Evaluating Public Grain Buffer Stocks in China: a Stochastic Simulation Model

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Abstract:

A stochastic simulation model, with adaptive expectation and multiplicative production shocks, is advocated to investigate the impacts of public grain buffer stocks in China. The effects of alternative public buffer stocks, with three price bands and nine storage capacity levels, are investigated from the perspectives of producer support, market stabilization, food security and social costs. The simulation results show that a narrow price band can improve policy performances and the storage capacity has marginal diminishing effects on above policy performances. For a given width of the price band, the symmetric price band could achieve policy goals at a relatively low cost. In practice, the Chinese government can lower floor price and restrict storage capacity in order to improve Minimum Price Procurement policies of rice and wheat.

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Keywords: Buffer stocks, Grain market, Stochastic simulation, Adaptive expectation

1 Introduction

The debate over public grain buffer stocks remains drastic at both national and worldwide levels(Gouel and Jean,2015; Cafiero, et al.,2014; Wright,2012; Wright and Williams,1988; Reutlinger,1976). Especially in China, public buffer stocks used to be the main approaches for the government to protect producers, stabilize grain market and ensure food safety. However, since 2014, the Chinese government has abolished public buffer stocks policies on some crops (such as corn, soybean, and sugar) and sought new approaches (such as target price policy and producer subsidy) (Huang and Yang, 2017). Even though the reform of public buffer stocks in China has begun, the research on their effects and consequences leaves couples of questions unanswered. Are public buffer stocks are totally unsuitable in current China? How do alternative public buffer stocks affect market performances and social welfare? Is it possible to adjust current buffer stock policies to cope up with new challenges? This paper draws upon a stochastic simulation model to answer these and related questions.

China's public buffer stocks policies are Minimum Price Procurement (MPP) and Temporary Storage (TS). Their ultimate purposes are to protect peasants' incentive to produce grain, further promoting grain market stabilization and national food security (MPPEP, 2004). The MPP covers rice and wheat. The TS is MPP's supplementary policy to cover corn, soybean, oilseed and so on. They are carried out in several main grain production provinces when market prices are below the floor prices which were set by the government. The government continues procuring excess production into public warehouses till prices increase above floor prices. If market prices are too high, government release public storage to depress price by increasing market supply. After operating for over ten years (started from 2004), public buffer stocks confronted many difficulties (Huang and Yang, 2017). They are criticized to be unsustainable due to increasing domestic production costs and low world prices (Cheng, 2012; Han et al, 2012). Grain processing industry suffers from high costs of domestic raw materials (Zheng, 2015; Zhan and Jiang, 2015; Feng, 2014). Besides, public buffer stocks are also blamed to distort market severely, leading to huge public storage and heavy social burdens (Zheng and Pu, 2015; Li and Zheng, 2014; Tan et al., 2014). After TS canceled in 2014, only MPP for rice and wheat is left. Currently, Chinese policymakers and scholars have a fevered debate on whether to replace MPP with a totally new policy or just adjust it partially.

As an age-old but extremely important topic (Gouel,2013; Williams and Wright,1991; Wright,2001), researchers have made a substantial contribution to public buffer stocks and relative price stabilization issues. In China, descriptive statistics studies reveal previous contributions of public buffer stocks and their shortcomings in the current situation (Zheng and Pu, 2015; Li and Zheng, 2014; Tan, 2014; He and Zhu, 2011). Based on Waugh-Oi-Massell's Comparative static analysis framework, welfare economics has given insights into policies' economic welfare distribution as well as social costs distribution (Massell,1969; Oi,1961; Waugh,1944). Accordingly, some Chinese scholars prefer to the new target price policy rather than the old public buffer stock policy (Zhan and Jiang, 2015; Feng, 2014; Zheng, 2014). Econometric studies, based on Chinese grain production data, have shown that China's buffer stock policies help to stabilize market prices and support producers (Chen, 2015; Wang and Li, 2013). While, they failed to give macro evidence on market distortion and social costs, as well as alternative policies comparison. Commodity price stabilization schemes can overcome shortcomings of econometric methods and have been widely used to analyze agricultural policies (Gouel,2013a; Gouel,2013b; Deaton and Laroque,1992; Deaton and Laroque,1996). Among these schemes, some exogenous policy rules were imposed in a rational expectations storage model to get corresponding market responses estimates (Gouel,2013a). Researchers evaluate and compare agricultural policies by analyzing these estimates. Commodity price stabilization schemes are proved to be of great help to understand price control, price supports, buffer stocks and the like (Wright,2001). However, current research conclusions are relatively sensitive to parameters and settings in commodity storage model (Helmberger and Miranda,1989; Miranda and Helmberger,1988; Reutlinger,1976).

As a result, some modifications should be done to study China's situation. The approach taken in this study is based on Reutlinger (1986) and Bigman (1982)'s stochastic simulation models. Thus, it allows to deep understanding and the trade-off for multiple policy's objectives (Reutlinger,1976). The model is kept simple just like most previous models did (Bigman,1982; Reutlinger,1976). Production reacts to expected price and is set as a multiplicative random shock (Wright and Williams, 1982; Newbery and Stiglitz, 1979). The expectation formation in this study is the adaptive expectation, which is more suitable for China but clearly departs from the previous commodity price stabilization schemes (Deaton and Laroque,1996; Williams and Wright,1991; Miranda and Helmberger,1988; Bigman,1982). Thus, a stochastic simulation model is constructed to trace out implications of several levels of price bands and storage capacities.

The next section describes the storage model without public buffer stocks. Section 3 assigns values to parameters in the model and alternative policy rules. Section 4 reports simulation results and section 5 gives some discussion. Main conclusions and policy implications are considered in section 6.

2 The model

This paper sets forward a partial equilibrium model of a storable grain product (such as wheat, rice or corn). The market is regarded as a closed market. Because Chinese government sets a high standard on grain self-sufficiency rates and impose strict restrictions grain trade activities. For example, the self-sufficiency rates of wheat and rice keep over 95% for several years in China. Besides, the market is viewed as one unified market. Any regional difference in production and consumption are disregarded in the model. In order to estimate national price fluctuations with and without public butter stocks, we begin with a competitive model.

Assume fluctuations in price depend only on fluctuations in production and the capacity of government's buffer stocks. Planned production S in crop year t is an upward sloping function of an adaptive expected price P_t^e, where the subscript t denotes the crop year. Production fluctuation stems from a random disturbance - weather variation, plant diseases or insect pests. The random disturbance w_t is multiplicative and drawn from a known probability distribution. Thus, the realized production S_t is

(1) $$S_t = S(P_t^e) \cdot (1 + w_t)$$

Quantity D_t for consumption in a crop year t is a downward sloping function of price P_t:

(2) $$D_t = D(P_t)$$

Assume that demand consists of two segments kinked at the point of mean production. The kinked structure gives a lower price elasticity in the range of short supplies and a higher elasticity in the range of abundant supplies (Bigman, 1985; Bigman, 1982; Reutlinger,1976). This is a reasonable specification. When grain supplies are in shortage and the majority of the population live at the minimum adequate nutrition level, grain consumption is a rigid demand regardless of increasing prices. When supplies are plentiful, demand will not exceed a certain level even though the price is extremely low.

Then the model is modified to take account of government intervention. The model simulates fluctuations with various buffer stocks rules. The policy rules are as follows. If production is above a prespecified level (or the price is below a corresponding price level), the surplus production is put into storage. If production is below a prespecified level (or the price is above a corresponding price level), a certain amount of grain is withdrawn from storage to augment supplies from production up to the prespecified level. Price and production interact closely, so we set price bands as trigger standards in this paper. Storage capacity is another key factor to determine the effects of public buffer stocks. Currently, there is no upper limit on government's public storage capacity in China. Some scholars criticize that it is responsible for huge stocks and the procurement amount should be limited (Ma, 2017). Accordingly, this paper put several constraints on public storage capacity to compare the market effects of different buffer stock capacities.

After considering buffer stocks B_t, the total grain availability in the market is composed of buffet stock from the preceding year B_{t-1} and the new production S_t in crop year t. In the new market-clear situation,

(3) $$B_{t-1} + S_t = D_t + B_t$$

Total demand equals current consumption plus current buffer stocks. According to equilibrium condition (3), production, price, consumption and buffer stocks can be derived. After getting estimated quantities and prices, not only the economic and financial benefits or losses attributable to butter stock but also gains or losses experienced by producers and consumers can be calculated.

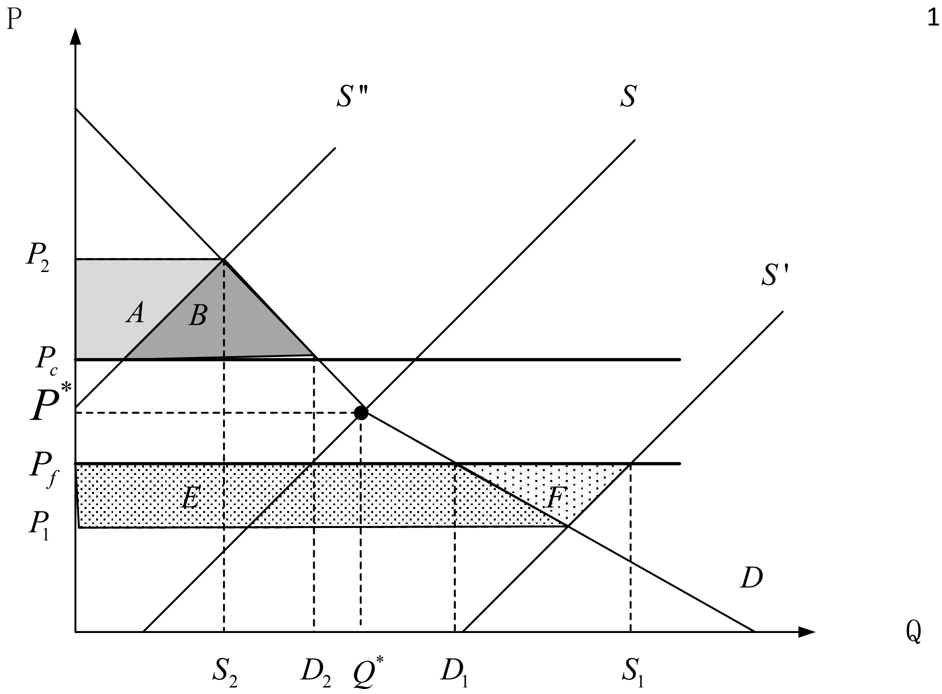

Figure 1 Illustration of public buffer stocks benefits and losses

The calculation of economic welfare gains or losses attributable to buffer stock is illustrated in figure 1. In a competitive market (namely without public buffer stocks), P^* and Q^* is the equilibrium price and production (or consumption) respectively. Then a buffer stock policy is carried out. If the market price P_1 is below the floor price P_f, a quantity $(S_1 - D_1)$ is placed in storage. Consumers lose the area *E* and producers gain areas (*E+F)*. Government's financial cost is procurement fees $(S_1 - D_1) \cdot P_f$ plus storage holding costs (spoilage and storage fee). If the market price P_2 is above ceiling price P_c, a quantity $(D_2 - S_2)$ is released from buffer stocks. Consumers gain the areas *(A+B)* and producers loss areas *A*. Government's financial gain is $(D_2 - S_2) \cdot P_c$.

The simulation method employed in this paper follows Bigman's three steps (Bigman,1985; Bigman,1982). Firstly, apply Monte Carlo simulations for production random events according to the prespecified probability distribution. Secondly, calculate the state variables for each sequence and each independent random event, based on the decision rules and initial conditions specified in the model. Finally, repeat the process a large number of times and average the results.

3 Parameters and Policy rules

In the simulation experiments, a time horizon of thirty years is assumed (Bigman, 1982,1985; Miranda, 1982; Reutlinger, 1976). Every simulation experiment involves 1000 iterations of a thirty-year sequence of random production shock events. Therefore, the total sample consists of 810 thousand observations drawn at random from a specified probability distribution.

Parameterization is required to quantify the welfare effects of buffer stock policies. Most of the parameters of the model are deliberately selected to approximate a specific type of grain market in China. For simplicity, production and price are specified in terms of index numbers instead of actual levels at the model's deterministic steady state. According to National Bureau of Statistics of China, China's grain production in 2015 is 621.44 million tonnes. Thus, the mean production is set to 600. And the mean price is normalized to 100 at the initial period. The expected price in this model is adaptively formed according to Bigman (1985). In this case, the producer doesn't have perfect foresight about the long-term mean price, but rather estimate the average price on the basis of the previous years (Bigman, 1982). Here the expected price calculated as an average of the prices in the preceding five years.

$$P_t^e = \frac{1}{n}\sum_{i=1}^{n} P_{t-i}, \qquad n = 1, \cdots, 5$$

Both the supply and demand functions are assumed to have linear forms (Bigman, 1982; Reutlinger, 1976). The market is assumed to produce an average of 600 million metric tons annually. Supply and demand elasticities are set based on previous studies. Cater and Zhong (1988) estimate the price elasticity of supply for winter wheat is 0.15 and 0.27 for spring wheat. Huang (1991) estimated the price elasticity of supply for wheat and rice were 1.05 and 0.2, and other grain crops were 1.51. The results estimated by the World Bank (1991) is 0.2 for rice, wheat and soybeans and 0.3 for corn and tubers. Recent Chinese research showed that the short-run price elasticity of supply for grain ranged from 0.09 to 0.36 (Lin and Zhu, 2015; Yu, et al.,2012; Fan et al., 2012; Liu and Zhou, 2011;). Accordingly, the price elasticity of supply is set to be 0.25 at the mean level. Huang and Rozelle (1995) estimated own-price elasticities of demand for grain in China was -0.52. Hsu et al. (2002) estimated that the demand elasticity was -0.16 for urban consumers and -0.37 for rural consumers in China. From their research, we choose the price elasticity of demand is -0.275 when supplies are short and -0.35 when supplies are plentiful. So we can deduce the precise demand function used in the simulations is as follows:

$$D_t = 765 - 1.65P_t, P_t \le 100$$
$$D_t = 810 - 2.1P_t, P_t > 100$$

The random disturbance w_t is assumed to be independently and identically distributed following a beta distribution (Gouel, 2013a). We assume the distribution to have shape parameters 2 and 2, which makes it unimodal at 0.5 and symmetric. The distribution is translated and rescaled to vary between -0.1 and 0.1 ($w_t \sim Beta(2,2)*0.2-0.1$). The storage holding cost is set to be 5 per ton.

The decision variables that determine buffer stock operation are two trigger prices and the buffer stock capacity. For the trigger prices, three price bands are considered in Table 1 (Bigman,1982). Price band A[-5,5] and B[-10,10] specify a symmetric band centered on the mean price. The difference between them is in the width of the band. Price band A has a narrower band than B. Price band C[0,10] specifies an asymmetric band, which provides higher protection when the market price decreases. It necessitates storing as much grain as possible so as to offset the most severe shortages. For the storage capacity, firstly we consider a number of levels ranging from 10% to 80% of mean annual consumption in the competitive model (equals to mean production 600) (Bigman,1982). Secondly, remove the constraints on public storage capacity and allow an infinite buffer stock. These nine storage capacities are listed at bottom part in Table 1. At the first year of operation, no grain is assumed to be in public storage.

Table 1 Public buffer stocks' operating rules

	percentage deviation from the mean price			
		the lower limit	the upper limit	
price band	A[-5,5]	-5	+5	
	B[-10,10]	-10	+10	
	C[0,10]	0	+10	
	the stock-to-utilization ratio			
storage capacity	10%	20%	30%	40%
	50%	60%	70%	80%
	infinite			

4 Simulation Results

This section provides a comparison of the market effects of the above alternative buffer stocks rules. In China, the general goals of the Minimum Procuement Price policy can be grouped into three categories:

producer support, market stabilization, and food security. Accordingly, this paper analyzes the results from these three perspectives. Besides, financial costs are necessary factors government has to consider in reality, so social costs are set to be the fourth perspective.

4.1 Buffer stock and producer support

Two variables are set to measure policies' producer-support effects. One is the mean market price, the other is mean producer revenue. In the competitive market, the mean market price is 100.908 and mean producer revenue is 60231.36. The mean market price is a little higher than 100 because demand curve has a kink structure. Table 2 shows the supporting effects of all buffer stocks rules.

Table 2 Mean price and producer revenue under alternative buffer stocks rules

Sto. capacity Price	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	Infinite
A[-5,5]	100.699	100.854	100.939	100.954	100.961	100.912	100.923	100.896	100.954
B[-10,10]	100.906	100.817	100.880	100.865	100.889	100.898	100.873	100.893	100.871
C[0,10]	100.799	101.283	101.963	102.315	102.833	103.203	103.386	103.533	103.510

Sto. capacity Prod. revenue	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	Infinite
A[-5,5]	60330.31	60489.66	60565.08	60575.96	60589.06	60569.85	60568.91	60559.90	60581.98
B[-10,10]	60361.44	60366.32	60396.77	60394.05	60397.67	60407.65	60389.49	60400.51	60391.81
C[0,10]	60424.59	60835.52	61316.67	61662.52	62040.72	62316.92	62458.67	62545.07	62549.07

Note: In the competitive model, mean price is 100.908 and mean production revenue is 60231.36.

The first result from Table 2 is that buffer stock policies do have some supporting effects compared with the competitive market, but the supporting effects vary with operating rules. In most cases, the higher the floor price, the higher the market prices. The price band B[-10,10], which has the lowest floor price, has nearly no supporting effects. The price band C[0,10], which has the highest floor price, increases the mean price by 1-3 units compared with band A[-5,5], providing more support to producers. Besides, the supporting effects increase gradually with the growth of storage capacity, especially for the asymmetric price band C[0,10]. But for the asymmetric price bands, the increasing effects of storage capacity disappear gradually. Although the price band A and B support price only a little bit, all buffer stocks rules help to increase producer revenues. It can be explained that buffer stocks give an expectation that price will not decrease below a certain level, producers tend to enlarge planting acreage. Consequently, total producer revenue increase.

The second result from Table 2 is that for the symmetric price bands, the narrow band offers more supports. The floor price of price band A[-5,5] is higher than the band B[-10,10]. Then the underpinning effect of the band A is stronger. Narrow price bands are criticized because they lower the probability that producers gain from high prices.The simulation results in this study show that the narrower price band is conducive to increase producer revenues in most cases. For example, except for 10% storage capacity level, the mean prices under price band A is higher than the band B. And the price band A increases the mean producer revenues by about 150 units compared with the band B.

The third result from Table 2 is that the storage capacity has a limited promotion role to support producers. When the stock-to-use ratio is 10% or below, public buffer stocks have little support to the producer. When the stock-to-use ratio increases above 20%, the supporting effects emerge and increase correspondingly. When the stock-to-use ratio reaches 50%, the price band A[-5,5] increases mean price by 0.11 units compared with the price when the stock-to-use ratio is 20%, and price band B[-10,10] increases by 0.72 units, price band C[0,10] increases by 1.5 units. Nevertheless, the supporting effects stop continual increasing when storage capacity keep going up. For instances, for price bands A and B, the producer revenues at the infinite storage capacity level are slightly lower than the ones at 50% storage capacity level. For the price band C, the producer revenues at the infinite storage capacity level have no significant difference with that at 50% storage capacity level. Overall, the producer revenues' supporting effect of the infinite storage capacity is close to that of 40% -50% storage capacity level.

4.2 Buffer stock and market stabilization

Based on past research experience ((Miranda and Helmberger,1988; Bigman,1982)), the market stabilization effect is measured by the coefficient of variation of price and producer revenue. The greater the price's coefficient of variation, the higher the market risks. The coefficient of variation of producer revenues reflects the income stabilization of the producers. The greater the coefficient of variation of producer revenues, the more unstable the producer revenues for peasants. This brings a difficulty to maintain producers' planting incentives. Figure 2 and 3 illustrate the simulation results. In the competitive market, the coefficient of variation of market price is 15.07%, and the coefficient of variation of planting income is 10.4%. Public buffer stocks' stabilization effects vary with price bands and storage capacities.

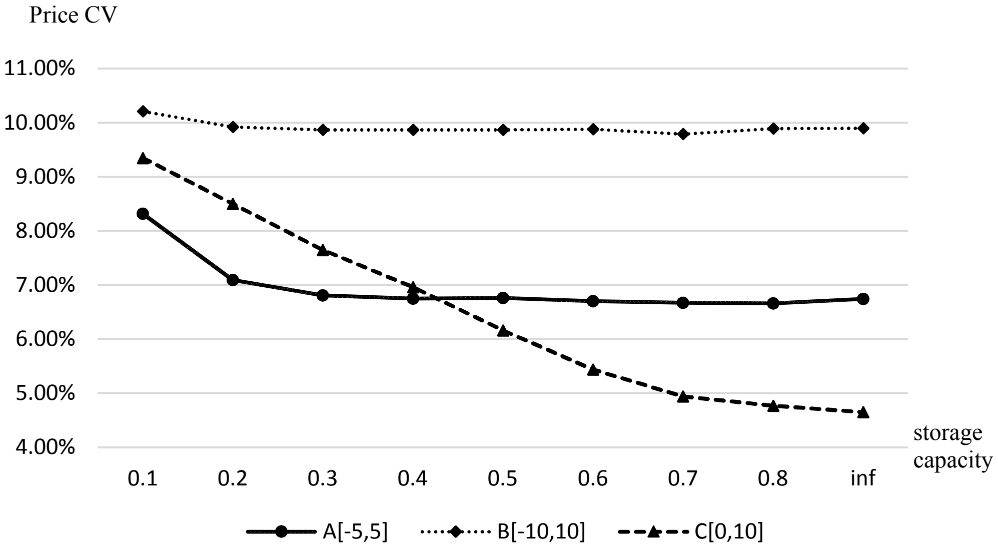

Figure 2 Buffer stock policies and price variance

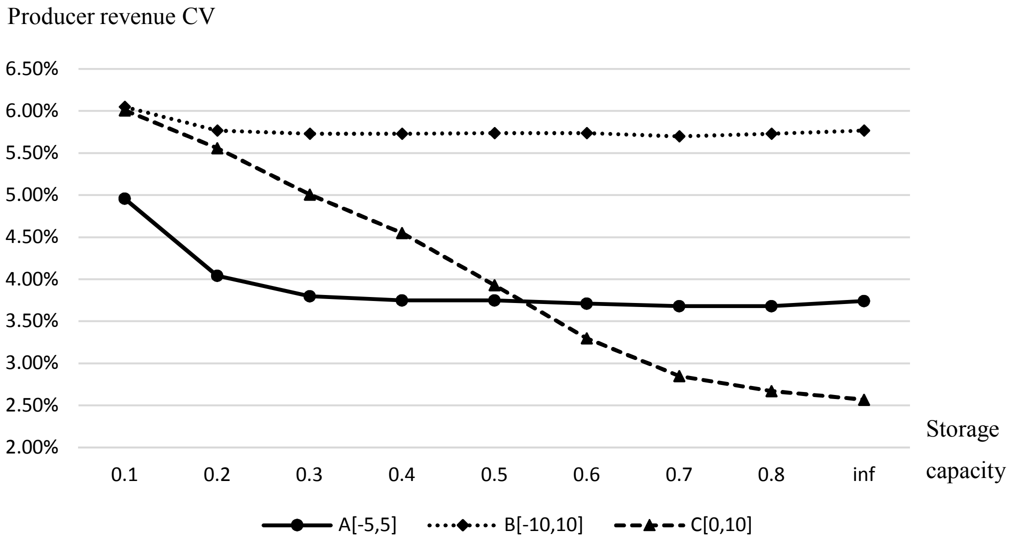

Figure 3 Buffer stock policies and producer revenue variance

First, for the symmetric price bands, the smaller the price band's width is, the more stable the market is. Besides, their stabilization effects keep constant with the increase of storage capacity. Both symmetric price bands lower the price variability. Under price band B[-10,10], the mean coefficient of variation of price is approximately 4%, lowering the variability of the price from a coefficient of variation of 5.5% under the price band A[-5,5]. For producer revenue variability, the coefficient of variation of A[-5,5] is about 4%, which is about 2 percentage points lower than 6% under the price band B[-10,10]. Take the storage capacity into consideration. Increasing storage capacity doesn’t change the stabilization effects too much. Both coefficients of variation decrease slightly as storage capacity increase from 10% to 20%, then keep at relatively stable values as storage capacity continues to increase.

Second, for the asymmetric price band, increasing storage capacity contributes to an increase in market stability. However, successive increases of the storage capacity have diminishing effects. For example in Figure 2, under the price band C[0,10] a storage capacity of 70% lowers the variability of the price from a coefficient of variation of 9.5% at 10% storage capacity level to 5%, a reduction of some 4.5 percent. Similarly, it lowers the variability of the producer revenue from a coefficient of variation of 6% at 10% storage capacity level to 2.8%, a reduction of some 3.2 percent. However, the variabilities of price and revenue decrease more slowly as long as the storage capacity increase above 70%. The stabilization effects of the infinite storage are very close to that at 80% storage level.

Third, under the premise of keeping width same, asymmetric and symmetric price bands have an overlapping section. In the case that the maximum public storage capacity is below 50%, the stabilization effect of symmetry band A[-5,5] is better than that of the asymmetric band C. But the band A loses its advantage gradually with the increase of storage capacity. When the government storage capacity is about 50%, the symmetrical and asymmetric price bands have similar stabilizing effects. After storage capacity increases above 50%, the market stabilizing effect of the asymmetric band C continues to increase, while the market stabilization effect of the symmetry band A remains unchanged.

4.3 Buffer stock and food security

Learning from Bigman(1982)’s specification, the probability that realized production above 90 percent of normal production is set to measure food security. The competitive market simulation shows that the food security rate is 99.41%. Other public buffer stocks simulation results are illustrated in Figure 1. The first major result from Figure 4 is that public buffer stocks contribute to an increase in food security as a whole. The mean food security rate of price band B[-10,10] is 99.6%, increasing by 0.19% compared with the competitive market. The mean food security rate of price band A[-5,5] and C[0,10] are 99.82% and 99.79% respectively, higher than the competitive level.

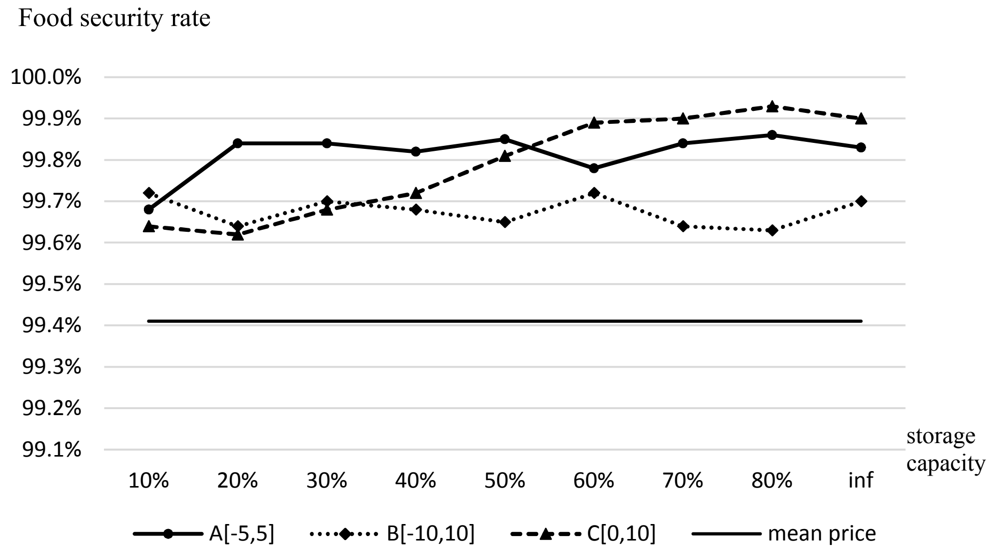

Figure 4 Buffer stock policies and food security

The second result is that storage capacity has diminishing effects on food security under an asymmetric price band. However, it has a relatively constant effect under symmetric price bands. With storage capacity increasing, food security rates of the price band C[0,10] keep increasing and approach a constant level 99.9%. Under the price band A[-5,5], a 30% storage capacity level leads to about 99.7% food security level. This food security rate equals to the food security rates under 60% storage capacity level and infinite capacity. The food security rates under B[-10,10] are similar but much lower than A. As a result, the effects of asymmetric and symmetric price bands have an overlapping section. Considering the same width bands A and C, the security effect of the asymmetric price band C[0,10] is lower than the symmetric price band A when storage capacity is below 50%. When storage capacity increases above 50%, security effects of C[0,10] increase rapidly above price band A[-5,5].

4.4 Buffer stock and social costs

The government has to pay for policy intervention. There are two variables to measure the costs of public storage: financial expenses and social deadweight loss. Financial expenses reflect the direct costs and benefits from operating public buffer stocks. The government pays for the procurement fees and storage holding costs when supporting market price and gains from releasing storage when depressing market price. The social deadweight loss is a welfare cost caused by breaking the free competitive market. Its value equals to total social welfare change with and without buffer stocks. This paper calculates the mean financial expenses and social deadweight loss under all policy rules. Figure 5 and 6 illustrate the simulation results.

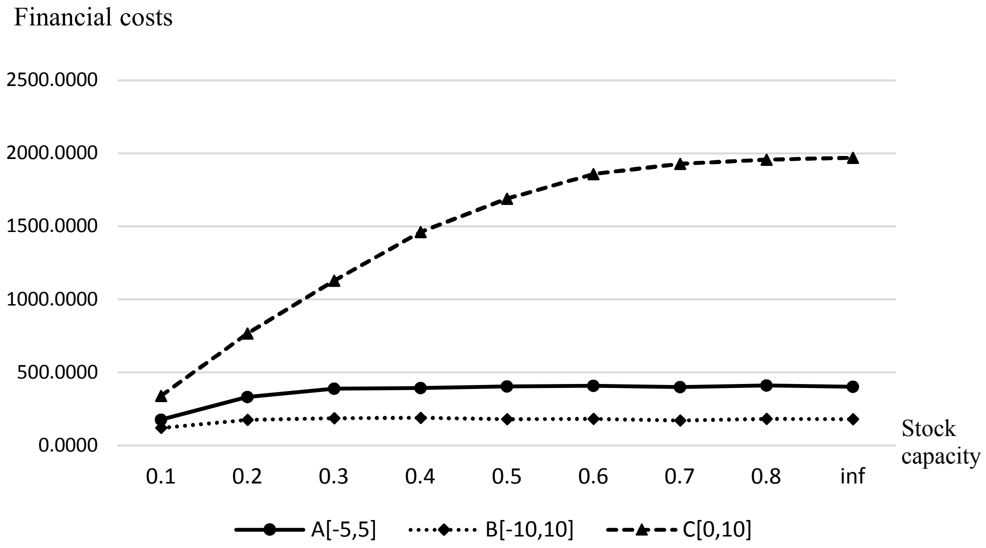

Figure 5 Buffer stock policies and financial costs

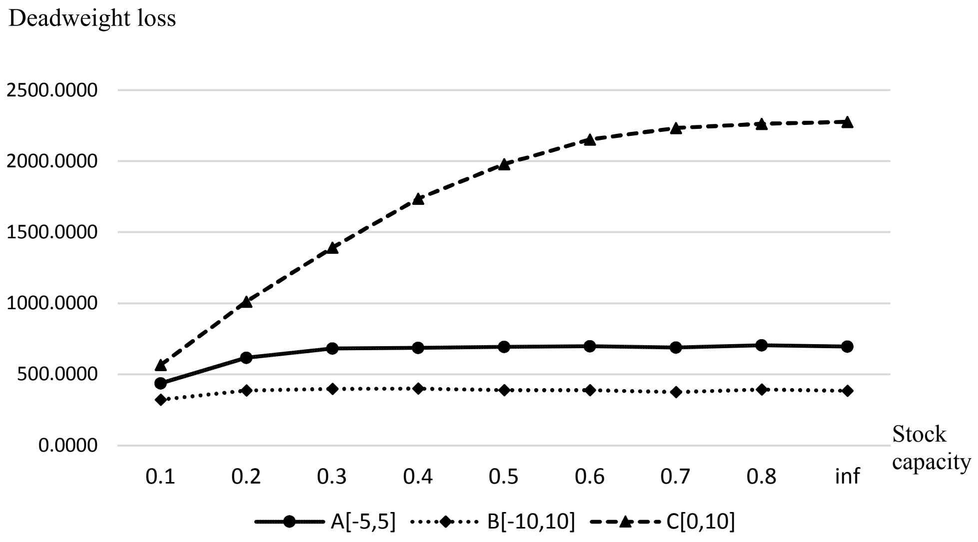

Figure 6 Buffer stock policies and social deadweight loss

First, a wider symmetric price band saves more social costs. The asymmetric price band C[0,10], shown in Figure 5 and 6, leads to much higher financial cost and deadweight loss than those of the symmetric bands A and B. When the storage capacity increases above 50%, the social costs of the asymmetric price band receive about four times the costs of the symmetric price bands. When it comes to the symmetric price bands, the narrow one A[-5,5] causes more social costs which are almost double that of B[-10,10]. These simulation results are intuitive. The price band B[-10,10] can tolerate more fluctuation and intervene market less, so the government pays less and the whole society loss less. However, the price band C[0,10] has little tolerance to the price drop. When the storage capacity is large enough, it's impossible for the market price to decrease below the floor price. Thus, government intervention is inevitable under the asymmetric price band so that government has to undertake this heavy social burden.

Second, the social costs of different price bands increase in different ways with the growth of storage capacity. For the symmetric price band A[-5,5] and B[-10,10], social costs keep increasing before the storage capacity reaches 30% then maintain at a relatively steady level when the storage capacity increase above 30%. The social costs at the steady level are as twice as that at 10% storage capacity level. For the asymmetric price band C[0,10], the storage capacity has diminishing increasing effects on social costs. At the beginning, the social costs increase rapidly. After the storage capacity reaches 50%, social costs' increase rate begins to slow down. Then the social costs don't change a lot after the storage capacity increase above 70%. However, the social costs at this steady level are as fourth even fifth as that at 10% storage capacity.

4.5 Summary

Different from Bigman's simulation results (Bigman, 1982), this model cannot tell that which is the best buffer stock rule to achieve policy's multiple goals. The form of the price band (symmetric or asymmetric) and the storage capacity determine policy's performances. Different rules have their respective advantages on a certain goal. Stochastic simulation results are summarized in Table 3.

From the perspective of buffer stocks' trigger conditions, the form of the trigger condition is closely related to the market responses. Although a wide price band can save social costs, its performances are too poor to reach policy's goals. Keeping the width of price bands same, the asymmetric price band has better supporting effects than the symmetric one but costs more. When it comes to market stabilization and food safety goals, the effects of these two policies depend on the storage capacity. At the lower range of storage capacity, the symmetric price band does better in stabilize the market and ensure food security. *Vice versa*.

Table 3 Performance comparison between alternative storage rules

Price band	Price support	Market stabilization	Food safety	Social cost
A[-5,5]	Fair	Stock capacity <=50%, good Stock capacity >50%, fair	Stock capacity<=50%, good Stock capacity >50%, fair	Fair
B[-10,10]	Limited	Limited	Limited	Good
C[0,10]	Good	Stock capacity <=50%, fair Stock capacity >50%, good	Stock capacity <=50%, fair Stock capacity >50%, good	Limited

From the perspective of the storage capacity, the simulation results showed that the public buffer storage has marginal diminishing effects on policy's goals. The performances of all buffer stocks increase with the increase of storage capacity, then will reach certain stable levels. For the symmetric price bands, their performance will reach the stable levels when the storage capacity increases above 30%. The asymmetric price band's regulation effects change more slowly. After increasing above 50% storage capacity level, its performances stop increasing. However, the asymmetric price band has better performances than the symmetric ones at the stable levels.

5 Concluding Remarks

This paper applies a modified stochastic simulation model to investigate the effects of public buffer stocks in China's grain market. The major conclusions are as follows. Firstly, in order to achieve better policy goals, keep the price band narrow. A narrow price band helps to prevent severe price fluctuation, further contributes to producer support, market stabilization and food security. However, the government has to pay more to achieve these goals compared with a wide price band. Secondly, the storage capacity has marginal decreasing effects on policy performances no matter how the price band changes. In most simulation results, the policy performances at the infinite level are similar to that at 60% storage capacity. Thirdly, if the government cannot pay for a large public storage, a narrow symmetric price band is the effective means to achieve policy goals. A wide symmetric price band tends to destabilize market and harm producers. An asymmetric price band, providing higher supports, intervenes market a lot and will lead to massive financial and social costs.

The Chinese government is reforming MPP of rice and wheat cautiously. This study gives an option to reform it partly instead of replacing it. Most drawbacks of MPP are outcomes of unreasonable operating rules, such as a high floor price and unlimited procurement amount. To save more social costs and while pursuing policy goals, cut down on procurement amount is necessary. A storage capacity, such as 50% stock-to-utilization ratio, could be set by the government. Meanwhile, lower the floor price so as to form a relatively symmetric price band. Also, this helps to improve policy performances at a limited storage capacity. However, a more accurate reform scheme needs more studies and policy practices in the future.

Several limitations of the present simulation model should be noted. First, regional difference in production and consumption causes crucial problems in China. Grains are produced in several main production provinces but consumed around the nation. In order to ensure food security, the total storage amount in different locations around the nation would be larger than the storage amount in an assumed unified market (Reutlinger, 1976; Zhu and Zhong, 2004). Taking regional difference into consideration is a big challenge to modified current model. Second, private storage exists in different forms. For example, some rural households, intermediate traders (Liangfanzi) and some private grain companies store grain. A part of private storage is to fulfill the consumption or processing demands, another is to gain speculative gains. The latter part is of great importance in forming market price. However, little information about private storage's structure and storers' behaviors can we get from existing researches and surveys. Besides, Fengtian and Mingzhe (2016) suggested that the government should not be the only storer to storage public buffer stocks and a multiple storage structure can provide high food security level. This put forward another challenge to modify the model. This paper disregard private storage for simplification but will consider it in our future works. Third, supply and consumption patterns are assumed unchanged over time. Actually, these patterns will change with the economic and social development. For instance, increasing protein need, derived by the higher income, will induce more demand for grain. Consequently, grain demand will keep increasing with the growth of income instead of decreasing. In order to make the model more realistic, more variables and conditions should be put into existing model. This will bring more difficulty in calculating and simulation. Thus, we have to make a tradeoff between model complexity and calculation difficulty.

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