INFLATION AND GRAIN STOCKS OF FARM HOUSEHOLDS: WHY DON'T FARMERS STORE GRAIN AS BEFORE?

Ruijuan Zhang, Laping Wu

College of Economics and Management, China Agricultural University, Beijing, China

Colin Carter

Department of Agricultural and Resource Economics, University of California, Davis
Davis, California, USA

Dingqiang Sun

College of Economics and Management, Nanjing Agricultural University, Nanjing, China

Selected Paper prepared for presentation at the Agricultural &Applied Economics Association's 2013 AAEA&CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013.

INFLATION AND GRAIN STOCKS OF FARM HOUSEHOLDS: WHY DON'T FARMERS STORE GRAIN AS BEFORE?

Abstract:

This paper empirically addresses how inflation rates affect China's private grain stocks.Storable grain is characterized as a capital asset. Farm households would choose either to store grain or to sell grain to get bank deposits. We first build a farm household model in which real interest rates can alter farmer's grain storage behavior. Using household survey data collected in Hebei province, China from 2004-2009, we empirically test the theory. Our estimates show that inflation rates significantly and negatively affect private grain storage. This finding provides an alternative explanation for the decline in private grain stocks since 2004 in China.

Key words: Grain storage, inflation rate; Chinese Agriculture

Acknowledgements: The authors acknowledge the financial support of National Scholarship Management Committee. We would like to thank seminars participants at University of California, Davis, and China Agricultural University for their invaluable comments and suggestions on earlier version of this work. Any errors are our responsibility.

1. Introduction

Grain stocks playan important role in ensuring national food security. Grain stocks can smooth grain supply and demand fluctuations, and providea “reservoir” to maintain grain supply and demand balance. As such, maintaining a reasonable level of grain storage has been a significantcomponent of national food security policies for many countries, especially for developing countries, such as China, wherecontinuous increase in population and national income stimulates high demand for grain(Ke, 1997 and 2005; Han, 2003; Zhu, 2007; Wan, 2007; Wright, 2010; Zhang, 2012).

Historically, farm households stored grain mainly for household consumption, while governments kept stocks forurban residents. In China,most grains are stored in rural households (see Figure 1).Several estimates of grain stocks at the rural households’ level, based on grain balance sheets from China’s Statistical Yearbook, show that farm households still hold a large proportion of grain stocks in China (Lv, 2009)[1].

<Insert Figure 1 about here>

Although grain stocks by scattered farm households have many advantages, such as low cost, low burden to the grain market, and quick response in emergencies, studies have shown that many rural households changed their grain stocks behaviour for a variety of reasons, such as grain market reforms, storage conditions, high grain

[1]Due partly to lack of micro data on private storage, however, there are no official statistics on private grain stocks in China. Chinese governments only periodically survey grain storage held by state-owned grain companies and classifies grain stocks data as a state secret. Stocks held by private companies or farm households are not included in official statistics.

price variation, and risk attitude.Several studies, both theoretical and empirical, have investigated impact of important factors that influence grain stocks at the household level (Crook, 1994; Buschena et al., 2005; Park, 2006; Wan 2007;Wright, 2009). For instance, Buschena et al. (2005) studied market liberalisation among farmers located in two provinces in China focusing on farm-level wheat consumption, market sales and on-farm storage during in 1994.They concluded that policymakers should account for changes in farm household behaviour in designing and assessing the consequences of market liberalisation programs. Park (2006) applied a dynamic model to examine a household's joint production, storage and trade decisions when facing transactions costs and risk in prices and yields, he showed that the desire to store grain explains why subsistence households were frequently net purchasers but rarely net sellers of grain.

However, what are the main driving factorsthat affectgrain stocks at farm household level in China was still unclear yet.Howdoes an external change, such as inflation or real interest rate, affect grain stocks at rural household level? What are the responses of farmer's grain stocks along with inflation changes? What are the implications of these changes?Although these are all very important issues, existing literature is limited.

The overall goal of this paper is to better understand how inflation rate affects the stock-holding behaviour of farm households in China. In order to better interpret episodic behaviour of grain market prices and identify causes for high volatility in prices,it is crucial to understand the relation between prices and grain stocks(Wright,

2009 and 2010). Previous studies show that grain prices tend to overshoot in response to inflation and interest rates through changes in rural household grain stocks and (Lu and Peng, 2002). There existed a common phenomenon from rising grain prices in periods of 1988/1989, 1993/1995 and 2003/2004, where the nominal grain prices tend to overshoot in response to inflation through changes (Sun and Mu, 2004). Facing high inflation, farm households would probably change their grain stock holding behaviour through two related channels. First, when the inflation rate is high, rural households tend to expect that future inflation rate would be high too. Consequently, they would increase their grain stocks as real assets. Secondly, this mechanism is likely to be further strengthened due toa negative relationship between real interest rate and inflation rate. In China, nominal interest rates are controlled by China'scentral government, and governmental response to inflation is often lagged, so the real interest rate is negatively related to the inflation rate.When inflation is high and the real interest rate falls, rural households tend to store more grain as real assets, rather than to liquidate their grain for cashes.

To achieve our objective, we used data on private grain stocks from household surveys from 2004 to 2009in Hebei province, China, to empirically examine the impact of inflation rate (or real interest rate) on private stock holding behaviour for farm households in China.To our best knowledge, this is the first attempt to understand how macro factors, such as inflation rate, affect China's grain markets.Anticipating the results, we find that inflation rates significantly and negatively affect private grain stocks.

The rest of the paper is organized as follows. In section 2, we present a farm household model in which real interest rates can alter farmer's grain storage behaviour. We then provide a detailed description on the data set we used in our empirical investigation in Section 3. Section 4 presents our econometric analysis.In section 5, we conclude with a discussion on policy implications.

2. Model

2.1 Conceptual Framework

The agricultural households in this study are assumed to maximize expected utility by allocating grain between household consumption, storage and market sales in an inter-temporal decision. It is common that semi-commercial farmers have access to local markets, and thus they make recursive decisions (Singh, Squire, and Strauss, 2004). Namely, production decision is dependent on market prices but independent of consumption and storage decisions. Thus, consumption and storage depends on production but production does not depend on consumption and storage.

Conditions for a recursive model include the existence of local input and output markets, a fixed land base, the practice of farmers marketing surplus products, and a situation where farmers are price takers.These conditions are most likely to be satisfied in post-reform China. Although there was debate over the extent to which regional or national grain marketing is integrated (Zhou, Wan, and Chen; Rozelle et al.), country fairs provide farmers with access to well-functioning local markets. In addition, a smell farm, with size of about 0.5 ha on average, can rarely

influencemarket prices. Therefore, it seems appropriate to estimate rural grain storage with a single equation, based on the recursive nature of rural household decision-making (Carter and Zhong, 1999).

It is assumed that a household can choose to store grain or sell grain to hold bank deposit. Following Saha and Stroud (1994), Carter and Zhong (1999) and Buschena et al. (2005), a farm household is assumed to optimize grain allocation among competing uses in the context of an additively separable utility maximization model, in which input decisions are taken to be exogenous and the allocation decision is subject to income constraints.

The farm household maximizes the discounted present value of expected utility in two periods, denoted 0 and 1, the farm has already harvested its grain, but the grain harvest in period 1 is unknown. Household utility in each period depends on household consumption onnumeracies good, c.

The farmer's objective function is:

$$\mathrm{U}(\mathrm{c}_0;\mathrm{F}_0)+\emptyset\mathrm{E}\left[\mathrm{U}\left(\mathrm{c}_1;\mathrm{F}_{1,}\ldots\ldots\right)\right](1)$$

whereU is a twice-differentiable utility function over household consumption.$\emptyset$ is the discount scalar and E is the expectation operator. Variability in production, prices and other factors can be identified empirically through observed departures from population averages.

Household income constraint in period 0 is defined as:

$$c_0\mathrm{p_o}+M_0+s_0p_{g_0}=\mathrm{p}_{g_0}*\mathrm{Q}_0+\mathrm{NW}(\mathrm{r}_0,\mathrm{F}_0,\mathrm{M}_0) \qquad (2)$$

Where Q_0 is the grain production in period 0, it is given； $p_0$is the market price fornumeraire good,$p_{g_0}$is the market price for grain, price is assumed to be known in period 0 but not in period 1, thus, income from any given level of grain sales in period 0 is not stochastic. $M_0$is the cash saving in period 0, which is hold to period 1 in a bank deposit form and earn interest rate i. $s_0$is grain stocks in period 0 and are hold to period 1. The function NW denotes income from sources other than sales of grain, and is assumed to depend on the value of other farm production (r_0), off-farm income and family wealth as proxied by the vector of family characteristics in the initial period (F_0), and the village market level (M_0). The vector F_0 includes household non-agricultural wealth and demographic information that reflects potential on and off farm labour supply.

The income constraint in period 1 is:

$$c_1 p_1 = p_{g_1} * Q_1 + M_0(1 + i) + s_0 p_{g_1} + NW(r_1, F_1, M_1) \quad (3)$$

Period 1 values of the market price for grain, non-grain income and wealth are unobserved and enter the period 0 decision through expectations. As only two periods are being modeled, the household does not carry grain stocks and bank deposit beyond period 1.

In this framework, the farm household's grain storing and cash saving allocation problem in period 0, the period for which data are available, is to maximize the sum of discounted utility in both periods:

$$\text{Max } H = U(c_0; F_0) + \emptyset E[U(c_1;\ F_{1,} \dots)] \quad (4)$$

subject to constraints in Equations (2) and (3). Allowing for the possibility of corner solutions, the Kuhn–Tucker first-order conditions for the choice variables of grain storing and cash saving yield the following results, where subscripts indicate partial derivatives:

$$H_{s_0} = -U_{C_0}\frac{p_{g0}}{p_0} + \emptyset E[U_{C_1}]\frac{p_{g1}}{p_1} \leq 0 (4a)$$

$$H_{M_0} = -U_{C_0}\frac{1}{p_0} + \emptyset E[U_{C_1}]\frac{1+i}{p_1} \leq 0 (4b)$$

From the Kuhn–Tucker first-order conditions, there are three possible solutions:

$$\frac{1+i}{\frac{p_1}{p_0}} < \frac{\frac{p_{g1}}{p_{g0}}}{\frac{p_1}{p_0}} (5a) , \frac{1+i}{\frac{p_1}{p_0}} > \frac{\frac{p_{g1}}{p_{g0}}}{\frac{p_1}{p_0}} (5b), or \ \frac{1+i}{\frac{p_1}{p_0}} = \frac{\frac{p_{g1}}{p_{g0}}}{\frac{p_1}{p_0}} (5c)$$

If (5a) happens, rural households will choose store more grain; if (5b) happens, rural households will choose sell grain to get bank deposit; if (5c) happens, rural households will be no difference between storing grain and holding bank deposit.

2.2 From Theory to Empirics

Our model specified above predicts that household grain stocks is reversely related to real interest rates$E_t R_{t+1} = \frac{1+i_t}{1+\pi_{t+1}}$, where $\pi_{t+1}$is inflation rate in the next period. Thereal grain price will affect the grain stocks at rural household' level as well. Theincomeconstraint shows that the grain stocks will be affected by grain output and income from sources other than sales of grain that mainly includes other farm production income, off-farm income and grain subsidies. In addition, many demographic factors,such as family size, livestock, off-farm workers, can affect grain stocks.Overall, the equation of grain stocks at the end of the year could be presented

as follows:

$$S_t = f(E_t R_{t+1}, E_t \frac{p_{g_{t+1}}}{p_{t+1}}, Output_{it}, Non\ grain\ income_{it}, L_{it}, Population_{it}, \sum Other_{it})$$

The Kuhn–Tucker conditions (5a) and (5b) provide useful and testable predictions about grain allocation decisions. They imply that grain stocks are related to: (i) the amount of available grain; (ii) the amount of other sources of income in period 0; (iii) the price of grain in period 0; (iv) the grain storage costs (be assumed to be 0, because of the advanced storage equipment).

The model's implications for own-price effects on grain storage are complicated by the commodity's role as a source of family income and as a store of wealth. An increase in grain price increase potential farm revenue and therefore could lead to either increases or decreases in grain storage because of offsetting farm revenue and substitution effects.

The nominal interest rate (i_t) is controlled by China's central government, which is not flexible; the expectation real interest rate in next year should be $E_t R_{t+1} = \frac{1+i_t}{1+\pi_{t+1}}$, it mainly depends on the expectation of the inflation rate (π_{t+1}) in next year. Given the fact that information is not sufficient for farm households, we assumed that farm householdsadopt an adaptive expectationfor inflation rate as follows:

$$E_t R_{it+1} = E_t R_{it}$$

The recursive nature of the model is attractive because it means all prices are exogenous. For instance, it can be shown that the storage for the staple commodity is a function of commodity prices and full income and one can obtain appropriate

estimates of this single equation.

Finally, to test the impact of real interest rate, and inflation rates on household grain storage separately, we specify three econometric modelsas follows:

$$\ln Storage_{it} = \alpha_1 + \tau_1 \ln E_t R_{it} + \gamma_1 \ln \frac{p_{g_{it}}}{p_t} + \beta_1 disaster_t + \delta_1 \ln Output_{it} + \varphi_1 \ln Nongrain_{it} + \phi_1 \ln L_{it} + \lambda_1 \ln Population_{it} + \theta_1 \sum Other_{it} + \varepsilon \quad (6)$$

$$\ln Storage_{it} = \alpha_2 + \tau_2 \ln i_t + \gamma_2 \ln \frac{p_{g_{it}}}{p_t} + \beta_2 disaster_t + \delta_2 \ln Output_{it} + \varphi_2 \ln Nongrain_{it} + \phi_2 \ln L_{it} + \lambda_2 \ln Population_{it} + \theta_2 \sum Other_{it} + \varepsilon \quad (7)$$

$$\ln Storage_{it} = \alpha_3 + \tau_3 \ln N_t + \gamma_3 \ln \frac{p_{g_{it}}}{p_t} + \beta_3 disaster_t + \delta_3 \ln Output_{it} + \varphi_3 \ln Nongrain_{it} + \phi_3 \ln L_{it} + \lambda_3 \ln Population_{it} + \theta_3 \sum Other_{it} + \varepsilon \quad (8)$$

3. Data

The data used in this paper are mainly from rural household surveysin Hebei province, China conducted by the Research Centre of Rural Economy of Chinafrom 2004 to 2009.Hebei province provides a good case study for farm household grain stocks. Located in northern China, Hebei province is one of important agricultural producing regions that supply grain for capital city Beijing and Tianjin municipalities (see Figure2).

<Insert Figure 2 about here>

Total population in Hebei province is around 69.2million in 2009, with a rural population of 42.7 million.The share ofagricultural production in GDPis about 13.5%. Sown areas of grain cropsis around 6,176 thousandhectares, accounting for 3.9% of national cultivated landacreage. Grain output was increasing from 24.8 mmtin 2004 to

29.1 mmt in 2009 accounting for about 5.5% of total national grain output,10% of national wheat output, and 8.5% of corn output. Wheat and corn are two main crops,together accounting for over 90% of total grain output in Hebei province(see Table 2).

<Insert Table 2 about here>

The survey gathered detailed information on household production, consumption, grain marketing, and other demographic information about farm households. There are about 1,000 households surveyed, providing a good representative sample of production operations.A stratified random sampling procedure was used in this survey. They first randomly select village in each county and then randomly choose farm household within each villages. The households in the sample are fixed once they were selected and were interviewed every year.

The survey datacontainedgrain balance sheet at the end of thecalendar year, by recording the grain balance every dayfor each sample household, including grain output, storage, consumption, market sales, and market purchases. Wheat and corn are the two main grains in Hebei province, accounting for over 95% of total grain output in our sample. Wheat is usually harvested in June and stored for about 6 months until the end of the year, whilecorn is harvested in September or earlyOctober, will be stored for 2 or 3 months. Average wheat production was about 1317kg per household, a little less than corn production (1622kg per household). On average, 62.8% of grain output was stored at the end of the year, 79.4%for wheat and 46.2% for corn.

Data on interest rates and inflation rates were obtained from China's Statistic Yearbooks. As the nominal interest ratesarecontrolled by Chinese central government, it was quietly stable with an average nominal interest rate of 2.64% in the period 2004-2010. The real interest rates, however, vary substantiallyranging from -2.68% to 2.97%. Inflation rates also changed significantly. The average inflation rate from 2004-2009 was3%, ranging from -0.7% to 5.9%. The real interest ratesand inflation rates are negatively correlated due partly to relatively stale normal interest rates controlled by China's governments.

The survey data also contain information on grain price, household income, off-farm employment, and demographic information farm households. First, an average grain prices was constructed to measure the relevant prices faced by farm households. Self-reported farm-level prices reflect seasonality, quality differences, differences in each farmer's negotiating ability, and differences in market opportunities across villages (David et al. 2005). In markets in which storage provides an effective means of inter-temporal arbitrage, seasonal differences in prices reflect differences in the opportunity costs of marketing grain (Williams and Wright 1991). Thus, we used grain salesamount, divided by grain sales in a whole year, to represent the average price, and then a Retail Price Index (RPI) based on 2003 was used to capture real grain prices, eliminating the effect of inflation. The RPI for grainalso are used as proxies for market prices faced by farmers who had no reported grain sales.

Second, we construct variable commercial rate, the value of grain sales compared to grain output,to measure grain market development. The commercial ratesvary

quietly across households, ranging from zero to 3. On average, more than a half of grain output was used or stored by farmer households from 2004 to 2009.

Third, non-grain income used in the study includes, economic crop income, governmental subsidies and off-farm income. Off-farm income has been an important incomesource for many households in rural China, overtwice higher than revenues from grain sales in our sample regions. The average non-grain income was 19.3 thousand Yuan per household, ranged from zero to 188 thousand Yuan per household.

Finally, the survey data also contained several demographic variables, including family size, farm labour,ration of off-farm workdays, years of schooling of household head, age of household head, number of natural disaster, and housing status.Table 3 provides descriptions and summary statistics for all variables used in this study.

<Insert Table 3 about here>

4. Econometric Analysis

Equations (6)-(8) can be estimated through a variety of estimation techniques. Given the panel structure ofour data, we apply different methods of estimation. We first estimated equation (6)-(8) using a fixed effect model. A fixed effects estimator can address potential correlation between explanatory variables and a time-invariant unobservable.The fixed effect model would ensure that the coefficients are not biased by the omitted time-invariant factors. In check robustness of our estimator, we then estimated the same equations with a random effect model and Ordinary Least Squares (OLS) estimate. However, Hausman tests indicate that a fixed-effectsmodel is superior

over other estimating methods. Thus, we only report estimation results from the fixed-effect modelin Tables 4-6.

Our results show that the end-of-year grain storage is inversely related to the real interest rateand the nominal interest rate, whilepositively related to the inflation rate. If the real interest rate falls, farm households tend to store more grain. The nominal interest rate is controlled by the Chinese government and it is basically steady, so a lower real interest rate means a higherinflation rate. Wheninflation increases, households tend tohold grain storage as real assets. This is the real story happening in Chinese farm households these years; since China's rapid economic development and the liberalizing grain market reform, inflation rate and CPI is higher month by month, year by year, farm households are reluctant to sell grain after harvest, we call it as "Xi Shou Xi Li" in Chinese, we can find many reports about Chinese farm households'"Xi Shou Xi Li" in China's website these years, farm households in China usually are confused by grain price, inflation rate and real interest rate, it is hard for them to make decision of the proper time to sell grain and store grain, sometimes their "Xi Shou Xi Li" will affect the grain market rules.

Our empirical results also show that end-of-year grain storages are inversely related to the market price, indicating that when the grain market price increases, farm households tend to sell more grain and store less. There are two different effects of the grain price on grain storage. When the price of this year is high, the opportunity cost of holding grain is high, so households will decrease end-of-year grain storage;

meanwhile, when the price is high, maybe the price expectation for next year is high too, and households will increase end-of-year grain storage.

<Insert Table 4 about here>

An increase of grain output in any given year significantly increases the volume of grain storage at the end of the year.The more natural disaster, the more grain will be stored at the end of the year, this is a kind of "store up grain against famine" thought.

Higher non-grain income reduced grain storage at the end of the year; this non-grain income effect on storage at the margin is consistent with grain stocks as a risk-reducing tool. More non-grainincomes farmers can get, less risk farmers will be hold; while is inconsistent with storage as a store of wealth, maybe because they earn more money from non-grain and do not care about storage as a store of wealth. Off-farm work proportion significantly decreased the grain storage at the end of the year, maybe because farm households do not have enough time at home to choose the appropriate time to sell and store grain after harvest, so they sell them immediately.

End-of-year storage is inversely related to commercial market proportion, the result consistent with the market development degree will decrease the grain storage at household level. Housing is not significant here, maybe because Chinese farmers usually store grain at their own house, pile in the yard or put inside house and housing also can be regarded as a proxy for farmers'wealth; these two effects are trade-off together.

An increase in the number of family members significantly increased grain storage at the end of the year, but the number of livestock is not significant; this result is consistent with one motive of grain storage, that is part of grain storage is consumed by people in next year. Household head' age significantly affected grain storage at the end of the year, older people tend to store less grain at the end of the year, and this is different with Chinesetradition, older peoplewho went throughdifficult periods in Chinasee grain as gold, they should store more.But from another angle, more and more people store grain at the end of the year are not for food security, but for the higher expectedprice,older people do not have as much as physical power and energy to store and manage grain,also food consumption for the older people is less than the younger one;at the same time,the income sources of older people is less than the younger people, they will sell grain for their daily living expenses, comparativelyspeaking, the older store less than the younger at the end of the year.

The end-of-year wheat and corn storage are inversely related to the market price, real interest rate, and positively related to inflation rate. It indicates that when the wheat or corn market price increased, farm households tend to sell them; while if the real interest rate decreased and inflation rate increased, farm households tend to store grain; the nominal interest rate is controlled by Chinese government and it is basically steady,so farm households in China usually are confused by grain price, real interest rateand inflation rate, it is hard for them to make decision of the proper selling time (Table5 and Table 6).

An increase of wheat and corn output in the year significantly increased the grain storage at the end of the year.The more natural disaster, the more wheat and corn will be stored at the end of the year.

Higher non-grain income decreased corn storage at the end of the year, but it won't affect wheat storage at the end of the year; this non-grain income effect on corn storage at the margin is consistent with stocks as a risk-reducing tool, while is inconsistent with storage as a store of wealth, and wheat storage was trade-off by the two different direction effects.

<Insert Table 5 about here>

<Insert Table 6 about here>

An increase in the number of family members significantly increased wheat and corn storage at the end of the year; while the number of livestock is not significant with wheat storage, it is significant with corn storage; this result is consistent with storage motives of wheatand corn, that is wheat storage is only consumed by people and corn storage will be consumed by people and livestock. Household head' age significantly affected grain storage at the end of the year; older people tend to store less grain at the end of the year.

Off-farm day's proportion and commercial market proportion are not significant by estimation wheat and corn storage separately, but it significantly affected the whole grain storage.Housing is significant inversely related to wheat and corn storage, housing can be regarded as a proxy for farmers' wealth here.

5. Conclusion

This paper empirically addresses how inflation rates affect farm household grain storage in China. We establish a capital asset select theory to explain the relationship between inflation rates and grain stocks.When inflation ratesare high, rural households tend to expect a future high inflation. Thus, they will increase their grain storage as real assets. As well, this mechanism is strengthened by the negative relationship between real interest rate and inflation rate. As the nominal interest rate is controlled by Chinese governments, it's response to inflation is lagged, so real interest rate is significantly and negatively related to inflation rates. When inflation rates are high, real interest rates decreased, it strengthens the motive of rural households that they want to store more grain as real assets.

References:

Anderson, J. R. and Dillon, J. L. 1977.*Agricultural Decision Analysis*，Iowa State University Press.

Brown, L.R. 1995. *Who Will Feed China?*Earthscan Publications.

Buschena, D. and Smith, V. 2005. "Policy Reform and Farmers' Wheat Allocation in Rural China: A Case Study." *The Australian Journal of Agricultural and Resource Economics*, 143–158.

Deaton, A. and Laroque, G. 1996."Competitive Storage and Commodity Price Dynamics."*Journal of Political Economy*,vol.104(5), 896–923.

Fan, S. G. 1991."Effects of Technological Change and Institutional Reform on Production Growth in Chinese Agriculture."*American Journal of Agricultural Economics*,73,266-275.

Frederick. W. C. 1994. "An Introduction to China's Rural Grain Supply and Use."China Situation and Outlook Series, USDA Economic Research Service.

Huang, J. K. and Rozelle, S. 1985. *China and the Future Global Food Situation*.IFPRI 2020 Brief, International Food Policy Research Institute, Washington D.C.

Han, J. 2003. "The Policy Points to Make Sure Chinese Food Security."[EB/OL].(2003-10-24) http://www.china.com.cn/authority/txt/2003-10/24.htm

Ke, B. S. 1997. "The Impacts of Chinese Farmers' Grain Storage on National Grain Market."*ChineseSoftScience*, 22-26.

Ke, B. S. 2005. "China's Food Security and Policy Ideas."*China State Farms*, 15-18.

Kuang, Y. P. 2008."Grain Storage Subsidies at Chinese Rural Household Level: Reasons and Realization Mechanism."*China Grain Economy*, 19-23.

Lv, X. Y. 2009."Chinese Rural Household Grain Storage Scale and Influence Factors Analysis."*A Concluding Report about Chinese Rural Household Grain Storage.*

Nerlove, M. 1958. "Adaptive Expectations and the Cobweb Phenomena."*Quarterly Journal of Economics*, 227-40.

Park, A. 1996.*Household Grain Management Under Uncertainty in China's Poor Areas.*PhD thesis, Stanford University.

Park, A. 2006."Risk and Household Grain Management in Developing Countries."*The Economic Journal*, 116, 1088–1115.

Ren, H. Y. and Shi, Q. H. 1999."An Empirical Analysis of Grain Balance at Chinese Rural Household Level in Shanxi Province."*Journal of Agrotechnical Economics*, 12-15.

Sun, X. F. and Mu, C. S. 2004."Inflation, Real Interest Rate and the Farmer's Stock of Grain: An Empirical Analysis of the Grain Stocks Behaviour of Chinese Farmers during 1980-2003."*China Rural Survey,* 23-33.

Song, G. Q. 2002."A slump of grain storage in China:Inflation and Real Interest Rate."http://magazine.caixin.com/2002-03-05/100078615.html

Shi, Q. H. and Zhuo, J. W. 2004."Grain Management Behaviour and Food Security at Chinese Rural Household Level."*Journal of Agrotechnical Economics,* 23-32.

Shi, Q. H. and Xu, C. P. 2009."Grain storage atChinese Rural Household Level: From Self Prevent to Social Security."*Journal of Agrotechnical Economics,* 30-37.

Shang, J. S. 2012."Strengthen the Grain Storage at Rural Household Level to Reduce National Burden."http://sp.chinadaily.com.cn/hot/qita/2116.html

Wan, G. H. and Griffiths, W. E. 1992."Estimation of Risk Effects with Seemingly Unrelated Regressions and Panel Data."*Empirical Economics,* 17, 35-49.

Wan, G. H. 2007."The Deciding Factor of Chinese Farmers' Grain Storage Behaviour."*China Rural Economy,* 13-23.

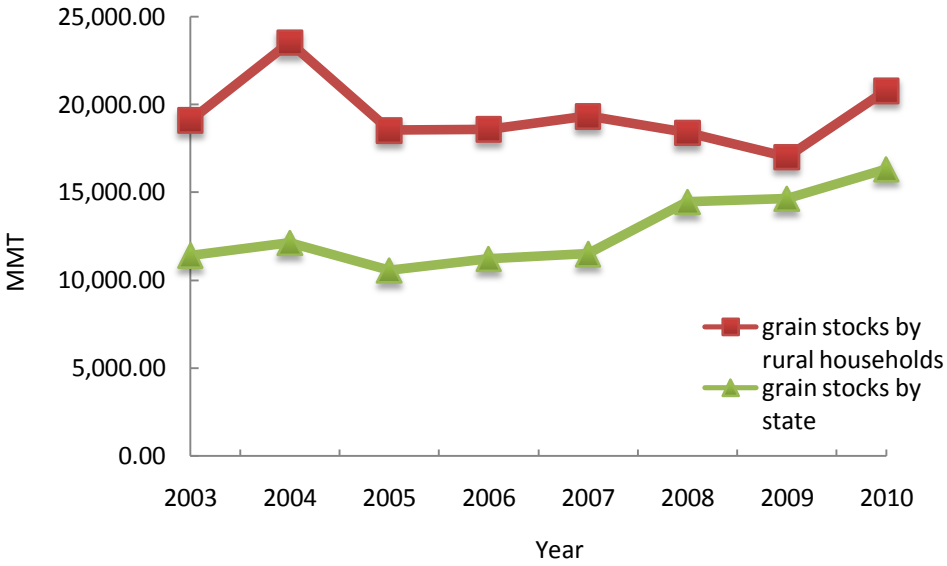
Williams, J. C. and Wright, B.D. 1991.*Storage and Commodity Markets*.Cambridge University Press.

Zhu, F. L. 2007.*The Attitude and Behaviour Research about Grain Production, Storage and Sale at Chinese Rural Household Level.*PhD thesis, Yangzhou University.

Zhang, R. J. and Wu, L. P. 2012."Research Review on Grain Storage at Chinese Rural Household Level."*Journal of China Agricultural University,* 176-181.

Figure1:

Grain Stocks by Rural Households and State in China



Sources: USDA GAIN reports from 2004 to 2010.

Figure 2:

Location of Sample Province (Hebei) in China

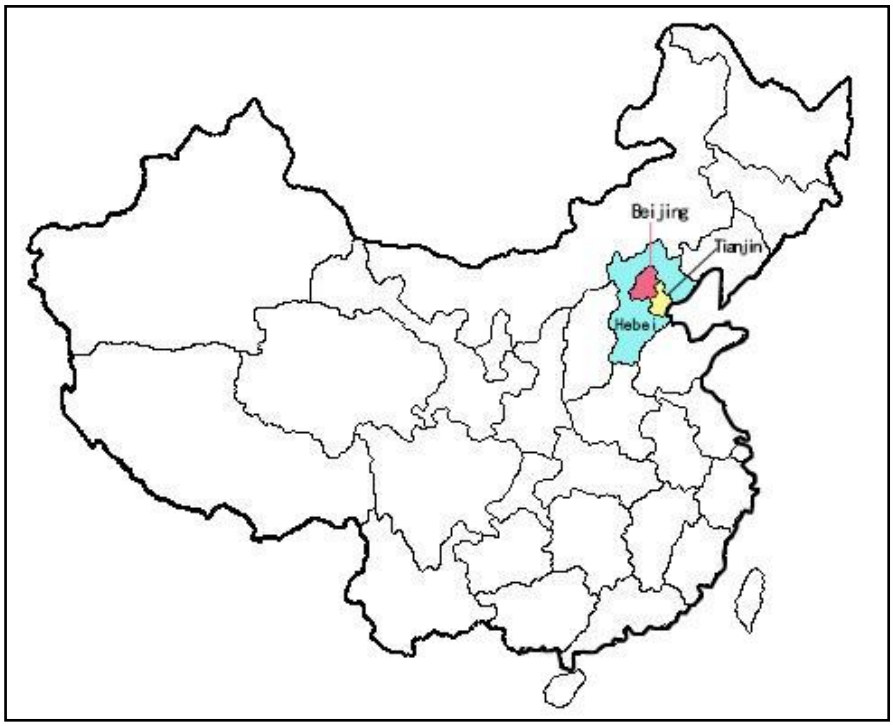


TABLE 1:

Estimated Grain Stocks at Farm household Level (10,000 metric tons)

Year	Total Output	Output of Commercial Farms	Farm Households			
			Output	Sales	Storage	Storage per capita (kg.)
2003	43,070	1,342.6	41,727.4	22,621.1	19,106.3	248.6
2004	46,947	1,666.2	45,280.8	21,746.2	23,534.6	310.9
2005	48,402	1,859.0	46,543.0	28,012.9	18,530.1	248.6
2006	49,748	2,055.6	47,692.4	29,101.5	18,590.9	252.1
2007	50,160	2,162.3	47,997.7	28,668.3	19,329.4	265.7
2008	52,871	2,421.5	50,449.5	32,060.4	18,389.1	254.9
2009	53,082	2,773.2	50,308.8	33,292.2	17,016.6	246.8
2010	54,648	2,953.3	51,694.7	30,902.9	20,791.8	309.8

Source: Data from 2003-2008 comes from Lv (2009) and were updated by authors to 2010.

TABLE 2:

Statistical Description of Hebei Province

year	Total Population (10,000)	Rural Population (10,000)	Agricultural Share in GDP (%)	Sown Area (1,000 ha)	Grain Output (10,000 MT)	Maize Output	Wheat Output
2004	6,809	5,000	16	6,003	2,480	1,158	1,053
2005	6,851	4,269	14	6,240	2,599	1,194	1,150
2006	6,898	4,200	13	6,272	2,781	1,349	1,190
2007	6,943	4,148	13	6,168	2,842	1,422	1,194
2008	6,989	4,061	13	6,158	2,906	1,442	1,222
2009	7,034	3,957	13	6,217	2,910	1,465	1,230

Source: Hebei Statistical Yearbook from 2004 to 2009.

TABLE 3:

Statistical Description of Variables

Variable	Mean	Std. Dev.	Min	Max
Grain Storage (kg)	1538	1424	0	14600
Wheat Storage (kg)	1046	1066	0	8821
Maize Storage (kg)	749	1048	0	10500
Grain Output(kg)	2448	2071	0	18290
Wheat Output(kg)	1317	1034	0	9000
Maize Output(kg)	1622	1224	0	11750
Grain Price (Yuan/kg)	1.2	0.2	0.6	2.8
Wheat Price(Yuan/kg)	1.4	0.1	0.6	2.8
Maize Price(Yuan/kg)	1.2	0.1	0.6	2.8
Real Interest Rate	-0.002	0.019	-0.027	0.030
Nominal Interest Rate	0.026	0.005	0.023	0.035
Inflation Rate	0.031	0.019	0.007	0.059
Commercial Market Proportion	0.246	0.390	0	3
Non-grain Income (Yuan/household)	19252	16454	0	187989
Population	3.6	1.4	1.0	9.0
Livestock	0.5	2.7	0.0	50.0
Off-farm days proportion	0.1	0.2	0.0	1.0
Age of Household Head	53.8	11.1	20.0	90.0
Schooling of Household Head	6.8	2.5	0.0	15.0
Natural Disaster Proportion	0.2	0.0	0.1	0.2
Housing(sq. m.)	115	68	30	500

Source: Authors' Calculation

Table 4:

Estimation Results of Impact of Interest Rate on Grain Storage

Variable	Dependent Variable: Log (Grain Storage)		
	(1)	(2)	(3)
Interest Rate:			
Log (real interest rate)	-4.091***		
Log (inflation rate)		0.087***	
Log (nominal interest rate)			-0.366***
Other Control Variables:			
Log (grain output)	0.160***	0.161***	0.162***
Log (grain price)	-0.832***	-0.833***	-0.658***
Log (off-farm income)	-0.062*	-0.066*	-0.047
Natural disaster	1.193***	1.020**	-0.072
Log (Population)	0.296***	0.300***	0.285***
Log (Livestock)	-0.01	-0.009	-0.017
Off-farm days proportion	-0.143*	-0.150*	-0.195*
Housing	0.000	0.000	0.000
Age of Household Head	-0.026***	-0.027***	-0.028***
Schooling of Household Head	-0.015	-0.015	-0.012
Commercial market proportion	-0.144*	-0.147*	-0.164*
Constant	7.235***	7.672***	6.024***
R-squares	0.24	0.24	0.24
Observation		5776	

Note: *, ** and *** indicate significances at 10%, 5% and 1%, respectively

TABLE 5:

Estimation Results of Impacts of Interest Rate on Wheat Storage

Variable	Dependent Variable: Log (Wheat Storage)		
	(1)	(2)	(3)
Interest Rete:			
Log (real interest rate)	-7.339 ***		
Log (inflation rate)		0.163***	
Log (nominal interest rate)			-0.534***
Other Control Variables:			
Log (wheat output)	0.143***	0.143***	0.142***
Log (wheat price)	-3.620***	-3.630**	-3.813***
Log (non-grain income)	0.071	0.063	0.104
Natural disaster	2.646 ***	2.371***	0.813
Population	0.306**	0.315*	0.276*
Livestock	0.058	0.059	0.035
Off-farm days proportion	-0.093	-0.102	-0.174
Housing	-0.001*	-0.001	-0.001
Age of Household Head	-0.063***	-0.064***	-0.063***
Schooling of Household head	-0.048*	-0.049	-0.042
Commercial market proportion	-0.055	-0.06	-0.097
Constant	8.345***	9.148***	6.556***
R-squares	0.16	0.16	0.16
Observation		5776	

Note: *, ** and *** indicate significances at 10%, 5% and 1%, respectively

TABLE 6:

Estimation Results of Impacts of Interest Rate on Maize Storage

Variable	Dependent Variable: Log (Maize Storage)		
	(1)	(2)	(3)
Interest Rate:			
Log (real interest rate)	-8.986***		
Log (inflation rate)		0.216***	
Log (nominal interest rate)			0.09
Other Control Variables:			
Log (maize output)	0.252***	0.254***	0.254***
Log (maize price)	-2.020***	-2.056**	-1.960***
Log (non-grain income)	-0.126*	-0.129*	-0.137*
Natural disaster	4.150***	3.915***	2.923***
Population	0.270*	0.064*	0.071*
Livestock	0.103*	0.032*	0.031*
Off-farm days proportion	0.087	0.074	-0.012
Housing	-0.002*	-0.002*	-0.003*
Age of Household Head	-0.036***	-0.036***	-0.043***
Schooling of Household head	-0.014	-0.008	-0.011
Commercial market proportion	-0.099	-0.102	0.15
Constant	4.816***	5.802***	5.977***
R-squares	0.13	0.13	0.12
Observation		5900	

Note: *, ** and *** indicate significances at 10%, 5% and 1%, respectively