{Mean}_{Pt} - \text{Mean}_{Pr}$	Diff.% $(\text{Mean}_{Pt} - \text{Mean}_{Pr})/\text{Mean}_{Pr}$
WA: Wheat-sown area (ha)	0.06	15.8%
SUB: Subsidy (CNY/ha)	−62.96 *	−3.3%
LAND: Land tenure (CNY/ha)	343.95 *	13.1%
LB: Labor input (Days/ha)	−12.86 *	−17.0%
TRAC: Tractor ownership (1 = Y, 0 = N)	0.02 *	5.6%
AGE: Age of HH	0.69	1.3%
EDU: Education of HH (Years)	0.08	1.0
AGT: Agricultural training (1 = Y, 0 = N)	−0.11	−29.2

Notes: Mean_{Pt} and Mean_{Pr} indicates means in the post- and pre-treatment groups, respectively; * $p < 0.05$ based on the *t* test.

3.2. DID Results

We empirically analyzed the impact of the grain subsidy reform on the wheat-sown area based on a DID approach. Since the samples are clustered (Figure 3), we applied a clustered ordinary least squares (OLS) estimation strategy to obtaining robust variance estimates. Based on Equations (1) and (2), we added the control variables step by step and arranged the estimation results in Table 4.

The most important finding of our results is that China's grain subsidy reform significantly, but negatively, affects smallholder farms' wheat-sown area in the Huang-Huai-Hai Plain. Controlling the characteristic variables (columns 3 (DID3) in Table 4), the ATET of the impact of the grain subsidy reform on the wheat-sown area was −25%. It indicates that after the grain subsidy reform, a smallholder farm would reduce 25% (0.10 ha) of its wheat-sown area. Further, it is not a surprise that labor input negatively affects the wheat-sown area, while tractor ownership positively affects the wheat-sown area. The relationship between the age of HHs and wheat-sown area shows an inverse "U-shape", while there is a "U-shape" relationship between the education level of HHs and wheat-sown area. Agricultural training, however, had no significant effect on the wheat-sown area.

Table 4. Estimation results of the DID models.

Variable	DID1 (1)	DID2 (2)	DID3 (3)
Dependent variable: lnWA			
$D_i \times T_t$	−0.16 * (0.08)	−0.26 ** (0.08)	−0.25 ** (0.08)
D_i	0.22 (0.12)	0.29 ** (0.09)	0.28 ** (0.08)
T_t	0.15 * (0.07)	0.15 * (0.06)	0.16 * (0.06)
lnWA		−0.31 *** (0.05)	−0.30 *** (0.05)
$TRAC$		0.24 *** (0.06)	0.22 ** (0.06)
AGE			0.03 * (0.01)
AGE^2			−0.00 ** (0.00)
EDU			−0.06 * (0.02)
EDU^2			0.00 ** (0.00)
AGT			0.08 (0.06)
Constant term	1.42 *** (0.09)	1.73 *** (0.12)	1.13 *** (0.29)
N	2063	2063	2063

Notes: Cluster robust (town level) standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

3.3. Parallel Trends Test

The time trend graph of the averages of the logarithmic values for the wheat-sown area is shown in Figure 4. In the 2013–2014 period, the trends for the treatment group and control group were essentially consistent in terms of the average logarithmic values for the wheat-sown area, exhibiting an upward trend. However, in the 2014–2015 period, the two groups showed different trends. The wheat-sown area for the treatment group showed a downward trend, which was consistent with the model estimation results, while the wheat-sown area for the control group showed an upward trend. The above analysis indicates that the model passed the parallel trend test.

3.4. Robustness Test

We first tested the robustness of the model estimation results by varying the control variables; the results are shown in Table 4. In columns 1 (DID1), we focus on the naive difference-in-differences estimators following Equation (1). Then, as shown in columns 2 (DID2), we added input variables (i.e., labor and tractor) to the naive model. Finally, we added all of the control variables. The results show that the coefficients of $D_i \times T_t$ are significant and the values are similar in all of the three models, indicating that the estimated results of this study have strong robustness.

Second, although the DID approach can eliminate geographical factors that do not change over time, our study area is too wide to control the time-variant geographical factors such as precipitation and drought. Thus, we narrowed the samples to three neighboring counties, Gaotang, Fan, and Qiu (Figure 3). The DID estimation results (columns 1 (DID4) in Table A2) suggest that the ATET of the impact of the grain subsidy reform on the wheat-sown area in the three neighboring counties is −28%, whose absolute value is three percentage points larger than the absolute value of the ATET in columns 3 (DID3) in Table 4. The results also support the robustness of our study.

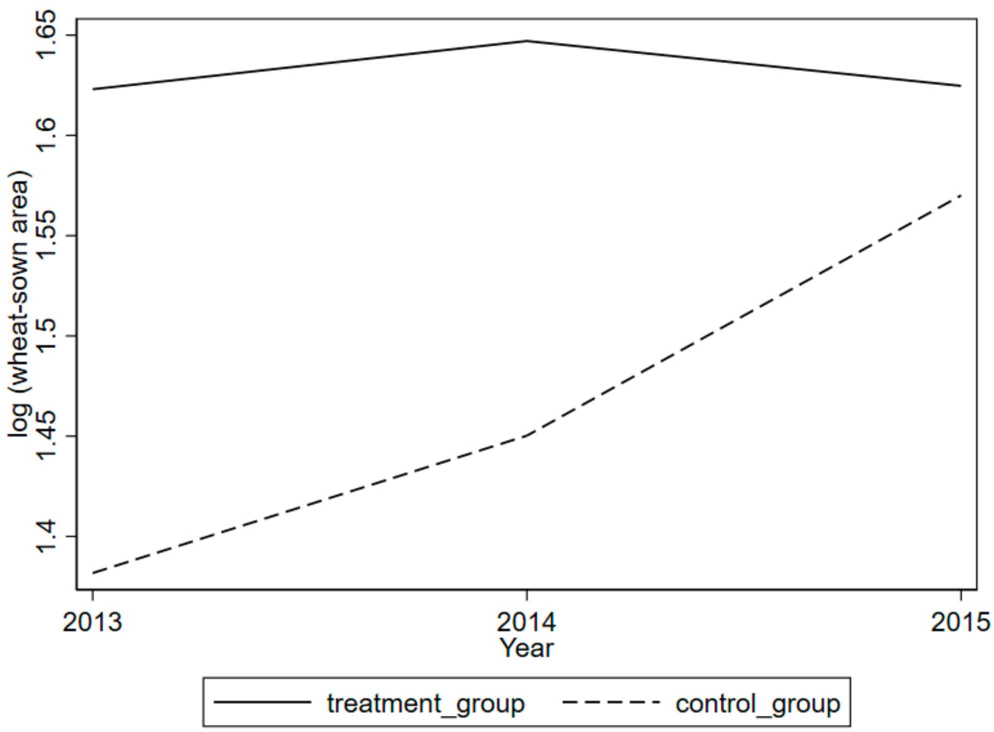

Figure 4. Result of parallel trends test.

Third, we compared our DID estimation results with the OLS model and fixed effects (FE) model using a dummy variable for the year 2015 (T_t in the DID model) as the proxy of reform. The dependent variable and control variables are the same as the DID model. The results listed in columns 2 (OLS) and columns 3 (FE) in Table A2 show that the coefficients of T_t are not significant. Considering the influence of unobserved factors that may lead to the endogeneity problem, the results of the OLS model and FE model are biased and unreliable.

3.5. Heterogeneity Effect

To further examine the heterogeneous effect of the subsidy reform on the wheat-sown area of farmers, we divided the wheat-sown area into three categories based on wheat-sown area 33%, 66%, and 100% percentiles. The threshold was 0.27 ha and 0.40 ha, respectively. Thus, the three categories were (1) Cat1: $0 < WA < 0.27$; (2) Cat2: $0.27 \leq WA < 0.40$; and (3) Cat3: $0.40 \leq WA \leq 2$ (the unit of WA is ha). The DID estimation results for the three wheat-sown area categories are shown in Table 5.

The results suggest that the subsidy reform had a significantly negative effect on farmers in Cat1 and Cat2, but no significant impact on those in Cat3. Specifically, the ATET of subsidy reform on farms in Cat1 and Cat2 was −9% and −4%, respectively. The results indicate that the effect of China's grain subsidy reform decreases as the wheat-sown area increases.

Table 5. Estimation results of the DID models for different wheat-sown area categories.

Variable	Cat 1 (1)	Cat 2 (2)	Cat 3 (3)
Dependent variable: lnWA			
$D_i \times T_t$	−0.09 * (0.04)	−0.04 * (0.02)	−0.11 (0.06)
D_i	−0.01 (0.07)	0.00 (0.04)	0.05 (0.06)

Table 5. *Cont.*

Variable	Cat 1 (1)	Cat 2 (2)	Cat 3 (3)
T_t	0.05 * (0.02)	0.02 (0.01)	0.10 * (0.04)
lnWA	−0.11 ** (0.04)	−0.03 * (0.01)	0.10 (0.04)
$TRAC$	0.15 *** (0.03)	0.02 (0.02)	−0.08 (0.04)
AGE	−0.00 (0.01)	0.01 * (0.00)	0.05 (0.05)
AGE^2	−0.00 (0.00)	−0.00 (0.00)	−0.00 * (0.00)
EDU	−0.03 (0.02)	−0.00 (0.01)	−0.04 * (0.02)
EDU^2	−0.00 (0.00)	0.00 (0.00)	0.00 * (0.00)
AGT	−0.01 (0.05)	0.00 (0.02)	0.06 ** (0.02)
Constant term	1.45 *** (0.33)	1.37 *** (0.10)	1.65 *** (0.39)
N	765	645	653

Notes: Cluster robust (town level) standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

4. Discussion

Increasing farm size was one of the aims of China's grain subsidy reform in 2015. Results show that smallholder farms significantly changed land use by decreasing wheat production in Huang-Huai-Hai Plain instead of increase their farm size to receive more subsidies. We also found that the reform has the greatest impact on the smallest farmers. These results indicate that there is a positive relationship between subsidy amount and grain-sown areas. Our findings are consistent with those of Yi et al. (2015) [23], Zou et al. (2020) [37], and Guo (2021) [38], but different from those of Gale et al. (2005) [22] and Huang et al. (2011) [31].

The empirical results have important policy implications for promoting grain subsidy policy reform and ensuring China's food security. First, China's grain subsidy reform has reduced the wheat-sown area of smallholder farms. Although this reform was purported to increase farm size, it is still necessary to take into account the basic national condition that China is a "large country with smallholder farms" and the reality that smallholder farms are the primary business entity in farming. Therefore, while encouraging large-scale farms, it is necessary to take into account farmers' small-scale operations and gradually promote the transformation of small-scale operations to large-scale operations.

From the perspective of international comparability, previous studies have shown that the reduction in subsidy or similar reforms would lead to a decline in land use. For instance, Ciaian (2007) and Helming and Tabeau (2018) found that the reduction in the Pillar I budget of the Common Agricultural Policy (CAP) of the European Union (EU) led to a decrease in utilised agricultural area [56,57]; Tranter et al. (2007) and Tzanopoulos et al. (2012) found that the 2003 CAP reforms, which decoupled of support payments from production decisions, led to a decline in the cereal and oilseed production area [58,59]. Tranter et al. (2007) also pointed out that farmers would like to transfer to produce forestry, woodland, and non-food crops [59]. In the United States, cropland acreage would also decrease if the payments of Farm Commodity Programs payments had been reduced [60]. Since China continues its reform in grain subsidy [18,61], those studies can also provide strong evidence about the potential impacts of subsidy reform to China's policymakers.

To further investigate whether smallholder farms transferred their land out, we estimated a naive DID model based on Equation (1). The dependent variable is the amount of outflow land area. The results show that China's grain subsidy reform has a significant and positive effect on the amount of outflow land area (Table A3). Thus, the impact pathway of China's grain subsidy reform is that smallholders might transfer their lands to large-scale farmers or cooperatives so as to decrease or terminate their grain production.

Previous studies found that if the smallholder farms transfer their lands to large farms, the land tenure increased accordingly [39,62]. We used another naive DID model to reveal the relationship between subsidy reform and land tenure (Table A3). The results show that the impact of subsidy reform on land tenure is insignificant, which is consistent with Lin and Huang (2021)'s study [63]. However, considering the evidence found by Tranter et al. (2007) [59] and the low ratio of profits to cost and expense in wheat production (1.77, −8.11, 0.61, and −15.74 in 2015–2018, respectively [64]), large farms may change the land use from producing wheat to cash crops or vegetables. Thus, the Chinese government should strengthen the supervision of land use to achieve the goal of ensuring food security. Furthermore, policymakers are suggested to improve the land rental market environment to protect the interests of smallholder farms.

There are several limitations to our study. First, since only a few samples in the SAVE data that we used are large farms, we only examined the effect of the subsidy reform on the land use behavior of smallholder farms. Therefore, the application of the results of this study is limited, and the impact of the policy reform on land use of large-scale farms is still unknown. Furthermore, whether large-scale farms continue producing grain is essential to China's food security. Second, limited by the unbalanced panel data, we could not investigate if the number of smallholders was decreasing or not after the reform. Third, as some farms do not transfer their lands, we could not further investigate how the land is used after farms reduced wheat planting. Additionally, although we found that the increase in grain subsidy payments for contracted farmland did not increase the farmland rental price, we still need more evidence to investigate who became the beneficiaries of the subsidy reform. Therefore, future research is required to answer the following questions empirically. (1) What are the impacts of China's grain subsidy reform on large-scale farms? (2) Will smallholder farms produce more cash crops or vegetables after the subsidy reform? (3) Who benefit more from the subsidy reform, smallholder farms or large farms?

5. Conclusions

In summary, we used the 2013–2015 Survey for Agriculture and Village Economy (SAVE) data and a difference-in-difference (DID) approach to empirically investigate the impact of China's grain subsidy reform on the land use of smallholder farms. Our study reveals three main conclusions. First, there is a negative impact of grain subsidy reform on the wheat-sown area. Influenced by the grain subsidy reform, a smallholder farm in Huang-Huai-Hai Plain would reduce 25% of its wheat-sown area. Second, the impact of subsidy reform is heterogeneous in scale. The smaller the farm, the greater the effect. Third, the impact pathway of China's grain subsidy reform is that smallholder farms might transfer their lands to large-scale farmers or cooperatives and thus decrease or terminate their grain production. At the end of 2013, the primary goal of China's agriculture policy was set to ensure basic self-sufficiency of grains and absolute security of food grains [65,66]. China's grain subsidy would like to be more precise and more focused on food security goals. Considering the fact that nearly 98% of farms in China are smaller than 2 ha [3,6], China can strengthen its food security only if farm size is successfully increased. Thus, how to increase farm size through subsidy programs would be an essential issue in future researches.

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Appendix A

Table A1. The number of sample farms.

Year	Hebei	Shandong	Henan
2013	152	168	395
2014	171	140	387
2015	190	101	359

Table A2. Estimation results of the DID, OLS, and FE models.

Variable	DID4 (1)	OLS (2)	FE (3)
Dependent variable: lnWA			
$D_i \times T_t$	−0.28 ** (0.10)		
D_i	0.10 (0.14)		
T_t	0.18 ** (0.07)	−0.04 (0.05)	−0.03 (0.03)
lnLB	−0.18 ** (0.07)	−0.29 *** (0.05)	−0.14 * (0.05)
$TRAC$	0.34 ** (0.12)	0.20 * (0.07)	−0.02 (0.02) (0.06)
AGE	0.06 ** (0.02)	0.04 ** (0.01)	0.01 (0.01)
AGE^2	−0.00 ** (0.00)	−0.00 ** (0.00)	−0.00 (0.00)
EDU	−0.08 ** (0.03)	−0.07 * (0.03)	−0.03 (0.02)
EDU^2	0.01 ** (0.00)	0.01 ** (0.00)	0.00 * (0.00)
AGT	0.03 (0.07)	0.08 (0.06)	0.03 (0.04)
Constant term	0.43 (0.54)	1.29 *** (0.33)	1.77 *** (0.38)
N	833	2063	2063

Notes: Cluster robust (town level) standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A3. Estimation results of the impacts of subsidy reform on the amount of outflow land area and land tenure.

	The Amount of Outflow Land Area	Land Tenure
$D_i \times T_t$	0.17 *** (0.04)	0.10 (0.09)
D_i	−0.15 *** (0.02)	0.10 (0.09)
T_t	−0.11 (0.00) (0.10)	38.89 *** (0.70)
Constant term	0.26 *** (0.10)	118.17 (0.70) ***
N	2063	2063

Notes: Cluster robust (town level) standard errors in parentheses; *** $p < 0.01$.

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