

Policy reform and farmers' wheat allocation in rural China: a case study*

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Market-oriented policy reforms often have important effects on farm-level grain production and utilisation decisions in developing countries. China's grain farmers are of particular interest because of China's importance in world grain markets and because of China's recent major agricultural policy advances and retrenchments. An empirical evaluation of market liberalisation among farmers located in two provinces in China on farm-level wheat consumption, market sales and on-farm storage during 1994 is presented. The results indicate that policymakers should account for such changes in farm household behaviour in designing and assessing the consequence of market liberalisation programs for agricultural sectors in developing countries.

Key words: China, grain storage, household allocation decisions, procurement quotas, wheat.

Shanghai/Singapore, Nov. 21, 2001 (Reuters) – 'If the world's optimists have their way, China's [sic] will throw open its gates to import huge shipments of grains and other commodities the moment it joins the World Trade Organization on December 10.' ... 'Analysts predict December 10 will yield a different reality.'

Beijing, Oct. 9, 2001 (Reuters) – 'China has begun easing a decades-old system forcing people to work where they are registered to live, allowing greater freedom of movement in an increasingly market oriented economy.' ... 'Analysts say China needs to allow more free movement of labour as it shifts away from less intensive agriculture, ...'

1. Introduction

China has been reforming its grain policy for over two decades (Economic Research Service 2003). The period 1993–1994 provides a particularly interesting case study of these policy changes and their consequences, as China's grain policy initially moved towards extensive market-oriented reforms, only to return to more extensive government control of grain procurement within 3 years. The Chinese government made extensive

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changes to grain acquisition policies and market controls during this period. Mandatory farm-level grain delivery quotas were reduced, private grain markets liberalised and prices paid by government grain buyers for both quota and over-quota purchases tied more closely to private market prices. In addition, government price subsidies for urban consumers were intended to be substantially reduced and urban market prices to be more closely aligned with procurement costs. In fact, in many regions, government procurement agencies continued to offer low prices for over-quota purchases (Park and Rozelle 1998). Relieved of most restrictions on sales to private markets, many farmers increased grain sales to these markets and increased storage in anticipation of future private market sales. However, these reforms were short-lived. In late 1994 and 1995, because urban consumers experienced up to 60 per cent increases in wheat prices, the government responded by rolling back many of the grain market reforms introduced in 1993. The government of China continues to reform agriculture in part to meet World Trade Organization (WTO) requirements and also in response to domestic concerns, but the consequences of these more recent policy adjustments are yet to be determined.

The quantitative effects of the short-run policy changes in 1993–1994 on farm household grain consumption, storage and marketing decisions have received relatively little attention. However, these effects have important implications for rural household incomes and nutrition. In addition, given China's important role as an importer in world wheat markets, changes in policies that affect domestic storage and consumption may have substantial ramifications for world wheat prices.

Assessments of the impact on Chinese farm-household decisions of these policy reforms have been hampered by a dearth of relevant data. This case study uses farm-level cross-section data from 155 farm households from six villages in two wheat producing regions to estimate the effects of changes in government quota and price policies on the farm-household level allocation of wheat between on-farm consumption, sales to the government, private market sales and on-farm storage. This data set was collected in 1994 under the supervision of researchers from the University of California at Davis and is highly regarded for its accuracy and representativeness. Numerous papers have used this data, including: Brandt *et al.* (2002); Rozelle *et al.* (1999a,b); Rozelle and Li (1998); and Li *et al.* (1998).

The survey data were collected during the spring of 1995 from Hebei and Liaoning provinces. Hebei has recently produced over 10 per cent of China's wheat, while the adjacent province of Liaoning produced less than 1 per cent of China's wheat (Lohmar 2004). Many farm households in both provinces have viable off-farm income opportunities. The survey provides information on farm household behaviour during 1994, the period in which China's private grain markets were least regulated. The results of the study, therefore, are of particular interest because parameter estimates of price effects are less likely to be biased downwards because of unobserved government restrictions on private market sales.

The determinants of end-of-year farmer-owned wheat stocks in China are of concern as those stocks have been estimated to be quite large, amounting in aggregate to between 85 and 111 per cent of production in the early 1990s (Crook 1996; Food and Agriculture Organization 2000). Crook has suggested that a number of factors are

important in determining the levels of stocks held by Chinese farmers. He has argued that Chinese farmers hold large grain stocks partly because they serve as a form of lifetime savings (private land ownership and enrolment in state pension plans by farmers are limited in China). Crook also hypothesises that Chinese farmers hold grain stocks because of financial and grain market imperfections, government grain price policy and market restrictions and historically developed farmer attitudes towards the risk of food shortages. The factors identified by Crook are generally consistent with commonly held views that farmers in developing countries such as India and China hold grain stocks because of convenience yields (Renkow 1990), grain or credit market imperfections, risk aversion (Saha and Stroud 1994; Johnson and Song 1999), food security concerns (Ke 1996), as a price hedge (Park 1996) and – as in developed countries – in anticipation of profits (Gardner 1979).

In this study, we develop an intertemporal theoretical model of wheat use for consumption, market sales and changes in storage by farm households. The model, while in many respects similar to those developed by Saha and Stroud (1994) and also Carter and Zhong (1999), is novel in that it accounts for the effects of China's grain quota program on farm household wheat allocation between consumption, storage and market sales. The predictions of the model are tested using cross-section survey data through an econometric model of wheat use that accounts for household demographic and economic characteristics.

The empirical results reported here are largely consistent with the predictions of the theoretical model and indicate that market prices and government quota policies have economically important effects on farm consumption, on-farm storage and market sales. Household wealth and the potential for households to earn off-farm income also significantly affect household wheat use decisions. In addition, the econometric results are consistent with the implications of Park's dynamic programming model of market grain sales by low-income households in China. The empirical results also suggest that while the policy changes undertaken in 1993 and 1994 increased market sales, paradoxically they may also have led to increased market prices, which contributed to the Chinese government's abandonment of many aspects of its grain market liberalisation program in 1997.

1.1 Chinese agricultural policy and grain use

Despite the abandonment of collective production teams and restrictions on grain production by individual households in 1979, the Chinese government continued to rely on a grain acquisition and distribution system in the 1980s and the early 1990s that involved a considerable degree of control by the central and provincial governments (Sicular 1995). Through a government quota procurement system introduced in 1953, grain producers were ordered to deliver specific quantities of grain to government grain bureaus at relatively low fixed prices. These bureaus then distributed grain at subsidised prices to permanent urban residents.

In the 1960s, an over-quota procurement system was implemented under which, after meeting the predetermined quotas, producers could sell grain to the government at a premium over the quota price. Despite some significant changes, the core elements

of this quota-based grain procurement program remained in place during the 1990s. In the early 1990s, farmers still had to comply with predetermined delivery quotas to government grain bureaus at prices well below those for over-quota sales either to government grain bureaus or to private buyers. Turner *et al.* (1999) report that cash settlements of quota became increasingly allowed at the village level in the mid-1990s, with farmers paying the difference between the market price and the quota price for these settlements.

Over the period 1991–1993, substantial market-oriented reforms were implemented for grain sales. In some provinces, under these reforms farmers enjoyed reductions in mandatory delivery quotas for wheat and were also allowed to sell over-quota production either to government grain bureaus at premium prices or, perhaps more importantly, into private markets. In addition, grain price subsidies to urban consumers were substantially reduced. In May 1991, for example, retail prices for government-procured grain increased by 67 per cent (Findlay and Watson 1999) and in 1992 were supposed to have been further increased to correspond approximately to procurement prices paid for over-quota grain (Lin 1994).

In late 1994 and in 1995, higher grain prices in urban markets created considerable political pressures. In response, the government effectively prohibited many farmers from selling over-quota production into private markets, essentially re-establishing monopsony powers for regional government grain bureaus. The government grain acquisition program, put into effect in 1998 during a period of low world market prices, had three key elements (Findlay and Watson 1999). First, farmers still had to meet grain delivery quotas and received lower prices for quota grain. Second, government grain bureaus had exclusive rights to purchase all farmer-marketed grain, while private merchants could only buy grain from these grain bureaus. Third, grain bureaus were required to pay market prices for any over-quota grain farmers wanted to sell unless prices fell below predetermined minimum levels; that is, farmers were guaranteed a minimum price.

In 1999, the Chinese government moved to increase prices for higher quality grain and to commercialise and allow autonomy for grain bureaus and grain stations (Lohmar 2004). Many provinces also abandoned the grain quota system, instead using taxes or cash fees (Lohmar 2004). This shift away from the quota system allowed some farmers to move into more profitable crops such as horticultural products. China's hybrid agricultural system continues to evolve as a mix of market forces and government planning, with this mix being driven by goals of: (i) achieving a high level of self-sufficiency in grain production and (ii) increasing rural incomes (Economic Research Service 2003).

The period of liberalisation of grain markets in 1993 and 1994 provided China's farmers with opportunities to respond to higher private market prices by reallocating grain between household consumption, storage and private market sales. Reportedly, although grain and credit markets remained imperfect (Park 1996), farmers responded to partial market liberalisation by reallocating grain into private markets (Park and Rozelle 1998; Findlay and Watson 1999). As evidenced by the Chinese government's decision to roll back the market liberalisation component of the reforms, the extent to which farmers reallocated grain between market sales and other uses was unanticipated.

In the next section, we present an intertemporal theoretical model of the farmer's grain allocation decision that captures the effects of the key elements of China's grain policy in the early 1990s and permits the development of an econometric model to assess the quantitative importance of these effects.

2. Model

The farmer's post-harvest decision for allocating wheat between household consumption, storage and market sales is modelled as an intertemporal decision. Following Saha and Stroud (1994) and also Carter and Zhong (1999), the farm household is assumed to optimise wheat allocation among competing uses in the context of an additively separable (in time) utility maximisation model, in which input decisions are taken to be exogenous and the allocation decision is subject to wheat quantity, quota and income constraints.

The farm household maximises the discounted present value of expected utility in two periods, denoted 0 and 1. In period 0, the farm has already harvested its crop, but the crop harvest in period 1 is unknown. Household utility in each period depends on household grain consumption, c and the consumption of a numeraire good, y . In each period, utility also depends on a vector F_t of measurable family characteristics, where t identifies the period of interest. Utility in period 1 is defined through the expected values of c_1 and y_1 and by a random vector μ that defines departures from these expected values as a result of variability in wheat production and prices. The farmer's objective function is:

$$U(c_0, y_0; F_0) + \Phi E[U(c_1, y_1; F_1, \dots)], \quad (1)$$

where $U(\bullet)$ is a twice differentiable utility function over wheat consumption and the numeraire good, Φ is the discount scalar and $E[\bullet]$ is the expectation operator defined over the random error vector μ . Variability in production, prices and other factors can be identified empirically through observed departures from population averages. Note that the cross-section survey data do not include any information allowing us to form reliable estimates of how realised prices, yields and other variables differ from expectations.

Household income in period 0 is defined as:

$$y_0 = p_{q_0} * \bar{q}_0 + p_{f_0} * q_{f_0} - k(s_0 + \Delta s_0) + NW(r_0, F_0, w_0), \quad (2)$$

where \bar{q}_0 is the government procurement quota, q_{f_0} is the quantity of grain sold on the free market, p_{q_0} is the price paid for grain under the government quota, p_{f_0} is the over-quota market price for wheat, s_0 is the initial level of storage in period 0 and Δs_0 is the net addition to household grain storage. Storage costs in period 0 are defined by the function $k(s_0 + \Delta s_0)$. Prices are assumed to be known in period 0 but not in period 1. Thus, income from any given level of wheat sales in period 0 is not stochastic.

The function $NW(\bullet)$ denotes income from sources other than sales of wheat, 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 wage level (w_0). The vector F_0 includes household non-agricultural wealth and demographic information that reflects potential on- and off-farm labour supply (see de Brauw *et al.* (2000) and also Giles (2000) for analysis of household labour patterns in rural China).

The wheat allocation constraint in period 0 can be written as:

$$c_0 = Q_0 - q_{f_0} - \bar{q}_0 - \Delta s_0, \quad (3)$$

where the farm's wheat output, Q_0 , is known. The income constraint in period 1 is:

$$y_1 = p_{q_1} * \bar{q}_1 + p_{f_1} * q_{f_1} + NW(r_1, F_1, w_1). \quad (4)$$

Period 1 values of the market price for wheat, the quota price, non-wheat income and wealth and the quota price and quantity levels are unobserved and enter the period 0 decision through expectations. For any given random harvest level Q_1 , the wheat allocation constraint in period 1 is:

$$c_1 = Q_1 - q_{f_1} - \bar{q}_1 + (s_0 + \Delta s_0). \quad (5)$$

As only two periods are being modelled, the household does not carry grain stocks beyond period 1.

In this framework, the farm household's wheat allocation problem in period 0, the period for which data are available, is to maximise the sum of discounted utility in both periods, H :

$$\max_{x_0} H = U(c_0, y_0; F_0) + \Phi E[U(c_1, y_1; F_1, \dots)], \quad (6)$$

subject to the constraints in Equations (2), (3), (4) and (5), where $x_0 = \{q_{f_0}, \Delta s_0\}$. Allowing for the possibility of corner solutions, the Kuhn–Tucker first-order conditions for the wheat allocation choice variables yield the following results, where subscripts indicate partial derivatives:

$$H_{q_{f_0}} = -U_{c_0} + p_{f_0} U_{y_0} \leq 0, \quad (7a)$$

and

$$H_{\Delta s_0} = -U_{c_0} - U_{y_0} * \frac{\partial k}{\partial \Delta s_0} + \Phi E[U_{c_1}] \leq 0, \quad (7b)$$

where these conditions hold as equalities for interior solutions.

As zero values are observed in the data set for two choice variables, market sales and on-farm consumption of wheat, the corner solutions are relevant. However, useful insights about the qualitative effects of exogenous variables can be obtained by examining the properties of interior solutions.

Given an interior solution, Equation (7a) implies that in period 0 the marginal rate of substitution between grain consumption and the composite good equals the ratio of the prices of the two commodities and also defines the marginal opportunity cost

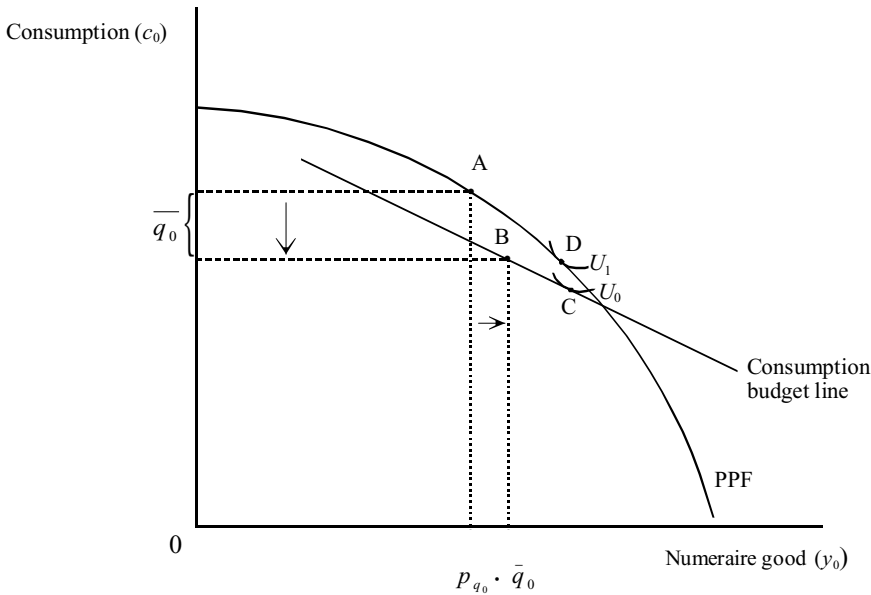


Figure 1 Production and consumption under quota.

of wheat consumption as $p_{f_0} U_{y_0}$. Equation 7(b) implies that the marginal utility loss from foregone grain consumption plus the marginal utility loss of income as a result of storage costs equals the discounted expected marginal utility from grain consumption in period 1. Optimal consumption in period 0 is determined simultaneously with optimal market sales and additions to storage through the constraint in Equation (3) and the first-order maximisation conditions, (7a) and (7b). In a reduced form context, these optimal values depend on grain production, quota levels, wheat market prices, sources of farm income other than wheat market sales (including quota revenue and market sales of other farm products), family characteristics, and expectations about grain production and other stochastic variables in period 1.

Insights about the implications of changes in exogenous variables on the solution to the farmer's maximisation problem in period 0 are provided by Figure 1, which abstracts from changes in stock levels and storage costs for purposes of illustration. In Figure 1, the production of wheat (c) and the aggregate good (y) in period 0 occur at point A on the farm's production possibilities frontier. However, A does not define the farmer's relevant market sales and consumption opportunities. Wheat available for market sales and consumption is reduced by the farm's government procurement quota (which is subject to a mandatory price discount), while the availability of the composite good is increased by the farm's quota revenue. Thus, the relevant initial endowments of wheat and the composite good available to the farm are defined by B. At B, market prices determine the budget line that defines the farmer's consumption opportunity set. Given this opportunity set, the farm household can sell wheat into private markets (or to government grain bureaus) to achieve the level of welfare associated with indifference curve U_0 at point C. Although, under pure autarky, the

farm would be able to improve its welfare to indifference curve U_1 by operating at a point such as D, the mandatory quota program precludes this option. Point D indicates that consumption of the composite good is lower and wheat consumption is higher under autarky than at Point C. Strictly speaking, this need not be the case given the income reductions from quota sales.

The Kuhn–Tucker conditions, (7a) and (7b) provide some useful and testable predictions about wheat allocation decisions. They imply that, if positive, wheat market sales are positively related to: (i) the amount of available wheat (production, reduced quota levels, carry-in stocks); (ii) the amount of other sources of income in period 0; and (iii) the price of wheat if the ratio of the marginal utilities (U_{c_0}/U_{y_0}) increases with y_0 . The model's implications for own-price effects on wheat consumption are complicated by the commodity's role as a source of family income and as a store of wealth. Increases in the price of wheat increase potential farm revenue and therefore could lead to either increases or decreases in consumption if wheat is a normal good because of offsetting farm-revenue and substitution effects (a similar result is shown in Carter and Zhong 1999).

The two-period model can also be used to obtain insights about the effects of changes in expected production, quota level, other farm sources of revenue, the wheat market price in period 1 and other variables of interest. However, these effects also depend on the nature of the farm households' risk attitudes. An important caveat for the estimates presented below is that the omission of expected period 1 prices in empirical estimation models may result in a bias in the estimated coefficients.

Provided that wheat is a normal good, wheat consumption in period 0 is predicted to increase with: (i) larger amounts of available wheat (increased production, reduced quota levels, increase carry-in stocks) and (ii) increases in other sources of income in period 0. Increases in the current market price for wheat increase the opportunity cost of holding stocks, but also increase the farm household's income available for current and future consumption. These potentially offsetting price and farm revenue effects preclude any definite predictions for the effects of increases in the current market price on wheat storage.

The first-order conditions in Equations 7(a) and 7(b) also provide predictions for stocks. Additions to wheat stocks are predicted to: (i) increase with available wheat (production, reduced quota levels, carry-in stocks); (ii) decrease with increases in other sources of revenue under decreasing absolute risk aversion; and (iii) decrease with increased storage costs.

3. Data

Cross-section household survey data were collected for crops harvested in 1994 under the direction of researchers at the University of California at Davis in the spring of 1995. This survey effort is described in detail in Jacoby *et al.* (2002). More than 200 households were surveyed across six villages in two wheat producing provinces in north-east China, Hebei and Liaoning, of which 155 provided sufficiently complete responses to be used in the econometric analysis presented here. Both the villages and the households within those villages included in the survey were randomly selected

Table 1 Descriptive statistics, data weighted by quality adjusted land area

Variable (<i>n</i> = 155)	Mean	SD	Min	Max
Harvested wheat (kg)	1813	1119	350	7000
Government wheat quota (kg)	356	498	16	2974
Wheat market price (yuan/kg)	0.611	0.078	0.372	0.872
Marketable wheat quantity (kg)	1229	721	-62	4035
Wheat stock additions (kg)	134	346	-602	1500
Wheat consumption (kg)	744	362	0	1800
Wheat market sales (kg)	644	1000	0	3500
Carry-in wheat stocks (kg)	398	379	0	2000
Village wage (yuan)	352	67	274	458
Marketable corn quantity (kg)	1893	1170	-170	5850
Total quota revenue (yuan)	210	296	10.8	1736
No. on-farm working age	2.33	1.00	0	5.1
No. off-farm working age	0.200	0.57	0	4.4
No. on-farm non-working age	1.39	1.07	0	4
Education years, household heads' average	5.17	2.73	0	12
Non-agricultural wealth (yuan)	16830	13918	320	69950

from within the two provinces. These two provinces together produced 9.8 per cent of China's total wheat production in 1994 (Fred Gale, Economic Research Service, pers. comm., 2002). Thus, the farm households can be viewed as providing a representative sample of production operations within these provinces. The survey recorded current and crop year-to-date demographic variables, consumption, market sales, quota deliveries, current storage, pre-harvest carry-in, prices, borrowing and other variables. Consumption, market sales and quota fulfilment were recorded in the spring, so the households' additional crop-year consumption, sales and stock reductions have not been recorded in the survey.

Descriptive statistics for variables included in the estimated econometric models are presented in Table 1. To avoid potential heteroscedastic error problems related to land area, for each household all dependent and independent variables were normalised by dividing them by the sum of wheat consumption, market wheat sales and additions to wheat stocks. Thus, the estimates are carried out over shares of consumption, sales and stock additions. Observations on two households were omitted because, as a result of stock withdrawals, the measured amount of wheat allocated to the three uses was non-positive and thus shares could not be computed.

Households were included in the analysis if they had 'farm resident status' (i.e., households lived on the farm) and also had to meet a government wheat-delivery quota. The households included in the sample obtained substantial income from farming, but some also had considerable off-farm income. After meeting mandatory delivery quotas, many farmers within the sample retained substantial quantities of wheat for household consumption or market sales.

Among the farms in the sample, average total harvested wheat production was over 1800 kg and ranged from about 350 to 7000 kg/household. On average, 19 per cent of wheat available to farm households was used to meet quota requirements, 40 per cent was consumed by the household, 32 per cent was sold into private markets, 2 per cent

was sold to government grain buyers through negotiated sales and 7 per cent was added to storage. The average amount of over-quota wheat available per farm included in the sample was 1229 kg (approximately 45 bushels), ranging from a minimum of a 62 kg deficit (approximately 2.3 bushels) to a maximum of a 4035 kg surplus (approximately 148 bushels). Government procurement quotas varied substantially among farms, ranging from a minimum of 16 kg to a maximum of 2974 kg. Evaluations of survey information and discussions with academic experts on Chinese agriculture indicated that on a per hectare basis quota differences depended primarily, but not exclusively, on expected total yield differences.

The post-harvest wheat allocation decision is affected by factors that are effectively exogenous in the short run, including crop yield in the current period (which is known prior to the allocation decision), carry-in wheat stocks, the government delivery quota, predetermined quota revenue, wheat market prices, the village wage, family characteristics and a measure of non-agricultural household wealth (value of consumer durables plus the value of the family's house). Diagnostic tests of regression errors provided no evidence of a statistically important relationship between regression errors for shares of wheat allocation and these explanatory variables, even at very high *P*-values (e.g., 35%). The separation of household income into revenue from wheat marketing, quota revenue and income from other sources permits an explicit empirical evaluation of the effects of exogenous (non-wheat) sources of income on wheat consumption, sales and storage. In this regard, the empirical analysis presented below differs from those of Carter and Zhong (1999) and Saha and Stroud (1994), who aggregate income from all sources.

The quantity of wheat available to farmers in period 0 after satisfying the quota requirements is defined as 'marketable wheat' (the difference between harvested wheat and the sum of the farm's delivery quota, seed use and wheat swaps). Wheat carry-in stocks are included as a separate explanatory variable to delineate between the effects of new production and carry-in stocks on current period wheat allocation decisions. Note that storage facilities in many areas of China are quite limited (Crook 1996) and thus grain quality issues may arise if stocks are held over for long periods of time.

Wheat swaps are aggregate non-market gifts and exchanges between family members, neighbours or other parties with social ties. The exact ties were not included in the survey data. Because variables explaining these swaps were not available, the empirical analysis does not account for them. We also estimated the model using separate variables for the quota and available wheat. There were few important differences in the estimates.

A wheat price variable was constructed to measure the relevant prices faced by farmers. In addition, reported farm-level sales prices reflect seasonality, quality differences, differences in each farmer's negotiating ability and differences in market opportunities across villages. In markets in which storage provides an effective means of intertemporal arbitrage, seasonal differences in prices reflect differences in the opportunity costs of marketing grain (Williams and Wright 1991). Thus, in these circumstances, observed seasonal price differences should not be included in reported price measures. In contrast, price differences arising from differences in quality, negotiating ability and location effects across villages should be included. To remove seasonal effects, prices

received by each farmer reporting market or negotiated grain sales were detrended using a linear time trend. If farmers have multiple sales during the marketing year then the value of the price variable is defined as a weighted average by the quantity of the detrended prices for these sales.

These detrended prices should still reflect variations in quality premiums, gains associated with negotiating ability and village market opportunities. Village averages of detrended prices are used as proxies for market prices faced by farmers who had no reported grain sales. Among the 155 households included in the econometric analysis, 58 reported market sales of wheat to private buyers, 15 reported negotiated sales of wheat to government grain buyers (three of which also had sales to private buyers), and 82 reported no market sales. Negotiated sales occur at relatively high detrended prices, suggesting that to some degree government grain buyers had to compete for grain on the basis of the price in 1994.

Other sources of farm income are defined to include quota revenues from government purchases of both wheat and corn (the two major grains in this survey area) and the quantity of the farm's marketable corn. The marketable quantity of corn is used as an indicator for both the income potential from corn sales or livestock feeding and potential effects on wheat storage costs (because corn stocks compete with wheat stocks for storage space). Off-farm earnings are also important sources of income for many of the households in the sample and on average are almost four times higher than revenues from corn and wheat sales. Instruments are therefore included to account for each household's potential for off-farm earnings to avoid a potential errors-in-variables problem associated with using off-farm earnings as an explanatory variable. Four demographic variables included in the survey are related to the potential for off-farm earnings, farm labour and consumption: (i) the number of family members of working age (between 13 and 60) living on the farm; (ii) the average wage level within the village, calculated as the mean wage for survey respondents working within a village; (iii) the number of family members of working age living off the farm (not more than 9 months) who can provide income remittances to the farm; and (iv) the household head's average educational level. Another variable, the number of family members of non-working age (under 13 or over 60) living on the farm, is included to account for differences in on-farm wheat consumption.

Household wealth is also a potentially important determinant of farm household decisions (e.g., de Brauw *et al.* 2000). Chinese farmers could not own land in 1994 and rural financial markets were underdeveloped, so consumer durables and housing may provide relevant measures for wealth other than that held in agricultural commodities. Here, we combine reported values of each farm family's consumer durables and housing to obtain a proxy for non-agricultural wealth.

Marketable wheat represents the post-harvest quantity of wheat available for consumption, storage and market sales allocations. On some farms, reported harvested wheat production was not sufficient to cover quota, seed and swaps and thus the quantity of marketable wheat was negative. In these circumstances, farms met their quota obligations and consumption needs from carry-in stocks, through market purchases or through swaps. Carry-in stocks were reported to be large and on average equalled one-fifth of the household's current year's harvest.

It should be noted that the theoretical model and the structure of the survey data mean that the empirical estimates presented in the next section should be interpreted as short-run responses. Given the policy rollbacks of 1995, farmers would have been rational to treat the policy reforms as being of a short-term nature. Clearly, the cross-section nature of the survey data precludes the estimation of wheat supply response.

4. Estimation procedures

Two important considerations complicate the empirical modelling of Chinese farmer's grain allocation decisions. First, over half (54%) of the farm households had no reported market or negotiated wheat sales, a *prima facie* corner solution. Observations of no market sales are common in many developing countries such as China where the transition to market-based exchange is incomplete. We do not discount the potential for unreported sales in China but are unable to identify them in this data set. Second, the on-farm allocation of grain between consumption, market sales and additions to stocks involves a simultaneous set of decisions. The equations are estimated simultaneously in share form, requiring one equation to be omitted. Omitting the market sales equation from the system addresses both empirical considerations. The adding up condition is used for tests of the resulting linear combination of coefficient estimates from the two-equation system, allowing estimation and tests for the effects of the explanatory variables on the market sales share. Diagnostic tests showed no significant heteroscedasticity or significant error-cross correlation within villages.

4.1 Estimation results

Estimation results from the systems estimation are presented in Table 2. An increase in the availability of marketable wheat statistically significantly decreased the share of wheat allocated to consumption while significantly increasing the shares allocated to stocks and to market sales. Additional unreported results from models in which the dependent variables are measured in levels indicate that wheat consumption by Chinese households increased with wheat available for marketing, but at a decreasing rate.

Larger carry-in stocks from the previous year's production led to significantly increased market sales and decreased additions to stocks. Consumption share significantly increased with the price of wheat, a result consistent with the implications of the theoretical model that substitution and farm revenue effects may be offsetting. The share of available wheat allocated to stocks significantly decreased with higher wheat prices. As the quantity of marketable corn increased, the share of available wheat allocated to market sales significantly increased while the share allocated to additional stocks significantly decreased, a result consistent with an upward sloping supply curve of grain storage.

An increase in the number of family members living on the farm significantly increased consumption share and decreased the share marketed. Increases in the number of family members of working age living off the farm (and presumably remitting income) led to significant reductions in the share of additional wheat stocks and apparent

Table 2 Systems regression estimates for wheat allocation, shares ($n = 153$)†

Variable	Consumption share	Additions to storage share	Market sales share
Constant	0.595 (4.56)***	0.3518 (2.93)	0.0528 (0.420)
Marketable wheat quantity	-0.14E-02 (3.83)***	0.7E-03 (2.03)**	0.7E-03 (1.93)*
Carry-in wheat stocks	0.6E-04 (0.219)	-0.7E-03 (-2.83)***	0.7E-03 (2.61)***
Wheat market price	3.09 (2.36)**	-2.69 (2.23)**	-0.397 (0.314)
Total quota revenue	-0.10E-03 (-0.084)	-0.1E-02 (-1.27)	0.15E-02 (1.26)
Marketable corn quantity	-0.88E-04 (-0.412)***	-0.7E-03 (-3.34)***	0.7E-03 (3.38)***
No. on-farm working age	0.42 (3.10)***	0.62E-04 (0.5E-03)***	-0.420 (-3.21)***
Numbers of off-farm working age	0.362 (1.45)	-0.66 (-2.86)***	0.294 (1.22)
No. on-farm non-working age	0.217 (2.46)**	-0.056 (-0.687)	-0.161 (1.90)*
Village wage	0.3E-02 (1.67)*	0.31 (1.78)*	-0.1E-03 (0.054)
Education years, household heads' average	-0.023 (-0.610)	0.035 (1.02)	-0.012 (0.341)
Non-agricultural wealth	-0.72E-05 (-0.967)	0.1E-04 (1.41)	0.001 (0.001)
Log-likelihood		-9.19	
R^2	0.35	0.27	

*Statistical significance at the 10 per cent level, **statistical significance at the 5 per cent level and ***statistical significance at the 1 per cent level. † t -values are in parentheses.

(though statistically small) increases in consumption and market sales. This off-farm family member effect is consistent with the argument that off-farm remittances substitute for commodity stocks in managing family risk.

Higher village wages increased consumption shares and also somewhat increased the share put into stocks (significant at the 10% level). This wage effect on stocks at the margin is consistent with stocks as a store of wealth but is inconsistent with stocks as a risk-reducing tool. Neither education levels nor the measure of non-agricultural household wealth used here significantly affected wheat allocation shares.

4.2 Policy implications

The empirical results of this case study provide some useful insights about the effects of China's wheat policy changes in the early 1990s. They indicate that, holding wheat production constant, the reduction in grain bureau delivery quotas resulted in the reallocation of some, but not all, of the wheat released from quota into private market sales. The coefficients presented in Table 2 and the descriptive statistics in Table 1 indicate that a quota reduction increased the shares of wheat to market sales and to additions to stocks, while decreasing the share allocated to farm household consumption

during this period (although, when quota reduction effects are measured at the sample means, total on-farm consumption increases). However, these results indicate that total supplies available to urban and other non-wheat-producing households may have declined quite substantially in the short-term as a result of the quota reductions.

To illustrate this quota reduction effect for 1994, consider a 10 per cent quota reduction at the population means for all data (a 35.6 kg quota reduction). Using the results in Table 2, average farm household consumption would be predicted to have increased somewhat by 15.5 kg, average additions to stocks would be predicted to have increased by 4.2 kg and average market sales would be predicted to have increased by 24.8 kg. Assuming for purposes of illustration perfect substitutability in quantities between quota wheat and wheat sold through markets, total wheat made available to urban consumers by this average farmer would have decreased by 10.8 kg. This effect was probably responsible for at least some of the increase in private market prices experienced, beginning in 1994. It should be noted that to the extent reductions in wheat quotas provided increased incentives for wheat production, over time the allocation of the additional wheat to market sales may have offset the impact of the quota reduction.

As discussed, the market liberalisation reforms of 1992 and 1993 were rolled back in late 1994, in part because of a substantial increase in private market prices. In addition, wheat farmers were accused by some of grain hoarding or, in other words, increasing on farm storage of wheat. The empirical findings presented here provide insights about why private market grain prices may have increased even though, paradoxically, quantities of wheat made available to the private market increased.

5. Conclusion

Grain stocks provide food and income security buffers for Chinese farmers. However, this study provides evidence that these farmers adjusted wheat stocks during 1994 in response to changes in government policy and changes in market prices, even in the short-term. The results reported above indicate that increases in potential revenues from family members living off the farm led farmers to reduce the share of wheat allocated to stocks. Opportunity costs associated with wheat stock holding also influenced farm storage decisions in the predicted manner. The Chinese farmers surveyed responded to increases in market prices in 1994 by allocating a smaller proportion of wheat to stocks. The share of wheat allocated to stocks increased with wages in the village. Changes in wheat market prices had a positive effect on consumption shares, possibly because of offsetting farm revenue and substitution effects, or alternatively because higher reported wheat prices reflect higher wheat quality. Wheat consumption share decreased with the total amount of wheat available for household allocations after delivery quotas have been fulfilled.

The share of available wheat allocated to market sales by Chinese farmers was relatively unresponsive to observed changes in reported wheat market prices during 1994. Increases in wheat available to the farm family led to increased market sales shares. It should be noted, however, that the cross-section nature of the data utilised

only permits an evaluation of short-term price responses, as effects on wheat production could not be estimated.

Finally, the empirical results provide useful insights into the net effects of changes in key elements of the government's grain acquisition program during the early 1990s. A 10 per cent decrease in the delivery quota for wheat would, on average, increase the quantity of grain available to farmers at the means by approximately 3 per cent. It is also predicted to have increased the 1994 average farm household consumption by approximately 2 per cent, and to have increased average market sales by approximately 4 per cent during 1994. However, the predicted increase in market sales were insufficient to fully compensate for the reductions in the quantity of quota wheat, effectively reducing the amount of grain available to urban consumers. Given these findings, the increased consumer prices experienced in China during these reforms, the accusations of farmers hoarding grain and the subsequent reform rollbacks, should have been anticipated.

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