Grain Subsidy, Liquidity Constraints and Food security—Impact of the Grain Subsidy Program on the Grain-Sown Areas in China

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Abstract

This study examined the effects of China's grain subsidy program, the largest food self-sufficiency project in the developing countries, on grain-sown areas within a context of liquidity constraints. A large household level panel was used to evaluate how the subsidy affects the cultivation schedule of farm households through the relaxation of households' liquidity constraints. Results suggest that in general, the grain subsidy program significantly improved farm householdsÕ grain planting areas for liquidity-constrained households. This finding provides a more comprehensive understanding of the effects of ChinaÕs grain subsidy than previous studies.

1 Introduction

Increases in China's grain output and sown areas were accompanied by substantial governmental subsidies. Since the launch of the grain subsidy program in 2004, China has become a major subsidizer in terms of per unit of cultivated area and total budget allocations Huang et al. (2011b). The amount of grain subsidy given to farmers, in 2004

was 14.5 billion yuan[1] (Ministry of Finance, 2005), and this rapidly increased to 166.8 billion yuan (Chen, 2013) in 2012. With the expansion of the subsidy budget from 2004 to 2012, the sown areas and outputs of grain crops (rice, wheat and corn) increased by 19% and 32% (National Bureau of Statistics of China, 2013), respectively.

Given the substantial amount of public resources dedicated to the grain subsidy program, however, its impacts on grain production remain unclear. On one hand, several previous researches have indicated that the recent increase of grain output was barely related to grain subsidy (Gale et al., 2005; Heerink et al., 2006; Huang et al., 2009, 2011b,a). Gale et al. (2005) posited that grain subsidy should have little impact on grain production because the subsidies are not large enough and not tied to production decision. Huang et al. (2011b) with the use of micro-survey data indicated that the subsidy program did not encourage grain production in terms of grain-sown areas and fertilizer uses.

On the other hand, Meng (2012) found that grain subsidy kept farmers from engaging in migratory work, thereby increasing labor inputs in grain production. Furthermore, Yu and Jensen (2010, 2014) showed that implementing the grain subsidy program increased the grain production and improved the farm income if grain subsidy disbursement was coupled with grain production, and Yu and Jensen (2010) found that the grain subsidies together with the elimination of agricultural taxes increased grain area and yield. Xu et al. (2012) confirmed that the repeal of China's agricultural taxes, which is similar to introducing subsidies, helped raise farm income through increasing grain production by using more inputs such as labor and planting areas. These studies implicitly assume that all rural markets in China work perfectly.

This article aims to examine the effect of China's grain subsidy on grain plantÂing areas of various farm households with different liquidity conditions. Previous studies rarely considered the impacts of relaxation of liquidity constraints for farm households

[1] 1 US dollar = 6.2 yuan.

from the subsidy transferred. A number of studies have shown that small farm households in China usually face incomplete credit markets (Feder et al., 1990; Rozelle et al., 1999; Simtowe and Zeller, 2006; Uchida et al., 2009; Dong et al., 2010), thus, liquidity constraints cause households to have underemployed and ill-allocated productive assets which could have been utilized under unconstrained condition (Sadoulet et al., 2001). It is expected that the money paid by the grain subsidy program can provide farmers with liquidity, allowing them to adjust their production by investing more in productive assets for grain crops. Importantly, farm households with various levels of liquidity constraints may be affected differently by the grain subsidy, and within this context, we therefore provide a new insight on the impact of grain subsidies on crop production.

Unlike previous studies, we relied on a ratio between agricultural costs and household income as an indicator for liquidity constraints. A household with a higher ratio is more likely to face liquidity restrictions than the one with a low ratio. We then divided the total sample into two subsamples according to the ratio to investigate the heterogeneous effects of grain subsidies on crop planting areas among farm households. One of the advantages of our method is that it takes into consideration the farm size of farm households: a household with large size farming areas, which usually has relative more liquidity assets and was assumed to have no liquidity constraints. However, this assumption is not necessarily right because large farm size, in the meantime, means more liquidity demand in agricultural production. Therefore, not only small farm households may face liquidity constraints, but also for the farm households with large sizes.

Using a unique survey dataset, the present study found that the grain subsidy program generally stimulated grain production in sown areas. However, the transferred money did not help households in the liquidity-constrained group to improve living expenditure and use the subsidy to expand non-grain-sown areas. As expected, the grain subsidy was less likely to encourage liquidity-unconstrained households to allocate more planting areas for grain production.

The rest of paper is organized as follows. Section 2 describes the grain subsidy program in China. Section 3 introduces the data used for the estimations. Sections 4, 5, and 6 present the empirical estimation, the empirical results, and the conclusion, respectively.

2 Grain subsidy program in China

The Grain subsidy program was originally designed for farmers who wanted to plant grain crops including rice, wheat and corn[2]. The program consisted of four elements: direct subsidy, comprehensive input subsidy, high-quality seed subsidy, and agricultural machinery subsidy. The latter three types of subsidies are supposed to be related to grain production. From the initial arrangements, the direct subsidy was expected to improve grain producers' income. The comprehensive input subsidy would offset the high production costs such as fuel and fertilizer price increases. The high-quality seed subsidy and agricultural machinery subsidy were for facilitating grain producers to adopt better varieties of seeds and to promote production efficiency, respectively.

Table 1 illustrates the composition of the steadily increasing amount of the grain subsidy from 2004 to 2012. The comprehensive input subsidy, although introduced in 2006, has grown rapidly and surpassed the other subsidies since 2007. The high-quality seed subsidy and machinery subsidy started at different magnitudes but converge to 22 billion yuan. As a subsidy program for stimulating grain production, the total budget for China's grain subsidy program is much more in comparison to that of other countries such as Honduras, Mexico, Malawi and Nicaragua (Handa and Davis, 2006; Dorward and Chirwa, 2011). Based on a per land area basis, the subsidies an average Chinese farm household could get in 2012 was 95 yuan/mu, equivalent to 92 US dollars per acre, which is therefore indicative of a greater subsidy intensity than that a typical US

[2]Four provinces and municipalities in Northeast China also have high-quality seed subsidy for soybean.

farmer received[3].

Table 1: Composition of grain subsidy 2004–2012

	2004	2005	2006	2007	2008	2009	2010	2011	2012
Direct subsidy (billion yuan)	11.6	13.2	14.2	15.1	15.1	15.1	15.1	15.1	15.1
Comprehensive input subsidy (billion yuan)	0	0	12	27.6	71.6	79.5	83.5	89.3	107.8
High-quality seed subsidy subsidy (billion yuan)	2.8	3.8	4.0	6.7	12.1	19.9	20.4	22	22.4
Machinery subsidy (billion yuan)	0.07	0.3	0.6	2.0	4.0	13.0	15.5	17.5	21.5
Total (billion yuan)	14.5	17.3	30.8	51.4	102.8	127.5	134.5	143.9	166.8

Data Sources: Ministry of Fiance.

The disbursement modes of the four subsidies are different. Currently, all of the subsidies, except machinery subsidy are wired to farmers' bank accounts[4]. However, most of farm households are unable to differentiate the value of each type of the three wired subsidies since the bank account does not provide this information. Machinery subsidy, on the other hand, is only targeted to the buyers of median- or large-size machines where approximately 30-50% of price-value subsidy is deducted from the price. Therefore, those households who apply for the machinery subsidy usually know how much they are subsidized. However, the fact that most of rural households have small farming areas dictates that only few of the farmers, either with large cultivation scales or specialized for agricultural machinery services, will apply for the machinery subsidy. In addition, the voluntary feature of the machinery subsidy differs from the other subsidies, and will become a major challenge for the impact analysis. Hereafter, the three wired subsidies are the research focus of this study and "grain subsidy" excludes machinery subsidy. The grain subsidies are accessible to farmers through a three-step implementation process. First, the State Council determines an annual subsidy

[3]The average household's land size in China is $\frac{1}{315}$ of that of the farmer in the US (Huang et al., 2011b), hence, per household subsidy is still low in China.

[4]With the rapid development of information technology, everyone, from the Ministry of Finance to the individual households, has a special bank account.

budget according to the regional differences in grain production. Second, provincial departments of finance divide the total available budget from the central government according to the grain production of all the counties. Finally, local financial bureaus distribute the subsidies to farmers in accordance with the specific criteria. In 2007, the Ministry of Finance stated that the criteria could be any of the following standards: (i) the amount of contracted land that a household was allocated during the late 1990s; (ii) the actual grain-sown areas; and (iii) the taxable grain production target during a normal year (although agricultural tax has been abolished since 2003).

In practice, however, the wired grain subsidies including direct subsidy, comprehensive input subsidy and high-quality seed subsidy are not distributed according to production choices. To date, most surveys have shown that China's grain subsidy program is not based on the current year grain inputs or outputs of farmers but is related to the historical grain production or the contracted land areas (Tian and Meng, 2010; Huang et al., 2011b,a), with contracted land area being the most commonly used. There are several reasons which drive this situation: first, the high number of small households in rural areas results in extremely high administrative costs if local governments intend to distribute the subsidies to farmers according to real grain-sown areas, i.e., standard (ii). Therefore, standards (i) and (iii) are preferred in most counties, and grain subsidy is paid as extra income rather than being directly correlated to current year input decisions. In addition, the elimination of the centuries-old agricultural tax in 2003 has forced local governments to cut administrative costs by merging small village governments. However, standard (ii) requires local governments to devote more resources to subsidy distribution task. Therefore, local governments should select a criterion that can reduce administrative costs by minimizing workloads. Moreover, standards (i) and (iii) seem to be the most appropriate political solution because almost every farmer can obtain the subsidy, considering that most households own contracted land since the land reallocation during the 1980s. Otherwise, village and town leaders are likely to

have queries. Therefore, given that rural contracted land has not been adjusted since 1990s, subsidy level per unit of land has kept increasing in the last ten years due to the growth of national budget in grain subsidy, for example, the aggregate of direct subsidy and comprehensive input subsidy in Jiangsu province increased from 89 yuan/mu in 2011 to 101.5 yuan/mu in 2012 (Jiangsu Departments of Finance, 2012). Additionally, standards (i) and (iii) seem not to be directly related to production, and we expect that the wired subsidies will not distort producersÕ decisions if all the markets function perfectly.

The focus of our study, the wired subsidies (including direct subsidy, comprehensive input subsidy and high-quality seed subsidy), accounted for more than 88% of the total amount of grain subsidy from Table 1. Based on the implementation procedure, the wired subsidy is a form of cash transfer and provides liquidities to farmers, which is critically important for China's small rural households when credit markets are not complete. In addition, the benefits of wired grain subsidy is similar or even better than those offered by credit programs because it eliminates the risk of the inability to repay. A large number of studies have proven that access to credit allows greater investments and thus increases the welfare of farmers (Feder et al., 1990; Rozelle et al., 1999; Simtowe and Zeller, 2006; Uchida et al., 2009; Dong et al., 2010; Kokoye et al., 2013). Therefore, once grain subsidy relaxes the liquidity constraints of farm households, the program can help farmers adjust their cropping patterns such that grain-sown areas may change. The literature suggests that this conjecture can be applied to China (Feder et al., 1990; Rozelle et al., 1999; Dong and Featherstone, 2006). From this point of view, the research empirically contributes to the limited studies that have examined the influence of public cash transfers on the productive investments of farm households (e.g., Davis et al. (2002), Todd et al. (2010), Maluccio (2010) and Gertler et al. (2012)).

To examine the grain proÂmotion effects of the grain subsidy program, the rural land markets in China should also be briefly discussed before our estimations are intro-

duced. The premise of the discussion regarding the relaxation of liquidity constraints through grain subsidy assumes that land markets are perfect. However, many researches have emphasized that the rural land rental markets in China are generally incomplete (Rozelle et al., 1999; Nyberg and Rozelle, 1999; Uchida et al., 2009), or restrictions on land market transactions are likely to increase transaction costs (Deininger and Jin, 2005). In addition, households may be reluctant to engage in land rental because it can be considered by village leaders as a signal that a household has land that the farmer cannot cultivate, which can be subjected to expropriation (Yang, 1997). Irrespective, the most recent development in the land market indicates that these arguments are outdated in a number of areas. Our data showed that 31% of households rent in/out land during the observation periods. Therefore, in the rest examination steps, rural land market conditions have to be considered to identify the effects of the subsidy program.

3 Data

We used a panel dataset from the Research Center for Rural Economy (RCRE), Ministry of Agriculture of China. In 1986, the Ministry of Agriculture established an annual survey system called the Fixed Observation Points System (FOPS). Operated by RCRE, the system conducts yearly surveys of rural economic and institutional changes in both household and village levels. To represent national rural development, different weights are allocated to each province or municipality according to the number of villages with various combinations of topographic and economic characteristics. The number of villages selected in every province or municipality varies from 3 to 25. HouseÂholds are then randomly chosen in each village. In FOPS, survey assistants help farmers to fill questionnaires every year, and the surveyed farm households are revisited annually. Once a farm household cannot be traced due to migration, a similar household is chosen for the vacancy to make the sample size stable. The questionnaire collects ex-

tensive information from farmers including households' production, consumption, social activities, assets, and income composition. Although FOPS now covers 31 provinces (municipalities), considering the focus of this study, 19 provinces (municipalities) were chosen and accounted for 84% of China's grain-sown areas in the last decade. These provinces (municipalities) were Hebei, Shanxi, Inner Mongolia, Liaoning, Heilongjiang, Jiangsu, Zhejiang, Anhui, Fujian, Shandong, Henan, Hunan, Hubei, Guangxi, Sichuan, Guizhou, Yunnan, Shaan'xi, and Gansu.

Prior to 2009, the amount of subsidy received was recorded as an aggregate with other income information which negated its individual quantification. Therefore, our panel data covered three years: 2009, 2010, and 2011. The summary statistics of all the key variables in this study are presented in Table 2. This dataset is unique in terms of the size of the sample: 5952 households surveyed in 19 major grain production provinces (municipalities).

Table 3 shows the ratios of households that received grain subsidy and the subsidy level wired to households, for both grain producers and non-grain producers in each area, which indicated that grain producers benefited most from the subsidy program. Overall, a total of 86% of the households in the entire sample received at least one of the three wired subsidies. The total amount of grain subsidies received by grain producers was generally greater than that received by households that did not produce grains except for Inner Mongolia and Heilongjiang. The main reason is that non-grain producers in these areas have larger contracted land areas than that of grain producers, and the local government subsidizes according to contracted land areas. Our test of difference in subsidy levels between grain producers and non-grain producers in the entire sample rejected the hypothesis that they are equal at 5% level. This finding contradicts that of Huang et al. (2011b), who found that the distributions of subsidies received by grain producers per household were almost identical to the distributions of subsidies received by non-grain producers per household. This could be attributed to two possible reasons.

Table 2: Summary statistics of variables: 2009-2011

Variable	Entire sample	
	Mean	S.D.
Number of households	5952	
Number of observations	13796	
Grain production		
Grain revenue (1000 yuan/mu)	0.8791	0.3641
Grain cost (1000 yuan/mu)	0.3126	0.1341
Grain sown area (mu)	5.2594	7.1865
Subsidy		
Wired subsidy (1000 yuan)	0.3931	0.4896
Household characteristics		
Asset holdings per capita (1000 yuan)	9.6491	21.8748
Age of household head	51.9768	9.4461
Education of household	7.0075	2.5780
Male household head	0.9599	0.1962
Number of residents	4.1329	1.4642
Labor number (age $>$ 16)	2.9034	1.1311
Contracted land area (mu)	5.9591	21.6646
Rent-in cultivated land (mu)	0.6141	3.8329
Land rent (1000 yuan/mu)	0.4293	0.4220
Ratio of off-farm labor in family (%)	33.9660	19.6712
Living expenditure (1000 yuan/year)	18.0831	13.6608
Total income (1000 yuan)	24.4294	20.8989
Ratio of ag. cost in total income (%)	16.2421	33.3313

Data Sources: RCRE. 1 hectare = 15 mu. Significance codes: * 5%, ** 1%, *** 0.1%.

First, we counted the three types of grain subsidies, whereas Huang et al. (2011b) only considered two subsidies: direct payment subsidy and comprehensive subsidy. Second, only 16% of households knew their subsidy levels in the survey by Huang et al. (2011b), whereas our data set showed that almost all the households knew their subsidy levels[5].

Table 3 also presents the share differences between grain producers that receive grain subsidy and that of non-grain crop households. Twenty five percent of all the households did not produce any of the three grains (wheat, rice, and corn) but 56% of them still received grain subsidies (In Table 3). In the group of farm households

[5]In FOPS, the survey assistant can check total subsidy levels for farmers from village leaders if they do not know how much they get. Obviously, this information is shared with the farmers during the visit. It might be arguable that, for households are not in FOPS, they do not have assistants to check subsidies for them. However, the subsidies are available from the village leaders and are easy to check, and Huang et al. (2011b) reported that more than 85% of households knew their subsidies are wired to their account.

Table 3: Share of households that receive grain subsidy and subsidy level per household

Province (municipality)	Pool sample		Households that produce grain		Households that do not produce grain	
	share(%)	(yuan)	share(%)	(yuan)	share(%)	(yuan)
Hebei	80.90	327.57	85.59	353.77	52.63	169.65
Shanxi	84.31	275.46	98.59	323.91	11.90	29.75
Inner Mongolia	100	367.01	100	350.75	100	440.17
Liaoning	89.44	577.61	99.27	654.05	34.69	151.72
Heilongjiang	98.64	1469.83	100	1278.26	95.56	1904.04
Jiangsu	76.92	303.46	96.02	376.27	26.74	112.12
Zhejiang	42.91	38.64	84.09	78.26	33.99	30.06
Anhui	89.31	473.64	93.43	534.73	76.02	280.71
Fujian	67.76	177.22	93.52	264.25	44.38	100.46
Shandong	84.10	296.05	94.27	326.16	7.41	10.54
Henan	95.30	355.93	92.19	380.24	68.00	183.83
Hubei	91.11	323.20	99.15	406.77	69.30	76.91
Hunan	81.82	304.21	98.51	364.19	60.00	151.02
Guangxi	87.76	319.08	90.36	362.71	45.00	148.94
Sichuan	99.12	316.69	99.64	324.82	96.77	279.98
Guizhou	98.91	297.09	99.17	304.05	97.14	249.43
Yunnan	76.19	210.30	85.62	288.64	63.21	102.24
Shaan'xi	88.25	263.64	97.90	305.81	45.98	78.98
Gansu	97.49	559.89	100	594.19	72.22	214.91
Average	85.99	381.92	96.04	414.31	55.70	248.19

Data Sources: FOPS. The data are mean over the surveyed three years.

that produce grain, 96% receive grain subsidy. The differences over all the areas were significant at 0.1% level. Specifically, whether local officials target the subsidy toward grain producers' inputs of grain cultivation may depend on the provinces, and a better perspective could be obtained by comparing the shares of households that produce grains and receive grain subsidy with the shares of households that did not produce grains but still received the subsidy. An enormous gap indicates that local governments may have specific subsidizing targets rather than subsidizing every household[6]. Comparison of columns 4 and 6 in Table 3 reveals that a number of provinces, such as Inner Mongolia, Heilongjiang, Sichuan, and Guizhou, may subsidize in accordance with a standard that cannot distinguish grain producers from non-grain producers (e.g., contracted land areas). Meanwhile, provinces such as Shanxi and Shandong apply a

[6]It is admissible that land rental markets may blur the fact that who will get the grain subsidy, but a big enough sample should be able to rectify the potential biases.

standard that can distinguish whether a household produces grains (e.g., actual grain-sown areas). However, the subsidy criteria in most of the other areas may be hybrid in practice, and whether a farm household produces grains seems not to be a determinant factor in deciding whether the farm household is eligible to receive grain subsidy.

In addition, FOPS data confirmed the earlier findings of a positive relationship between land ownership and the distribution of grain subsidy (e.g., Tian and Meng (2010); Huang et al. (2011b,a)). Table 4 shows that if households have contracted land and are producing grains, over 96% of them would obtain grain subsidies. However, this ratio would decrease to 60% if the households do not have contracted land. One might ask why grain producers still received grain subsidies despite not having contracted land. There are two interpretations: the first is that grain subsidy can be claimed from the owner of the land by tillers, mostly from their relatives, which then becomes part of their profit. Otherwise, grain profit would be too low to cover the farming opportunity costs for tenants. The other explanation is that the grain subsidy is capitalized into the land rent, therefore, the rent is higher when the tenants gets the subsidy than when the contractor get the subsidy, which has also been mentioned in Huang et al. (2011b). Similarly, for the non-grain crop households who do not produce grains, the percentage that received grain subsidies with contracted land, was 74%, and this ratio decreased to 17% in the absence of the contracted land. Over the entire sample, 92% of households with contracted land received grain subsidy, however, the percentage decreased to 21% for households without contracted land. These findings indicated that in practice, land ownership is a determining factor for households to obtain grain subsidies.

Table 4: The relationship between property of land and grain subsidy

	Number of households that have contracted land				Number of households that have no contracted land			
	Grain producer	%	Non-grain producer	%	Grain producer	%	Non-grain producer	%
Receive grain subsidy	4262	96.45	742	74.05	30	60.00	84	17.46
Do not receive grain subsidy	157	3.55	260	25.95	20	40.00	397	82.54
Total	4419		1002		50		481	

Data Sources: Authors' calculation based on FOPS data.

4 Econometric issues

4.1 Empirical model

The variability of the wired grain subsidy received by different farm households allows us to estimate the marginal effect of one unit of payment. The variabilities stem from two sources: first, Table 1 shows the wired subsidies kept increasing from 2009 to 2011, and the amount per unit of contracted land in the sample increased from 63 yuan/mu in 2009 to 73 yuan/mu in 2011. Second, each province or municipality has different land-based subsidy standards.

Studies on impact assessment indicate that biases that arise from the endogenous participation in the program should be controlled. Although the participation rates of the grain subsidy program is high, in our data set, more than 86% of farm households obtained grain subsidy and the voluntary feature of the subsidy program warns of the possibility of biased estimation. If the unobserved characteristics of a household, such as soil type and managerial ability, are correlated with the participation in the grain subsidy program or the amount of subsidy received, the estimation of the program effect would be biased. In fact, our suspicions have been partly confirmed by the sample: Tables 3 and 4 showed that the subsidy levels for grain producers were higher than the rates for farm households without grain production. To estimate the grain

subsidy effects, we suppose a household i's grain-sown area (Y_i) equation that relates to grain subsidy (T_i), market information and household's characteristics (Z_i), effect of unobservables (α_i), and error term (ε_i). After observations over years, we can achieve a yearly grain-sown area model as follows:

$$Y_{it} = \beta_0 + \beta_1 Z_{it} + \beta_2 T_{it} + \alpha_i + \varepsilon_{it}, \tag{1}$$

where $\boldsymbol{\beta} = [\beta_0 \ \beta_1 \ \beta_2]$ are parameters to be estimated, and t denotes year. β_2 is the marginal effect of grain subsidy on the grain-sown areas. The potential correlation between α_i and T_{it} results in several inconsistent estimators, such as pooled OLS. Therefore, a consistent estimate of β_2 needs a panel to eliminate α_i. In the household model, vector Z includes observed per unit land revenue, per unit land cost, land and time endowments for a household, and household characteristics (including the age of the household leader, his education, and household size). Off-farm payoff is an important opportunity cost for grain production, however, to obtain household level off-farm wage is impossible because only part of labor's off-farm wage information is observable. Instead of that, we used the ratio of off-farm work time in total available labor time in a family to represent the opportunity costs. To deal with the potential bias, we used fixed effect regression to account for time-invariant factors. This method has also been used in Sadoulet et al. (2001) and Huang et al. (2011b) for the similar program evaluation in Mexico and China, respectively.

To simplify the estimation of the empirical model (1), we assume that the production functions for all crops are linear. Therefore, per unit land revenue and cost are needed to capture how the output and input markets affect cultivation decisions. Another advantage of using per unit land revenue and cost for crops is that different non-grain crop additives can be considered. In consideration of the different units of outputs and inputs for over 20 non-grain crops in our dataset, incorporating all of these data into the

estimation would dramatically make the estimation more difficult. A similar method has been applied in a large number of land demand studies[7] (McGuirk and Mundlak, 1992; Holt, 1999; Arnberg, 2002; Coxhead and Demeke, 2004). The national consumer price index deflates all prices to 2000 values.

Land demand functions are difficult to estimate because farmers can plant multiple crops in most regions, therefore, estimating land demand functions usually face a number of challenges. First, estimating land demand function is associated with censored data problems. Approximately, 25% of the farm households in our sample did not produce any of the three grain crops even though most of them received grain subsidy. Therefore, a Tobit model is an alternative option. Moreover, controlling both the unÂobserved household specific effects and the dynamics of a panel is still an econometric challenge in nonlinear Tobit models (Hu, 2002; Coxhead and Demeke, 2004). Although we can use Tobit model to control the shift driven by data censoring, econometric theory indicates that a sufficient statistic that allows the fixed effects to be conditioned out of likelihood does not exist, suggesting that the random effect is the only choice for the panel data used in the Tobit model. From another perspective, we believe that fixed effect model, which is the same method used in Huang et al. (2011b), may be more acceptable because the potential endogenous participation is a relatively serious problem for consistent estimates. Therefore, if we pool the sample, the fixed-effect model results should be interpreted carefully because disregarding the data censoring would lead to an underestimation of the effect of grain subsidy, which leaves us on the safe side.

[7]An obvious limitation of this method is that the intensive margin effect is not considered.

4.2 Strategies of estimating the impact of liquidity on grain production

For farmers who produce grains, the bound level of liquidity constraints decides the effects of the grain subsidy program. We are particularly interested in examining whether the influence of the grain subsidy program on land reallocation differs among farm households with and without liquidity constraints. According to Zeldes (1989), Jappelli (1990) and Jappelli et al. (1998), households are ideally classified, based on credit and loan application history, into two groups: liquidity-constrained households and unconstrained households. However, there was insufficient information for the farmers from our dataset. During the practice, some used the actual credit use as a proxy for credit access (e.g., Stephens and Barrett (2011)), some used liquid assets of the households for the possibilities that farmers may face liquidity constraints (e.g., Uchida et al. (2009)), and Sun et al. (2013) considered liquidity constrained households as those who have to pay off their debt before a certain point in time.

Alternatively, we measured liquidity constraints by using the ratio of agricultural cost to a household's total income. The larger share of agricultural cost to income, the more likely that a household will have liquidity restrictions in production. This method has a noteworthy advantage that can exclude the disturbance from farming scale. The magnitudes of credit use or liquidity assets of households for measuring the possibility of liquidity constraints are assuming that, normally, a farm household with large size farming area is likely to have more liquidities. However, in the failure of the credit markets, such as the case in China, a farmer with large size farming area also has liquidity constraints, otherwise, high-value machinery subsidy is not necessary. Therefore, we believe that our proposed method is better for evaluating the liquidity conditions in agricultural production.

The sample was categorized into two sections according to the ratios of agricultural cost to total income. We set $Q_j, \forall\ j = [1, 2]$, where $Q_j = 1$ if a household is in

section j and 0 otherwise. Let $j = 1$ represent households without liquidity constraints, and $j = 2$ be liquidity-constrained households. After grouping the households, we then tested whether the program effects differed among households with and without liquidity constraints. Adding interaction terms between the section dummy variable and subsidy policy can identify the heterogeneity of the subsidy program effects. Thus, we estimate the following empirical equation:

$$Y_{it} = \beta_0 + \beta_1 Z_{it} + \sum_{j=1}^{2} \beta_{2j}(T_{it} \times Q_j) + \alpha_i + \varepsilon_{it}, \tag{2}$$

This equation is similar to equation (1) but the subsidy term is replaced with interaction terms composed of the subsidy and section dummy variables.

The entire sample was divided into two sections at the point of 15% of agricultural cost in income and the comparisons of variables for the two subsamples are shown in Table 5. We define a household that has liquidity restrictions when the agricultural production cost accounts for more than 15% of total income, and a household with a ratio below 15% is treated as unconstrained. It is noted that the contracted land areas for households with liquidity constraints were almost doubled that of unconstrained farmers. Consequently, the wired subsidies received by liquidity-constrained households were the same types of subsidies received by unconstrained households. In the two subsamples, the average ratio of agricultural cost to total income for the households with liquidity constraints was five times that of liquidity-unconstrained households. Further more, the aggregate of living expenditure and agricultural costs for liquidity-constrained farmers were close to total income, while the aggregate for unconstrained farmers only accounted for 70% of total income. Therefore, we believe that the proposed method was successful in distinguishing households with liquidity constraints from the entire sample.

5 Effects of grain subsidy on grain planting areas

5.1 Results

The estimates of the grain subsidy effect on grain-sown areas are shown in Table 6. We have exact information on who makes production decisions in households every year. Thus, the time invariant characteristics of the head of the household, such as education and sex, which are typically dropped in fixed effect models' results, were included in the estimation because the decision maker in a household is not necessarily the same member for the entire observation period.

Scenario (1), (2) and (3) differ in terms of the assumptions of local land markets. As discussed in section 2, in relation to the rural land markets, we used the percentage of households that have land transactions in their own villages to represent local land market conditions. Using such rate is reasonable because we believe that in villages with better functioning land markets, the corresponding land rent in/out times in such villages should be higher than the frequencies in villages that have poor land rental markets. In Scenario (1), to make our estimation comparable with that by Huang et al. (2011b), we treated both contracted land area and rent-in cultivated land area as explanatory variables. The key finding is that the wired grain subsidies had significantly positive effects on grain-sown areas, that is, a 1,000 yuan subsidy per household enabled a household to produce 1.5 mu more grain crops. This estimation contradicts that by Huang et al. (2011b), which concluded that grain subsidy did not influence land demand of grain production. Scenario (2) assumes that no land market exists. Thus, the decision of allocating grain or non-grain crops is based on total farming land. In this unrealistic scenario, we found that grain subsidy did not affect grain-sown areas. Scenario (3) is preferred because we incorporated land rental market conditions into the estimation. This model gave us similar results as Scenario (1), in which grain subsidy had a non-negligible effect on grain planting areas. One may be concerned that the fixed effect

model is unable to eliminate the impacts of other uncontrolled time-variant factors, therefore, scenario (4) incorporated year dummy variables. However, we did not find significant differences in the subsidy effects on land uses for grain production between scenario (3) and (4). We also reported the estimation results that only used grain producers in scenario (5). Overall, the results using the partial sample were similar to the estimations in Scenarios (1) and (3), and the magnitude of the grain subsidy effect in Scenario (5) was slightly higher than the values in the other two scenarios.

Scenario (6) shows a Tobit model of the panel data. The grain subsidy effect was significantly stronger than the effects in the previous five scenarios. The main reason for this phenomenon is that the estimation in Scenario (6) was based on the random effect assumption and was affected by data censoring. Overall, despite the difficulty of accounting for both the fixed effect and the censored data in a single model using panel data, the signs of the grain subsidy effects on grain-sown areas in all scenarios were consistently positive.

5.2 Liquidity constraints

In the previous section, with the use of the pool sample, we found that the wired grain subsidy led to increases in grain-sown areas. However, the hypothesis for the liquidity constraints for farm households could not be verified directly. In fact, we were interested in underÂstanding how the liquidity conditions of farm households impacted the grain subsidy program in relation to land uses. In this section we tested whether grain subsidy had heterogeneous effects on cropping patterns and living expenditure with respect to liquidity restrictions.

We found that the effect of the grain subsidy program on grain-sown areas was statistically significant for households with large ratios of agricultural cost to income (Table 7, column (4)). However, the liquidity-unconstrained group defined as the ratio of agricultural cost to income less than 15%, did not allocate more land for grain pro-

duction. Due to the arbitrary standard for dividing the sample to liquidity-constrained and unconstrained groups, Table 7 provides two other critical values for splitting the full sample at 10% and 20%. The effects of the subsidy on grain-sown areas for liquidity-constrained farmers were close over the different classification methods (Table 7, column (2), (4) and (6)). We also noted that, once 10% was used as a critical value to split the sample, the number of liquidity-constrained households was more than that of liquidity-unconstrained households. This fact warns that the amount of potential liquidity-constrained farm households is not small and also explains why the pool sample estimation results in the last section are different from Huang et al. (2011b). In essence, the findings robustly revealed that the liquidity-constrained households were likely to allocate more land for grain production.

From the view of a household model that consumption and production cannot be decoupled if credit markets are not complete, a household can use the new liquidity in different ways to aid their crop production or consumption, and the directions and intension of the effects depend on the extent to which the household was constrained by liquidity. In other words, the influence of grain subsidy on production and consumption depends on the marginal effects of the payment with respect to changes in different activities. If a household has limited liquidities, then the household would prefer to use the extra income to adjust agricultural land uses so that total income would improve. When a household is most likely to face challenges for survival, we believe that an increase in consumption dominates the increase of crop sown areas.

As shown in Table 8, the effects of grain subsidy on grain-sown areas, non-grain-sown areas, and living expenditure differed among households with different liquidity conditions. For farm households that belong to the liquidity-constrained group, grain subsidy had significantly positive influence on grain-sown areas. However, the influence of the subsidy for the liquidity-unconstrained group farm households was not statistically significant. With regard to the influence of grain subsidy on non-grain sown areas

and living expenditure, we did not find significant impacts of the subsidy program. Between grain crop and non-grain crop production, the estimation also indicated that farm households in the liquidity-constrained group, with large cultivated land areas in Table 5, intended to expand grain-sown areas. One possible reason is that, given more cultivated land areas that are normally related to large liquidity demand, liquidity-constrained farmers tend to choose land intensive crops, such as wheat, corn, and rice, instead of labor intensive crops. Compared to other inputs, labor is more difficult to store and thus, sufficient liquidity should be prepared to be used at any moment, in other words, labor-saving crops are better choices when households have liquidity constraints. In the unreported estimation, we also chose the value of liquid assets as an indicator for the possibilities that households have liquidity constraints and obtained similar results.

6 Conclusion

The present study examined the impact of China's grain subsidy on grain-sown areas within the context of liquidity constraints. We found that in general, the grain subsidy program in China had a positive effect on grain-sown areas. By using a ratio between agricultural costs and household income as an index of householdsÕ liquidity conditions, our results indicated that with grain subsidies liquidity-constrained households were likely to distribute more land to grain production. The grain land uses of the non-constrained group, however, were not significantly impacted by the grain subsidy. Additionally, the non-grain planting areas and household living expenditure were not influenced by the grain subsidy.

Our findings provide a new insight on the effects of China's grain subsidy on the grain production by considering the potential relaxation of farmersÕ liquidity constraints. This is the critical factor responsible for the difference in our results from Huang et al.

(2011b)'s conclusions. Moreover, our data base covered most of major grain production areas including Northwest and Southwest provinces with less developed economies where famers in these regions are more likely to have liquidity constraints. Our sample also specified that the number of liquidity-constrained households was non-negligible. Hence, the present study is favored to have a relatively large sample and the findings indicated that the grain subsidy program had an effect on relaxing farm households' liquidity constraints.

Irrespective of the differences, the conclusions by our study and Huang et al. (2011b) warn that the potential grain promotion should only be targeted to farmers who have liquidity constraints. In other words, given the goal of promoting domestic grain supply, China's huge amount of grain subsidy does not work effectively. At the policy level, the targeting efficiency of grain subsidy could be improved by focusing on liquidity-constrained farm households, which can be achieved by the method proposed in this study.

On the other hand, since the grain subsidy program has distorted part of producers' land use decision, it cannot be categorized as green-box policy in WTO. As half of the beneficiaries in our sample did not increase grain-sown areas, therefore, instead of subsidizing almost every farm household over the whole country, China's government could design a direct approach to subsidization. Technically, it will be helpful to compare the efficiency of promoting grain production by the current program and other potential subsidy approaches, and a partial equilibrium model for China's agricultural sector is needed.

Our study could be improved in several ways. First, we examined only the effect of grain subsidy on land uses due to the data limitation. Impacts of grain subsidy on grain yield driven by intensive use of inputs such as fertilizer might be important. Second, our measurement for liquidity constraints is not perfect. A better data collection to represent households' liquidity conditions are preferred in the future research. Third,

one of the original targets of the subsidy policy was aiming to improve the income of rural households (Gale et al., 2005), however, this subject has yet to be investigated in the literature. Those are left for future investigation.

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Table 5: Comparison of variables between liquidity-constrained and -unconstrained households: 2009-2011

Variable	Group 1 Liquidity-constrained (ratio of ag. cost in income $\leq 15\%$)		Group 2 Liquidity-unconstrained (ratio of ag. cost cost in income $> 15\%$)		Test of difference in variables between group 1 and group 2
	Mean	S.D.	Mean	S.D.	
Number of households	3668		2284		
Number of observations	8251		5544		
Grain production					
Grain revenue (1000 yuan/mu)	0.8788	0.3355	0.8798	0.4029	
Grain cost (1000 yuan/mu)	0.2989	0.1260	0.3330	0.1429	***
Grain sown area (mu)	3.5037	4.6466	7.8723	9.2175	***
Subsidy					
Wired subsidy (1000 yuan)	0.3124	0.3863	0.5133	0.5918	***
Household characteristics					
Asset holdings per capita (1000 yuan)	10.0151	25.6273	9.1045	14.5893	*
Age of household head	52.3692	9.5752	51.3930	9.2205	***
Education of household head	6.9169	2.5938	7.1425	2.5487	***
Male household head	0.9518	0.2143	0.9720	0.1649	***
Number of residents	4.2554	1.4701	3.9508	1.4362	***
Labor number (age > 16)	3.0036	1.1683	2.7547	1.0560	***
Contracted land area (mu)	4.6570	25.3846	7.8966	14.2377	***
Rent-in cultivated land (mu)	0.1726	1.6414	1.2711	5.6414	***
Land rent (1000 yuan/mu)	0.4219	0.4254	0.4403	0.4167	*
Ratio of off-farm labor in family (%)	38.2013	19.3571	27.6440	18.4078	***
Living expenditure (1000 yuan/year)	19.2180	14.3118	13.0295	8.7496	***
Total income (1000 yuan)	28.7572	22.4322	17.9897	16.3896	***
Ratio of ag. cost in total income (%)	5.3585	4.73	27.6403	20.8836	***

Data Sources: RCRE. 1 hectare = 15 mu. Significance codes: * 5%, ** 1%, *** 0.1%.

Table 6: Impact of grain subsidy on grain crop sown area

	Dependent variable: grain-sown area					
	Fixed effect model					Tobit model[a]
	(1)	(2)	(3)	(4)	(5)	(6)
Policy						
Grain subsidy	1.5807**	0.0211	1.5723**	1.5762**	1.8499**	4.7966***
(1000 yuan)	(0.5262)	(0.4197)	(0.5280)	(0.5283)	(0.6442)	(0.1440)
Output & input Market						
Grain crop revenue	0.3034**	0.2061**	0.3132**	0.2131	0.3325*	0.0051
(1000 yuan/mu)	(0.1148)	(0.0611)	(0.1181)	(0.1126)	(0.1332)	(0.1370)
Grain crop production cost	0.3932	0.5254	0.4166	0.2331	0.0411	-0.7834*
(1000 yuan/mu)	(0.5734)	(0.4234)	0.5805)	0.5710)	(0.6356)	(0.3906)
Non-grain crop profit	0.0912	0.3491***	0.0932	0.0479	0.1014	-0.0361
(1000 yuan/mu)	(0.0822)	(0.0552)	(0.0819)	(0.0857)	(0.1000)	(0.0831)
Off-farm labor share	-0.5680*	0.6600**	-0.5748*	-0.6174*	-0.8674*	-4.9398***
(%)	(0.2938)	(0.2290)	(0.2934)	(0.2932)	(0.3950)	(0.3159)
Household characteristics						
Age of household head	0.0078	0.0134	0.0085	-0.0006	0.0111	0.0189*
	(0.0158)	(0.0088)	(0.0159)	(0.0170)	(0.0181)	(0.0086)
Education of household	0.0417	0.0324	0.0433	0.0346	0.0654	-0.0094
head	(0.0407)	(0.0211)	(0.0407)	(0.0412)	0.0511)	(0.0296)
Male household head	0.1444	0.0580	0.1341	0.1385	0.1165	0.6952
	(0.3365)	(0.1463)	(0.3369)	(0.3407)	(0.4272)	(0.3680)
Number of household	0.2020**	0.0381	0.2004**	0.2050**	0.2224**	0.6779***
labor	(0.0670)	(0.0464)	(0.0668)	(0.0670)	(0.0804)	(0.0569)
Depostit & cash in hand	0.0012**	0.0002	0.0012**	0.0011*	0.0025**	
& loan (1000 yuan)	(0.0005)	(0.0002)	(0.0005)	(0.0005)	(0.0011)	
Land market						
Land rent	-0.1211**		-0.1428**	-0.1334*	-0.1831*	-0.4064**
(1000 yuan/mu)	(0.0545)		(0.0543)	(0.0556)	(0.0747)	(0.1195)
Contracted land area	0.0004		0.0004	0.0004	0.0031	0.0030
(mu)	(0.0005)		(0.0005)	(0.0005)	(0.0059)	(0.0021)
Rent-in cultivated land	0.5002***		0.5003***	0.5002***	0.6152***	0.5885***
area (mu)	(0.1260)		(0.1260)	(0.1261)	(0.1238)	(0.0130)
Total cultivated land		0.7145***				
(mu)		(0.0627)				
Percent of households who			0.8030	0.8459	1.0883	
rent in/out land in the vill.			(0.7762)	(0.7874)	(1.0888)	
Year 2010 dummy				0.1734**		
				(0.0636)		
Year 2011 dummy				0.1657*		
				(0.0732)		
Constant	2.6917*	-2.0906**	2.5521*	3.1272**	3.6676**	-0.2569
	(1.0405)	(0.7155)	(1.0762)	(1.1280)	(1.2590)	(0.6759)
ρ						0.8291***
						(0.0046)
R^2	0.2082	0.6089	0.2084	0.2093	0.2571	
Observations	13796	13796	13796	13796	10406	13796

Significance codes: * 5% level, ** 1% level, *** 0.1% level. Standard errors are in parentheses. [a] Tobit model reports marginal effects.

Table 7: Impact of grain subsidy on grain crop sown area based on various divisions of the sample according to the share of agricultural cost in income

	Dependent variable: grain-sown area Fixed effect model					
	Divide the sample at 10% of agricultural cost in income		Divide the sample at 15% of agricultural cost in income		Divide the sample at 20% of agricultural cost in income	
	(1)	(2)	(3)	(4)	(5)	(6)
	$\leq 10\%$	$> 10\%$	$\leq 15\%$	$> 15\%$	$\leq 20\%$	$> 20\%$
Policy						
Grain subsidy	0.0828	2.1075**	0.6618	2.0617**	1.0121	1.9606*
(1000 yuan)	(0.7656)	(0.6498)	(0.6605)	(0.7346)	(0.5921)	(0.8556)
Output & input Market						
Grain crop revenue	-0.0128	0.5990**	0.0128	0.6439**	0.0850	0.7370**
(1000 yuan/mu)	(0.0847)	(0.1872)	(0.0890)	(0.2153)	(0.0885)	(0.2437)
Grain crop production	-1.9117***	1.2088	-1.6160***	1.6807	-0.9571**	1.7330
cost (1000 yuan/mu)	(0.3454)	(0.8703)	(0.3398)	(1.0531)	(0.3727)	(1.3020)
Non-grain crop revenue	0.0902	0.2330	0.0976	0.2915	0.0640	0.3733
(1000 yuan/mu)	(0.0645)	(0.1606)	(0.0642)	(0.2095)	(0.0713)	(0.2748)
Non-grain crop production	-0.1057	0.4348	-0.1441	0.5853*	-0.1570	0.6867*
cost (1000 yuan/mu)	(0.1539)	(0.2257)	(0.1453)	(0.2761)	(0.1377)	(0.3237)
Off-farm labor share	-0.9919***	-0.2399	-0.7291**	-0.4736	-0.8062**	-0.0819
(%)	(0.2601)	(0.5133)	(0.2670)	(0.6456)	(0.2534)	(0.8161)
Household characteristics						
Age of household head	0.0043	0.0114	0.0003	0.0196	0.0178	-0.0043
	(0.0146)	(0.0234)	(0.0167)	(0.0280)	(0.0151	(0.0351)
Education of household	0.0094	0.0933	0.0299	0.0956	0.0253	0.1123
head	(0.0259)	(0.0772)	(0.0342)	(0.0975)	(0.0349)	(0.1115)
Male household head	0.2319	-0.0733	0.3868	-0.2780	0.1512	0.0174
	(0.5381)	(0.3706)	(0.4827)	(0.3745)	(0.4103)	(0.4762)
Number of household	0.1769*	0.1712	0.2421**	0.0768	0.2352**	0.0675
labor	(0.0749)	(0.0997)	(0.0810)	(0.1131)	(0.0724)	(0.1408)
Depostit & cash in hand	0.0001	0.0036*	0.0002	0.0039*	0.0006	0.0031
& loan (1000 yuan)	(0.0003)	(0.0015)	(0.0003)	(0.0018)	(0.0004)	(0.0016)
Land market						
Land rent	0.0446	-0.2805**	-0.0523	-0.2893**	-0.1271*	-0.2537*
(1000 yuan/mu)	(0.0532)	(0.0850)	(0.0537)	(01.036)	(0.0546)	(0.1144)
Contracted land area	0.1206**	-0.0000	0.0006	0.0042	0.0006	-0.0021
(mu)	(0.0360)	(0.0004)	(0.0006)	(0.0042)	(0.0006)	(0.0044)
Rent-in cultivated land	0.0327	0.6002***	0.0591	0.6021***	0.1387	0.6054***
area (mu)	(0.0337)	(0.1223)	(0.0527)	(0.1239)	(0.1054)	(0.1301)
Percent of households who	-0.1330	1.4756	-0.2810	2.6141	0.3626	1.5079
rent in/out land in the vill.	(0.5798)	(1.5377)	(0.7027)	(1.9013)	(0.7418)	(2.1224)
Constant	1.9927*	2.8267	2.7295**	2.5526	2.2711**	3.1321
	(1.0041)	(1.6410)	(1.0295)	(2.0542)	(0.9835)	(2.4726)
R^2	0.0468	0.2809	0.0227	0.3016	0.0287	0.3327
Observations	6456	7340	8251	5545	9682	4114
Number of households	2902	3050	3668	2284	4269	1683

Significance codes: * 5% level, ** 1% level, *** 0.1% level. Standard errors are in parentheses.

Table 8: Impact of grain subsidy on grain crop sown area, non-grain crop sown area and living expenditure with section dummies of liquidity constraints (fixed effect model)

	(1) Grain crop sown area	(2) Non-grain crop sown area	(3) Living expenditure
Policy			
Low share of ag. cost in income (dummy) ×	0.6669	1.3184	1.7999
grain subsidy (1000 yuan)	(0.6588)	(1.1588)	(1.1515)
High share of ag. cost in income (dummy) ×	2.2166**	0.2451	0.5964
grain subsidy (1000 yuan)	(0.7324)	(0.2877)	(0.4515)
Output & input Market			
Grain crop revenue	0.3148**		
(1000 yuan/mu)	(0.1167)		
Grain crop production cost	0.3793		
(1000 yuan/mu)	(0.5827)		
Grain crop profit		-0.2156**	2.2330***
(1000 yuan/mu)		(0.0780)	(0.4685)
Non-grain crop revenue		-0.0455	
(1000 yuan/mu)		(0.0484)	
Non-grain crop cost		-0.3297*	
(1000 yuan/mu)		(0.1316)	
Non-grain crop profit	0.0880		0.6854*
(1000 yuan/mu)	(0.0814)		(0.2799)
Off-farm labor share	-0.6219*	-1.1841***	2.9807*
(yuan/day)	(0.2916)	(0.2140)	(1.2363)
Household characteristics			
Age of household head	0.0087		
	(0.0158)		
Education of household head	0.0417	-0.0278	0.0528
	(0.0400)	(0.0207)	(0.1172)
Male household head	0.1403	-0.0895	2.6961
	(0.3405)	(0.1813)	(1.6491)
Number of household residents			2.2252***
			(0.2509)
Number of household labor	0.1993**	0.0605	0.3360
	(0.0671)	(0.0479)	(0.2649)
Depostit & cash in hand & loan	0.0012**	-0.0001	0.0026
(1000 yuan)	(0.0005)	(0.0003)	(0.0038)
Land market			
Land rent	-0.1330*	0.0281	-0.2754
(1000 yuan/mu)	(0.0526)	(0.0426)	(0.4002)
Contracted land area	0.0005	0.0001	0.0008
(mu)	(0.0005)	(0.0004)	(0.0027)
Rent-in cultivated land area	0.4978***	0.0370	0.0192
(mu)	(0.1262)	(0.1178)	(0.0230)
Percent of households who	0.8821	-0.9814**	3.5187
rent in/out land in the village	(0.7709)	(0.3273)	(1.8341)
Constant	2.6042*	3.0611***	1.3048
	(1.0679)	(0.3874)	(2.0888)
R^2	0.2106	0.0156	0.0198
Observations	13796	13796	13796

Significance codes: * 5% level, ** 1% level, *** 0.1% level. Standard errors are in parentheses.