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Political Economy of Trade and Storage Policies Coordination, and the Role of Domestic Public Storage in the World Market

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Abstract

In this paper, a standard theoretical model of trade policy is extended to incorporate domestic public storage policy, so as to explore government political motivations in the context of border and domestic policy coordination. Theoretically, domestic storage policy can add to price stabilization in the presence of trade policy, and can reinforce a price-insulating trade policy through increasing the country's market power. However, the effects of these two price stabilization instruments on the international market price are in opposite directions. Furthermore, the effect of domestic public storage on the world market is then tested, using China cotton as a case study. The VAR econometrics reveal that in the case of cotton during 2011-14, China as a large player in the global market was able to stabilize to a non-trivial extent the international price of cotton through altering its public stockpile.

Key words: Public storage policy; Trade policy; Policy coordination; World cotton price; VAR simulation; China

JEL classification: C32, E64, F14, Q17,

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1 Introduction

During world price fluctuation periods, the Chinese government not only applies trade distortions but also carries out a domestic storage policy to stabilize domestic agricultural prices by ‘buying low and selling high’. Between 2010 and 2014, the Chinese government bought up a large amount of domestic cotton at high support prices and stored it in their government reserve. The other perplexing phenomenon is that the government still stores some imports in the official reserve. Cotton storage in China has climbed to 65,632 million 480lb bales which is equivalent to more than 55 percent of the world’s annual production in 2014.¹ China, as the largest player in the world, could potentially have a significant effect on the international cotton market, particularly on the world cotton price.

World cotton prices in 2010 reached the highest level in the past half century. However, the world cotton price promptly returned to a more normal level (blue dot line in Figure 1) from 2011. Compared to the stock-to-use ratios (SUR)², including world SUR, the ROW cotton SUR and SUR of China, China dominated fluctuations in the world cotton market from 2011 to 2014. The mass increase of world SUR is driven by soaring cotton storage in China.

MacDonald *et al.* (2015) note that a future release of China’s large stockpile of cotton could depress the world cotton price to a considerable degree, consistent with research by Wiggins and Keats (2009). According to Wright and Williams (1982), Wright (2002, 2011) and Gouel (2012, 2013), a low level of storage is one of the main factors that can contribute to spikes in

¹ The year in this paper refers to crop year instead of calendar year. The world cotton production, consumption, import, export and storage are all measured in crop year periods. Thus, we adopt the world cotton price in crop years as well.

² $SUR = \frac{\text{Ending stock}}{(\text{Mill use} + \text{export})}$. The SUR is a convenient measure of supply and demand interrelationships of cotton. It indicates the level of carryover cotton stock as a percentage of the total demand, which equals total use plus export.

agricultural product prices when the market receives a production shortfall or an unexpected surge in demand.

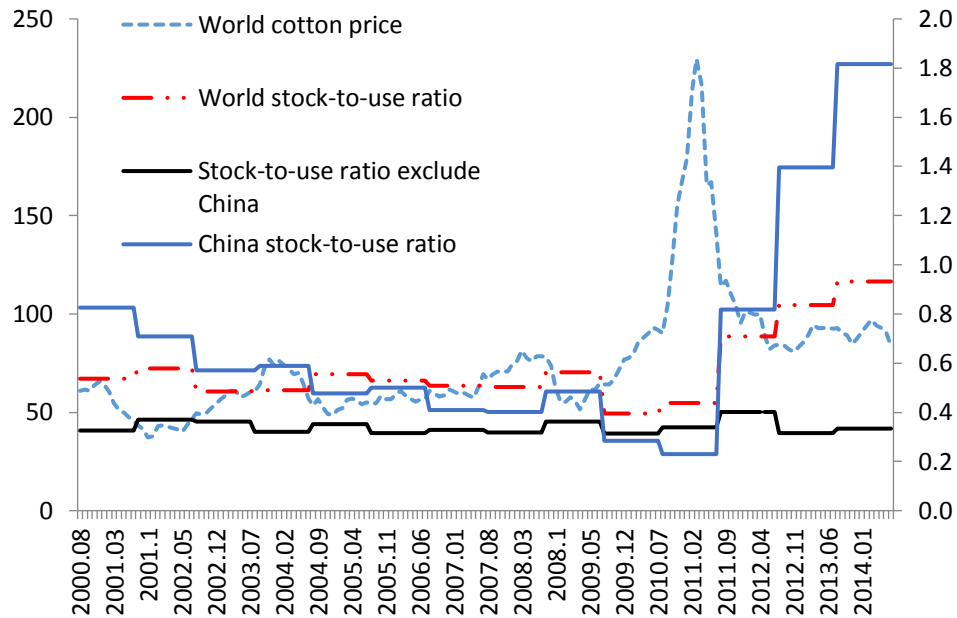


Figure 1: Stock-to-use ratio and world cotton price

Previous research mostly focuses on the welfare effects of trade and storage policies. However, no research, to the best of my knowledge, tries to explore the government's motivations in the context of trade policy and domestic storage policy coordination. In this paper, we develop a partial equilibrium model but also incorporate domestic storage to explore government motivations. The results show that domestic storage policy strengthens price stabilization motivation in the context of trade policy, and can reinforce price-insulating trade policy. However, the effects of the two price stabilization instruments on the international market price are in opposite directions.³ That is, domestic public storage policy has a stabilization effect on

³ Trade policy intervention functions as the border instrument to insulate domestic market price from the international market price through countrolling trade volumes. Storage policy is a domestic policy to stabilize the domestic market price by smoothing the quantity of the agricultural product available for purchase on the domestic market.

the international market price, whereas trade policy actions add to international price fluctuations.

The effects of domestic storage on the world market are then empirically tested, using China cotton as a case study. We ask “what if” China did not increase its cotton storage during 2011-2014. A vector auto-regression (VAR) model is used to model the effects of China’s cotton storage on the world cotton market. The exogenous behavior of the Chinese cotton storage policy provides an ideal experiment to apply counterfactual data to simulate the effects of China’s cotton storage on the world cotton market.

The VAR econometrics reveal that in the case of cotton during 2011-14, China as a large player in the global market is able to stabilize to a non-trivial extent the international price of cotton through altering its public stockpile. The dynamic mechanism is more complex than static partial equilibrium model predictions. The relationships indicate that the sale of cotton from China’s stockpile would depress world production and suppress storage by the ROW, resulting in a subsequent increase of the world market price and a decline in world cotton consumption.

The structure of this paper is as follows: Section 2 reviews pertinent literature; Section 3 assesses the political incentives for cotton storage and the role of China’s cotton in the international market; the VAR model is set out in section 4 and the model qualifications are tested in section 5; the counterfactual effects of China’s public cotton storage is simulated in section 6; and section 7 concludes.

2 Literature review

Numerous articles document the effects of agricultural trade insulation policies during upward price spike periods (Abbott, 2011; Anderson, 2012; Martin and Anderson, 2011; Martin and Anderson, 2012; Anderson and Nelgen, 2012a; Anderson, 2013; Ivanic and Martin, 2014;

Anderson and Thennakoon, 2015) and also downward price periods (Thennakoon and Anderson, 2015). Importing countries feel susceptible to sudden world price spikes, especially if dominant exporters have a history of limiting their exports at such times (Bouët and Laborde Debucquet, 2012). When a shock in the world food market drives up prices, unilateral action by exporting countries accentuates that price rise (Giordani *et al.*, 2016). If importing countries respond by lowering their import restrictions that pushes the international price even higher (Anderson and Nelgen, 2012b; Thennakoon and Anderson, 2015). In this environment, domestic public storage can play a complementary role by ‘buying low and selling high’. Of course the government’s intervention could crowd out private storage agents because of political uncertainty, and perhaps regulations limiting profit from arbitrage (Wright and Williams, 1982; Tschirley and Jayne, 2010). Before the 2008 food crisis, the world SUR reached a low level and a decline in SUR indeed contributed to food price volatility in 2008 (Wright, 2009). The relationship between grain stocks and price spikes analyzed by Wiggins and Keats (2009), however, found that Chinese grain stocks were largely irrelevant to global markets because they were meant to insure against domestic shortage.

Cotton price spikes are different from staple food price spikes. The price elasticity of demand for cotton is much higher than that of staple food in the short-term. Consumers can continue to wear their current clothes and do not tend to buy cotton products during price peaks at the highest level, so cotton price spikes have few direct adverse impacts on the incomes of the poor (Martin, 2009). Meanwhile, cotton producers enjoy price spikes, as most of them are net cotton sellers.

3 Government motivations behind domestic storage policies

This paper explores the role of public storage policy in contributing to the government's objective of stabilizing the domestic market price, and explains the political motivations in the context of border and domestic policy coordination. It then provides evidence of the effects of domestic storage on the world cotton market price during a cotton price-declining period, going beyond the analysis of upward price spike periods.

3.1 Model framework and predictions

Model setting

Consider a partial equilibrium model of a global agricultural market. There are two countries, Home and Foreign, and Foreign is indicated by an asterisk '*'. The demand of each country is set as linear and identical: $d(P_t) = a - P_t$ and $d(P_t^*) = a - P_t^*$. P_t and P_t^* denote the agricultural product prices. Consumer surplus functions are defined as $CS_t = \int_{P_t}^a (a - P_t) dP_t$ and $CS_t^* = \int_{P_t^*}^a (a - P_t^*) dP_t^*$ for each country. In terms of production of the agricultural product, we assume that the good is produced with a specific factor in both countries. The input-output coefficient is constant with the value of one. Let x_t and x_t^* denote the quantity of specific factor used to produce this good, and assume the production functions are inelastic. For the owners of the specific factors, their return could be calculated as the products of domestic price and the volume of output, written as $P_t x_t$ and $P_t^* x_t^*$ for importing and exporting countries. Home is always in a position to import from the foreign country. In this case, the two random outputs should satisfy the production and deficit conditions, and trade positions always hold such that $x_t^* > x_t$.

During world market price downward (upward) spikes, the importer will impose higher (lower) import tariffs, τ_t . Conversely, the agricultural-exporting country at such times tends to decrease

(raise) exporter barriers τ_t^* . We assume that the government implements border distortions, so the wedge between domestic market price and world price is $P_t = P_t^w + \tau_t$, and $P_t^* = P_t^w + \tau_t^*$, where P_t^w is defined as the world market price. In addition, we assume that the home country adopts domestic storage policy as well, aiming to stabilize the domestic market through “buying low and selling high.” The single representative speculative agent is assumed to be risk neutral and to act competitively. Storage goods quantity, Z_{t-1} , is allowed to be transferred from one period to the next. Domestic market clear condition could be expressed as:

$$Z_{t-1} + x_t + M_t = d(P_t) + Z_t \quad (1)$$

where M_t represents the quantity of imports of the agricultural product.

World price equilibrium determination

The world market price is determined by the international market-clearing condition. The total world demand for the agricultural product includes the total consumption in both countries plus the storage demand in the home country in period t . The total world demand can be written as:

$$D_t^{total} = d(P_t) + Z_t + d(P_t^*) = [a - (P_t^w + \tau_t)] + Z_t + [a - (P_t^w + \tau_t^*)] \quad (2)$$

The total world supply in period t covers production in both countries and the storage in the previous period $t - 1$ in the home country.

$$S_t^{total} = S_t + S_t^* = x_t + Z_{t-1} + x_t^* \quad (3)$$

Therefore, the world market-clearing condition is:

$$x_t + Z_{t-1} + x_t^* = [a - (P_t^w + \tau_t)] + Z_t + [a - (P_t^w + \tau_t^*)] \quad (4)$$

We can get the equilibrium international market price by solving the above equation:

$$P_t^w = a - \frac{\tau_t + \tau_t^*}{2} - \frac{x_t + x_t^*}{2} + \frac{\Delta Z_t}{2} \quad (5)$$

where $\Delta Z_t = Z_t - Z_{t-1}$.

In the absence of storage policy, the world price would be

$$P_t^w = a - \frac{\tau_t + \tau_t^*}{2} - \frac{x_t + x_t^*}{2} \quad (6)$$

In a situation of free trade, the world price would be

$$P_t^f = a - \frac{x_t + x_t^*}{2} \quad (7)$$

Given the relationship between the domestic market price and the world market price, equilibrium domestic market prices for home and foreign countries are:

$$\begin{cases} P_t = P_t^w + \tau_t = a + \frac{\tau_t - \tau_t^*}{2} - \frac{x_t + x_t^*}{2} + \frac{\Delta Z_t}{2} \\ P_t^* = P_t^w + \tau_t^* = a + \frac{\tau_t^* - \tau_t}{2} - \frac{x_t + x_t^*}{2} + \frac{\Delta Z_t}{2} \end{cases} \quad (8)$$

Trade volumes and revenue

The import trade volume is the difference between demand and supply in the home country:

$$M_t = d(P_t) + Z_t - x_t - Z_{t-1} = \frac{\tau_t^* - \tau_t}{2} + \frac{x_t^* - x_t}{2} + \frac{\Delta Z_t}{2} \quad (9)$$

The import revenue for the home country is given by:

$$\tau_t M_t = \tau_t \left(\frac{\tau_t^* - \tau_t}{2} + \frac{x_t^* - x_t}{2} + \frac{\Delta Z_t}{2} \right) \quad (10)$$

For the foreign country, the export trade volume is calculated as:

$$E_t = d(P_t^*) - x_t^* = \frac{\tau_t - \tau_t^*}{2} + \frac{x_t - x_t^*}{2} - \frac{\Delta Z_t}{2} \quad (11)$$

The import and export volume are the same in absolute value, but they have opposite signs.

The export subsidy or tax of the foreign country is given by:

$$\tau_t^* E_t = \tau_t^* \left(\frac{\tau_t - \tau_t^*}{2} + \frac{x_t - x_t^*}{2} - \frac{\Delta Z_t}{2} \right) \quad (12)$$

Accordingly, in the absent of the home country's storage policy, the trade volume would be:

$$M_t' = \frac{\tau_t^* - \tau_t}{2} + \frac{x_t^* - x_t}{2} \quad (13)$$

Free trade volume would be:

$$M_t^f = \frac{x_t^* - x_t}{2} \quad (14)$$

Government objective function

We model the government's preference as an aggregate of welfare which is able to account for the various economic and political motivations. The government is trying to maximize the social welfare function, including producer's surplus, consumer's surplus, storage policy revenue, and tariff revenue. In addition, the government has the incentive to stabilize domestic agricultural price by insulating domestic market from the international market. Therefore, in this paper, a quadratic term in the domestic price is added into the government objective function characterizing the preference for price stability (Anderson and Nelgen, 2012c; Gouel, 2016). The government objective functions are defined as functions of trade policies and home country's storage policy by:

$$\begin{cases} W_t = \int_{P_t}^a (a - P_t) d_{P_t} + P_t x_t + \tau_t M_t + \delta \Delta Z_t - \frac{\lambda}{2} (P_t - \bar{P})^2 \\ W_t^* = \int_{P_t^*}^a (a - P_t^*) d_{P_t^*} + P_t^* x_t^* + \tau_t^* E_t - \frac{\lambda}{2} (P_t - \bar{P})^2 \end{cases} \quad (15)$$

The first three terms represent consumer surplus, producer revenue, and trade revenue or cost. $\delta \Delta Z_t$ is the cost or revenue of changing domestic storage policy in static equilibrium. $\lambda \geq 0$ is a parameter charactering the preference for price stability (Gouel, 2016). The government tries to stabilize the domestic market by undertaking trade policies that are related not just to high agricultural prices but also to downward price spikes. The parameter of preference for price stability (λ) does not go to infinity,⁴ making $P_t = \bar{P}$ and \bar{P} is the reference price. The reference

⁴ Firstly, the higher preference of agricultural price stabilization leads to higher social welfare cost. Secondly, the stabilized price results in a revenue loss for the storage representative speculative agent.

price is a target price, set by the government, around which policy makers want the price to be stabilized.

Politically optimal storage and trade policy

Before analyzing the static Nash equilibrium, we firstly explore the motivations of trade policies and domestic storage policy in responding to fluctuations in the international market price. To get the politically optimal trade and storage policies, we maximize government objective functions (W_t and W_t^*) with respect to trade policies and storage policy separately. Therefore, the politically optimal policies are given through taking the first order conditions of equation (15):

$$\begin{cases} \tau_t = \frac{(1+\lambda)\tau_t^* + (1+\lambda)x_t^* + (\lambda-1)x_t + (3-\lambda)\Delta Z_t + 2(\lambda\bar{P} - a\lambda)}{(3+\lambda)} \\ \Delta Z_t = \frac{(\lambda-1)\tau_t^* + (\lambda-1)x_t^* + (\lambda+1)x_t + (3-\lambda)\tau_t + 2(\lambda\bar{P} - a\lambda + 2\delta)}{(\lambda-1)} \\ \tau_t^* = \frac{2\lambda\bar{P} - 2a\lambda + (1+\lambda)\tau_t - (1+\lambda)\Delta Z_t + (1+\lambda)x_t - (1-\lambda)x_t^*}{3+\lambda} \end{cases} \quad (16)$$

In order to get the economic and political motivations of each policy, optimal trade policies are rewritten as functions of free trade price and reference price. Home country's optimal storage policy is written as a function of the reference price and the international market price in the context of trade distortions. From equations (5) and (6), the politically optimal policies are:

$$\begin{cases} \tau_t = \frac{\overbrace{\lambda(\bar{P} - P_t^w)}^{\text{Price smoothing by trade policy}} - \overbrace{(x_t - a - 2\Delta Z_t + P_t^w)}^{\text{Market power}}}{(2+\lambda)} \\ \Delta Z_t = \frac{\overbrace{\lambda(\bar{P} - P_t^{w'})}^{\text{Price smoothing by storage policy}} + \overbrace{\frac{(2-\lambda)\tau_t}{2}}^{\text{Trade policy effect}} + \overbrace{\frac{\widehat{2\delta}}{2}}^{\text{Storage revenue}} + \overbrace{(x_t - a + P_t^{w'})}^{\text{Market power}}}{\frac{(\lambda-1)}{2}} \\ \tau_t^* = \frac{\overbrace{\lambda(\bar{P} - P_t^w)}^{\text{Price smoothing by trade policy}} - \overbrace{(x_t^* - a + P_t^w)}^{\text{Market power}}}{(2+\lambda)} \end{cases} \quad (17)$$

The trade policy in each country could be divided into two terms. The first term is the government price-smoothing motivation through insulating the domestic market from the

international market. This term is the price adjustment welfare cost of the world price deviating from the reference price. The importer tends to apply import tax (subsidy) and the exporter is more likely to apply an export subsidy (tax) when the world price is lower (higher) than the reference price. The second term represents the country's market power, which allows an optimal trade policy to maximize social welfare. The difference between home country and the foreign country is that storage power goes into determining the politically optimal trade policy. The home country could apply storage policy to affect its terms of trade, which could benefit the home country's social welfare. The politically optimal storage policy includes four terms. The first term represents the price smoothing motivation in the context of trade policy, which allows a complimentary trade policy to help stabilize the domestic market price. The second term is the trade policy effect incorporating the price stabilization preference. The storage revenue motivation and market power effect are expressed in the last two terms separately.

The Nash equilibrium

We write the interior Nash equilibrium and express all results as a function of the free-trade price and volume, so that best policy responses are expressed as follows. One optimal policy depends on the best responses from the other two optimal policies.

$$\begin{cases} \tau_t = 2 \frac{\lambda(\bar{P}-P_t^f)+M_t^f}{(3+\lambda)} + \frac{(\lambda+1)}{(3+\lambda)} \tau_t^* + \frac{(3-\lambda)}{(3+\lambda)} \Delta Z_t \\ \Delta Z_t = 2 \frac{\lambda(\bar{P}-P_t^f)-M_t^f+2\delta}{(\lambda-1)} + \tau_t^* + \frac{(3-\lambda)}{(\lambda-1)} \tau_t \\ \tau_t^* = 2 \frac{\lambda(\bar{P}-P_t^f)-M_t^f}{(3+\lambda)} + \frac{(1+\lambda)}{(3+\lambda)} \tau_t - \frac{(1+\lambda)}{(3+\lambda)} \Delta Z_t \end{cases} \quad (18)$$

In order to solve the Nash equilibrium, we write the above three equations in a system of equations as follows:

$$\begin{cases} \tau_t - \frac{(\lambda+1)}{(3+\lambda)}\tau_t^* - \frac{(3-\lambda)}{(3+\lambda)}\Delta Z_t = 2 \frac{\lambda(\bar{P}-P_t^f)+M_t^f}{(3+\lambda)} \\ \frac{(\lambda-3)}{(\lambda-1)}\tau_t - \tau_t^* + \Delta Z_t = 2 \frac{\lambda(\bar{P}-P_t^f)-M_t^f+2\delta}{(\lambda-1)} \\ -\frac{(1+\lambda)}{(3+\lambda)}\tau_t + \tau_t^* + \frac{(1+\lambda)}{(3+\lambda)}\Delta Z_t = 2 \frac{\lambda(\bar{P}-P_t^f)-M_t^f}{(3+\lambda)} \end{cases} \quad (19)$$

We can solve these equations in terms of τ_t , τ_t^* and ΔZ_t . The three government policies are endogenously determined and expressed as functions of other exogenous parameters, including λ , δ , \bar{P} , P_t^f and M_t^f :

$$\begin{cases} \tau_t^N = \frac{\lambda^2 M_t^f - 2M_t^f - \lambda^2 P_t^f + \lambda^2 \bar{P} + 4\delta - \lambda\delta - \lambda^2 \delta}{\lambda^2 + 2\lambda - 4} \\ \tau_t^{*N} = \frac{2M_t^f - 2\lambda M_t^f + \lambda^2 M_t^f + 4\lambda P_t^f - \lambda^2 P_t^f - 4\lambda \bar{P} + \lambda^2 \bar{P} - \lambda\delta - \lambda^2 \delta}{\lambda^2 + 2\lambda - 4} \\ \Delta Z_t^N = \frac{-2\lambda M_t^f - 4\lambda P_t^f - 2\lambda^2 P_t^f + 4\lambda \bar{P} + 2\lambda^2 \bar{P} + 4\delta + 2\lambda\delta}{\lambda^2 + 2\lambda - 4} \end{cases} \quad (20)$$

The above Nash equilibrium solution helps us to get the Nash international market price as a function of price stabilization preferences and storage revenue.

The Nash equilibrium international market price

Based on the interior Nash equilibrium solutions, the Nash equilibrium price is a function of Nash equilibrium trade policies in both countries and the Nash equilibrium storage policy in the home country. The relationship is expressed as:

$$P_N^w = P_t^f - \frac{\tau_t^N + \tau_t^{*N}}{2} + \frac{\Delta Z_t^N}{2} \quad (21)$$

Substituting the Nash equilibrium solutions for τ_t^N , τ_t^{*N} and ΔZ_t^N into the above Nash equilibrium international market price reveals that the effects of trade policies and home country's storage policy are in opposite directions. The Nash equilibrium world price is rearranged and simplified as:

$$P_N^w = P_t^f - \frac{\tau_t^N + \tau_t^{*N}}{2} + \frac{\Delta Z_t^N}{2} = P_t^f + \frac{(\lambda^2 + 2\lambda)\delta + 4\lambda(\bar{P} - P_t^f) - \lambda^2 M_t^f}{\lambda^2 + 2\lambda - 4} \quad (22)$$

The Nash equilibrium price consists of two terms. The first term is the benchmark free trade market price in the absence of trade policies and storage policy. The additional term is the effect of storage revenue and the price stabilization preference on the international market price. With the above equation, we will exploit the effects of a price stabilization preference and storage revenue on the international market price in the context of border and domestic storage policy coordination.

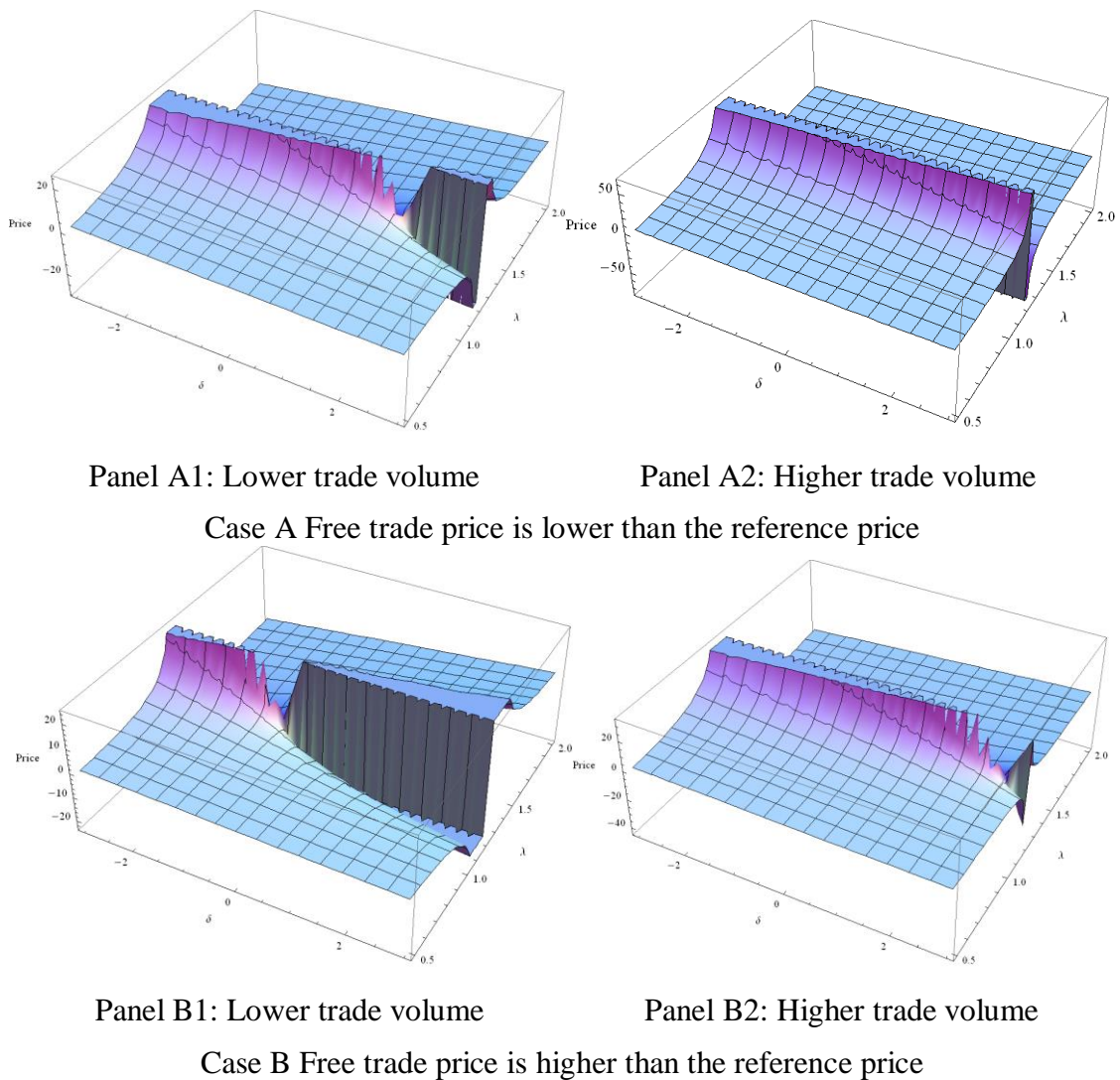


Figure 2: Nash world price as functions of preference for price stability and storage revenue

According to theoretical predictions by Gouel (2016), a higher price stabilization preference leads to a higher Nash international market price, and the large country contributes more than small countries (Giordani *et al.*, 2016). However, in the context of domestic and border policy coordination, the Nash equilibrium international market price is a non-linear function of the price stabilization preference parameter, and the international market price is not monotonically increasing with respect to trade distortions.

The above Figure 2 illustrates the changes in the international market price with respect to the preference for price stabilization and storage revenue. Panel A1 and Panel A2 show the response of international price to the changes in price stabilization preference (λ) and the effect of storage revenue (δ) when the free trade price is lower than the reference price. Panel A1 shows the reaction of the change of the international market price under lower trade volume conditions, and the results in panel A2 reveal the responses when the trade volume is higher. The international market price responses are in Panel B1 (under lower trade volume) and Panel B2 (under higher trade volume) when facing higher free trade price relative to the reference price. The results show that the Nash equilibrium trade policy does not necessarily lead to further increases in the international market price when the government balancing preference is for price stability and storage revenue. According to the above predictions, storage policy has a price stabilization effect on the international market price.

3.2 China's role in the world cotton market

China plays a critical role in the international cotton market, involving sizable consumption, being the world's largest importer and the second largest producer (Table 1) in 2014. China's cotton production accounted for around a quarter of world's production and had been ranking number 1 before 2014, in which year it was exceeded by India. China consumes more than 30%

of the world's cotton production. That means it still imports a large amount of cotton from the world market, and relatively little cotton produced in China is exported to other countries.

Table 1: China's role in the international cotton market

| Year | Production (Million 480lb bales) | Share of world production (%) | World Rank No. | Consumption (Million 480lb bales) | Share of world consumption (%) | World Rank No. |
|-------------|---|--|-------------------------------|--|---|-------------------------------|
| 2000 | 20.30 | 22.78 | 1 | 23.50 | 25.49 | 1 |
| 2005 | 28.40 | 24.41 | 1 | 45.00 | 38.45 | 1 |
| 2010 | 30.50 | 25.94 | 1 | 46.00 | 39.73 | 1 |
| 2014 | 30.00 | 25.13 | 2 | 35.50 | 31.91 | 1 |
| Year | Import (Million 480lb bales) | Share of world import (%) | World Rank No. | Export (Million 480lb bales) | Share of world Export (%) | World Rank No. |
| 2000 | 0.23 | 0.88 | 25 | 26.16 | 1.69 | 13 |
| 2005 | 19.28 | 43.17 | 1 | 44.71 | 0.08 | N/A |
| 2010 | 11.98 | 32.58 | 1 | 35.36 | 0.34 | 26 |
| 2014 | 7.30 | 21.35 | 1 | 34.24 | 0.15 | N/A |

Notes: 1) Data are from NCCA; 2) N/A means that China does not rank in top 30.

Between 2011 and 2014, China amassed 65,632 million 480lb bales of cotton which is equivalent to more than 55 percent of the total world's production in 2014. This abnormal behavior of China has meant it doubled the world cotton stock compared to average levels since 1950 (MacDonald *et al.*, 2015). China has become the main source of world cotton market uncertainty due to its trade volatility and its unpredictable storage policy.

The unprecedented domestic cotton policies and the critical role of China in the world market have attracted much attention by other main cotton producers (United States, India, Pakistan, Brazil and Australia) and some international organizations (WTO, OECD, and NCCA).

Numerous small cotton-exporting countries also care about the cotton policy in China, notably Benin, Burkina Faso, Chad, Mali and Uzbekistan.

4 Data and methodology

4.1 Data and variables

The dataset consists of annual observations between 1970 and 2014 including prices, world production, consumption, China storage and the storage of the ROW. The "A" index is a proxy for the world price of cotton. It is an average of the cheapest five quotations from a selection of the principal upland kinds of cotton traded internationally.⁵

Table 2: Overview of data and sources

| Variable name | Coverage | Units | Description | Source |
|---------------|-----------|-----------------------|--|-------------|
| CROPA | 1975-2014 | (cents/pound) | World cotton price | NCCA (2015) |
| PRODUCTION | 1975-2014 | (000) 480-pound bales | World cotton production | NCCA (2015) |
| CONSUMPTION | 1975-2014 | (000) 480-pound bales | World cotton consumption | NCCA (2015) |
| CESTOCK | 1975-2014 | (000) 480-pound bales | China cotton ending stocks | NCCA (2015) |
| ESEXCLUDCHINA | 1975-2014 | (000) 480-pound bales | World cotton ending stocks excluding China | NCCA (2015) |

The time series data, covering forty years, range from 1975 to 2014 (Table 2). All the variables' data are collected from NCCA website.⁶ The units for world cotton prices and other variables, including production, consumption, and stocks, are in cents/pound and (000) 480-pound bales

⁵ See <https://www.cotlook.com/information/the-cotlook-a-index-plus-an-explanation/>

⁶ See <http://www.cotton.org/>

respectively. We decompose the total world cotton storage into China's cotton storage and the cotton storage of the ROW. Table 3 reports the summary statistics of the variables. The standard deviation of China's storage is almost twice those of the world price, production, consumption and the world storage excluding China. China's unanticipated changes of cotton storage exaggerate the uncertainty in the world cotton market. The world cotton price, production, consumption and world cotton storage excluding China approximately have the same variations except that the storage of the ROW has a bit higher fluctuations.

Table 3: Basic statistics of variables

| Variables | No. Observ. | Mean | Std. Dev | Min | Max |
|-------------------|-------------|-------|-------------|-------|-------|
| LN(CROPA) | 40 | 4.27 | 0.24 | 3.73 | 5.11 |
| LN(PRODUCTION) | 40 | 11.38 | 0.24 | 10.90 | 11.76 |
| LN(CONSUMPTION) | 40 | 11.37 | 0.21 | 11.01 | 11.73 |
| LN(CESTOCK) | 40 | 10.62 | 0.44 | 9.93 | 11.61 |
| LN(ESEXCLUDCHINA) | 40 | 10.22 | 0.29 | 9.71 | 10.70 |

Notes: All the variables are expressed in logarithms.

4.2 Setting the VAR model

The general VAR model in matrix form is simply:

$$Y_t = \mu + \sum_{i=1}^j \beta_i Y_{t-i} + \varepsilon_t \quad (23)$$

Y refers to all the endogenous variables, μ is a vector containing deterministic terms and β is the coefficient matrix. If the equation form is expanded, we get the following equations:

$$\begin{cases} p_t = \mu_p^0 + \mu_p^t + \sum_{i=1}^j \beta_i^p p_{t-i} + \sum_{i=1}^j \beta_i^q q_{t-i} + \sum_{i=1}^j \beta_i^x x_{t-i} + \sum_{i=1}^j \beta_i^z z_{t-i} + \sum_{i=1}^j \beta_i^s s_{t-i} + \varepsilon_t^p \\ q_t = \mu_q^0 + \mu_q^t + \sum_{i=1}^j \beta_i^p p_{t-i} + \sum_{i=1}^j \beta_i^q q_{t-i} + \sum_{i=1}^j \beta_i^x x_{t-i} + \sum_{i=1}^j \beta_i^z z_{t-i} + \sum_{i=1}^j \beta_i^s s_{t-i} + \varepsilon_t^q \\ x_t = \mu_x^0 + \mu_x^t + \sum_{i=1}^j \beta_i^p p_{t-i} + \sum_{i=1}^j \beta_i^q q_{t-i} + \sum_{i=1}^j \beta_i^x x_{t-i} + \sum_{i=1}^j \beta_i^z z_{t-i} + \sum_{i=1}^j \beta_i^s s_{t-i} + \varepsilon_t^x \\ s_t = \mu_s^0 + \mu_s^t + \sum_{i=1}^j \beta_i^p p_{t-i} + \sum_{i=1}^j \beta_i^q q_{t-i} + \sum_{i=1}^j \beta_i^x x_{t-i} + \sum_{i=1}^j \beta_i^z z_{t-i} + \sum_{i=1}^j \beta_i^s s_{t-i} + \varepsilon_t^s \\ z_t = \mu_z^0 + \mu_z^t + \sum_{i=1}^j \beta_i^p p_{t-i} + \sum_{i=1}^j \beta_i^q q_{t-i} + \sum_{i=1}^j \beta_i^x x_{t-i} + \sum_{i=1}^j \beta_i^z z_{t-i} + \sum_{i=1}^j \beta_i^s s_{t-i} + \varepsilon_t^z \end{cases} \quad (24)$$

μ^0 is the constant term and μ^t is the time trend. We treat all the variables as endogenous variables for this first step in which we test the explanatory ability and function of the VAR model. In addition, we assume all cotton is homogenous across countries, and there is no trade distortion in the VAR system.

The variables are defined as follows:

- p_t : nominal world price (LN(CROPA)), crop year consistent with the crop year production, consumption and storage variables;
- q_t : total world cotton production (LN(PRODUCTION));
- x_t : total world consumption in period t (LN(CONSUMPTION));
- z_t : world cotton stocks in period t and China is excluded (LN(ESEXCLUDCHINA));
- s_t : cotton storage in China in period t (LN(CESTOCK));
- $z_t + s_t$: total world cotton storage.

5 Diagnostic tests, estimation, and forecast evaluations

5.1 Stationary tests

More than 90 percent of agricultural time series data are not stationary. Table 4 reports the basic diagnostic tests for the data stationary characteristic. In the process of testing, ADF test (Dickey and Fuller, 1979) and KPSS test (Kwiatkowski *et al.*, 1992) are applied. Columns 1 and 3 report that most of the variables are not stationary, including the world cotton price, total production and consumption, China's cotton storage, and the storage of the ROW. If the first difference is taken for each variable, all the time series are stationary with 5% significance level at least, regardless of whether we include a constant term, trend or lag numbers.

Table 4: Unit root tests on data series during 1975 to 2014

| Variables | ADF (levels)* | ADF (1 st diff.) | KPSS (level) | KPSS (1 st diff.) |
|-----------------------|----------------------|-----------------------------|----------------------|------------------------------|
| LN(CROPA) | -0.1275** (C, 0, 0) | -7.1191*** (C, 0, 0) | -3.4557** (C, 0, 0) | -7.1191*** (C, 0, 0) |
| | -3.4067 (C, T, 0) | -7.0244*** (C, T, 0) | -3.4067 (C, T, 0) | -7.0244*** (C, T, 0) |
| | -0.1275 (0, 0, 0) | -7.2237*** (0, 0, 0) | -0.1013 (0, 0, 0) | -7.2237*** (0, 0, 0) |
| LN(PRODUCTI ON) | -1.8187 (C, 0, 0) | -7.4613*** (C, 0, 0) | -1.7560 (C, 0, 0) | -7.5788*** (C, 0, 0) |
| | -4.5165*** (C, T, 0) | -7.4142*** (C, T, 0) | -4.5165*** (C, T, 0) | -7.5292*** (C, T, 0) |
| | -1.2881 (0, 0, 0) | -7.1803*** (0, 0, 0) | 2.0871 (0, 0, 0) | -7.2361*** (0, 0, 0) |
| LN(CONSUMP TION) | -1.1602 (C, 0, 0) | -5.8447*** (C, 0, 0) | -1.1602 (C, 0, 0) | -5.8447*** (C, 0, 0) |
| | -1.8322 (C, T, 0) | -5.8835*** (C, T, 0) | -1.9778 (C, T, 0) | -5.8835*** (C, T, 0) |
| | 2.0974 (0, 0, 0) | -5.2773*** (0, 0, 0) | 2.0974 (0, 0, 0) | -5.2773*** (0, 0, 0) |
| LN(CESTOCK) | -0.7762 (C, 0, 0) | -4.2562*** (C, 0, 0) | -1.0189 (C, 0, 0) | -4.3500*** (C, 0, 0) |
| | -2.5578 (C, T, 0) | -4.1914** (C, T, 0) | -2.9073 (C, T, 0) | -4.2944*** (C, T, 0) |
| | -0.8872 (0, 0, 0) | -4.1966*** (0, 0, 0) | 0.7831 (0, 0, 0) | -4.3024*** (0, 0, 0) |
| LN(ESEXCLU DCHINA) | -1.4326 (C, 0, 0) | -7.9096*** (C, 0, 0) | -0.8653 (C, 0, 0) | -8.0817*** (C, 0, 0) |
| | -3.9864** (C, T, 0) | -7.8048*** (C, T, 0) | -3.9864** (C, T, 0) | -7.9723*** (C, T, 0) |
| | 0.7729 (0, 0, 0) | -7.8043*** (0, 0, 0) | 1.6666 (0, 0, 0) | -7.9249*** (0, 0, 0) |

Notes: 1) All the five variables are in expressed in logarithms; 2) Testing format: C-constant; T-Trends; K-lag number; 3) Statistical significance is indicated with * (10%), ** (5%) and *** (1%).

5.2 Fix the lags of the dependent variables

Three lag lengths are chosen based on the criteria reported in Table 5 bearing in mind that the maximum lag is four due to the limited sample size. Based on the criteria of FPE, AIC, HQIC and SBIC, we finally fix the lag number at three for VAR estimation. The test results indicate that we have 36 observations and the sample is from 1979 to 2014.

Table 5: Selection-order criteria output

| Lag No. | LL | LR | d.f | p | FPE | AIC | HQIC | SBIC |
|---------|---------|---------|-----|-------|-----------------|------------------|------------------|-----------------|
| 0 | 58.4606 | | | | 5.7e-07 | -3.02559 | -2.96418 | -2.84964 |
| 1 | 213.695 | 310.47 | 16 | 0.000 | 2.5e-10* | -10.7608 | -10.4538* | -9.8811* |
| 2 | 227.692 | 27.995 | 16 | 0.032 | 2.9e-10 | -10.6496 | -10.0969 | -9.06606 |
| 3 | 245.975 | 36.566 | 16 | 0.002 | 2.8e-10 | -10.7764* | -9.97808 | -8.4891 |
| 4 | 261.766 | 31.582* | 16 | 0.011 | 2.4e-10 | -10.7648 | -9.72082 | -7.7737 |

Notes: * indicates the optimal lag number based on different types of measuring criteria.

After fixing the lag numbers and checking the units of the variables, it is time to test the long-run relationships between variables and the tolerance of the VRA model. According to the

unrestricted cointegration rank test, we could have long-term equilibrium between variables. Table 6 presents the test, equation by equation. The R-squared values are high for each of the equations, indicating that the total explanation of each model is high. The residual normality is tested and reported in row five (Jarque-Bera), and we could not reject the null hypothesis test that the residual is normally distributed.

Table 6: Results of equation by equation diagnostic tests

| | LN(CESTOCK) | LN(CONSUMPTION) | LN(CROPA) | LN(ESEXCLUDCHINA) | LN(PRODUCTION) |
|---------------|-------------|-----------------|-----------|-------------------|----------------|
| S.E. equation | 0.289615 | 0.038825 | 0.133962 | 0.119777 | 0.067227 |
| R^2 | 0.943253 | 0.977335 | 0.853132 | 0.902336 | 0.736235 |
| Adj. R^2 | 0.895282 | 0.958249 | 0.711032 | 0.820093 | 0.514116 |
| Prob.(F) | 19.70193 | 51.20594 | 6.382549 | 10.97156 | 3.314606 |
| Jarque-Bera | 0.9123 | 0.4229 | 0.3939 | 0.7259 | 0.4985 |

Notes: The individual coefficients are not reported here which is not our interest.

Even testing the stationary of the five time-series variables, we could visually get that all the eigenvalues lie within the unit circle as shown in Figure 3. The further tests confirm that the VAR model is stable.

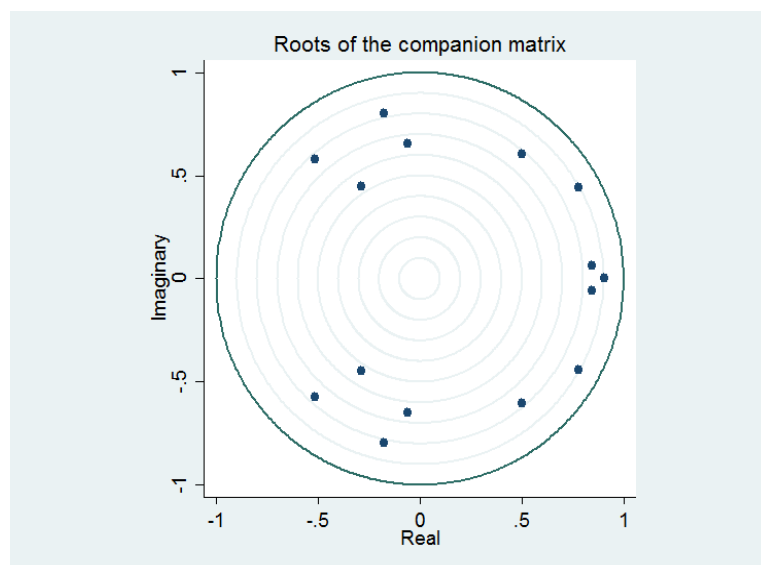


Figure 3: VAR model's stability test

5.4 Model evaluation based on two types of forecasts

The best application of the VAR model is forecast and the precise forecast offers the best criteria to judge the tolerability and function of the model. Firstly, Figure 4 presents the within-sample prediction of world cotton price between 1975 and 2014. The reproduced historical data match quite well the real world cotton price.

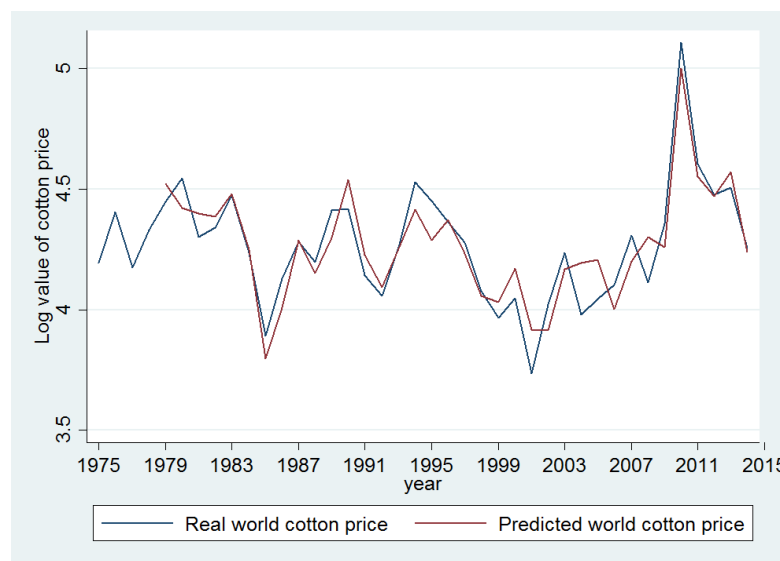


Figure 4: Within-sample prediction of VAR model

Given the within-sample forecast above, we estimate the VAR model based on the subsample between 1975 and 2010. We forecast China's cotton storage, cotton storage of the ROW, and the world cotton price, production and consumption from 2011 to 2014. Figure 5 shows the out of sample forecast results compared with actual data. The out-of-sample predictions work as well. Jointly considering the within-sample prediction and out-of-sample test of the VAR model, the explanatory ability of our VAR model seems strong.



Figure 5: Out-of-sample forecast between 2011 and 2014

5.5 Dynamic interactions between variables

Now the VAR model is adopted to identify the dynamic interactions between different variables using Impulse Response Functions (IRF) and Forecast Error Variance Decompositions (FEVD).

Impulse response

The impulse response function is used to get the response of one variable to unexpected changes in all other variables. Figure 6 represents the responses of world cotton price to the

shocks of China's cotton storage, world consumption, the change of the world cotton price itself, cotton storage of the ROW, and total world production. The responses of the world cotton price to the unforeseen changes in China's cotton storage decrease for the first two periods and then rise from period three. China's cotton storage has a large effect on the world cotton market price in the first period. Comparing the responses to China's cotton storage with that to storage of the ROW, the effect in the first period is negative but, from period two, the responses are persistently positive. The response of the world cotton price to China's cotton storage turns to positive one period later than responses to the storage of the ROW.

Regarding the responses of the international market cotton price to the shocks of consumption and production, total world consumption matters more than world production. As for to consumption response, after initially a small level increase, it then sharply turns to a decrease for one period and then, in period three, it increases markedly. The dynamic responses to total world consumption are more complicated than we expected. In contrast to world consumption, world production takes fewer turns. The international cotton price responds to the production shocks four periods later. The world shock of itself is positive for the first three periods with a continuously declining trend, and then it stabilizes with negative values.

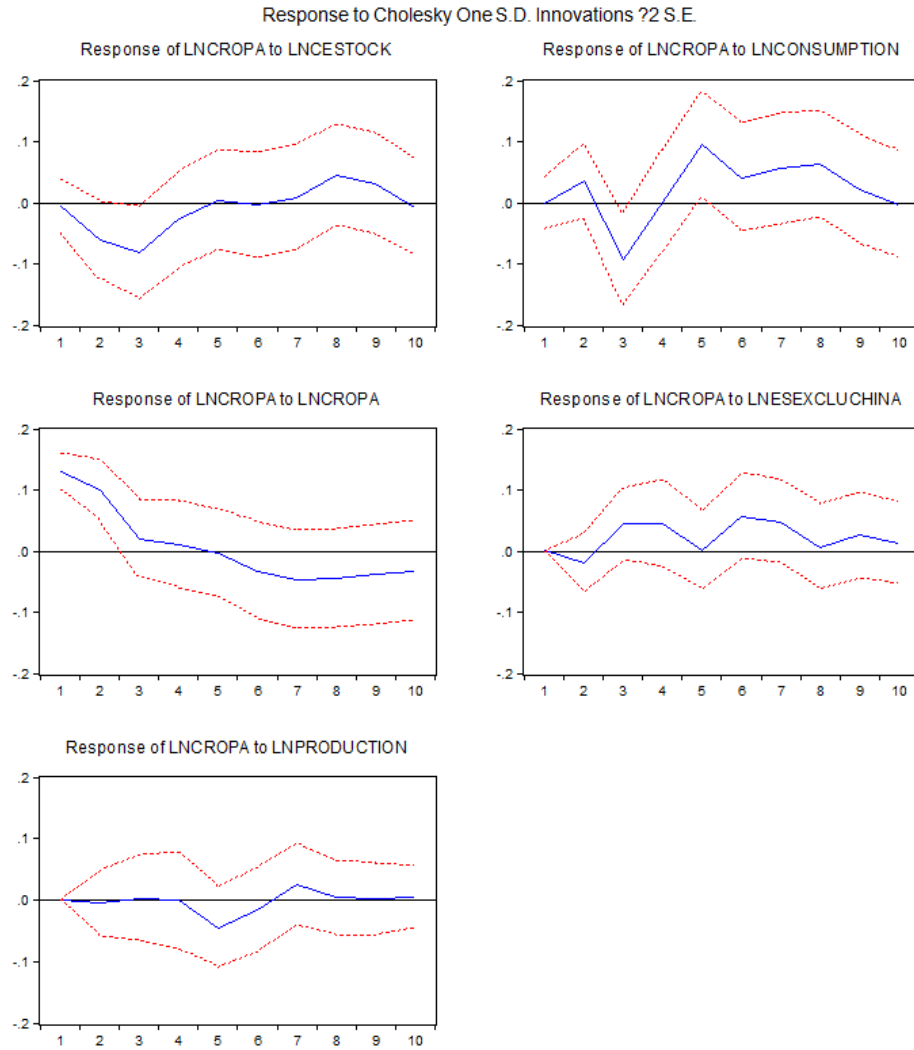


Figure 6: Responses of world cotton price to changes in all other variables

To sum up, 1) the responses of world cotton market price to China's storage and the storage of the ROW are quite different, particularly in period two and period three; 2) consumption shocks matter more than production shocks; 3) the complex dynamic relationships between world cotton price, China's cotton storage, cotton storage of the ROW, cotton consumption, and production suggest a static partial equilibrium model would be inadequate.

Forecast error variance decompositions

Forecast error variance decompositions analysis answers the question as to how much of the forecast error variance in each of the variables can be explained by other variables. Figure 7 presents the contributions of each variable to forecast variance change within the horizon. As with the variance decomposition of China's cotton storage, the most important contributors are world cotton consumption and the world market cotton price. The role of the world cotton price is higher than that of consumption for the first four periods. World cotton production and the storage of the ROW play a limited role in influencing China's cotton storage, which is consistent with impulse response analysis. China's cotton storage takes the highest weight in the variance decomposition of total world consumption. The world price ranks number two followed by world production which ranks number three, while the storage of the ROW has a minimal effect. In the short-term, China's cotton storage ranks number one in world cotton price variance decomposition, rather than consumption which takes the highest weight three periods later. In the variance decomposition of the storage of the ROW, world cotton consumption, China's cotton storage, world cotton price and world production rank from number one to number four. China's cotton storage has the highest weight concerning world production variance decomposition, and the other three contributors' roles are parallel with the expansion in time.

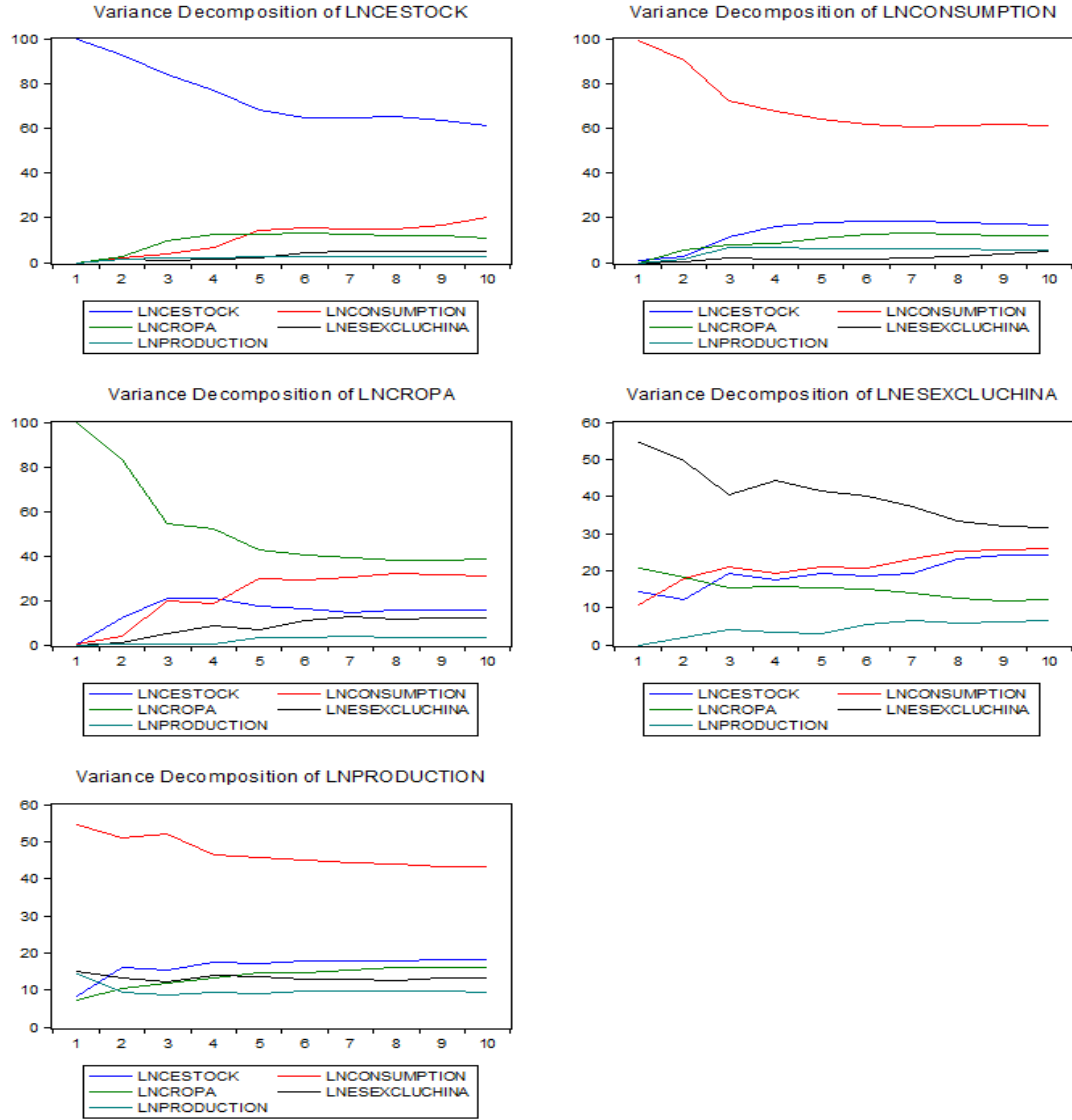


Figure 7: Forecast error variance decomposition

In brief, the role of China's cotton storage has the highest weight in the variance decomposition in terms of world consumption, production and the first three periods of world cotton price. This is consistent with our hypothesis that China's cotton storage does affect world cotton production. The role of world consumption, which takes the most important weight just after two or three periods, is higher than production. The result is consistent with our expectation that international trade across countries could mitigate the effects of production shocks globally.

6 Simulations

6.1 Does China's storage cause the world cotton price to change?

Having investigated each variable's response to unforeseen shocks of other variables, we now explore the effects of China's cotton storage on the world cotton price, which will be tested by Granger causality.⁷

Table 7 reports the Granger causality test results. The last row indicates that past information could provide valuable information for current values for each of the five dependent variables (column 1 to 5). Our most interesting variable is China's cotton storage. The columns in Table 7 show that world cotton consumption, production, world price and the storage of the ROW are not the cause of China's cotton storage in that each test does not reject the null hypothesis. Regarding the second-to-last row, China's cotton storage is not Granger causality for other variables in the VAR system. The Granger causality test results suggest that past values of China's cotton storage do not help forecast current values of other variables. Conversely, the past information of world cotton consumption, production, world price and the storage of the ROW also are not useful in making current China's cotton storage forecasts. China's cotton storage is quite possibly irrelevant for the VAR system, and we could treat China's cotton storage as an exogenous variable. This is consistent with previous research that suggests China's storage policy is aiming at the domestic self-sufficiency target and is irrelevant to the world market (Dawe *et al.*, 2009).

⁷ Likelihood ratio test (Sims, 1980) is formally applied here.

Table 7: Results of block exogeneity (Granger causality) test

| | Exclude LNCESTOCK | Exclude LNCONSUMPTION | Exclude LNCROPA | Exclude LNESEXCLUCHINA | Exclude LNPRODUCTION |
|----------------|----------------------|--------------------------|--------------------|---------------------------|-------------------------|
| LNCONSUMPTION | 2.138208 | | 22.28182*** | 3.608608 | 2.607298 |
| LNCROPA | 4.705642 | 12.02402*** | | 1.069429 | 2.909880 |
| LNESEXCLUCHINA | 7.009195 | 1.599387 | 3.061816 | | 2.775533 |
| LNPRODUCTION | 5.652870 | 1.953656 | 0.591033 | 2.234861 | |
| LNCESTOCK | | 0.145530 | 2.869948 | 5.664711 | 1.806506 |
| All | 22.78387*** | 22.82222*** | 66.79397*** | 18.11659 | 29.10377*** |

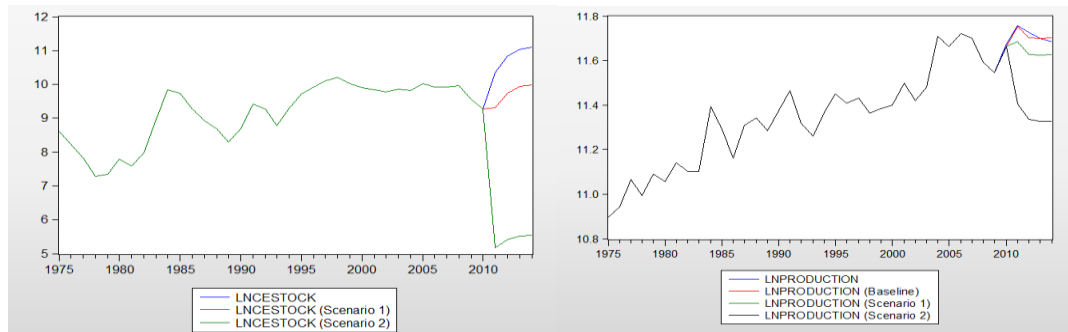
Notes: 1) the values in the table mean the chi-sq. value; 2) *** significantly different from zero at 1% significant level.

6.2 Simulating the effects of a reduction of China's cotton storage

Based on the tests above, China's cotton storage can be considered an exogenous variable in the VAR system. Myers *et al.* (1990) put forward the theory relating to counterfactual simulation. A percentage reduction of China's cotton storage from 2011 to 2014 is used in the dynamic stochastic simulation. This simulation is based on one assumption which is the VAR model still describes the data as accurately as the originally set model. The real data series are the benchmark line of the counterfactual scenario simulations. The exogenous condition is satisfied based on the Granger causality test above. We could decrease China's cotton storage by some percentage to create the counterfactual. The dynamic simulation is run with world cotton production, consumption, world cotton price and the storage of the ROW.

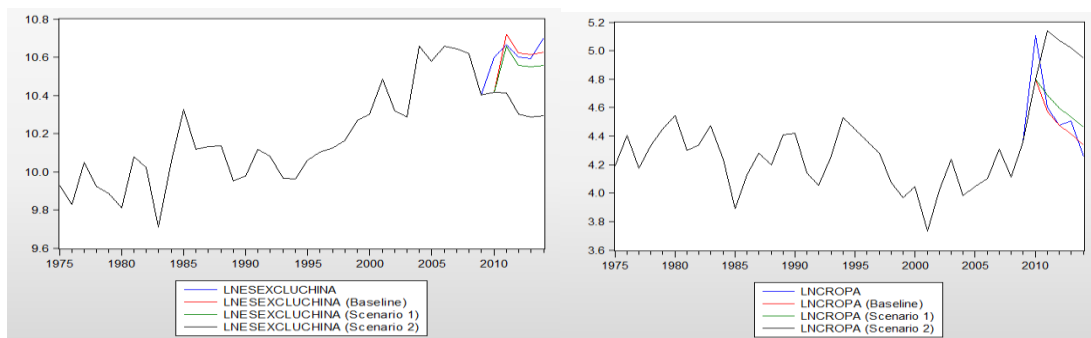
In the following, we create two scenarios by decreasing China's cotton storage by 20% and 50% to see the responses of other variables, particularly the world cotton price. Figure 8 shows the counterfactual results of changing China's cotton storage. The decreasing of China's cotton storage (Panel A) results in a dramatic decline of the world cotton production. The storage of

the ROW would decrease subsequently too. The most interesting outcome is that the world cotton price would be much higher than the realized price during 2011-2014. World cotton consumption would decrease a bit even if world consumption has less impact on the world price based on the impulse response test and forecast error variance decompositions.



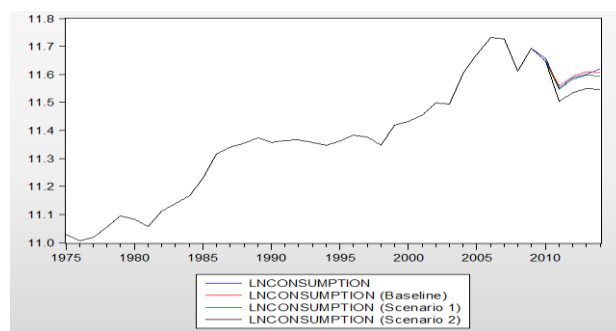
Panel A Cotton storage change of China

Panel B Changes of world cotton production



Panel C Storage changes of the ROW

Panel D Changes of world cotton price



Panel E Changes of world cotton consumption

Figure 8: Simulations of decreasing China's cotton storage by 20% (Scenario 1) and 50% (Scenario 2)

Even China's cotton price increases the uncertainty of the international market. China's cotton storage during 2011-2014 does not drive up and contribute to the fluctuations of world cotton market prices. Based on the dynamic simulation results, we can conclude that China's cotton storage between 2011 and 2014 functioned as a signal which stimulated the total world production and drove the world price down from the peak level in 2010. Meanwhile, China's storage policy between 2011 and 2014 contributes to returning the world cotton price from the highest level of the past 50 years in 2010 to a more normal level.

7 Conclusions

This paper firstly sets out a political economy model to explore the government's motivations for a national storage policy in the context of border and domestic policy coordination. The theoretical model predicts that domestic storage policy could not only strengthen price stabilization, but also increase its social welfare. However, the effects of the two instruments on the Nash equilibrium international market price are in opposite directions. It implies that the world market price is not monotonically increasing with respect to trade policy interventions when domestic storage policy is incorporated in the theoretical model. This means that domestic storage policy has the potential to have a price stabilization effect in both the domestic and international market.

China dominates the world's storage of cotton and it provides ideal experimental data to identify the effects of China's cotton storage policy on the world cotton market. The VAR method used to model those effects shows that domestic public storage could indeed contribute to the stabilization of the international market price of cotton. These simulated dynamic relationships indicate that a counterfactual decline of China's cotton storage between 2011 and

2014 would depress world production and suppress storage in the ROW, which in turn would lead to an increase in the world cotton market price and a decline of world cotton consumption.

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