The Australian Journal of Agricultural and Resource Economics

AARES AUSTRALASIAN AGRICULTURAL & RESOURCE ECONOMICS SOCIETY

Australian Journal of Agricultural and Resource Economics, 64, pp. 1328–1349

The effect of price support policies on food security and farmers' income in China

Jiarong Qian, Shoichi Ito and Zhijun Zhao†

The current price support policies in China have positive impacts on grain prices and production costs. These policies mediate the impacts on grain supply and demand, and, in turn, affect food security and farmer income. This paper simulates and empirically establishes the effect of price support policies on food security and farmers' net incomes through a partial equilibrium model that considers the policy impact mechanism. The results indicate that a 10 per cent support price increase in 2012 may result in (1) an increase of 1.38 and 6.19 percentage points in self-sufficiency rates for rice and wheat, respectively, in the current year and (2) a respective increase of 28.6 and − 18.5 yuan/mu in net income for rice and wheat production in the year. Given the significant growth in grain support prices since 2008, the price support policies have produced a tremendous impact in terms of enhancing grain self-sufficiency, while playing a crucial role in China's food security strategies. However, due to the increased production costs associated with policy implementation, the income effect of the price support policies is rather small and even negative for wheat production. Hence, increasing farmers' incomes should rely on other effective measures, such as providing income subsidies.

Key words: food security, farmers' income, partial equilibrium, price support, simulation.

1. Introduction

China has the largest population in the world and accounts for the greatest proportion of food grain supply and demand in the global market (Qian *et al.* 2013a). Accordingly, food security has been a fundamental concern for China. Given China's massive population, food security is partially achieved through ensuring 'quantitative security', which is reflected through the indicators of grain self-sufficiency rate, stocks-to-use ratios and import reliance. Since the late 1990s, China's grain production has been characterised by a steady decline due to low grain prices. To halt the decreasing trend in grain production and increase farmers' net income, in 2004, the Chinese government enforced a grain price support policy that guarantees a minimum purchasing price, in line with a pricing policy for rice. The aim is to

* This study is financially supported by the National Social Science Foundation of China (Grant No. 17CJY037)

†Jiarong Qian (email: qianjiarong@caas.cn) and Zhijun Zhao are with, Institute of Agricultural Economics and Development, Chinese Academy of Agricultural Sciences, Beijing, 100081, China. Shoichi Ito is at, Department of Agricultural and Resource Economics, Kyushu University, Fukuoka, 812-8581, Japan.

doi: 10.1111/1467-8489.12398

stimulate greater grain productivity and ensure that farmers continue to benefit from grain production. This policy system establishes an annual minimum purchase price every year for each grain type (e.g. rice and wheat) and releases the minimum prices prior to grain production. If the price of a grain drops below the minimum price benchmarks, the government purchases the grain at the minimum prices until the market prices recover to above this threshold.

Averaging at 73.2 yuan per 50 kg of rice, pricing for rice remained constant between 2004 and 2007. However, from 2008, the price gradually increased under the control of the Chinese government. This ultimately led to a 2014 price of 146 yuan per 50 kg, which is double the opening price of 2004, with a price increase of 72.8 yuan per 50 kg of rice. Wheat became the second grain to be subject to the pricing policy in 2006. The support price of 70 yuan per 50 kg was constant until 2007. From 2008, the support price of wheat gradually increased at a mean rate of 8.2 per cent. This rapid escalation leads to an increase of 68.6 per cent from the 2006 price, resulting in a peak price of 118 yuan per 50 kg in 2014. Thus, these powerful price support measures appear to exert significant impacts on the food grain sector.

Since the implementation of the price support policies, their comprehensive effects have attracted extensive attention from academics. Many studies have been conducted to assess the effects on agriculture. Mu and Koike (2009) simulate the impacts of the minimum purchasing price policy for grains on outputs, income and welfare of the agricultural and non-agricultural sectors using the spatial computable general equilibrium model (SCGE). Wang and Li (2012) evaluate the impact of this policy on grain market prices using the double-difference model on weekly price data for a 10 year period. Their results suggest that the policy has promoted grain prices significantly. Qian *et al*. (2013b) assess the effect of the same policy on regulating China's domestic grain prices using grey relational analysis. They find that the price support policy plays a most important role in determining grain market prices relative to other factors, including production costs, international prices and production. Zhao *et al*. (2017) develop a more complex non-linear model to examine the relationship between income and wheat price support in developing countries, including China. In addition, there are many relevant international studies in this area. Barker and Hayami (1976) compare the effect of the price support policy and the input subsidy policy on food self-sufficiency in developing countries. Otsuka and Hayami (1985) examine the impact of Japan's rice price support policy on social welfare using an partial equilibrium framework. Lu (2002) investigates the effects of the double-track price system on crop production using cross-sectional data on the Zhejiang Province in China. Beghin *et al*. (2003) assess the impact of the price support policy on welfare and trade volume in Korea.

Ensuring food security and boosting farmers' income underpin fundamental policy objectives in most nations. They are especially important in developing countries. The Chinese government intends to achieve these two

basic targets simultaneously with implementation of grain price support policies. However, to the best of our knowledge, previous studies have not empirically linked the price support policies to China's food security strategies. Besides, the actual income effect of the policies anticipated by the Chinese government still remains uncertain. Therefore, this paper aims to simulate the impact of price support policies on grain food security (quantitative) and farmers' net income using a partial equilibrium model and to examine whether all policy goals are achieved via price support policies. Through this analysis, we attempt to identify the measures required to improve the support policy system. This is of practical significance in safeguarding food security and farmers' interests and in designing more effective future support policies for agriculture. Other countries can also draw policy inferences from China's experience of policy implementation.

2. Theoretical base

To assess the connection of price support policies with food security and farmers' income, it is crucial to identify the mechanism by which price support policies impact the grain sector. The current price support policies in China may show direct impacts on grain prices and production costs. These impacts are the channels linking these policies to food security and income from grain production. These mechanisms are used as the basis for the construction of our grain partial equilibrium model.

2.1 Price support and grain prices

As mentioned above, the minimum pricing policy was implemented in China in 2004. This policy relates primarily to grain purchases and establishes an annual minimum purchase price for each type of grain. In the event that the market price of a grain crashes below the required minimum price, the government assumes responsibility for buying the grain at the minimum price. This intervention continues until the market price rises and reaches its minimum level. This regulation can stabilise and effectively manage grain market pricing by generating further demand for grain. Due to the existence of grain price support policies, market prices usually do not drop below the minimum levels as the government always pre-emptively intervenes and buys the grain during the policy implementation period. Thus, grain demand increases and the demand curve for grains shifts to the right as the government stimulates the demand for grain in the market. This in turn stabilises grain market prices above the required minimum levels. In addition, grain price support policies can also determine grain market prices by affecting the grain market expectations (Qian and Zhao 2019). Therefore, it may conclude that grain support policies establish and highly influence grain market prices.

2.2 Price support and production costs

Grain price support policies affect the costs of grain production by affecting the behaviour of farmers with regard to input practices. When the government raises grain price support levels, farmers try to increase their grain production to gain more profits. Increasing production depends on expanding their plantation area and enhancing productivity per unit land (yield). But expanding plantation area is unrealistic, as many Chinese farmers only have a restricted area of land to produce their goods. Thus, there should be greater reliance on increasing yield through more input factors. As a result, the production costs for farmers rise due to increased inputs required per unit of land. In addition, increase in the total usage of agricultural input occurs due to the launch of price support policies. This creates demand for agricultural input factors and may cause their prices to increase. Whilst the input price index has been in constant decline in the decade prior to 2004, it has increased by 87.6 per cent since then. This suggests that increased production costs due to more input usage and higher input prices are a direct consequence of price support policies.

3. Model specifications

The current price support policies in China show a direct impact on grain prices and production costs, and thereby transmit impacts to grain supply and demand, grain food security and production income. The partial equilibrium model can demonstrate the policy mechanism and transition process and capture in detail the impacts on the grain sector. Moreover, the partial equilibrium model has been widely applied to research on grain market prospects, or policy impacts on grain supply and demand (Meilke and Griffith 1983; Song and Carter 1996; Lee and Kennedy 2007; Marette *et al.* 2012; Antoine *et al.* 2014 and Kozicka *et al.* 2017). Therefore, this paper employs the partial equilibrium model to evaluate the impact of price support policies on grain food security and farmers' net income.

Based on the impact mechanisms, a partial equilibrium model is constructed to reflect the direct connections between price support policies, grain prices and production costs by incorporating a support price variable into the equations of grain prices and production costs. The support price variable is expected to take a positive sign in these equations. Generally, the equilibrium model includes five parts: production sector, consumption sector, trade sector, price and cost linkage, and market clearance.

3.1 Production sector

The Nerlovian supply response model is powerful in explaining variations in grain supply. It has been extensively applied to model grain areas and yield (Nerlove 1956; French and Mathews 1971; Froster and Mwananmo 1995;

Mushtaq and Dawson 2002; Vitale *et al.* 2009; Yu *et al.* 2012 and Qian *et al.* 2018). Thus, grain-planted area and yield are specified as an extended Nerlovian model. Generally, grain-planted area is specified as a function of one-year lagged planted area, one-year lagged grain producer prices, prices of competitive crops, total grain subsidy amount and a time trend variable. Grain yield is specified as a function of one-year lagged yield, one-year lagged producer prices, total grain subsidy amount, prices of input factors and a time trend variable. Grain production is determined by the product of grain-planted area and grain yield. The production sector is modelled via equations 1 – 3 in Table 1.

3.2 Consumption sector

The total grain consumption is divided into four sections in terms of purposes of grain use: (1) food consumption; (2) feed consumption; (3) seed consumption; and (4) other consumption comprising of industrial use, processing use and losses. Besides grain own prices, income and prices of substitutes as the main factors determining grain consumption, meat prices also show a significant influence on grain consumption (Qian *et al.* 2013a). Therefore, meat prices are also incorporated into the corresponding equation to explain variations in grain consumption. Generally, grain consumption for food and feed use is identified as a function of grain consumer prices, per capita income, meat prices and prices of substitutes. Seed consumption is a function of the grain-planted areas and the per capita seed usage per unit land (per mu, 1 mu = 0.067 ha). Total grain consumption is the sum of consumption of food and feed determined by per capita

Table 1 Structure for grain partial equilibrium model

Production sector

$lnA_{it} = f(lnA_{it-1}, lnP_{it-1}, lnS_t, lnPC_{it-1}, T)$(1)

$lnY_{it} = f(lnY_{it-1}, lnP_{it-1}, lnS_t, lnA_{it}, lnPF_t, T)$(2)

$QP_{it} = A_{it} \times Y_{it}$(3)

Consumption sector

$lnFOD_{\mathrm{it}} = f(lnCP_{\mathrm{it}}, lnIN_t, lnPM_t, lnPS_{it})$(4)

$lnFED_{\mathrm{it}} = f(lnCP_{\mathrm{it}}, lnIN_t, lnPM_t, lnPS_{it})$(5)

$lnSED_{it} = f(lnA_{it})$(6)

$QC_{it} = (FOD_{it} + FED_{it}) \times POP_t + SED_{it} + OTH_{it}$(7)

Trade sector

$lnQI_{it} = f\left(lnCP_{it}, lnIP_{it}, ln\left(\frac{QC}{QP}\right)_{it}, \ln IN_t, lnER_t\right)$(8)

$lnQE_{it} = f\left(lnCP_{it}, lnIP_{it}, ln\left(\frac{QC}{QP}\right)_{it}, lnER_t\right)$ (9)

Price and cost linkage

$lnP_{it} = f(lnS_t, lnQP_{it}, lnM_{it})$(10)

$lnCO_{it} = f(lnY_{it}, lnPI_{it}, lnM_{it})$(11)

$lnCP_{it} = f(lnP_{it}, lnIP_{it})$(12)

Market clearance

$QP_{it} + QI_{it} + QS_{it-1} = QC_{it} + QE_{it} + QS_{it}$(13)

consumption for food and feed and China's population, seed consumption and other consumption. For details, see equations 4 − 7 in Table 1.

3.3 Trade sector

The trade sector consists of imports and exports. Overall, the grain trade is determined by domestic grain consumption, international grain prices, income and the exchange rate. Currently, China's domestic grain prices are high and may have a significant influence on grain imports and exports. Therefore, domestic grain prices are considered in the trade equations. Generally, the trade sector is specified as a function of domestic grain consumer prices, the ratio of the domestic consumption and production, international grain prices, China's domestic income (for import) and the exchange rate of the Chinese yuan against the U.S. dollar. Note that there is a tariff-rate quota (TRQ) for grain imports in China. The TRQs remain unchanged in recent years. The import equation is constructed under the assumption of not exceeding the import quotas. The trade sector is expressed via equations 8 and 9 in Table 1.

3.4 Price and cost linkage

Grain price support policies can effectively sustain grain producer prices. Thus, the grain support prices are included in the grain producer price equation and are expected to take a positive sign. Agricultural subsidies have impacts on grain prices (Qian *et al*. 2013c and Qian *et al*. 2015). Also, grain production is an important factor affecting grain producer prices. Thus, all these elements are incorporated into the equation for grain producer prices. Price support policies can in turn increase grain production costs. Therefore, the price support variable is incorporated in the cost equation to describe the connection between grain price support policies and grain production costs. According to the classical cost function, grain output (yield) and input factor prices also impact production costs. Therefore, the cost equation is modelled as a function of grain yield, price of input factors and grain support prices. The grain consumer prices are modelled as a function of grain producer prices and international grain prices. For details, see equations 10 − 12 in Table 1.

3.5 Market clearance

Grain ending stock is the residual of the total grain supply (production, imports and beginning stocks) minus total demand (total domestic consumption and exports). This is added to close the model. Moving the consumption and export sectors to the right side, the clearance equation is expressed as equation 13 in Table 1.

Here, A_{it} and Y_{it} indicate grain-planted area and yield, respectively, for grain i in year t. P indicates grain producer prices. S represents the amount of

total subsidies. *PC* represents the price of competitive crops. *PF* is the price of main input factors. *T* is a time trend variable. *QP* represents grain production. *FOD* indicates per capita grain consumption for food. *FED* indicates per capita grain consumption for feed. *SED* indicates grain consumption for seed. *OTH* indicates grain consumption for other purposes. *IN* indicates per capita GDP of China. *PM* represents meat prices in the form of an index. *PS* represents prices for substitutes. *POP* denotes China's population. *QI* indicates imports. *QE* indicates exports. *CP* indicates grain consumer prices. *IP* indicates international grain prices. *QC* indicates the total domestic grain consumption. *ER* indicates the exchange rate of the Chinese yuan against the U.S. dollar. *CO* indicates grain production costs. *M* indicates the grain minimum purchasing prices. QS indicates grain ending stocks. *i* indicates rice or wheat. *t* is the year. *ln* indicates natural logarithm operator.

4. Data and model estimation

4.1 Data

National annual time series data since 1990 are used to estimate the equations of the equilibrium model. Grain supply and demand data from 2012 to 2016 are used for simulation analysis. Data on grain food consumption and ending stocks are taken from the *Food and Agriculture Organization* (FAO). Grain imports, exports, consumer prices, meat prices and subsidy amounts are collected from the *China Agricultural Development Report*. Grain producer prices and production costs are obtained from the *China Rural Statistical Yearbook*. Grain production costs include seed, fertiliser, herbicides, pesticides, fuel, direct labour and similar inputs that are used up within one production cycle per unit farmland. Grain-planted area, yield and production, and the Chinese population data come from the *China Statistical Yearbook*. Per capita *GDP* serves as a variable reflecting China's overall income level, which is also taken from the *China Statistical Yearbook*. Data on prices, income and production costs are deflated using the consumer price index with 1990 as the base year (Table 2).

4.2 Model estimation

To solve the endogeneity caused by including lagged dependent variables in the area and yield equations, the generalised method of moments (GMM) is used to estimate these equations. To reflect the competitiveness between crops, corn prices are included in the rice area equation, and rapeseed prices are included in the wheat area equation. Soybean is not an important competitive crop for rice and wheat in China. Its planted area is small in the main rice- and wheat-producing areas. Hence, soybean prices are not considered in the model. The time trend variable is insignificant in the rice

Table 2 Descriptive statistics for model variables

Variable	Description	Unit	Mean		SD	
			Rice	Wheat	Rice	Wheat
A	Grain-planted areas	thousand ha	30114.27	26090.73	1316.87	3003.75
Y	Grain yield	tonnes/ha	4.42	0.25	4.21	0.68
P	Grain producer prices	yuan/50 kg	37.96	34.51	8.88	5.50
CP	Grain consumer prices	yuan/50 kg	63.24	36.28	11.81	6.25
CO	Grain production costs	yuan/mu	222.33	176.09	64.67	52.86
M	Grain support prices	yuan/50 kg	42.03	36.62	8.08	4.32
IP	Grain international prices	U.S. $/50kg	8.57	4.26	2.92	1.33
QP	Grain production	thousand tonnes	132981.80	108314.50	7780.87	11595.38
QC	Grain consumption	thousand tonnes	125329.70	111988.40	6817.14	7628.57
FOD	Per capita food consumption	kg/person	78.47	71.72	1.76	6.95
FED	Per capita feed consumption	kg/person	9.29	6.56	1.36	7.43
SED	Total usage for seed purpose	thousand tonnes	4715.67	4713.18	199.09	288.04
OTH	Total other consumption	thousand tonnes	8205.48	7030.78	726.23	1355.23
QI	Grain import quantity	thousand tonnes	887.26	4055.59	1020.35	4062.50
QE	Grain import quantity	thousand tonnes	1151.71	627.67	946.47	752.98
PC	Corn producer prices	yuan/50 kg	29.37		6.57	
CPC	Corn consumer prices	yuan/50 kg	33.07		6.06	
CPW	Wheat consumer prices	yuan/50 kg	36.28		6.25	
PF	Agricultural input factor prices	indexed	105.51		12.71	
PRS	Rapeseed producer prices	yuan/50 kg	70.29		16.53	
PM	Meat consumer prices	indexed	118.97		27.82	
IN	Per capita GDP in China	yuan/person	7611.28		5559.46	
S	Total subsidy amount	billion yuan	36.95		17.59	
POP	China's population	million	1281.04		70.52	

yield equation, and therefore, it is omitted. In the rice food consumption equation, consumer prices for the main substitute wheat are taken into the equation. For the wheat food consumption equation, corn consumer prices are included to reflect the substitution between wheat and corn. As most of the corn is used as feed, corn consumer prices are included in the feed consumption model for rice and wheat. In the rice trade equations and the wheat export equation, the ratio of the domestic consumption to production is insignificant and cannot improve the estimation results. Therefore, it is dropped from these equations.

Tables 3 and 4 display the detailed estimation results and the structure for the rice and wheat models. According to the estimated results, the support price variables are highly significant and take a positive sign, as expected, in the grain producer price and the grain production cost equations. This suggests that grain price support policies have a positive impact on grain producer prices and production costs. These results are in line with the analysis in the theory section. The elasticities of grain producer prices with respect to support prices, for rice and wheat, are estimated to be 0.684 and 0.947, respectively. The elasticities of production costs with respect to support prices, for rice and wheat, are estimated to be 0.633 and 1.236, respectively.

5. Simulation analysis

5.1 Baseline solution and definition of policy shocks for simulation

The specific structures of the equilibrium models and the parameters are confirmed in terms of the econometric estimation. To ensure accuracy of the simulation, the add factors are employed to adjust the results for the baseline solution and to match the actual values. Overall, the equilibrium model can precisely capture the effects of the price support policies on the grain sectors. The results for the baseline solution are reported in Tables 5 and 6.

Two policy shock scenarios are defined to simulate the corresponding changes over the baseline solution. The impacts of price support policies on grain food security and farmers' income are evaluated in terms of the simulation results. The support prices represent the magnitude of price support policies. Grain support prices are assumed to be increased by 10 per cent over the actual values in 2012 for Scenario 1. To consider the WTO regulation on reducing domestic support, grain support prices are assumed to decrease by 20 per cent in 2012 for Scenario 2. The simulated strategies of changes in price support policies (support prices) for rice and wheat are reported in Table 7.

5.2 Simulation results

The major objective of the simulations is to identify the effects of price support policies on grain prices, yield, production costs, supply and demand,

Table 3 Estimated results for rice models

Production

$lnA = 3.290 + 0.692lnA_{t-1} + 0.083lnP_{t-1} + 0.003lnS - 0.009lnPC_{t-1} - 0.002T$
$(0.263)^{***}$ $(0.026)^{***}$ $(0.020)^{***}$ $(0.001)^{*}$ (0.020) $(0.000)^{***}$
Adj. $R^2 = 0.96$ D.W. = 1.61 RMSPE = 0.001 Method = GMM Obs. = 25 (1992 − 2016)

$lnY = 0.421 + 0.774lnY_{t-1} + 0.069lnP_{t-1} + 0.003lnS - 0.086lnPF$
$(0.075)^{***}$ $(0.038)^{***}$ $(0.016)^{***}$ (0.002) $(0.051)^{*}$
Adj. $R^2 = 0.98$ D.W. = 1.79 RMSPE = 0.004 Method = GMM Obs. = 25 (1992 − 2016)

Consumption

$lnFOD = 4.439 - 0.147lnCP - 0.011lnIN + 0.090lnPM + 0.050lnCPW + 0.053lnCPC$
$(0.021)^{***}$ $(0.031)^{***}$ $(0.006)^{*}$ $(0.024)^{***}$ (0.034) $(0.023)^{**}$
Adj. $R^2 = 0.81$ D.W. = 2.27 RMSPE = 0.001 Method = OLS Obs. = 22 (1995 − 2016)

$lnFED = 3.478 - 1.463lnCP - 0.272lnIN + 0.919lnPM + 0.869lnPC$
$(0.343)^{***}$ $(0.352)^{***}$ $(0.089)^{***}$ $(0.382)^{**}$ $(0.329)^{**}$
Adj. $R^2 = 0.55$ D.W. = 1.79 RMSPE = 0.045 Method = OLS Obs. = 22 (1995 − 2016)

Trade

$lnQI = 8.448 + 5.508lnCP - 2.258lnIP^{*}ER - 0.150lnIN$
$(0.681)^{***}$ $(0.497)^{***}$ $(0.293)^{***}$ (0.134)
Adj. $R^2 = 0.92$ D.W. = 2.23 RMSPE = 0.036 Method = OLS Obs. = 22 (1995 − 2016)

$lnQE = 5.352 - 3.982lnCP + 0.740lnIP^{*}ER$
$(0.227)^{***}$ $(0.445)^{***}$ $(0.335)^{**}$
Adj. $R^2 = 0.88$ D.W. = 2.11 RMSPE = 0.042 Method = OLS Obs. = 22 (1995 − 2016)

Price and cost linkage

$lnP = 12.350 + 0.093lnS - 1.073lnQP + 0.684lnM$
(9.388) $(0.041)^{*}$ (0.789) $(0.128)^{***}$
Adj. $R^2 = 0.96$ D.W. =2.23 RMSPE = 0.029 Method = OLS Obs. = 13 (2004 − 2016)

$lnCO = - 0.2.592 + 2.666lnY + 0.369lnPF + 0.633lnM$
$(1.006)^{**}$ $(0.634)^{***}$ $(0.165)^{*}$ $(0.081)^{***}$
Adj. $R^2 = 0.99$ D.W. =1.92 RMSPE = 0.016 Method = OLS Obs. = 13 (2004 − 2016)

$lnCP = 0.449 + 0.788lnP + 0.063lnIP$
$(0.092)^{***}$ $(0.064)^{***}$ (0.047)
Adj. $R^2 = 0.94$ D.W. = 1.61 RMSPE = 0.044 Method = OLS Obs. = 22 (1995 − 2016)

Note: Values in parentheses are standard errors; ***, ** and * indicate 1 per cent, 5 per cent and 10 per cent significance levels, respectively.

Table 4 Estimated results for wheat models

Production

$lnA = 1.916 + 0.837lnA_{t-1} + 0.1154lnP_{t-1} + 0.009lnS - 0.014lnPRD_{t-1} - 0.006T$
$(0.487)^{***}$ $(0.047)^{***}$ $(0.018)^{***}$ $(0.002)^{***}$ (0.019) $(0.001)^{***}$
Adj. $R^2 = 0.99$ D.W. = 1.75 RMSPE = 0.001 Method = GMM Obs. = 25 (1992 − 2016)

$lnY = 0.994 + 0.335lnY_{t-1} + 0.127lnP_{t-1} + 0.010lnS - 0.107lnPF + 0.009$T
$(0.186)^{***}$ $(0.147)^{***}$ $(0.030)^{***}$ $(0.002)^{***}$ $(0.042)^{***}$ $(0.003)^{***}$
Adj. $R^2 = 0.99$ D.W. = 2.11 RMSPE = 0.008 Method = GMM Obs. = 25 (1992 − 2016)

Consumption

$lnFOD = 4.781 - 0.041lnCP - 0.122lnIN + 0.020lnPM + 0.053lnCPC$
$(0.088)^{***}$ $(0.032)^{***}$ $(0.021)^{***}$ (0.032) $(0.023)^{***}$
Adj. $R^2 = 0.99$ D.W. = 1.91 RMSPE = 0.002 Method = OLS Obs. = 25 (1992 − 2016)

$lnFED = -7.542 - 3.734lnCP + 1.811lnIN + 2.217lnCPC$
$(0.507)^{***}$ $(0.520)^{***}$ $(0.073)^{***}$ $(0.547)^{***}$
Adj. $R^2 = 0.98$ D.W. = 2.01 RMSPE = 0.092 Method = OLS Obs. = 22 (1995 − 2016)

Trade

$lnQI = 18.504 + 9.056lnCP - 2.245lnIP^*ER - 1.156lnIN + 10.754lnQC/QP$
$(1.447)^{***}$ $(1.049)^{***}$ $(0.651)^{***}$ $(0.241)^{***}$ $(2.384)^{***}$
Adj. $R^2 = 0.77$ D.W. = 2.09 RMSPE = 0.098 Method = OLS Obs. = 27 (1990 − 2016)

$lnQE = 6.720 - 2.423lnCP + 2.397lnIP^*ER$
$(1.298)^{***}$ $(1.040)^{**}$ $(0.673)^{***}$
Adj. $R^2 = 0.66$ D.W. = 2.01 RMSPE = 0.075 Method = OLS Obs. = 23 (1994 − 2016)

Price and cost linkage

$lnP = 14.276 + 0.162lnS - 1.243lnQP + 0.947lnM$
$(4.092)^{***}$ $(0.030)^{***}$ $(0.341)^{***}$ $(0.155)^{***}$
Adj. $R^2 = 0.94$ D.W. = 2.25 RMSPE = 0.019 Method = OLS Obs. = 11(2006 − 2016)

$lnCO = 0.693 + 0.775lnY + 0.689lnPF + 1.236lnM$
(0.741) $(0.366)^{***}$ $(0.160)^{***}$ $(0.177)^{***}$
Adj. $R^2 = 0.99$ D.W. = 1.99 RMSPE = 0.025 Method = OLS Obs. = 11 (2006 − 2016)

$lnCP = 0.349 + 0.946lnP + 0.115lnIP$
$(0.131)^{**}$ $(0.040)^{***}$ $(0.067)^{***}$
Adj. $R^2 = 0.89$ D.W. = 1.30 RMSPE = 0.056 Method = OLS Obs. = 27 (1990 − 2016)

Note: Values in parentheses are standard errors; ***, ** and * indicate 1 per cent, 5 per cent and 10 per cent significance levels, respectively.

Table 5 Baseline solution for grain supply and demand and self-sufficiency (1000 tonnes, %)

Grain	Year	Prod.	Cons.	Imports	Exports	E. Stocks	Self-sufficiency rate	Stocks-to-use ratio	Import reliance
Rice	2012	143000	133250	2369	279	75540	107.32	56.69	1.78
	2013	142530	133507	2271	478	86356	106.76	64.68	1.70
	2014	144331	134868	2579	419	97979	107.02	72.65	1.91
	2015	145126	137495	3377	287	108700	105.55	79.06	2.46
	2016	145399	137477	3560	395	119787	105.76	87.13	2.59
Wheat	2012	121023	123589	3701	286	51729	97.92	41.86	2.99
	2013	121930	125246	5535	278	53670	97.35	42.85	4.42
	2014	126106	128246	3004	190	54344	98.33	42.37	2.34
	2015	128411	121350	3007	122	64290	105.82	52.98	2.48
	2016	129516	124656	3412	113	72449	103.90	58.12	2.74

Source: Model solution.

Table 6 Baseline solution for grain price, yield and costs (yuan/50 kg, kg/mu, yuan/mu)

Grain	Year	Price	Yield	Revenue	Costs	Net income
Rice	2012	138.1	448.6	1239.0	880.1	358.9
	2013	136.5	451.4	1232.4	957.8	274.6
	2014	140.6	454.3	1277.5	970.5	307.0
	2015	138.0	457.1	1261.7	987.3	274.4
	2016	136.8	459.0	1256.0	979.9	276.1
Wheat	2012	108.3	330.7	716.2	688.1	28.1
	2013	117.8	339.3	799.5	760.9	38.6
	2014	120.6	348.7	841.0	783.8	57.2
	2015	116.4	354.7	825.7	784.6	41.1
	2016	111.6	357.3	797.6	805.6	−8.0

Source: Model solution.

Table 7 Policy shock scenarios for price support policies in 2012 (yuan/50 kg)

Grain	Support prices (baseline)	Scenario 1 10% Increase	Scenario 2 20% Decrease
Rice	131.7	144.9	105.4
Wheat	102.0	1123.2	81.6

Note: Changes are assumed to be added to the actual support prices in 2012.

as well to identify alterations in measurements for grain food security and farmers' net income. Food security measurements incorporate the self-sufficiency rate, defined as the ratio of grain production to domestic consumption, and the stocks-to-use ratio, characterised as the ratio of grain ending stocks to domestic consumption, alongside the import reliance, defined as the ratio of import to domestic consumption. Income incorporates the revenue and net income per unit land in relation to rice and wheat production. The revenue is a product of grain producer price and grain yield, while the net income includes the production costs. The two scenarios are simulated using the equilibrium models for rice and wheat and the detailed simulation results are illustrated in Tables 8 and 9, respectively. Changes in grain food security measurements and income for each scenario are presented in Tables 10 and 11, respectively.

5.3 Changes in grain sectors

Price support policies produce a positive impact on the current year's grain prices and negatively shape the forthcoming years' grain prices by increasing production. Statistically, a 10 per cent increase in the support price results in a 6.73 per cent increase in rice producer prices in the current year, with the impact after the current year becoming negative and then weakening gradually. The move reduces rice prices by 1.07 per cent in the second year. Subsequently, the effect decreases to 0.20 per cent by the fifth year. For

Table 8 Simulation results for rice sector (%, 1000 tonnes, yuan/50 kg, kg/mu, yuan/mu)

Scenario	Year	Price	Yield	Costs	Prod.	Cons.	Imports	Exports	E.Stocks
1 (+10%)	2012	6.73 (9.3)	– (–)	6.22 (54.8)	– (–)	−1.27 (−1690.5)	32.7 (774.7)	−18.5 (−51.6)	3.33 (2516.8)
	2013	−1.07 (−1.5)	0.45 (2.0)	1.21 (11.6)	1.00 (1429.2)	0.23 (310.1)	−4.54 (−103.2)	3.41 (16.3)	4.07 (3516.4)
	2014	−0.60 (−0.8)	0.28 (1.3)	0.74 (7.1)	0.56 (811.3)	0.13 (177.6)	−2.58 (−66.5)	1.91 (8.0)	4.16 (4075.6)
	2015	−0.34 (−0.5)	0.17 (0.8)	0.46 (4.5)	0.32 (463.1)	0.07 (102.3)	−1.47 (−49.8)	1.08 (3.1)	4.03 (4383.5)
	2016	−0.20 (−0.3)	0.11 (0.5)	0.29 (2.9)	0.18 (265.8)	0.04 (56.2)	−0.85 (30.2)	0.61 (2.4)	3.81 (4560.5)
2 (−20%)	2012	−14.1 (−19.5)	– (–)	−13.2 (−116.0)	– (–)	3.20 (4259.2)	−48.4 (−1147.5)	61.4 (171.4)	−7.38 (−5578.1)
	2013	2.56 (3.5)	−1.05 (−4.7)	−2.78 (−26.6)	−2.31 (−3291.2)	−0.54 (−717.7)	11.5 (261.3)	−7.57 (−36.2)	−9.10 (−7854.1)
	2014	1.42 (2.0)	−0.64 (−2.9)	−1.70 (−16.5)	−1.30 (−1881.8)	−0.31 (−413.2)	6.31 (162.7)	−4.32 (−18.1)	−9.33 (−9141.9)
	2015	0.80 (1.1)	−0.40 (−1.8)	−1.06 (−10.5)	−0.74 (−1078.4)	−0.17 (−238.6)	3.54 (119.5)	−2.47 (−7.1)	−9.07 (−9855.1)
	2016	0.44 (0.6)	−0.26 (−1.2)	−0.68 (−6.7)	−0.43 (−620.5)	−0.10 (−126.3)	2.01 (71.7)	−1.44 (−5.7)	−8.57 (−10266.9)

Note: Values in parentheses are quantitative changes with a unit of thousand tonnes for supply and demand, yuan/50 kg for price, kg/mu for yield and yuan/mu for costs. In Scenarios 1 and 2, the support prices are supposed to be raised by 10 per cent and reduced by 20 per cent in 2012, respectively.

Table 9 Simulation results for wheat sector (%, 1000 tonnes, yuan/50 kg, kg/mu, yuan/mu)

Scenario	Year	Price	Yield	Costs	Prod.	Cons.	Imports	Exports	E.Stocks
1 (+10%)	2012	9.45 (10.2)	– (–)	12.5 (86.0)	– (–)	−5.94 (−7345.0)	12.1 (448.8)	−18.7 (−53.6)	15.2 (7847.2)
	2013	−3.13 (−3.7)	1.15 (3.9)	0.89 (6.8)	2.59 (3159.5)	2.66 (3337.3)	−23.3 (−1286.9)	7.55 (21.0)	11.9 (6361.5)
	2014	−0.81 (−1.0)	−0.02 (0.1)	−0.01 (−0.1)	0.66 (826.0)	0.69 (891.2)	−6.31 (−189.7)	1.89 (3.6)	11.2 (6103.0)
	2015	−0.41 (−0.5)	−0.11 (−0.4)	−0.09 (−0.7)	0.33 (423.0)	0.29 (348.8)	−3.87 (−116.5)	0.90 (1.1)	9.43 (6059.6)
	2016	−0.27 (−0.3)	−0.09 (−0.3)	−0.07 (−0.6)	0.22 (279.7)	0.21 (279.7)	−2.37 (−80.8)	0.62 (0.7)	8.28 (6000.2)
2 (−20%)	2012	−19.1 (−20.6)	– (–)	−24.1 (−165.9)	– (–)	23.7 (29328.3)	61.5 (2275.9)	62.3 (178.2)	−52.6 (−27230.6)
	2013	7.72 (9.1)	−2.65 (−9.0)	−2.06 (−15.7)	−5.82 (−7091.5)	−5.24 (−6559.4)	102.1 (5652.5)	−15.7 (−43.6)	−41.1 (−22066.6)
	2014	1.91 (2.3)	0.05 (0.2)	0.04 (0.3)	−1.52 (−1911.8)	−1.55 (−1993.7)	17.2 (515.6)	−4.26 (−8.1)	−39.5 (−21461.0)
	2015	0.95 (1.1)	0.26 (0.9)	0.20 (1.6)	−0.77 (−984.6)	−0.66 (−798.4)	9.82 (295.4)	−2.13 (−2.6)	−33.2 (−21349.1)
	2016	0.63 (0.7)	0.21 (0.8)	0.16 (1.3)	−0.50 (−652.3)	−0.48 (−594.2)	5.83 (198.9)	−1.42 (−1.6)	−29.3 (−21206.7)

Note: Values in parentheses are quantitative changes, with a unit of thousand tonnes for supply and demand, yuan/50 kg for price, kg/mu for yield and yuan/mu for costs. In Scenarios 1 and 2, the support prices are supposed to be raised by 10% and reduced by 20% in 2012, respectively.

Table 10 Changes in grain security measurements to baseline (percentage point)

Scenario	Year	Self-sufficiency rate		Stocks-to-use ratio		Import reliance	
		Rice	Wheat	Rice	Wheat	Rice	Wheat
1 (+10%)	2012	1.38	6.19	2.64	9.40	0.61	0.58
	2013	0.82	−0.07	2.48	3.84	−0.08	−1.12
	2014	0.46	−0.04	2.92	4.43	−0.05	−0.16
	2015	0.26	0.04	3.13	4.83	−0.04	−0.10
	2016	0.15	0.01	3.28	4.68	−0.02	−0.07
2 (−20%)	2012	−3.32	−18.8	−5.81	−25.8	−0.89	0.91
	2013	−1.90	−0.59	−5.56	−16.2	0.21	5.01
	2014	−1.07	0.04	−6.58	−16.3	0.13	0.45
	2015	−0.60	−0.12	−7.04	−17.4	0.09	0.26
	2016	−0.35	−0.03	−7.39	−16.8	0.05	0.17

Source: Model solution.

Table 11 Changes in farmers' production income to baseline (yuan/mu)

Scenario	Year	Revenue		Production costs		Net income	
		Rice	Wheat	Rice	Wheat	Rice	Wheat
1 (+10%)	2012	83.4	67.5	54.8	86.0	28.6	−18.5
	2013	−7.5	−14.5	11.6	6.7	−19.1	−21.2
	2014	−4.6	−7.0	7.1	−0.1	−11.7	−6.9
	2015	−7.5	−4.4	4.5	−0.6	−6.5	−3.8
	2016	−7.5	−2.1	2.8	−0.6	−3.0	−1.5
2 (−20%)	2012	−175.8	−136.2	−116.0	−165.9	−59.8	29.7
	2013	18.3	41.5	−26.6	−15.7	44.9	57.2
	2014	10.0	16.0	−16.6	0.3	26.6	15.7
	2015	4.8	9.4	−10.5	1.6	15.3	7.8
	2016	2.9	6.5	−6.7	1.3	9.6	5.2

Source: Model solution.

wheat, the current year increase in wheat producer prices is 9.45 per cent. The price then decreases by 3.13 per cent in the second year and downs to a 0.27 per cent decrease in the fifth year. Price support policies can promote grain yield in the subsequent year. However, from the third year onwards, the impact directions are opposite for both rice and wheat. As such, increasing support prices by 10 per cent strengthens the rice and wheat yields in the following year by 0.45 per cent and 1.15 per cent, respectively. The impact on yields is positive for rice but negative for wheat after the third year. The increase for rice yield varies from 0.28 per cent to 0.11 per cent, and the decrease for wheat yields varies between 0.02 per cent and 0.09 per cent. Furthermore, price support policies positively impact grain production costs in the current year, with a 10 per cent increase in grain support prices generating a 6.22 per cent increase for rice and a 12.5 per cent increase for

wheat. Subsequently, the impacts on rice production costs in the following years remain positive, decreasing from 1.21 per cent to 0.29 per cent, while for wheat, the impacts are negative and smaller after the third year.

The price support policies produce continuous positive effects on grain production in the following years, with a 10 per cent support price increase potentially resulting in an increase of 1.0 per cent and 2.59 per cent in rice and wheat production in the subsequent year, respectively. Additionally, the positive impacts in the following years range between 0.56 per cent and 0.18 per cent for rice and between 0.66 per cent and 0.22 per cent for wheat. However, price support policies produce a negative effect on grain consumption by increasing grain market prices in the present year, while producing a positive effect on the subsequent years' consumption by decreasing prices in the subsequent years. Statistically, a 10 per cent support price increase may diminish rice consumption in the present year by 1.27 per cent and then increase the subsequent years' consumptions by 0.23 per cent to 0.04 per cent. For wheat consumption, the reduction in the present year is 5.94 per cent, while the increase in subsequent years ranges between 2.66 per cent and 0.21 per cent.

For grain trading, price support policies typically have a positive effect on imports in the present year and a negative impact in the following years. However, for exports, the effects are reversed—negatively impacting the present year's exports and positively impacting the following years' exports. According to the simulation results, a 10 per cent increase in grain support prices may strengthen imports by 32.7 per cent and 12.1 per cent in the present year for rice and wheat, respectively, while reducing imports in the subsequent years from 4.54 per cent to 0.85 per cent for rice and from 23.3 per cent to 2.37 per cent for wheat. Exports could be reduced by 18.5 per cent for rice and 18.7 per cent for wheat in the current year, with exports in the subsequent years rising by 3.41 per cent to 0.61 per cent for rice and by 7.55 per cent to 0.62 per cent for wheat. Finally, price support policies can increase grain ending stocks continuously by influencing the supply and demand of grain. A 10 per cent increase in support prices may lead to a 3.33 per cent increase in rice ending stocks in the current year and then a 4.07 per cent to 3.81 per cent increase in the subsequent years. For wheat, the increase in the current year is much higher, with an increase of 15.2 per cent in the current year and then from 11.9 per cent to 8.28 per cent in the following years. The detailed simulation results are presented in Tables 8 and 9, wherein the simulation results for Scenarios 2 are also presented.

According to the simulations, the wheat sector has a greater sensitivity to price support policies, given that the magnitude in corresponding alterations is relatively greater than that for the rice sector. The effect on grain stocks is relatively greater than that on production. The Chinese government employs price support policies to strengthen grain productivity. Furthermore, growth in grain ending stocks occurs more swiftly than it does for production,

implying enhanced pressure on grain ending stocks because of price support policies.

5.4 Changes in measurements of food security

Food security (quantitative) is typically measured according to the self-sufficiency rate, the stocks-to-use ratio and the import reliance. Changes in these measurements resulting from China's price support policies are quantified based on the simulation results, which are presented in Table 10. For Scenario 1, where rice and wheat support prices are assumed to increase by 10 per cent in 2012, the rice self-sufficiency rate rises by 1.38 percentage points in the current year, gradually ranging from 0.82 to 0.15 percentage points in subsequent years. The wheat self-sufficiency rate shows an increase of 6.19 percentage points in the current year, after which the changes in the following years are not significant. For Scenario 2, where a 20 per cent reduction in grain support prices are assumed in 2012, the net percentage point increase in rice's self-sufficiency rate falls by 3.32 percentage points in 2012 and downs from 1.90 to 0.35 percentage points in the following years. Meanwhile, the wheat self-sufficiency rate sees a dramatic decrease of 18.8 percentage points, which may bring potential risk to the wheat sector as well as threatening overall wheat food security (Table 10).

For grain stocks-to-use ratios, a 10 per cent expansion in grain support prices in 2012 may increase the rice stocks-to-use ratio by 2.64 percentage points in the current year, with the increase gradually expanding from 2.48 to 3.28 percentage points in the following years. Additionally, the wheat stocks-to-use ratio rises by 9.40 percentage points in the current year and from 3.84 to 4.68 percentage points in the following years. For Scenario 2, in which a reduction of 20 per cent in grain support prices is assumed in 2012, the rice stocks-to-use ratio declines by 5.81 percentage points in the current year, with the decline expanding from 5.56 to 7.39 percentage points in the following years. For wheat, the stocks-to-use ratio reveals a significant drop of 25.8 percentage points in the present year and of more than 16 percentage points in each subsequent year (Table 10).

Import reliance indicates the extent to which domestic consumption is dependent upon grain imports. Essentially, the greater the import level, the lower the food security. For Scenario 1, whereby grain support prices are assumed to increase by 10 per cent over the actual 2012 support prices, the import reliance sees a slight increase of 0.61 and 0.58 percentage points in 2012 for rice and wheat, respectively. The import reliance decreases in the following years from 0.08 to 0.02 percentage points for rice and from 1.12 to 0.07 percentage points for wheat. For Scenario 2, a reduction of 20 per cent in grain support prices may result in a decrease of 0.89 percentage points in rice import reliance in the current year, with an increase of 0.21 to 0.05 percentage points in the following years. Finally, for wheat, the import reliance grows by

0.91 percentage points in 2012 and by 5.01 to 0.17 percentage points in the following years (Table 10).

The simulation results indicate that the price support policies can strengthen food security by enhancing self-sufficiency rates and stocks-to-use ratios. A 10 per cent grain support price increase may elevate self-sufficiency rates for rice and wheat by 1.38 and 6.19 percentage points, respectively. These are approximately equivalent to a rise of 1.28 per cent and 6.32 per cent in the respective self-sufficiency rates of rice and wheat. A 10 per cent increase in the grain support price may promote the stocks-to-use ratios by 2.64 percentage points for rice and 9.40 percentage points for wheat in the current year, with respective percentage increases of 4.66 per cent and 22.5 per cent. Considering the sharp increase in grain price support levels since 2008, both grain self-sufficiency rates and stocks-to-use ratios have been significantly enhanced by the price support policies.

By reducing grain support prices by 20 per cent, the rice self-sufficiency rate drops by 3.32 percentage points in the current year, or a decrease of 3.06 per cent, while the rice stocks-to-use ratio drops by 5.81 percentage points, or a decrease of 9.80 per cent. The wheat self-sufficiency rates have an 18.8 percentage points decrease in the current year, which equals to a drop of 18.0 per cent, while the wheat stocks-to-use ratios fall by 25.8 percentage points, which is a dramatic decrease of 50.4 per cent in the current year. This indicates that sharp reductions in grain support prices threaten food security, typically wheat food security. For grain import reliance, only a marginal proportion of domestic consumption is accounted for by grain imports, with price support policies generally indicating a tiny effect on grain import reliance. Indeed, this places a significant impact neither on China's food security, nor on grain supply and demand within the global market, even in the case of dramatic changes in grain price support levels. Consequently, this suggests that grain price support policies significantly enhance China's grain self-sufficiency level and play an important role in food security strategies.

5.5 Changes in farmers' income

A unit of land's per capita revenue can be calculated by product of the producer price and the yield. Table 11 presents the simulation results for production revenue, costs and net income per mu. In Scenario 1, when grain support prices are assumed to grow by 10 per cent, the rice revenue expands by 83.4 yuan/mu in the current year and reduces by less than 8 yuan/mu in each subsequent year. Rice production costs rise by 54.8 yuan/mu in the current year and by 11.6 to 2.8 yuan/mu in the subsequent years. Consequently, farmers' net income for rice increases by 28.6 yuan/mu in the present year, suggesting that the policy's income effect in the current year will be offset by the increased production costs. Meanwhile, wheat revenue grows by 67.5 yuan/mu in the current year, and the impacts in the subsequent years are negative, dropping from 14.5 to 2.1 yuan/mu. Wheat production

costs witness a significant increase of 86 yuan/mu in the current year and small changes in the following years. Consequently, farmers' net income for wheat is calculated to be negative at − 18.5 yuan/mu in the current year, with the decrease growing to − 21.2 yuan/mu in the second year.

In Scenario 2, where the price support levels are assumed to be cut by 20 per cent in 2012, revenues for rice and wheat decrease markedly by 175.8 and 136.2 yuan/mu, respectively. Likewise, the respective production costs for rice and wheat decrease by 116.0 and 165.9 yuan/mu. Thus, farmers' net income for rice falls by 59.8 yuan/mu and for wheat rises by 29.7 yuan/mu. However, the production costs are characterised by rigidity and as such are unlikely to fall significantly, even when a dramatic policy shock occurs. Therefore, the simulation results for both production costs and net income in Scenario 2 are merely a reference guide. The details are presented in Table 11.

Grain price support policies simultaneously increase grain production revenue and production costs. Consequently, farmers' actual income is significantly offset by the increased costs and may become rather small and even negative when grain support prices rise. Therefore, the current price support policies appear to have very limited income effects for farmers, and the original policy goal of increasing farmers' income that the government intends is not realised.

6. Conclusion and policy implications

This paper analyses the impact mechanism of the price support policies, concluding that these government intervention policies positively affect grain market prices, while raising grain production costs by altering farmers' behaviour on input usage and increasing input factor prices. Furthermore, such policies can transmit impacts on the grain sector via the price and costs channels. Based on this impact mechanism, a grain equilibrium model is devised to simulate the policy effects on grain sectors, as well as empirically associate food security and income changes.

Overall, the price support policies can enhance food security status, based on an in-depth reflection on increased self-sufficiency rates and a stocks-to-use ratio. A 10 per cent grain support price increase may result in an overall increase of 1.28 per cent and 6.32 per cent in the grain self-sufficiency rate for rice and wheat, respectively, alongside an overall increase of 4.66 per cent and 22.5 per cent in the grain stocks-to-use ratio for rice and wheat, respectively, in the current year. Although China's grain price policies strengthen the country's reliance on grain imports, in general the effect on import reliance is too minimal to influence food security. As evidenced by the sharp increase in support prices since 2008, the effect of the price support policies on enhancing food security has been remarkable. As a result, these policies continue to play a vital role with respect to China's food security strategies.

Dramatic oscillations in support prices will undermine grain supply and demand, threatening China's food security. With regard to ensuring food

security, the government should continue with this policy system and maintain relatively stable support prices. It is notable that China's price support policies have significantly increased the country's grain ending stocks. Given that these stocks are already considerable, continuing to incrementally increase the support prices may place tremendous pressure on grain ending stocks, producing greater storage costs. As a result, measures to encourage the consumption of stocks should be developed to alleviate the pressure from high grain ending stocks.

Price support policies were initially adopted by the Chinese government to increase farmers' income, but they were not expected to increase grain production costs. The price support policies can increase farmers' revenue, but the increment may be largely offset by increased production costs stemming from the policy itself. This leads to an especially low increase in farmers' net incomes. Also, a negative effect on net income for wheat is observed. Therefore, price support policies' effects in terms of increasing farmers' net incomes are marginal. To effectively realise the political goal of enhancing farmers' income, other potential measures, such as providing direct income subsidies for grain production, should ideally be employed. Prospective policy reformation should comprehensively take costs into account. This should aim to avoid policies affecting farmers' behaviour with regard to input usage. In addition, auxiliary measures to control input factor prices should be implemented with price support policies simultaneously.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Antoine, B., Estrades, C. and David, L. (2014). Differential export taxes along the oilseeds value chain: a partial equilibrium analysis, *American Journal of Agricultural Economics* 96, 924–928.

Barker, R. and Hayami, Y. (1976). Price support versus input subsidy for food self-sufficiency in developing countries, *American Journal of Agricultural Economics* 58, 617–628.

Beghin, J.C., Bureau, J.C. and Park, S.J. (2003). Food security and agricultural protection in South Korea, *American Journal of Agricultural Economics* 85, 618–632.

French, B.C. and Mathews, J.L. (1971). A supply response model for perennial crops, *America Journal of Agricultural Economics* 53, 478–490.

Froster, K.A. and Mwananmo, A. (1995). Estimation of dynamic maize supply response in Zambia, *Agricultural Economics* 12, 99–107.

Kozicka, M., Kalkuhl, M. and Brockhaus, J. (2017). Food grain policies in India and their implications for stocks and fiscal costs: a dynamic partial equilibrium analysis, *Journal of Agricultural Economics* 68, 98–122.

Lee, D. and Kennedy, P.L. (2007). A political economic analysis of U.S. rice export programs to Japan and South Korea: a game theoretic approach, *American Journal of Agricultural Economics* 89, 104–115.

Lu, W. (2002). Effects of agricultural market policy on crop production in China, *Food Policy* 27, 561–573.
Marette, S., Roe, B.E. and Teisl, M.F. (2012). The consequences of a human food pathogen vaccine on food demand: a calibrated partial-equilibrium analysis of the U.S. beef market, *Australian Journal of Agricultural and Resource Economics* 56, 366–384.
Meilke, K.D. and Griffith, G.R. (1983). Incorporating policy variables in a model of the world soybean/rapeseed market, *American Journal of Agricultural Economics* 65, 65–73.
Mu, Y. and Koike, A. (2009). SCGE model construction and simulation analysis of the agricultural subsidy policy in China, *Journal of Quantitative & Technical Economics* 26, 3–14.
Mushtaq, K. and Dawson, P.J. (2002). Acreage response in Pakistan: a co-integration approach, *Agricultural Economics* 27, 111–121.
Nerlove, M. (1956). Estimates of the elasticities of supply of selected agricultural commodities, *Journal of Farm Economics* 38, 496–509.
Otsuka, K. and Hayami, Y. (1985). Goals and consequences of rice policy in Japan, 1965–80, *American Journal of Agricultural Economics* 67, 529–538.
Qian, J. and Zhao, Z. (2019). The mechanism and impact of price support policy on grain prices in China, *Journal of Agrotechnical Economics* 8, 89–98.
Qian, J., Ito, S., Mu, Y., Saito, H. and Isoda, H. (2013a). High meat price and increasing grain consumption in China, *Japanese Journal of Farm Management* 51, 67–72.
Qian, J., Ito, S., Mu, Y. and Isoda, H. (2013b). Effect of grain price support policy in China: a grey relational analysis, *Journal of the Faculty of Agriculture Kyushu University* 58, 485–491.
Qian, J., Ito, S., Mu, Y. and Isoda, H. (2013c). Impact of agricultural subsidies on rice price in China: a cointegration analysis, *Journal of Rural Problems* 49, 172–176.
Qian, J., Ito, S., Zhao, Z., Mu, Y. and Hou, L. (2015). Impact of agricultural subsidy policies on grain prices in China, *Journal of the Faculty of Agriculture Kyushu University* 60, 273–279.
Qian, J., Ito, S., Mu, Y., Zhao, Z. and Wang, X. (2018). The role of subsidy policies in achieving grain self-sufficiency in China: a partial equilibrium approach, *Agricultural Economics (Czech Republic)* 64, 23–35.
Song, J. and Carter, C.A. (1996). Rice trade liberalization and implications for U.S. policy, *American Journal of Agricultural Economics* 78, 891–905.
Vitale, J.D., Djourra, H. and Sidibe, A. (2009). Estimating the supply response of cotton and cereal crops in smallholder production systems: recent evidence from Mali, *Agricultural Economics* 40, 519–533.
Wang, S. and Li, X. (2012). The effect of price support policy on grain prices in China, *Journal of Agrotechnical Economics* 4, 105–111.
Yu, B., Liu, F. and You, L. (2012). Dynamic agricultural supply response under economic transformation: a case study of Henan, China, *America Journal of Agricultural Economics* 94, 370–376.
Zhao, J., Miller, J.I. and Thompson, W. (2017). Modeling and extrapolating wheat producer support using income and other factors, *Journal of Agricultural Economics* 69, 338–350.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Supplementary Material