Impacts of agricultural price support policies on price variability and welfare: evidence from China's soybean market

Wenting Wang

China Academy for Rural Development, Zhejiang University, Hangzhou, Zhejiang, China

Department of Economics and Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa, USA

wenting@iastate.edu

Longbao Wei

China Academy for Rural Development, Zhejiang University, Hangzhou, Zhejiang, China

lbwei@zju.edu.cn

Impacts of agricultural price support policies on price variability and welfare: evidence from China's soybean market

Abstract: As the world's largest importer of agricultural commodities, China's agricultural policies have significant implications for the world agricultural market. For the first time, we develop an aggregate structural econometric model of China's soybean market with linkage to the rest of the world to analyze the worldwide impacts of China's soybean price support policies from 2008 to 2016. We investigate the impacts of China's policies on the variability of their domestic and world prices, and adopt a Monte Carlo simulation to evaluate the distributional and aggregate welfare effects. Results indicate that (a) China's soybean price support policies play an effective role in stabilizing their domestic price, while its increasing imports absorb world production surplus and reduce world price swings; (b) China's producers gain at the expense of consumers and budgetary costs, and the net welfare change in their domestic market is negative; (c) Soybean exporting countries experience considerable welfare gains, and the world net welfare change is positive. Our findings provide new insights for future trade negotiations and agricultural market reforms in developing countries.

1. Introduction

The 2008 global food price crisis, which caused malnutrition and hunger, provoked riots in many countries and rekindled academic interest in food security (Barrett, 2010). In China, food security is expressed as "grain security" and evaluated by grain self-sufficiency, which has long been proclaimed a top policy priority. To achieve grain self-sufficiency, China has continued to stimulate production with price incentives and producer subsidies, and has directly intervened in both the domestic agricultural market and international trade. The last two decades have also witnessed China's tremendous transition from a net grain exporter to a net importer. As the world's largest producer, consumer, and importer of agricultural commodities, any alteration in China's agricultural policies exerts great influence on the world market.

Agricultural policies and their impacts have attracted the attention of many researchers over the years. To the best of our knowledge, Johnson (1975) is the first to propose an integrated impression of the worldwide impacts of domestic agricultural policies. Most researchers focus on the price and welfare effects of agricultural subsidy policies (e.g., Thompson et al., 2002; Bhagwati, 2004; Koo and Kennedy, 2006; Schmitz et al., 2006) and trade distortion policies (e.g., Martin and Anderson, 2011; Götz et al., 2013; Diao and Kennedy, 2016; Porteous, 2017). Studies investigating the impacts of price support policies in importing countries are scarce. Although there has been continually increasing concerns about China's agricultural policies, especially on the historical reform of agricultural tax exemption, subsidy introduction, and the recently increasing investment in agricultural development (e.g., Gale et al., 2005; OECD, 2009; Huang et al., 2013), most researchers restrict their attention to China's domestic market instead of an integrated picture of the world market. Moreover, a substantial body of literature has developed using partial or general equilibrium models

for ex-ante analysis that are increasingly sophisticated and incorporate a variety of assumptions on market conditions (e.g., Bohman et al., 1991; Valenzuela et al., 2008; Diao and Kennedy, 2016; Li et al., 2018); however, there are no ex-post empirical analyses on the impacts of China's soybean policies. China's soybean price support policies have existed for more than ten years, providing a sufficient observation period to conduct an ex-post analysis.

The objective of our article is to fill these gaps in the literature by providing an empirical assessment on the ex-post impacts of China's soybean price support policies on price variability and economic welfare in an integrated picture of the world market. The price support policies included are the 2008 temporary procurement for reserve policy and the 2014 target price policy. Empirically, our analysis is based on an aggregate structural econometric model of the China/rest-of-the-world soybean market as estimated from 1985 to 2016. Compared to the partial or general equilibrium models, our model captures China's soybean price support policies in an aggregate form and provide a more transparent framework. We use the model to evaluate the actual effects of China's soybean price support policies on price variability in both the domestic market and the world market and compare it to the same situation without the policies. Utilizing the estimated values of our model parameters, we adopt a Monte Carlo simulation to investigate the distribution of gains and losses to China's producers and consumers, China's budgetary costs, and exporters in the rest of the world, as well as the aggregate welfare effects.

Our contributions to the literature are as follows: first, we update the literature by addressing the worldwide impacts of China's agricultural policies. We highlight the unanswered question of whether China's agricultural market interventions to realize food security affect the world market; however, our findings are initial. Second, we

contribute to the understanding of China's agricultural policy development and inform the debate about the appropriate future roles for agricultural support policies in China and other developing countries.

The remainder of this article is organized as follows. The next section introduces the background of China's soybean support policies. Section 3 documents our efforts to develop the theoretical framework. The empirical model and data description are presented in section 4. Section 5 details the empirical results and section 6 provides conclusions and implications.

2. Background of China's soybean support policies

The 2008 world food crisis caused unexpectedly high and volatile soybean prices. From July 2007 to June 2008, the world soybean price surged by 82.4% and then dropped by 43% from its December 2008 peak. Alarmed by the adverse effects of world price instability and the possibility of food insufficiency in their domestic market, the Chinese government intervened by first providing and then steadily increasing price supports. The temporary procurement for reserve policy, which guaranteed Chinese farmers a minimum soybean price, was introduced in October 2008. When the market price falls below the minimum price, farmers can sell their soybeans to state-owned grain enterprises (e.g., COFCO and SINOGRAIN), which stockpile soybeans with the goal of stabilizing the supply and consequently the domestic price (OECD, 2013). Each year since 2008, the Chinese government has increased the procurement price (see Table 1), intensifying its intervention and leading to serious price distortion in their domestic soybean market. China's higher price increased the gap between their domestic price and the world soybean price, leading to rapidly increasing demand for lower-priced soybean imports (Zhong and Zhu, 2017; see Figure 1). Furthermore,

Chinese authorities purchased a large volume of domestic soybeans at the minimum price level and soybean stocks gradually accumulated as the enterprises could not resell them at a profitable price in their domestic markets, leaving the government with excessive stockpiles and huge expenditures (Carter et al., 2012; Clever and Wu, 2016). As a result, China's new food security challenge is that imports and stocks continue to increase at the same time (see Figure 1). As presented in Table 1, the Chinese government grain and oil reserve expenditure increased from 110.6 billion yuan in 2009 to 164.9 billion yuan in 2013.

[Figure 1 about here]

In January 2014, the temporary procurement for reserve policy was abolished and the soybean target price policy was initiated. Under the target price policy, farmers receive a direct payment form the government when their domestic market price is below the target price (Huang and Yang, 2017). Table 1 shows that support prices remained at 4800 Yuan/t from 2014 to 2016 and a general uptrend in the government grain and oil reserve expenditure.

In March 2017, the target price policy was withdrawn, due to unsustainably high costs and inefficient policy implementation (Yu, 2017), and followed with a producer subsidy policy. The objective of this policy is to encourage their domestic soybean production while allowing domestic soybean price to decline, which helps stimulate consumption of domestic soybean and reduce imports. Accordingly, it is expected that the government can reduce expenditures for procurement and storage (Zhong and Zhu, 2017).

[Table 1 about here]

We identify the fundamental policy regime period as being from 1985 to 2016.[1] Since the producer subsidy policy in 2017 separated direct subsidy from price support and intervened in the domestic market differently than the former two policies, we identify the temporary procurement for reserve policy (2008–2013) and the target price policy (2014–2016) as China's soybean price support policies in this article.

3. Theoretical framework

It has long been recognized that domestic market intervention policies by large trading countries influence the worldwide trade flows. The extent of distortion depends not only on the trade volume of the country,[2] but also the nature of the policies (Larue and Ker, 1993). Figure 2 summarizes how different agricultural support policies of a large country influence the world price. Agricultural support policies mainly include trade policies, storage policies, subsidy policies and price support policies. It is acknowledged that agricultural subsidies are prevailing in developed countries while price support policies are common in developing countries. In developed countries, farmers adjust the allocation of resources in agricultural commodity production. The production surplus or shortage changes the aggregate demand or supply in the world market and eventually distorts trade flows. However, the situation in China is quite different—the support prices for soybeans are much higher than the world soybean

---

[1] Time period prior to 1985 are not considered in this article because China implemented a government monopoly on soybean purchasing and marketing before 1985. In 1985, the Chinese government eliminated the mandatory grain purchase plan and established a market operation mechanism in the soybean market (No.1 documents issued by the Central Committee of the Chinese Communist Party and the State of China, 1985).

[2] It is assumed that small exporting (importing) countries face a perfectly elastic import demand (export supply) from the rest of the world. Thus, for small trading countries, market intervention will not influence the world market, because the changes in imports or exports are not large enough to influence the world price (Koo and Kennedy, 2005).

prices, yet the policies fail to stimulate their domestic production.[3] Thus, low-priced

soybeans in the world market gain a competitive edge over China's soybeans. China's

soybean price support policies and import demand raise the aggregate demand in the

world market and eventually influence the world price.

[Figure 2 about here]

[Figure 3 about here]

Figure 3 illustrated the impacts of China's soybean price support policies on supply,

demand and trade. Figure 3(a) shows China's domestic soybean market, which faces

an upward-sloped export supply schedule (ES) from the rest of the world in Figure 3(b).

Under free trade, the equilibrium in the rest of the world is established at point M, where

import demand schedule (ED) intersects with export supply schedule in Figure 3(b),

and the trade volume equals Q_1 at the world price of P_{w1}. Now consider China's soybean

market under price support policies, or if the Chinese government sets a support price

higher than the world price—import demand increases, the corresponding schedule is

kinked upward to ED', and new trade equilibrium is created at point N where export

supply schedule intersects with the new import demand schedule, as depicted in Figure

3(b). Accordingly, world price increases from P_{w1} to P_{w2} and trade volume increases

from Q_1 to Q_2. Producer welfare increase since they receive higher domestic price (P_d)

and they gain by areas A and C in Figure 3(a). Now assume that their domestic

consumers face the world price under free trade—domestic consumption decreases

---

[3] From 2009 to 2014, China's soybean acreage declined from 20.8 million acres to 12.5 million acres—farmers tend to not grow more soybeans as there is no comparative advantage. For instance, according to the National Cost-Benefit Compilation of Agricultural Product (NSBC, 2010–2015), from 2009 to 2014, the average net income from corn production was 1047.31 yuan/acre and the average net income from soybean production was 527.31 yuan/acre.

from D_1 to D_3 with the world price increasing from P_{w1} to P_{w2}, and consumers lose by areas C, D, E, and F. In the rest of the world, exporters are better off since the world price increases under China's price support policies. They gain their surplus by the areas G and H in Figure 3(b). Accordingly, the net social welfare loss in China can be divided into four segments: (*a*) social welfare loss owing to misallocation of domestic resources; (*b*) consumers' losses resulting from the rising world price; (*c*) extra outlays paid by the Chinese government; and, (*d*) welfare transfer from China to the exporting countries.

[Figure 4 about here]

Since world soybean production and soybean exports have maintained a steady growth rate from 2001 to 2017 (see Figure 4), we consider a new situation where the export supply in the rest of the world increases in the meantime. As shown in Figure 3(c), the corresponding export supply moves downward to ES' as world production increases, then trade equilibrium is re-established at point O, and the world price increases from P_{w1} to P_{w3}, which is lower than P_{w2}. In this case, the distortion of the world price is much smaller since China's increase of soybean imports absorbs part of the world production surplus.

4. Empirical model and data

4.1. China/rest-of-the-world soybean market model

We develop an aggregate structural econometric model of China and the rest-of-the-world soybean market to quantify the relationships between the two markets and to examine the impacts of China's soybean price support policies. With the assumption of

nonlinear relationships and constant elasticities, we define the one-commodity, two-region model as follows:

$$lnQ_t^D = K_1 + \eta_1 \cdot lnP_t^w + \gamma_1 \cdot lnQ_{t-1}^D + u_1, \tag{1}$$

$$lnQ_t^S = K_2 + \eta_2 \cdot lnP_t^d + \gamma_2 \cdot DV_t + \theta_1 \cdot lnT + u_2, \tag{2}$$

$$lnX_t^D = K_3 + \eta_3 \cdot lnP_t^d + \gamma_3 \cdot lnP_t^w + \theta_2 \cdot lnQ_{t-1}^D + u_3, \tag{3}$$

$$lnX_t^S = K_4 + \eta_4 \cdot lnP_t^w + \gamma_4 \cdot lnQ_{t-1}^{RW} + u_4, \tag{4}$$

$$lnP_t^d = K_5 + \eta_5 \cdot lnP_t^w + \gamma_5 \cdot lnT_t + \theta_3 \cdot DV_t + u_5, \tag{5}$$

$$lnX_t^D = lnX_t^S, \tag{6}$$

where Q_t^D is China's demand quantity; Q_t^S is China's supply quantity; X_t^D is China's import demand quantity; X_t^S is the rest of the world's aggregate export supply quantity; P_t^d is China's domestic soybean price; P_t^w is world soybean price; Q_{t-1}^D is China's demand quantity in the previous year; Q_{t-1}^{RW} is the rest of the world's production in the previous year; DV_t is a dummy variable representing the implementation of China's soybean price support policies; T is a linear trend; the exponent parameters η, γ, and θ are constant elasticities representing the percentage response of the dependent variable with regard to a 1% change of the corresponding explanatory variables; K_i is a constant term; and, u_i is the error term, which is independently and identically distributed with zero mean and constant variance σ_i^2.

Equations (1) to (6) capture China's soybean price support policies in an aggregate form that can be examined within a structural model. The dummy variable (DV_t) is set to one after 2007 and to zero otherwise. DV_t is specified as a regressor in equation (2) since farmers are supposed to consider the policies while making acreage allocation decisions. Equation (3) embodies the hypothesis that when world prices rise relative to

their domestic prices, imports become unprofitable and importers will import less.[4]

Therefore, we expect η_3 to be positive and γ_3 to be negative in the results. Considering the possibility of imperfection transmission of policy support prices, DV_t is included in the price transmission equation (Colman, 1985). Coefficient θ_3 represents the likely adjustments in domestic price resulting from the price support policies. There are six endogenous variables (Q_t^D, Q_t^S, P_t^d, P_t^w, X_t^D and X_t^S) and four predetermined variables (Q_{t-1}^D, Q_{t-1}^{RW}, T_t and DV_t) in the model and each equation is fully identified. Therefore, the three-stage least squares (3SLS) method is adopted to solve the endogenous problem.

Although our aggregation model may confound the likely impacts of other important factors, including transportation costs and imperfect substitutability of different crops, it provides a more transparent framework and is easier to understand (Roberts and Schlenker, 2013). It should be noted that we have not specified China's soybean tariff as an argument in the model since tariffs from 1985 to 2016 are fixed at the level of 3%. No attempt is made to model the China stockholding behavior since soybean stock volumes are resolved as a byproduct of the soybean price support policies, not as a result of an optimization procedure. However, China's soybean supply volumes are adjusted for the stock changes in the model estimation.

Rearranging equations (3) to (6) we get the following:

$$lnP_t^d = \frac{(\gamma_3 - \eta_4)(K_5 + \gamma_5 \cdot lnT_t + \theta_3 \cdot DV_t + u_5) + \eta_5(K_4 - K_3 - \theta_2 \cdot Q_{t-1}^D + \gamma_4 \cdot lnQ_{t-1}^{RW} + u_4 - u_3)}{\gamma_3 - \eta_4 + \eta_3 \eta_5}. \qquad (7)$$

For $\gamma_3 \neq \eta_4$ we yield

$$lnP_t^w = \frac{1}{\gamma_3 - \eta_4}(K_4 - K_3 - \eta_3 \cdot lnP_t^d - \theta_2 \cdot lnQ_{t-1}^D + \gamma_4 \cdot lnQ_{t-1}^{RW} + u_4 - u_3). \qquad (8)$$

---

[4] The original formulation of an aggregate import demand equation relates the import demand quantity to the ratio of import price to domestic price (Houthakker and Magee, 1969), which assumes a degree of substitutability between import and domestic commodities. Since China's soybeans and imported soybeans are imperfect substitutes, we assume that the domestic and world price elasticities are different in equation (3).

Using the variances and covariances of the disturbance variables, variances can be calculated as follows:

$$\sigma^2_{lnP^d_t} = \frac{(\gamma_3-\eta_4)^2 \cdot \sigma^2_5 + (\eta_5)^2 \cdot (\sigma^2_3 + \sigma^2_4 - 2\delta_{3,4}) + 2\eta_5(\gamma_3-\eta_4) \cdot (\sigma_{4,5} - \sigma_{3,5})}{(\gamma_3 - \eta_4 + \eta_3\eta_5)^2}, \tag{9}$$

$$\sigma^2_{lnP^w_t} = \frac{\sigma^2_3 + \sigma^2_4 - 2\sigma_{3,4} + (\eta_3)^2 \cdot \sigma^2_{lnP^d_t} - 2\eta_3 \cdot (\sigma_{4,lnPd} - \sigma_{3,lnPd})}{(\gamma_3 - \eta_4)^2}. \tag{10}$$

Expressions (9) and (10) show clearly and distinctly that the variance of their domestic and world soybean prices can be calculated utilizing model estimates, and that the dependence of variance on the price transmission elasticity, η_5, is nonlinear. The policy instruments of intervention prices exert a downward pressure on the transmission of world price to domestic markets (Thompson et al., 2000), which means the price transmission elasticity, η_5, would decrease if China's soybean price support policies were implemented. Accordingly, if $\partial\sigma^2_{lnP^d_t}/\partial\eta_5 > 0$, then domestic price variability decreases after China's soybean price support policies. If $\partial\sigma^2_{lnP^d_t}/\partial\eta_5 < 0$, then domestic price variability increases after China's soybean price support policies. If $\partial\sigma^2_{lnP^w_t}/\partial\eta_5 > 0$, then the world price variability decreases after China's soybean price support policies. If $\partial\sigma^2_{lnP^w_t}/\partial\eta_5 < 0$, then the world price variability increases after China's soybean price support policies.

4.2. Economic welfare analysis

From the above structural econometric model, we can calculate the distributional welfare changes in China and the rest of the world, including the changes in China's producer surplus (ΔPS), consumer surplus (ΔCS), annual budgetary costs (BC) and exporter surplus in the rest of the world (ΔPS). From (7) and (2), succeedingly and iteratively, we get

$$lnP_t^d = \frac{(\gamma_3-\eta_4)(K_5+\gamma_4\cdot lnT_t+\theta_2\cdot DV_t+v_{5,t})+\eta_5(K_4-K_3-\theta_1\cdot Q_{t-1}^D+\gamma_4\cdot lnQ_{t-1}^{RW}+v_{4,t}-v_{3,t})}{\gamma_3-\eta_4+\eta_3\eta_5}, \quad (11)$$

$$lnQ_t^S = K_2 + \gamma_2\cdot DV_t + \theta_1\cdot lnT_t + v_{2,t} + \eta_2\cdot lnP_t^d. \quad (12)$$

Equations (11) and (12) are calculated for t=1, …, 33. We define $m_t = K_2 + \gamma_2 \cdot DV_t + \theta_1 \cdot lnT_t + v_{2,t}$. Normally distributed random numbers, $V_{i,t}$, with contemporaneous covariance matrix Σ are generated.[5] Solving equation (2) for P_t^d, we get the annual domestic supply functions

$$P_t^d = e^{-m_t/\eta_2} \cdot (Q_t^S)^{1/\eta_2}. \quad (13)$$

Domestic prices are simulated under both the soybean price support policies, $(P_t^{d,1})$, and the free market, $(P_t^{d,0})$, using the dummy variable. For each t, the area above the supply curve from $(P_t^{d,0})$ to $(P_t^{d,1})$ is the annual change of China's producer surplus due to the price support policies,

$$\Delta PS_t = \int_{P_t^{w,0}}^{P_t^{w,1}} exp[\eta_2\cdot lnp + m_t]dp = \int_{P_t^{d,0}}^{P_t^{d,1}} e^{m_t}\cdot p^{\eta_2}dp = e^{m_t}\cdot\frac{(P_t^{d,1})^{1+\eta_2}-(P_t^{d,0})^{1+\eta_2}}{1+\eta_2}. \quad (14)$$

Similarly, we compute the change in China's consumer surplus. From equation (1), succeedingly and iteratively, we get

$$lnQ_t^D = K_1 + \gamma_1\cdot lnQ_{t-1}^D + v_{1,t} + \eta_1\cdot lnP_t^w. \quad (15)$$

We define $n_t = K_1 + \gamma_1\cdot lnQ_{t-1}^D + v_{1,t}$. Solving equation (1) for P_t^w, we get the annual demand functions

$$P_t^w = e^{-n_t/\eta_1} \cdot (Q_t^D)^{1/\eta_1}. \quad (16)$$

World prices are simulated under both the soybean price support policies, $(P_t^{w,1})$, and the free market, $(P_t^{w,0})$, using the dummy variable. For each t, the area below the demand curve from $P_t^{w,0}$ to $P_t^{w,1}$ is the annual change of China's consumer surplus due to the price support policies,

---

[5] Σ is obtained from the econometric model and is an estimate of the covariance matrix of the disturbance variables $u_{i,t}$, which are assumed to be constant over time.

$$\Delta CS_t = \int_{P_t^{w,0}}^{P_t^{w,1}} exp[\eta_1 \cdot lnp + n_t]dp = \int_{P_t^{w,0}}^{P_t^{w,1}} e^{n_t} \cdot p^{\eta_1}dp = e^{n_t} \cdot \frac{(P_t^{w,1})^{1+\eta_1}-(P_t^{w,0})^{1+\eta_1}}{1+\eta_1}. \quad (17)$$

We then calculate the exporters' welfare change in the rest of the world. From equation (4), succeedingly and iteratively, we get

$$lnX_t^S = K_4 + \gamma_4 \cdot lnQ_{t-1}^{RW} + v_{4,t} + \eta_4 \cdot lnP_t^w. \quad (18)$$

We define $h_t = K_4 + \gamma_4 \cdot lnQ_{t-1}^{RW} + v_{4,t}$. Solving equation (4) for P_t^w, we get the annual export supply functions

$$P_t^w = e^{-h_t/\eta_4} \cdot (X_t^S)^{1/\eta_4}. \quad (19)$$

For each t, the area above the export supply curve from $P_t^{w,0}$ to $P_t^{w,1}$ is the exporters' welfare change due to the price support policies,

$$\Delta RW_t = \int_{P_t^{w,0}}^{P_t^{w,1}} exp[\eta_4 \cdot lnp + h_t]dp = \int_{P_t^{w,0}}^{P_t^{w,1}} e^{h_t} \cdot p^{\eta_4}dp = e^{h_t} \cdot \frac{(P_t^{w,1})^{1+\eta_4}-(P_t^{w,0})^{1+\eta_4}}{1+\eta_4}. \quad (20)$$

Finally, China's annual budgetary costs (BC_t) are calculated. Under the temporary procurement for reserve policy, the government procurement price is represented by P_t^G and the procurement quantity is represented by Q_t^G. Thus, we get

$$BC_t = P_t^G \cdot Q_t^G. \quad (21)$$

The domestic net welfare change (ΔDNW_t) and world net welfare change (ΔWNW_t) are calculated as

$$\Delta DNW_t = \Delta PS_t + \Delta CS_t + BC_t, \quad (22)$$

$$\Delta WNW_t = \Delta PS_t + \Delta CS_t + BC_t + \Delta RW_t. \quad (23)$$

4.3. Data

To estimate the econometric model and generate the welfare results, we compile a dataset with both Chinese and international sources from 1985 to 2016. The quantity demanded and supplied in China are sourced from the China Rural Statistical Yearbook (NSBC, 1986–2017). The quantity demanded in China is defined as the sum of

domestic consumption and exports, and the quantity supplied is defined as the sum of domestic production and changes in stocks. China's import demand data are obtained from the General Administration of Customs, P.R. China. The production quantity data of the world are obtained from the Economic Research Service by the United States Department of Agriculture (USDA-ERS). China's domestic prices are obtained from the National Cost-Benefit Compilation of Agricultural Product (NSBC, 1986–2017). World soybean prices, CIF Rotterdam($US), are also collected from the USDA-ERS. Government procurement prices and quantities are sourced from the National Food & Strategic Reserves Administration, P.R. China. To ensure the consistency and comparability of the nominal variables, currency exchange rates collected from the International Monetary Fund are used to convert China's domestic prices in U.S. dollars. To remove the general inflationary trend, both nominal prices are converted to real prices using 2010 as the base year. We use the logarithm form to eliminate the trend effects and to alleviate the problems of heteroscedasticity, which satisfies the hypotheses of nonlinear relationships and constant elasticities.

Table 2 shows the descriptive statistics of main variables. The nonstationary of the levels and the first differences for each variable are tested through the augmented Dickey-Fuller (ADF) test and the results are presented in the Appendix Table A1. All the variables are integrated of order one, thus enabling the following empirical analysis.

[Table 2 about here]

5. Model estimation

In this section, we first estimate the structural econometric model defined in the previous section and analyze the impacts of China's price support policies on soybean

price variability. We then calculate the distributional and aggregate welfare changes in both China and the rest of the world using the estimated model. Lastly, we perform three robustness tests by (a) employing the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model; (b) using data from different source; (c) using data of different time period.

5.1. Impacts of China's soybean price support policies on price variability

For our structural econometric model, ordinary least squares (OLS) estimates are inconsistent and inefficient since the correlations among equations are neglected. The two stage least squares (2SLS) method does account for the endogenous variables, but ignores the possible correlations among the disturbances. The seemingly unrelated regression (SUR) method does account for the covariance structure of the residuals, but not the endogenous variables, which could lead to simultaneity bias. Therefore, with the right-hand side endogenous variables and contemporaneous correlation among the disturbances in our model, we adopt the 3SLS method to derive the estimates. The 3SLS could be considered a combination of 2SLS and SUR. Table 3 reports the parameter estimates. We also tabulate the OLS, SUR, and 2SLS parameter estimates to illustrate the likely endogeneity bias in comparison to the 3SLS estimates.

[Table 3 about here]

Compared with the results from the 2SLS method, estimates based on the 3SLS method are more statistically significant; while some variable estimates show variations. The OLS, SUR, and 2SLS regressions give relatively inelastic estimates of domestic supply and import demand. The price multipliers $\frac{1}{\eta_2-\eta_1}$ and $\frac{1}{\eta_4-\gamma_3}$ are at least two

times the 3SLS estimates, which indicates that the predicted price increase would be much larger if we ignore the endogeneity problem and the cross-correlation in error terms. The ADF test on all residual series of five equations in 3SLS regression rejects the null hypothesis that series is non-stationary, which eliminates the possibility of spurious regression. All F-statistics for first-stage instruments in 3SLS regression are greater than ten, which indicates that the null hypothesis of weak instruments can be rejected.

The estimates of elasticity coefficients are reasonable. Domestic demand elasticity is -0.121, domestic supply elasticity is 0.549, domestic price elasticity of import demand is 0.934, world price elasticity of import demand is -1.081, export supply elasticity is 0.516 and price transmission elasticity is 0.412. The domestic demand is extremely inelastic to world price, which is consistent with the conclusion from Tan and Wu (2009). The price elasticity of China's soybean supply is close to the 0.64 estimate obtained by Liu and Guo (2017). Equations (3) and (4) imply a relatively large response of soybean imports to the world price and a relatively small response of soybean exports in the rest of the world to world price, which is consistent with the findings derived by Zhao and Zheng (2015). The price transmission elasticity compares to the 0.36 estimate of Wang and Xie (2012). The sign and significance of the dummy variable parameter in equation (5) indicate an ascending trend in domestic price since China's soybean price support policies.[6] According to Xu et al. (2016), China's soybean price support policies decrease the price transmission effects from the world soybean market to their domestic soybean market.

---

[6] A Chow-test (Chow, 1960) for structural change is performed based on two regressions of P^d on p^w and T. The first regression is for t=1 (1985), …, 23 (2007) and the second one is for t=24 (2008), …, 32 (2016). The null hypothesis of no structural change is rejected as p-value is less than 0.0001.

Figure 5 plots the dependency of price variances on price transmission elasticity from equations (9) and (10). It is appreciable that as the price transmission elasticity decreases, both domestic and world price variabilities decrease and the predicted variability drop of domestic price is larger than that of world price. According to the above theoretical analysis, we can get the following inequalities: $\partial \sigma^2_{lnP_t^d}/\partial \eta_5 > 0$, $\partial \sigma^2_{lnP_t^w}/\partial \eta_5 > 0$ and $\partial \sigma^2_{lnP_t^d}/\partial \eta_5 > \partial \sigma^2_{lnP_t^w}/\partial \eta_5$. On the one hand, China's soybean price support policies play an effective role in stabilizing domestic price; and, on the other hand, China's soybean import increase that resulted from the price support policies balance the surplus of world soybean production, and thus reduce the world price variability. In other words, the disruption in world market production is partly accommodated for by the adjustments in China's soybean market caused by price support policies.

[Figure 5 about here]

The effects of such domestic policies can best be visualized through a hypothetical example. Assume that China accounts for one-third of the world's soybean consumption and that they intervene in domestic prices through price support policies;[7] and assume there is an exogenous shock that increases the world's output of soybeans by 5%.[8] Assume further that the world's short-run price elasticity of demand for soybeans is -0.1 and China's policies increase its soybean imports by 10%.[9] The effects of China's policies are to require the rest of the world that normally consumes two-

---

[7] The level of one-third is not chosen arbitrarily—approximately one-third of world soybean use in recent years has occurred in China (Authors' calculation from the USDA data).

[8] The level of 5% is not chosen arbitrarily. The soybean production in the world grew at an annual rate of around 5% from 2008 to 2016 (Authors' calculation from the USDA data).

[9] The level of 10% is not chosen arbitrarily. China's soybean imports have shown an average annual growth of about 10% from 2008 to 2016 (Authors' calculation from the USDA data).

thirds of the world's soybeans to increase their use by 2.5%. If the price elasticity of demand were -0.1 in the rest of the world, the decrease in price from a world production surplus of 5%, assuming stable demand, would be 25%. If there were no price support policies in China, the decline in price for the world would be approximately 50%. Thus, one-third of the world following such policies decreases the price swings for the rest of the world unless there are stocks to absorb the production surplus.

5.2. Impacts of China's soybean price support policies on economic welfare

The Monte Carlo method is adopted to evaluate uncertainty in welfare computations that is difficult to predict due to the interference of random variables. Using the model estimates, we perform a Monte Carlo simulation with 10,000 replications. Table 4 provides the numerical results from 2008 to 2016. The welfare estimates are mean values and the uncertainty measures are standard deviations from all 10,000 simulated series. The estimated welfare impacts of China's soybean price support policies include: change in China's producer surplus (ΔPS_t), consumer surplus (ΔCS_t), annual budgetary costs (BC_t), China's net welfare change (ΔDNW_t), exporters' welfare change in the rest of the world (ΔRW_t) and world net welfare change (ΔWNW_t).

[Table 4 about here]

China's soybean price support policies benefit domestic producers; however, domestic consumers suffer because they pay a higher price for soybeans. China's net welfare change resulting from price support policies is negative. Since the world soybean price is higher under China's soybean price support policies as compared to free trade, exporters in the rest of the world benefit a lot and their welfare increase is,

to a large extent, an income transfer from China. Overall, the world net welfare change attributed to China's soybean price support policies is positive and continues to increase from $520.3 million in 2008 to $2.1 billion in 2016. Standard errors of welfare estimates show a high level of confidence in the results.

There are two interesting things to be noted about 2016. First, the budgetary costs and social welfare loss in 2016 are far less than those during the temporary procurement for reserve policy (2008–2013), while the changes in producer surplus basically remain at the same level—above $2.7 billion—which indicates that the target price policy could improve farm income at the same level as the temporary procurement for reserve policy, but with relatively less budgetary costs. Second, the domestic social welfare loss in 2016 remains high—above $10 billion. Although the target price policy significantly reduces government expenditure, it is still economically inefficient due to the huge loss of consumer welfare.

These findings corroborate the ex-ante findings by Yu and Jensen (2010) that China's agricultural support policy would significantly increase domestic farm income. Compared to coupled policy, decoupled policy instruments are more economically efficient.[10] Our results are also in favor of the ex-ante arguments obtained by Huang et al. (2010) that China's agricultural policies would benefit the rest of world. They use the Global Trade Analysis Project model and emphasize that, since it is to China's comparative advantage to import land-intensive products (such as oilseeds), China's increasing imports of oilseeds and oilseed products could help countries with a comparative advantage in these products expand their production and benefit from the trade surplus.

---

[10] Yu and Jensen (2010) use the CGE model and maintain that if China uses all the support permitted under WTO de minimis limits, their farm income would increase by 12%. However, if decoupled instruments, for instance the producer subsidy policy, are adopted to raise China's agricultural support to the same level, their farm income would increase by nearly 15%.

5.3. Further robustness checks

To verify the validity of the effects of China's soybean price support policies on price volatility, we perform a robustness test using daily data through the GARCH model.[11] We extend the traditional GARCH model to derive the possible adjustments in price volatility associated with China's soybean price support policies. An AR(k)-GARCH(p, q) model with a dummy variable is specified in the following:

$$R_t = \mu + \sum_{s=1}^{s=k} \delta_s R_{t-s} + \varepsilon_t, \tag{24}$$

$$\varepsilon_t | \Omega_t \sim t(0, \sigma_t^2, v), \tag{25}$$

$$\sigma_t^2 = \omega + \sum_i^p \alpha_i \varepsilon_{t-i}^2 + \sum_j^q \beta_j \sigma_{t-j}^2 + dDV_t, \tag{26}$$

where R_t represents the price return; $t(0, \sigma_t^2, v)$ is the student's t density with mean zero, variance σ_t^2, and degree of freedom v; k, p, and q are lag lengths; DV_t is a vector of China's soybean price support policies dummies; μ, δ_s, ω, α_i, β_j, and d are the parameters to be estimated. Price volatility is considered by the conditional variance σ_t^2 in equation (26), which is specified as a linear function of squared errors ε_{t-i}^2, conditional variance σ_{t-j}^2, and dummy variable DV_t. The positive (negative) sign of the coefficient d implies the upward (downward) trend in the price volatility.

We utilize the daily data on China's soybean futures prices and Chicago Board of Trade (CBOT) soybean futures prices from January 3, 2000 to December 30, 2016. Data are obtained from Dalian Commodity Exchange (DCE) and Chicago Board of Trade, respectively.[12] The price returns are calculated based on the first difference of

---

[11] In the GARCH model, price volatility is generally analyzed as the conditional variance, as pioneered by Engle (1982) and generalized by Bollerslev (1986).

[12] The DCE is the largest soybean trading exchange in China. The specified futures contracts are the No. 1 soybean

logarithm of prices. Appendix Table A2 reports the descriptive analysis and ADF test results of both China's and CBOT soybean futures price returns. The results indicate that both prices data are stationary and significantly different from normal distribution.

The robustness test is conducted in GARCH $(1,1)$.[13] Table 5 presents the results. The coefficients of GARCH effects (α and β) are significant in both cases, which confirms the time-varying pattern of price variabilities. The coefficient d is negative and significant at the 1% level for China's soybean price return and at the 10% level for the CBOT soybean price return, implying a decrease in price volatilities of both China's soybean price and CBOT soybean price after China's price support policies. Moreover, the downward pressure on China's price volatility is greater than that on the CBOT price volatility, which is consistent with previous results from the structural econometric model.

[Table 5 about here]

To prove that our estimates are invariant and reliable, we perform two additional robustness checks and report the results in Appendix Table A3. First, we use quantity data from the Foreign Agricultural Service by the United States Department of Agriculture (USDA-FAS) to re-estimate the model.[14] Second, we re-estimate our model using data prior to the introduction of the target price policy (1985–2013). The target price policy, introduced in 2014, may intervene in the domestic soybean price differently than the temporary procurement for reserve policy and change the domestic

---

futures in DCE (http://www.dce.com.cn/DCE/) and soybean futures in CBOT (https://www.cmegroup.com/company/cbot.html).

[13] According to the parsimony criteria, GARCH models are considered a special case of an AMAR process (Tsay, 1987). Through a Box-Jenkins methodological procedure, a GARCH (1,1) model presents the best fit. Higher-order GARCH formulations add no significant improvements in goodness-of-fit.

[14] The quantity data refer to the quantity demanded, quantity supplied, and import quantity.

supply differently. If the change in domestic supply and corresponding import demand were large enough, it would confound our results. In Appendix Table A4, we can see that the results remain generally robust, as the price multipliers of domestic demand shift in both cases are around 1.4 and the price multiplier of import demand shift in the first case is 0.535, which are close to our estimated results from the structural model. The multiplier of import demand shift in the second case is smaller and a possible reason is the data loss.

6. Conclusions and implications

Over the last two decades, a series of fundamental changes took effect in China's soybean markets and drastically changed the dynamics of the world soybean market. The impacts of agricultural subsidy and trade policies have been thoroughly analyzed in the literature. However, ex-post empirical analyses on the impacts of China's soybean price support policies have not been conducted, a momentous analytical gap that deserves more attention. This article contributes to the literature by evaluating, theoretically and empirically, the ex-post worldwide impacts of China's soybean price support policies on price variability and economic welfare.

We present, for the first time, an integrated picture of the worldwide impacts of China's soybean price support policies through a structural econometric model of the China/rest-of-the-world soybean market. Although our model is simple, it gains transparency. The estimates can be taken as a supplement to the more sophisticated computational models, wherein other important factors (including the transportation costs, imperfect substitutability of different crops, and so forth) are considered, and different regions are estimated individually. Our model estimates provide an effective

check for whether negligible changes add up to big results that can be observed in the aggregate data.

We first explore the price variability effects of China's soybean price support policies by estimating the model using 3SLS method. We derive the dependency of domestic and world price volatility on price transmission elasticity based on the model estimates. On the one hand, China's soybean price support policies stabilize domestic prices. On the other hand, China's policies reduce the world price swings. The disruption in the world market production is partly accommodated for by the increasing soybean imports driven by China's soybean price support policies. We then use our model estimates to explore the distributional and aggregate welfare impacts of China's soybean price support policies in both China and the rest of the world. The results indicate that China's producer welfare gain at the expense of consumer and budgetary costs. The net welfare change in their domestic market is negative. Compared to the temporary procurement for reserve policy, the target price policy could improve farm income with relatively less government expenditures. Meanwhile, China's soybean price support policies result in a welfare gain for exporters in the rest of the world. Overall, the world net welfare change is positive and continues to increase from 2008 to 2016. These results are proven to be generally robust through a GARCH model and two sensitivity tests.

What is the practical importance of this study? First, the price effects of China's soybean price support policies challenge the conventional wisdom that the realization of price stabilization in one country or region would cause price instability elsewhere (e.g., Zwart and Meilke, 1979; Sarris and Freebairn, 1983). Different types of agricultural support policies could have remarkably different impacts on world price variability. In the case of China's soybean market, the price support policies increase the domestic prices and lead to increasing imports, which, to some extent, is similar to

the trade liberalization policies. Thus, both the amount and the type of agricultural support policies should be accounted for if the trade negotiations under the WTO agreements are to address the issue of price variability. Second, this study informs the debate about the functioning of the price support policies and provides some insights for future policy reform. The dilemma in China's soybean market is that the costs of support policies are high while the benefits are low. This problem also emerged in other Asian and Latin American countries, where producers relied on a variety of agricultural support policies to stimulate grain production and farm income. Throughout history, many agricultural support policies suffered from excessive costs, especially when the world price fell below the domestic support price. The excessive costs typically led to new reforms, which happened in 1990s both in the United States (Gardner, 2006) and the European Union (Grant, 1997). Looking forward, China and other developing countries in Asia and Latin America should gradually withdraw the high-cost price support policies and find more efficient policy instruments to increase grain production capacity and improve farm income. Third, with increasing soybean imports driven by China's soybean price support policies, the price risk in the world market reduces and the soybean exporting countries experience considerable welfare gains. However, while pursuing food security, the Chinese government initiated the producer subsidy policy for soybeans in 2017 with the aim to separate direct subsidy from price support. It is well known that China's soybean imports fell from 95 million tons in 2017 to 88 million tons in 2018. Furthermore, under escalating tensions regarding U.S.-China agricultural trade, a significant uncertainty exists in the world soybean trade pattern. If China's soybean imports continued to decrease, it might have the opposite impacts on the world market, which should be re-examined in future research.

Acknowledgements

References

Barrett C. B., 2010. Measuring food insecurity. Science 327(5967), 825–828.

Bhagwati, J., 2004. *In Defense of Globalization: With a New Afterword*. Oxford University Press, Oxford, England.

Bohman, M., Carter, C. A., Dorfman, J. H., 1991. The welfare effects of targeted export subsidies: A general equilibrium approach. Americ. J. Agric. Econ. 73(3), 693–702.

Bollerslev, T., 1986. Generalized autoregressive conditional heteroskedasticity. J. Econom. 31(3), 307–327.

Carter, C. A., Zhong, F., Zhu, J., 2012. Advances in Chinese agriculture and its global implications. Appl. Econom. Perspect. Policy 34(1), 1–36.

Chow, G. C., 1960. Tests of equality between sets of coefficients in two linear regressions. Econom. 28(3), 591–605.

Clever, J., Wu, X., 2016. Chinese Production and Impacts to Drop to Lowest Level in Over a Decade. Washington, D.C.: U.S. Department of Agriculture, Foreign Agricultural Service, GAIN Report CH16024.

Colman, D., 1985. Imperfect transmission of policy prices. Eur. Rev. Agric. Econ. 12(3), 171–186.

Diao, X., Kennedy, A., 2016. Economywide impact of maize export bans on agricultural growth and household welfare in Tanzania: A dynamic computable general equilibrium model analysis. Dev. Policy Rev. 34(1), 101–134.

Engle, R. F., 1982. autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. Econom. 50(4), 987–1007.

Gale, H. F., Lohmar, B., Tuan, F. C., 2007. *China's New Farm Subsidies*. USDA-ERS WRS-05-01.

Gardner, B. L., 2006. *American Agricultural in the Twentieth Century: How it Flourished and What it Cost*. Harvard University Press, Cambridge, MA.

Götz, L., Glauben, T., Brümmer, B., 2013. wheat export restrictions and domestic market effects in Russia and Ukraine during the food crisis. Food Policy 38, 214–226.

Grant, W., 1997. *The Common Agricultural Policy*. Macmillan Press Ltd, Basingstoke, UK.

Houthakker, H. S., Magee, S. P., 1969. Income and price elasticities in world trade. Rev. Econ. Statistics 51(2), 111–125.

Huang, J., Wang, X., Rozelle, S., 2013. The subsidization of farming households in China's agriculture. Food Policy 41, 124–132.

Huang, J., Yang, G., 2017. Understanding recent challenges and new food policy in China. Glob. Food Secur. 12, 119–126.

Huang, J., Yang, J., Rozelle, S., 2010. China's agriculture: Drivers of change and implications for China and the rest of world. Agric. Econ. 41, 47–55.

Johnson, D. G., 1975. World agriculture, commodity policy, and price variability. Americ. J. Agric. Econ. 57(5), 823–828.

Koo, W. W., Kennedy, P. L., 2006. The impact of agricultural subsidies on global welfare. Americ. J. Agric. Econ. 88(5), 1219–1226.

Koo, W. W., Kennedy, P. L., 2005. *International Trade and Agriculture*. Blackwell Publishing, Malden, MA.

Larue, B., Ker, A., 1993. World price variability versus protectionism in agriculture: A causality analysis. Rev. Econ. Statistics 75(2), 342–346.

Li, M., Balistreri, E., Zhang, W., 2018. The 2018 trade war: Data and nascent general equilibrium analysis. Working paper no. 18-wp 587. Center for Agricultural and Rural Development, Iowa State University.

Liu, H., Guo, J., 2017. Positive analysis on supply response of soybean in China based on Nerlove model. J. Huazhong Agric. University (Soc. Sci. Ed.). 6, 44–50+149. Available at http://www.cnki.com.cn/Article/CJFDTotal-HZND201706006.htm

Martin, W., Anderson, K., 2011. Export restrictions and price insulation during commodity price booms. Americ. J. Agric. Econ. 94(2), 422–427.

National Statistical Bureau, China (NSBC), 1986–2017. China Rural Statistical Yearbook. China Statistics Press, various issues. Beijing, China.

National Statistical Bureau, China (NSBC), 1986–2017. National Cost-Benefit Compilation of Agricultural Product. China Statistics Press, various issues. Beijing, China.

Organization for Economic Co-operation and Development (OECD). 2009. *Agricultural Policies in Emerging Economies 2009*: *Monitoring and Evaluation*. OECD Publishing, Paris, France.

Organization for Economic Co-operation and Development (OECD). 2013. *Agricultural Policy Monitoring and Evaluation 2013*: *OECD Countries and Emerging Economics*. OECD Publishing, Paris, France.

Porteous, O., 2017. Empirical effects of short-term export bans: The case of African maize. Food Policy 71, 17–26.

Roberts, M. J., Schlenker, W., 2013. Identifying supply and demand elasticities of agricultural commodities: Implications for the US ethanol mandate. Americ. Econ. Rev. 103(6), 2265–2295.

Sarris, A. H., Freebairn, J., 1983. Endogenous price policies and international wheat prices. Americ. J. Agric. Econ. 65(2), 214–224.

Schmitz, A., Schmitz, T. G., Rossi, F., 2006. Agricultural subsidies in developed countries: Impact on global welfare. Rev. Agric. Econ. 28(3), 416–425.

Tan, L., Wu, L., 2009. Analysis of soybean demand and supply in China. Issues Agric. Econ. 11, 98–101. Available at http://www.cnki.com.cn/Article/CJFDTotal-NJWT200911014.htm

Thompson, S. R., Gohout, W., Herrmann, R., 2002. CAP reforms in the 1990s and their price and welfare implications: The case of wheat. J. Agric. Econ. 53(1), 1–13.

Thompson, S. R., Herrmann, R., Gohout, W., 2000. Agricultural market liberalization and instability of domestic agricultural markets: The case of the CAP. Americ. J. Agric. Econ. 82(3), 718–726.

Tsay, R. S., 1987. Conditional heteroscedastic time series models. J. Americ. Statistical Assoc. 82(398), 590–604.

Valenzuela, E., van der Mensbrugghe, D., Anderson, K., 2009. *General Equilibrium Effects of Price Distortions on Global Markets, Farm Incomes and Welfare.* Palgrave Macmillan, Malden, MA.

Wang, X., Xie, S., 2012. How do prices of foreign agricultural products affect prices of Chinese agricultural products?. Econ. Res. J. 3, 141–153. Available at http://en.cnki.com.cn/Article_en/CJFDTOTAL-JJYJ201203014.htm

Xu, X., He, L., Gao, L., 2016. How agricultural policy affects the price pass-through effect of international markets to domestic futures market: Take cotton and soybean products for example.

World Econ. Stud. 6, 55–68. Available at http://www.cnki.com.cn/Article/CJFDTotal-JING201606007.htm

Yu, W., 2017. *How China's Farm Policy Reforms Could Affect Trade and Markets: A Focus on Grains and Cotton*. International Centre for Trade and Sustainable Development, Geneva, Switzerland.

Yu, W., Jensen, H. G., 2010. China's agricultural policy transition: Impacts of recent reforms and future scenarios. J. Agric. Econ. 61(2), 343–368.

Zhao, Y., Zheng, Z., 2015. China's soybean and soybean oil demand: An empirical analysis based on SDAIDS model. Chin. Rural Econ. 11, 15–28. Available at http://www.cnki.com.cn/Article/CJFDTotal-ZNJJ201511004.htm

Zhong, F., Zhu, J., 2017. Food security in China from a global perspective. Choices 32(2), 1–5.

Zwart, A. C., Meilke, K. D., 1979. The influence of domestic pricing policies and buffer stocks on price stability in the world wheat industry. Americ. J. Agric. Econ. 61(3), 434–447.

Tables

Table 1. China's soybean support policies, 2008–2017

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Support price (Yuan/t)	3700	3740	3800	4000	4600	4600	4800	4800	4800	--
Procurement volume (1000t)	3134	6530	6488	4657	5639	3080	3172	1401	660	--
Grain and oil reserve expenditure (Billion yuan)	148.1	110.6	117.2	127.0	137.6	164.9	193.9	261.3	219.0	225.1

Sources: Support prices: National Development and Reform Commission, P.R. China; procurement volume: National Grain & Oil Information Center, P.R. China; Grain and oil reserve expenditure: Ministry of Finance of People's Republic of China, Central Budget and Final Accounts Public Platform: 2009–2018.

Table 2. Descriptive statistics of main variables, 1985–2016

Variable	Obs.	Mean	SD	Minimum	Maximum
Quantity demanded of China (1000 tons)	32	10.21	0.85	9.08	11.52
Quantity supplied of China (1000 tons)	32	9.51	0.16	9.18	9.76
Import quantity (1000 tons)	32	9.31	1.43	7.31	11.37
Domestic price (U.S. dollar/ton)	32	5.81	0.40	5.34	6.56
World price (U.S. dollar/ton)	32	5.71	0.33	5.28	6.39
Production of the Rest of World (1000 tons)	32	11.97	0.43	11.34	12.73

Table 3. Model parameter estimates, 1985–2016

	OLS	SUR	2SLS	3SLS
Equation (1)				
lnP^w	-0.102	-0.121*	-0.091	-0.121*
	(0.084)	(0.077)	(0.113)	(0.105)
lnQ^D_{t-1}	1.041***	1.048***	1.037***	1.051***
	(0.035)	(0.032)	(0.042)	(0.039)
lnK_1	0.242	0.275	0.215	0.252
	(0.315)	(0.298)	(0.369)	(0.348)
Equation (2)				
lnP^d	0.242*	0.128	0.245	0.549**
	(0.128)	(0.104)	(0.542)	(0.353)
DV	-0.017	-0.113	-0.332	-0.520**
	(0.099)	(0.079)	(0.358)	(0.242)
lnT_t	0.195***	0.187***	0.141*	0.101**
	(0.041)	(0.035)	(0.077)	(0.053)
lnK_2	10.418***	9.803***	7.812***	6.202***
	(0.692)	(0.558)	(2.897)	(1.903)
Equation (3)				
lnP^d	-0.015	-0.007	0.474	0.934*
	(0.413)	(0.267)	(1.238)	(0.847)
lnP^w	-0.195	-0.118	-0.538	-1.081*
	(0.421)	(0.301)	(1.146)	(0.810)
lnQ^D_{t-1}	1.793***	1.744***	1.766***	1.678***
	(0.088)	(0.074)	(0.176)	(0.129)
lnK_3	-7.661***	-7.642***	-7.126***	-6.948***
	(0.722)	(0.652)	(1.080)	(0.909)
Equation (4)				
lnP^w	0.297*	0.358**	0.437**	0.576**

	(0.201)	(0.186)	(0.262)	(0.242)
lnQ_{t-1}^{RW}	3.175***	3.092***	3.041***	3.001***
	(0.163)	(0.149)	(0.191)	(0.175)
lnK_4	-30.272***	-29.621***	-30.019***	-29.781***
	(1.409)	(1.312)	(1.453)	(1.360)
Equation (5)				
lnP^w	0.902***	0.891***	0.478	0.412*
	(0.127)	(0.118)	(0.491)	(0.375)
lnT_t	0.060*	0.060*	0.084*	0.095**
	(0.035)	(0.033)	(0.049)	(0.042)
DV	0.121	0.132*	0.368*	0.399**
	(0.092)	(0.085)	(0.293)	(0.227)
lnK_5	0.472	0.0530	2.761	3.104*
	(0.694)	(0.641)	(2.657)	(2.028)
Effect of domestic demand shift				
Multiplier $\frac{1}{\eta_2-\eta_1}$	2.906	4.021	2.973	1.493
Effect of import demand shift				
Multiplier $\frac{1}{\eta_4-\gamma_3}$	2.030	2.100	1.030	0.604
Obs.	31	31	31	31

Notes: The four columns present results for OLS regressions, Seemingly Unrelated Regressions (SUR), Two-stage Least Squares (2SLS) and Three-stage Least Squares (3SLS), respectively. Two multipliers translate percentage changes in demand into percentage changes in equilibrium price in China's soybean market and the world market, respectively.

*, **, and *** denote statistical significance at 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses.

Table 4. Welfare estimates in China and the rest of the world (Million U.S. Dollars)

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
ΔPS_t	2620.6	2940.9	2408.5	2599.3	3283.3	2884.2	2803.3	2496.3	2796.9
	(55.7)	(62.5)	(51.1)	(55.2)	(69.7)	(61.2)	(59.5)	(53.0)	(59.4)
ΔCS_t	-6312.1	-7723. 6	-6522.8	-8087.7	-10600.0	-10800.0	-10800.0	-9693.0	-12500.0
	(489.2)	(598.5)	(505.5)	(626.8)	(977.9)	(836.2)	(838.1)	(751.2)	(970.3)
BC_t	-1669.6	-3575.2	-3642.0	-2751.8	-4109.2	-2287.7	--	--	-904.9
ΔDNW_t	-5361.1	-8358.2	-7756.3	-8240.2	-11425.9	-10203.5	--	--	-10608.0
ΔRW_t	5881.4	8680.6	8519.9	9341.3	12500.0	11600.0	12500.0	12300.0	12700.0
	(260.4)	(295.3)	(332.7)	(412.9)	(551.7)	(556.6)	(598.1)	(632.8)	(780.8)
ΔWNW_t	520.3	322.4	763.6	1101.1	1074.1	1396.5	--	--	2092.0

Sources: Authors' computation.

Notes: China's soybean procurement prices and quantities data (2008–2013) are collected from the National Food & Strategic Reserves Administration, P.R. China (http://www.lswz.gov.cn/). The 2016 budgetary cost is obtained from the Ministry of Finance of the People's Republic of China (http://www.mof.gov.cn/); however, 2014 and 2015 data are unavailable. Standard deviations are in parentheses.

Table 5. Results of GARCH (1,1), 2000–2016

Coefficient	China's soybean futures price	CBOT soybean futures price
R_{t-1}	0.013	-0.016
	(1.16)	(-0.97)
ω	0.000*	0.000
	(1.70)	(1.26)
α	0.208***	0.052***
	(30.82)	(10.46)
β	0.657***	0.934***
	(70.07)	(147.38)
d	-0.212***	-0.145*
	(-7.62)	(-1.72)
$\alpha + \beta$	0.865	0.986

Notes: *, **, and *** denote statistical significance at 10%, 5%, and 1% levels, respectively. Z statistics are in parentheses.
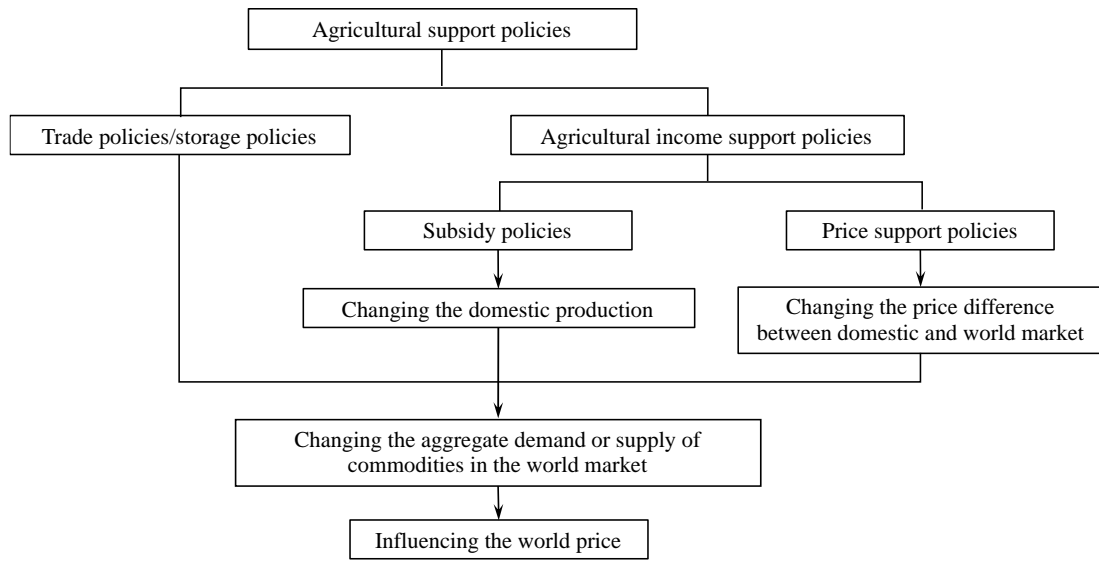
Figures

Fig. 1. China's soybean production, imports, stocks, and China's prices and world prices.
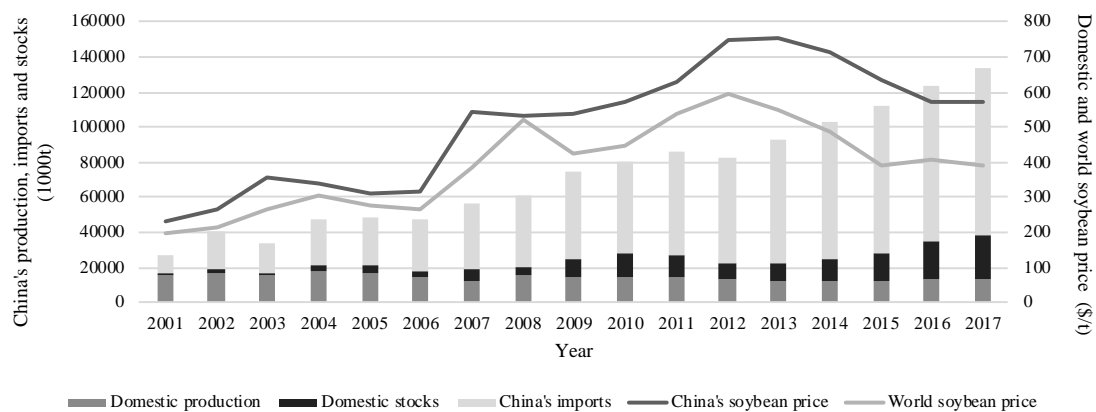
Sources: China's production and soybean prices: China Grain Yearbook (2002–2018); stocks: BRIC Agricultural Database; imports: General Administration of Customs, P.R. China; world soybean prices: Food and Agricultural Organization (FAO).
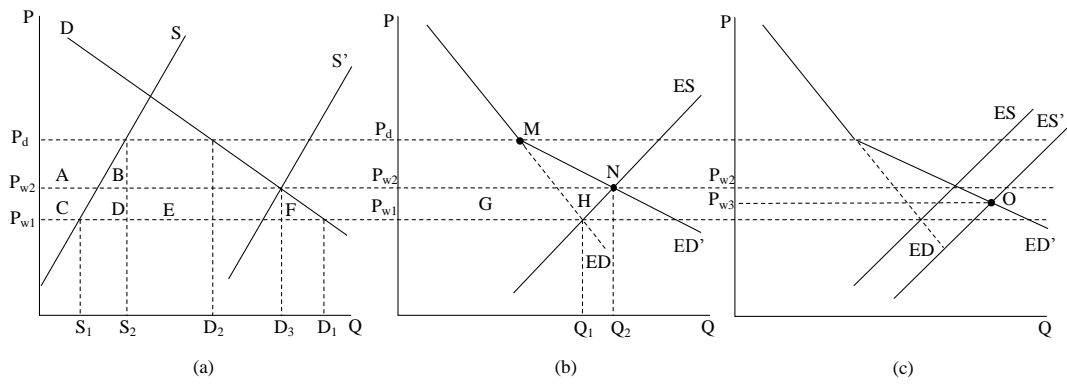
Note: The world soybean prices refer to the No. 1 Yellow, FOB gulf in U.S. dollars.

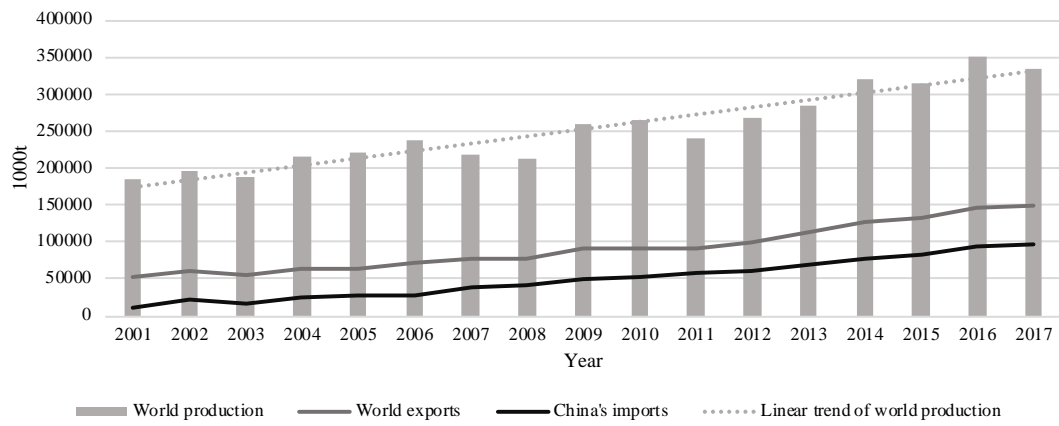Fig. 2. Influence mechanism of agricultural support policies.

Fig. 3. Effects of China's soybean price support policies on supply, demand and trade.
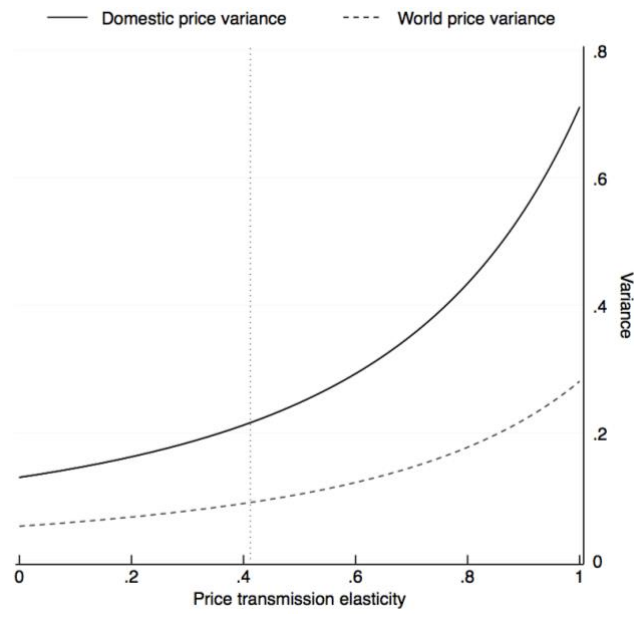

(a)   (b)   (c)

Source: Authors.

Fig. 4. World soybean production, world soybean exports and China's soybean imports.

Fig. 5. Variances of domestic and world soybean prices and the price transmission elasticity.

Source: Authors' calculations.

Appendix

Table A1. Results of ADF test, 1985–2016

Values	lnQ^D	lnQ^S	lnX	lnP^d	lnP^w	lnQ^{RW}
Levels	0.393	-2.420	-0.258	-1.164	-1.288	-0.020
First Differences	-4.652	-5.610	-6.073	-4.822	-4.560	-8.774
Critical Value of 1%	-3.709	-3.709	-3.709	-3.709	-3.709	-3.709

Table A2. Data description and ADF test results of China's and world soybean futures price (U.S.

dollar per metric ton), 2000–2016

Values	China's soybean futures price	CBOT soybean futures price
Data description		
Mean	0.000	0.000
St. deviation	0.013	0.015
Skewness	-1.425	-0.208
Kurtosis	31.013	5.247
Observations	4280	4280
ADF test results		
Levels	-70.622	-66.570
Critical Value of 1%	-3.430	-3.430

Table A3. Results of two additional robustness checks

	USDA-FAS data (1985–2016)	Original data (1985–2013)
Equation (1)		
lnP^w	-0.084	-0.076
	(0.114)	(0.111)
lnQ^D_{t-1}	1.041***	1.038***
	(0.045)	(0.045)
lnK_1	0.140	0.123
	(0.362)	(0.377)
Equation (2)		
lnP^d	0.749***	0.620*
	(0.698)	(0.457)
DV	-0.531***	-0.500*
	(0.471)	(0.308)
lnT_t	0.090	0.084*
	(0.106)	(0.063)
lnK_2	4.666*	5.847**
	(3.649)	(2.462)
Equation (3)		
lnP^d	0.842	4.670**
	(1.113)	(2.088)
lnP^w	-1.055*	-4.419**
	(1.077)	(1.821)
lnQ^D_{t-1}	1.848***	1.424***
	(0.791)	(0.248)
lnK_3	-8.237**	-6.926***
	(2.284)	(1.065)
Equation (4)		
lnP^w	0.814	0.606**

	(0.338)	(0.247)
lnQ_{t-1}^{RW}	3.262***	3.076***
	(0.204)	(0.194)
lnK_4	-36.245***	-30.829***
	(1.802)	(1.603)
Equation (5)		
lnP^w	0.327	0.378
	(0.288)	(0.349)
lnT_t	0.084*	0.099***
	(0.042)	(0.031)
DV	0.626***	0.393*
	(0.201)	(0.233)
lnK_5	5.015***	3.279*
	(1.776)	(1.898)
Multiplier $\frac{1}{\eta_2 - \eta_1}$	1.200	1.438
Multiplier $\frac{1}{\eta_4 - \gamma_3}$	0.535	0.199
Obs.	31	28

Notes: The first column shows regression results utilizing quantity data from the USDA-FAS. The second shows the results utilizing the 1985–2013 data.

*, **, and *** denote statistical significance at 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses.