Food Scares, Market Power and Farm-Retail Price Spread: The Case of Pork Market in China

Jiawu Dai

College of Economics and Management,

Hunan Normal University, Hunan, China

Xun Li

School of Economics and Management,

Wuhan University, Wuhan, China

li.xun@whu.edu.cn

Xiuqing Wang

School of Economics and Management,

Wuhan University, Wuhan, China

Qiushuo Yu

Department of Agricultural and Resource Economics,

University of Connecticut, CT, USA

Qiushuo.yu@uconn.edu

Xiaojie Mao

School of Economics and Management,

Wuhan University, Wuhan, China

Selected Paper prepared for presentation for the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Francisco, CA, July 26-28, 2015.

Food Scares, Market Power and Farm-Retail Price Spread: The Case of Pork Market in China

Jiawu Dai[1], Xun Li[2], Xiuqing Wang[3], Qiushuo Yu[4], Xiaojie Mao[2]

1. College of Economics and Management, Hunan Normal University, Hunan, China
2. School of Economics and Management, Wuhan University, Wuhan, China
3. School of Economics and Management, China Agricultural University, Beijing, China
4. Department of Agricultural and Resource Economics, University of Connecticut, CT, USA

Food Scares, Market Power and Farm-Retail Price Spread: The Case of Pork Market in China

Abstract: Pork market, as one of the most important food markets in China, is frequently exposed to food scare events such as Porcine Reproductive & Respiratory Syndrome (PRRS), Swine Influenza (SI), and Classical Swine Fever (CSF). This research first investigates the impact of food scare incidents on pork market in China with a theoretical framework, proving that if there is no market power, farm-retail price spread should be a function of marketing cost only. Using monthly data of pork retail price and pork producer price from 2001 to 2014, empirical analysis provides evidence that food scare events significantly influence both pork retail price and farm-retail price spread, indicating the existence of market power in Chinese pork market as well as the differential impact of food scares on retailers and producers.

Key words: food scares; market power; price spread; Chinese pork market

Introduction

China is the biggest pork producer in the world, with a record output of pork of 54.93 million tons in 2013, accounting for about 48% of the world pork products (National Bureau of Statistics of China, 2014). On the other side, pork is the most heavily consumed in China, compared to other important meats (e.g., chicken and beef). As shown in Figure 1, on average, the consumption of pork is four times as large as that of chicken and nearly eight times as large as that of beef.

Chinese pork industry is frequently exposure to food scare events such as Porcine Reproductive & Respiratory Syndrome (PRRS), Swine Influenza (SI), and Classical Swine Fever (SCF), which are documented as three main porcine diseases in China (Yang, 2010; Li and Yang, 2014; Cai, 2002), causing a huge economic loss of 10 billion RMB annually (Ding, 2011). These food scare events directly affect the supply of pork. PRRS, occurring in most major pig-producing areas throughout the world, is characterized by reproductive failure of sows and respiratory problems of piglets and growing pigs. The reproductive failure is characterized by infertility, late fetal mummification, abortions, stillbirths, and the birth of weak piglets that often die soon after birth from respiratory disease and secondary infections. Older pigs may demonstrate mild signs of respiratory disease, usually complicated by secondary infections. The Ministry of Agriculture of the People’s Republic of China (MAPRC) forbids the slaughter, transportation and transactions of hogs infected with or died from PRRS virus (MAPRC, 2007). SI is a highly contagious viral infection of pigs. The disease usually spreads very quickly within swine units, even though all infected pigs might not demonstrate clinical signs of infection, followed by a rapid recovery of the infected animals. Morbidity rates can reach 100% with SI infections, while mortality rates are generally low. MAPRC require farmers to kill and destroy all the hogs infected with or died from SI virus (MAPAC, 2009). Classical swine fever (CSF), formerly known as hog cholera, is a fatal disease in pig industry. It is also among the diseases included in List A of Office International des Epizooties (OIE) with mortality up to 80-90%. Similarly, MAPRC require farmers to kill and destroy any hogs infected with or died from CSF virus (MAPAC, 2009).

These food scare events also represent risks for consumers and generally affect pork consumption. Generally speaking, the outbreaks of porcine diseases will be reported simultaneously on websites, TV, newspapers, and magazines. Being exposure to these information, consumers might be aware of potential risks, thus decrease pork consumption. In a word, shocks to supply and demand caused a volatile market price and farm-retail price spread, undermining the profits of farmers and entrepreneurs, as well as the social welfare of the consumers.

Although important, food scare incidents in pork industry have received less attention in the literature. Previous research on the effect of food scare events has mainly focus on meat demand and prices. For example, Gardner (1975) is the first one to show how the farm-retail price spread changes when retail food demand, farm product supply, or the supply function of marketing services shifts. Piggott and Marsh (2004) found that the demand response to food safety concerns is small compared to price effects. Marsh et al. (2008) reported a minor short-term price effect on U.S. cattle prices due to two BSE events that occurred in North American. Schlenker and Villas-Boas (2009) further found a pronounced and significant reduction in beef sales following the BSE outbreak at the end of 2003. In the United Kingdom (UK), Leeming and Turner (2004) found that the BSE outbreak in 1996 significantly lowered the price of beef. However, most of these studies focus on scare events in beef market, with few studies analyzing food scare events in pork market, in particular, in China.

Price spread in red meat industry has been analyzed extensively (e.g., Armah, 2007; Brester &Marsh, 2001; Capps, Byrne & Williams, 1995; Marsh & Brester, 2004; Wohlgenant & Mullen, 1987), while only a few studies evaluate the effect of food scare events on price spreads. For example, Sanjuan and Dawson (2003) and Lloyd et al. (2006) analyzed the effect of the 1996 BSE-UK outbreak on price spreads in the beef sector and found a differentiated impact on retailers and producers. Price at the producer level fell by more than double compared to those at the retail level. Saghaian (2007) examined the impact of the BSE discovery in 2003 in the United States on the beef marketing chain and also found a differentiated impact on producers and retailers. This BSE event resulted in a widening of price spreads, pointing to imperfect price transmission in the industry. Hassouneh, Serra, and

Gil (2010) also found that BSE scares affect beef retailers and producers differently in the Spanish bovine market. However, research about effects of food scare events such as PRRS, SI and CSF on farm-retail price spread, particularly in China, is still lacking.

Few existing domestic literature shed light on food scare events in Chinese pork market from an economic perspective. For example, Zhang and Zhang (2011) investigated effect of aggregated exogenous shock on pork market, rather than specific food scare events. Qi et al. (2007) documented that animal disease is one of the most important factors that increases the pork retail price. However, they haven't analyzed them with a quantitative framework and gotten an accurate estimation. In a word, the effects of food scare events on Chinese pork market are still in a blank. A comprehensive framework to analyze this topic is required.

Following Capps, Jr et al. (2013), the analysis of potential effects of food scare events on Chinese pork supply chain requires considering certain aspects. First, because outbreaks of PRRS, SI, and CSF may occur simultaneously, it is important to isolate the effects of them when assessing their impacts on the marketing channel. Another aspect is that adjustments in the pork market are not necessary instantaneous after a food scare event (Schlenker and Villas-Boas, 2009). So here we account for immediate and lagged effects of food scare events on price spreads. We explore different model specifications and identify the optimal lagged effects with values of Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

Several contributions emanate from this work. We assess in detail the impact of three food scare events on the pork market, which is closely connected to the production and consumption of the most important red meat in China. Second, we jointly model these three food scare events and disentangle their effects on price spread. Previous studies only center their attention on some specific food scare event, ignoring that they might occur and affect the market simultaneously, which could lead to a biased estimation. Third, our empirical analysis provides evidence that market power exists in Chinese pork market. Overall, given changes in price spread may reflect changes in the efficiency and equity of the market system, the analysis of this study is useful to provide valuable information to policymakers about making strategies to the food scare events, to keep the stability of the market, and to minimize the welfare loss of consumers.

The remainder of this article is organized as follow. Section 2 and section 3 respectively, presents the theoretical model and empirical model. Section 4 describes the data used in this study. The estimation results are presented and discussed in section 5. Concluding remarks are given in section 6.

2. Theoretical model

Following Lloyd et al. (2006), the demand function of retail pork product is

$$Q = h(R, R^s, X), \tag{1}$$

where R denotes pork retail price, R^s denote retail prices of substitute goods, X denote demand shifters (e.g., food scare events). The supply function of live hog is given by

$$P = k(A, \Gamma), \tag{2}$$

where A is quantity of the live hogs and Γ are exogenous shifters in farm supply equation (e.g., animal disease incidents).

A representative firm i's profit maximization problem is:

$$\pi_i = R(Q)Q_i - P(A)A_i - C_i(Q_i), \tag{3}$$

where C_i denote other costs, for example, marketing cost. Q_i is quantity of pork products for firm i. We assume there is a fixed proportional technology, $Q_i = A_i/a$, where a is the input-output coefficient. The first-order condition for profit maximization is given by:

$$R + Q_i \frac{\partial R}{\partial Q}\frac{\partial Q}{\partial Q_i} = \frac{\partial C_i}{\partial Q_i} + aP + aA_i \frac{\partial P}{\partial A}\frac{\partial A}{\partial A_i}. \tag{4}$$

In order to get an explicit solution, equation (1) and (2) are both assumed to be linear, also, following Lloyd et al. (2006), we assume input-output coefficient a=1:

$$Q = h - bR + eR^s + cX, \tag{5}$$

$$P = d + \omega\Gamma + gS, \tag{6}$$

with supply S is given by

$$S = Q + N, \tag{7}$$

where N denotes exports which are exogenously determined.

Now aggregating over n firms based on equation (4), we get:

$$R - \frac{\theta}{b}Q = M + P + \mu g Q, \tag{8}$$

where $\theta = (\sum_i \frac{\partial Q}{\partial Q_i}\frac{\partial Q_i}{\partial Q})/n$ and $\mu = (\sum_i \frac{\partial A}{\partial A_i}\frac{\partial A_i}{\partial A})/n$ are average output and input conjectural elasticities respectively, interpreted as an index of market power with $\theta = \mu = 0$ representing competitive behavior and $\theta = \mu = 1$ representing collusive behavior. M denote all other costs that affect the retail–farm price spread. Following Lloyd et al. (2006), We assume a linear marketing cost function:

$$M = \gamma + \delta E + G \tag{9}$$

where γ is a constant, δE represents the costs of inputs from the marketing sector (for example, wages) and G represents regulatory costs, which are assumed to be exogenous and determined by government. Based on equation (5) (6) (7) (8) and (9), we have

$$Q = \frac{h+cX+eR^S-b\delta E-bG-bgN}{(1+\theta)+bg(1+\mu)}, \tag{10}$$

$$R = \frac{h+[(1+\theta)+bg(1+\mu)][\,(1-b)(G+gN)+(1-b\delta)E+cX+eR^S]}{(1+\theta)+bg(1+\mu)}, \tag{11}$$

and

$$P = \frac{g[h+cX+eR^S-b\delta E-bgG]-g[b-\left((1+\theta)+bg(1+u)\right)(N)]}{(1+\theta)+bg(1+\mu)}. \tag{12}$$

The retail-farm spread is defined as:

$$R-P = \frac{h\left(\frac{\theta}{b}+gu\right)+(1+bg)(\delta E+G)+\left(\frac{\theta}{b}+gu\right)(cX+eR^S)-(\theta+bgu)(gN)}{(1+\theta)+bg(1+\mu)}, \tag{13}$$

which shows that the retail-farm price spread depends on factors such as marketing costs, price of substitute goods, food scare events, as well as oligopoly and oligopsony power. As $\theta = \mu = 0$, equation (13) reduces to

$$R-P = \delta E + G, \tag{14}$$

which implies that in a perfectly competitive market, the farm-retail price spread is only determined by the marketing costs. Exogenous shifters (e.g., animal diseases) play no role in determining the relative gap between the prices at each stage of the food chain. In other words, if we find the price spread is also determined by other factors other than marketing costs, it implies that either oligopoly power or oligopsony power or both exist.

3. Empirical Model

A vector autoregressive (VAR) framework is applied in the empirical analysis. Consider a VAR (p) model:

$$X_t = \Phi_1 X_{t-1} + \Phi_2 X_{t-2} + \cdots + \Phi_p X_{t-p} + \Psi_0 w_t + \Psi_1 w_{t-1} + \cdots + \Psi_q w_{t-q} + \epsilon_t, \tag{15}$$

where X_t is a $n \times 1$ vector of endogenous variables, including price spread $PS_t = RP_t - PP_t$, and chicken retail price RC_t, where RP_t and PP_t are pork retail price and producer price respectively. Note that only prices of pork and chicken are included in empirical model, although there might be other candidates such as beef and lamb. The reasons are, first, chicken is a better substitute of pork, compared to other types of meat (e.g., beef and lamb). In China, prices of beef and lamb are much higher than that of pork and chicken. Second, our sample size is not enough if too many variables are included in the model. $\mathrm{w_t}$ is a $k \times 1$ vector of exogenous variables, which include variables such as oil price O_t, wage rate W_t, porcine diseases $PRRS_t$, SI_t and SF_t, and export EXP_t. Φ_i $(i = 1, \dots, p)$ and Ψ_j $(i = 0, \dots, q)$ *are* $(m \times n)$ and $(m \times k)$ matrices of coefficients to be estimated. ϵ_t is a $(m \times 1)$ vector of disturbances with zero mean and non-diagonal covariance matrix, Σ.

Prior to estimating the empirical model, we test the orders of integration for these variables, to guarantee the stationary of all variables. In addition, number of lags p and q are selected to achieve the minimum values of AIC and BIC. The stationary of the model system are confirmed with unit roots. Residuals should be serially uncorrelated.

4. Data

All data sets used in this study are monthly data from January 2001 to July 2014, with a total of 163 months. The retail prices of pork and chicken, price of live hogs, as well as export data are from official website of MAPRC. Oil price are obtained from the Wind database, which is monthly price of crude oil at Daqing oil field. Wage rate for employees in manufactural industry is smoothed monthly using seasonal wage rate data from Bureau of Statistics.

Information of diseases such as PRRS, SI, and CSF are collected from www.baidu.com, one of the most popular search engines in China, from which one can get news and information originated from newspaper, websites, and TV, etc. Generally speaking, the volume of news and reports online increase dramatically to the peak at the outbreak of diseases and decay as the diseases are brought under control. In this study, we create the index for the negative information shocks by taking logarithm of the numbers of news, which are used as a proxy for consumers' exposure to the negative information (i.e., demand shifter), and a proxy for shocks to supply as well (i.e., supply shifter).

Table 1 illustrate us the summary statistics of the main variables in this study. The mean of SI are higher than that of PRRS and CSF, indicating consumers are exposure to much more negative information of SI than that of the other two.

Figure 2 illustrates the incidences of three porcine diseases. PRRS outbreaks mainly in 2007 and keep active for nearly three years. SI outbreaks mainly in 2009 and continues in the following years. CSF outbreaks almost every year after 2004.

Figure 3 shows the trends of pork retail price and farm-retail price spread, corresponding to the outbreaks of PRRS and SI. Both pork retail price and price spread show an upward trend after the outbreak of PRRS, and a downward trend after that of SI. Note that CSF is not marked in figure 3, given that it outbreaks almost every year.

5. Empirical results

Prior to the estimation, variables are tested for the order of integration. Table 2 gives augmented Dickey-Fuller test statistics for all these variables in logarithm, which are all stationary after taking the first-order difference.

The lags for endogenous and exogenous variables are selected based on AIC and BIC. We find that the values of AIC and BIC reach the minimum and no serial correlation is found for the residuals if four lags for both endogenous variables and exogenous variables are taken. In addition, all the unit roots are located in the unit circle, implying that the VAR (4) system is stationary. Test results for serial correlation and stationary are given in the Appendix for simplicity.

Table 3 reports the empirical results for pork retail price. Pork retail price in one period lagged has a positive and significant effect on current price, while that in two and four periods lagged negatively impacts current pork retail price. Chicken retail price has a negative effect on pork retail price in one period lagged and four periods lagged, while a positive effect on pork retail price in three periods lagged.

As for the exogenous variables, wage rate positively affects pork retail price in two and three periods lagged, and negatively affects pork retail price in four periods lagged. The effect from oil price shock is around 0.084 and highly significant, without any lagged effects. Exports in all the four periods affect pork retail price positively and significantly, where the effect in three periods lagged is the largest.

PRRS, SI and CSF have differential effects on pork retail price, which attract our attention. The coefficients of PRRS are positive and highly significant in current period and in one period lagged, implying that PRRS incidents stimulate the rise of pork retail price. The reason could be that PRRS leads to abortions of sows and death of small piglets, resulting in shortage of supply. On contrast, SI negatively affects retail price significantly in one period lagged. One possible explanation is that SI is a relatively moderate disease with low mortality. Thus, SI won't affect supply severely. However, it could decrease demand as a type of negative information, resulting in a decline of pork retail price. CSF is a much more serious animal disease. Given CSF could sharply decrease pork supply and demand, the signs of coefficients of CSF depend on total effects of demand-side shock and supply-side shock. The estimated coefficients are all negative and significant in current period, as well as in one and two periods lagged, implying that negative effect on demand is much higher than that on supply.

Table 4 reports the estimation results for farm-retail price spread. The price spread in one period lagged positively and significantly impacts current price spread, while that in two periods lagged and in four periods lagged negatively affects current price spread. Chicken retail price in two and three periods lagged significantly increases the price spread.

Similarly, wage rate positively affects price spread in three periods lagged. Oil price shock has a positive effect on price spread. Export positively affects price spread positively and significantly in two periods lagged and three periods lagged.

Coefficients for food scare events are almost significant. PRRS affects price spread significantly in current period, one period lagged and three periods lagged, indicating that outbreaks of PRRS widen farm-retail price spread. In contrast, SI and CSF both narrow the price spread. Specifically, SI affects price spread in one period, two periods and three periods lagged. CSF has a negative effect on price spread in first four periods. In addition, the effect of CSF is larger than that of SI. This is because CSF is a much more severe animal disease compared to SI. These estimated results also imply these porcine diseases have a differential impact on retailers and producers. Based on our theoretical model, if there is no market power in Chinese pork market, price spread should be a function of inputs in marketing channel only. In other words, empirical results provide strong evidence that market power exists in Chinese pork market.

Figure 4 illustrates the impulse response functions as there is an endogenous shock from chicken retail price. The minimum effect and maximum effect on pork retail price happen, respectively, at period 1 and period 3, followed with fluctuations to zero till period 9. On the other side, the effect on price spread reaches the peak after first three periods, and declines from period 3 to period 7, then fluctuate to zero.

Figure 5, Figure 6 and Figure 7 illustrate the dynamic multiplier function for exogenous shocks of PRRS, SI and CSF. Figure 5 illustrates the effect of PRRS on pork retail price and price spread, which follow very similar patterns. Effects of PRRS go up during first period, and then decline dramatically till period 5, followed with fluctuations till both of them decay to zero. Figure 6 shows the effects of SI on pork retail price and price spread. Both two decrease first and bounce back, then fluctuate to horizon. Although patterns of them are similar, the impact of SI on price spread is much larger than that on pork retail price. In addition, roughly speaking, pork retail price responds to the shock of SI much more quickly than price spread does. Figure 7 describes the impacts of CSF on pork retail price and price spread. First, impact on pork retail price is much larger than that on price spread. In addition, both of two decrease at first two periods, and go up in the following seven periods, then go back to horizon at last.

6. Concluding Remarks

This paper investigates the effects of food scare events on Chinese pork market, with national monthly data from 2001-2014. A theoretical model is constructed based on the profit maximization problem for a representative firm, showing that if there is no market power, the farm-retail price spread should depends on marketing costs only, i.e., market power exists if other factors that significantly affects price spread are found. Empirically we estimate the VAR model for pork retail price and farm-retail price spread, as well as plot the impulse response function and dynamic multiplier function respectively for chicken retail price and three food scare events. Results provide evidence that other factors such as prices of substitutes, and porcine diseases also affect price spread, indicating market power exists in

Chinese pork market. In addition, food scare incidents are found to impact retail price and price spread differentially. For example, the effect of PRRS is positive, while effects of the other two are both negative, with differentiated magnitudes and time periods lagged. Last, empirical results point to imperfect price transmission in the industry.

This research provides implications for farmers, business managers and policy makers to make strategies in response to food scare events. Future research can be fruitful in two ways. First is obtaining higher quality data, for example, data in longer time period. The other way is to apply different approach, such as natural experiment, which could be promising.

References

Armah, S. E. (2007). An empirical analysis of recent changes in U.S. beef marketing spreads. Selected paper for the American Agricultural Economics Association Annual Meeting, Portland, OR, US, July 29–August 1.

Brester, G. W., and J. M. M. (2001). The effects of U.S. meat packing and livestock production technologies on marketing spreads and prices. Journal of Agricultural and Resource Economics, 26 (2), 445–462.

Cai, B. (2002). Problems and countermeasures for classical swine fever prevention in China. Animal Husbandry and Veterinary Medicine, 34(11), 1-4.

Capps, O., Colin-Castillo, S. and Hernandez M. (2013). Food recalls and disease outbreaks in the U.S. red meat industry. Agribusiness, 29(4), 426-454.

Capps, O., P. J. Byrne, and G. W. W. (1995). Analysis of marketing spreads in the U.S. lamb industry. Agricultural and Resource Economics Review, 24 (2), 232–240.

Ding, B. (2011). The epidemic characteristics of several main swine diseases. Veterinary Journal, 1, 19-22.

Gardner, B. (1975). The farm-retail price spread in competitive food industry. American Journal of Agricultural Economics, 57, 399-409.

Hassouneh, I., T. Serra, and J. M. Gil. (2010). Price transmission in the Spanish bovine sector: The BSE Effect. Agricultural Economics, 41 (1), 33–42.

Leeming, J., and P. Turner. (2004). The BSE crisis and the price of red meat in the U.K. Applied Economics, 36 (16), 1825–1829.

Li, J, and Yang, X. (2014). Research progress of highly pathogenic porcine reproductive and respiratory syndrome. Chinese Journal of Veterinary Medicine, 50(6), 61-63.

Lloyd, T. A., S. McCorriston, C. W. Morgan, and A. J. Rayner. (2006). Food scares, market power and price transmission: The U.K. BSE crisis. European Review of Agricultural Economics, 33 (2), 119–147.

Marsh, J. M., and G. W. Brester. (2004). Wholesale-Retail Spread Behavior in Pork and Beef. Journal of Agricultural and Resource Economics, 29 (1), 45–64.

Marsh, J. M., G. W. Brester, and V. H. Smith. (2008). Effects of north American BSE events on U.S. cattle prices. Review of Agricultural Economics, 30 (1), 136–150.

Marsh, T. L., T. C. Schroeder, and J. Mintert. (2004). Impacts of meat product recalls on consumer demand in the U.S.A. Applied Economics, 36 (9), 897–909.

Ministry of Agriculture of the People's Republic of China. (2007). Handbook of technology for prevention and control of highly pathogenic PRRS. http://www.ynagri.gov.cn/km/gd/n-ews1909/20090415/78635.shtml. Accessed on 10/20/2014.

Ministry of Agriculture of the People's Republic of China. (2009). Handbook of technology for prevention and control of SI. http://www. xjbzny.gov.cn/html/gonggao/2009-5/11/19_47_06_83.html. Accessed on 10/20/2014.

Ministry of Agriculture of the People's Republic of China. (2009). Handbook of technology for prevention and control of CSF. http:// www.czs.gov.cn/xmj/dwfy/content_126449.htm-l. Accessed on 10/20/2014.

Piggott, N. E., and T. L. Marsh. (2004). Does Food Safety Information Impact U.S. Meat Demand? American Journal of Agricultural Economics, 86 (1), 154–174.

Qi, Y., Lv jie, & Song, L. 2007. Economic analysis of fluctuations in the price of live hogs. Chinese Journal of Animal Science. 43(2), 31-35.

Saghaian, S. H. 2007. Beef Safety Shocks and Dynamics of Vertical Price Adjustment: The Case of BSE Discovery in the U.S. Beef Sector. Agribusiness, 23 (3), 333–348.

Sanjuan, A. I., and P. J. Dawson. (2003). Price transmission, BSE and structural breaks in the U.K. meat sector. European Review of Agricultural Economics, 30 (2), 155–172.

Schlenker, W., and S. B. Villas-Boas. (2009). Consumer and market responses to mad cow disease. American Journal of Agricultural Economics, 91 (4), 1140–1152.

National Bureau of Statistics of China. (2014). Statistical communique of the People's Republic of China on the 2013 national economic and social development. National Bureau of Statistics of China. http://www.stats.gov.cn/english/ PressRelease/201402/t201-40224515103.html. Accessed on 10/20/2014

Wohlgenant, M. K., and J. D. Mullen. (1987). Modeling the farm-retail price spread for beef. Western Journal of Agricultural Economics, 12 (2), 119–125.

Yang, H. (2010). Epidemic characteristics and problems in prevention and control of Swine

Fever in China. Animal Husbandry and Veterinary Medicine Daily, 5, 11-12.

Zhang, L., & Zhang, X. (2011). Impacts of external shocks on price of agricultural product in China: A perspective of agricultural industry chain. Management World, 1, 71-81.

Table 1. Summary statistics of main variables

Variable	Obs	Mean	Std. Dev.	Min	Max
RP	163	14.64	3.48	9.80	22.70
RC	163	10.70	1.25	8.35	13.30
PS	163	5.55	1.08	4.14	8.20
O	163	397.84	131.18	147.27	766.67
W	163	1933.17	780.97	778.63	3808.86
$PRRS$	163	122.57	530.55	0	6317
SI	163	1003.69	7124.51	0	78433
CSF	163	46.99	77.52	0	571
EXP	163	16640.87	4619.27	1150.00	31050.00

Table 2. Augmented Dickey-Fuller test statistics

Variable	Levels (lag)	Differences (lag)	Inference
$lnRP_t$	-1.85（2）	-7.90***（1）	$lnRP_t$ ~ I（1）
$lnRC_t$	-1.94（6）	-8.03***（1）	$lnRC_t$ ~ I（1）
$ln\,PS_t$	-1.53（8）	-8.00***（1）	$ln\,PM_t$ ~ I（1）
lnO_t	-2.32（1）	-7.00***（1）	lnO_t ~ I（1）
lnW_t	-2.64（12）	-4.85***（11）	lnW_t ~ I（1）
$lnPRRS_t$	-1.91（1）	-9.41***（1）	$lnPRRS_t$ ~ I（1）
$lnSI_t$	-1.45（1）	-10.91***（1）	$lnSI_t$ ~ I（1）
$lnCSF_t$	-1.84（1）	-12.36***（1）	$lnCSF_t$ ~ I（1）
$lnEXP_t$	-1.45（11）	-6.73***（13）	$lnEXP_t$~I（1）

Note：Lag length of the ADF regression was selected according to the SC (Schwarz Criterion) and AIC and is reported in parentheses adjacent to test statistics.

*** Significant at 1%

Table 3. Estimation Results for pork retail price

	Level	Lag(1)	Lag(2)	Lag(3)	Lag(4)
Endogenous					
$D.lnRP_t$	——	0.746***	-0.198*	0.127	-0.183**
	——	(0.086)	(0.105)	(0.107)	(0.087)
$D.lnRC_t$	——	-0.249***	0.052	0.189**	-0.138*
	——	(0.086)	(0.082)	(0.084)	(0.086)
Exogenous					
$D.lnW_t$	-0.011	-0.013	0.059*	0.101*	-0.081*
	(0.043)	(0.049)	(0.036)	(0.057)	(0.050)
$D.lnO_t$	0.084***	-0.031	-0.020	0.025	0.003
	(0.030)	(0.031)	(0.031)	(0.029)	(0.028)
$D.lnPRRS_t$	0.014***	0.009**	0.002	0.002	-0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$D.lnSI_t$	-0.002	-0.004**	0.001	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$D.lnCSF_t$	-0.010***	-0.015***	-0.009**	-0.004	0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$D.lnEXP_t$	0.012**	0.028***	0.041***	0.034***	0.011*
	(0.005)	(0.008)	(0.010)	(0.009)	(0.006)
$Constant$	0.001	——	——	——	——
	(0.002)	——	——	——	——

Note: This table reports the results for equation of pork retail price only, i.e., the dependent variable is pork retail price. Standard errors are reported in parentheses.

*** Significant at 1%

** Significant at 5%

* Significant at 10%

Table 4. Estimation results for farm-retail price spread

	Level	Lag(1)	Lag(2)	Lag(3)	Lag(4)
Endogenous					
$D.lnPS_t$	——	0.261***	-0.229**	0.002	-0.216**
	——	(0.092)	(0.095)	(0.103)	(0.090)
$D.lnRC_t$	——	0.132	0.217**	0.282**	-0.021
	——	(0.114)	(0.110)	(0.111)	(0.112)
Exogenous					
$D.lnW_t$	0.080	-0.077	0.066	0.165**	-0.026
	(0.055)	(0.063)	(0.046)	(0.072)	(0.064)
$D.lnO_t$	0.115***	0.035	0.008	0.037	0.022
	(0.039)	(0.041)	(0.041)	(0.038)	(0.037)
$D.lnPRRS_t$	0.014***	0.015***	0.008	0.009*	-0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$D.lnSI_t$	-0.0001	-0.009***	-0.008***	-0.004*	-0.002
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
$D.lnCSF_t$	-0.015***	-0.018***	-0.013**	-0.012**	-0.0004
	(0.005)	(0.006)	(0.006)	(0.006)	(0.005)
$D.lnEXP_t$	0.004	0.015	0.031***	0.030***	0.007
	(0.007)	(0.011)	(0.012)	(0.011)	(0.007)
$Constant$	-0.001	——	——	——	——
	(0.003)	——	——	——	——

Note: This table reports the results for equation of farm-retail price spread only, i.e., the dependent variable is price spread. Standard errors in parentheses。

*** Significant at 1%

** Significant at 5%

* Significant at 10%

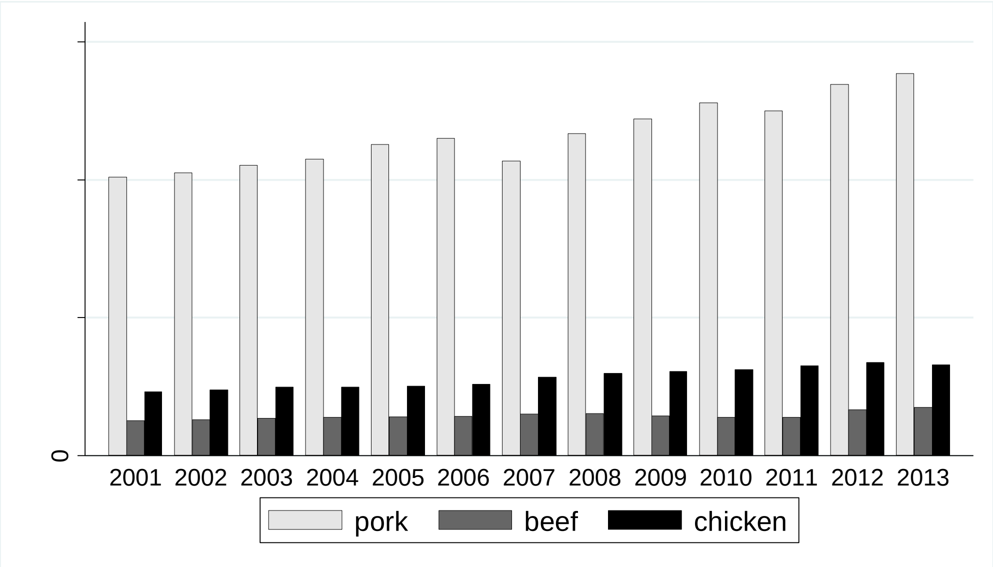

Figure 1. Consumption of pork, beef and chicken in China during 2001-2013

Data source: World Agricultural Supply and Demand Estimates, USDA

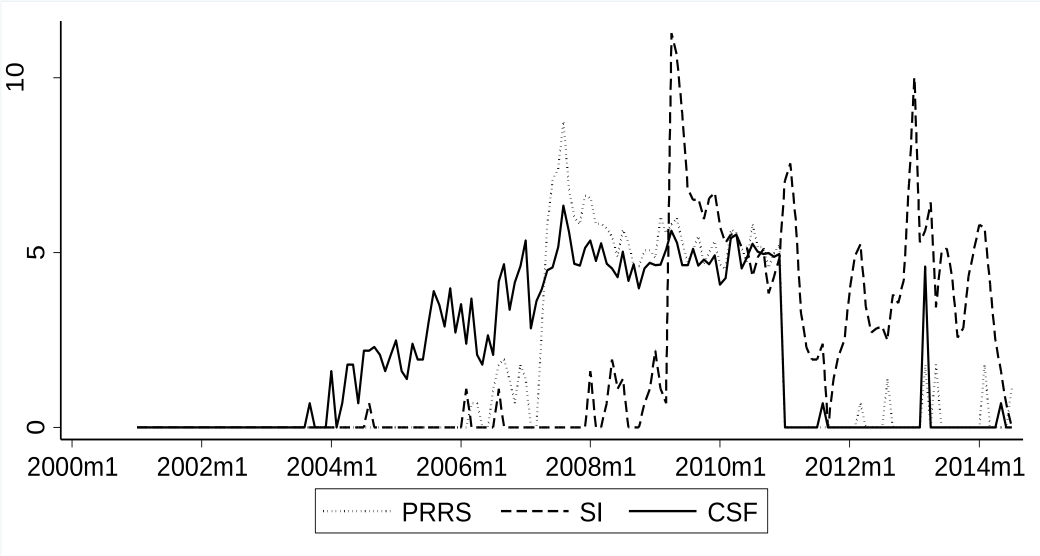

Figure 2. Index for PRRS, SI and CSF during 2001-2014

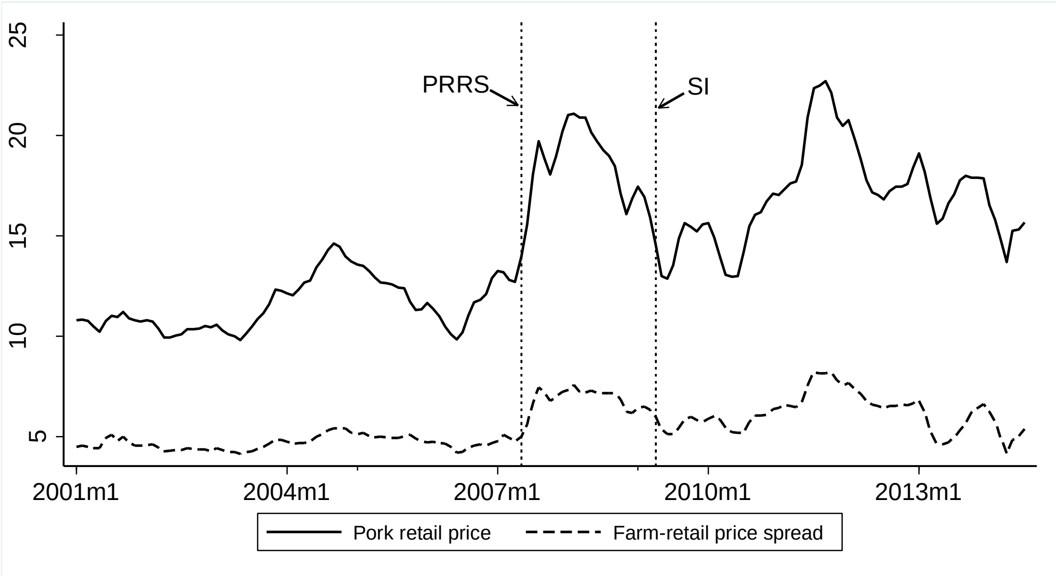

Figure 3. Trends of pork retail price and farm-retail price spread during 2001-2014

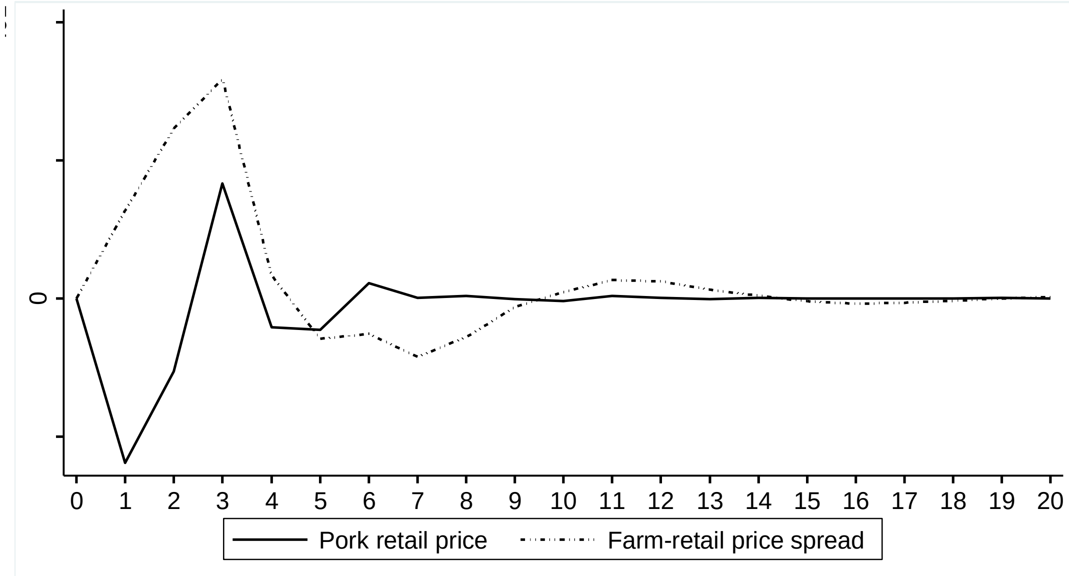

Figure 4. The simulated dynamic effect of a (one standard error) shock from chicken retail price (impulse response function)

Figure 5. The simulated dynamic effect of a (one standard error) shock from PRRS (dynamic multiplier function)

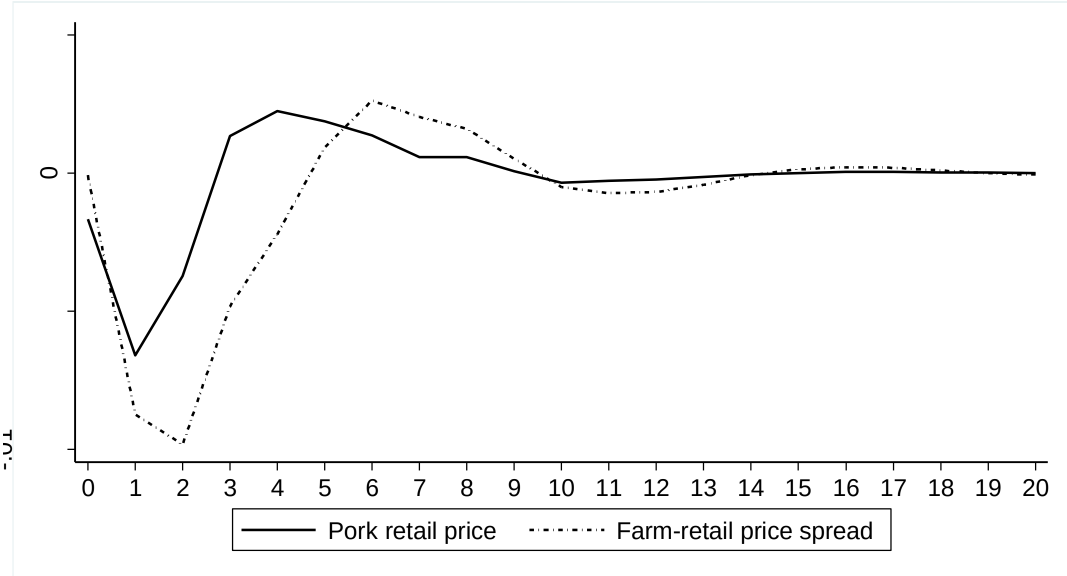

Figure 6. The simulated dynamic effect of a (one standard error) shock from SI (dynamic multiplier function)

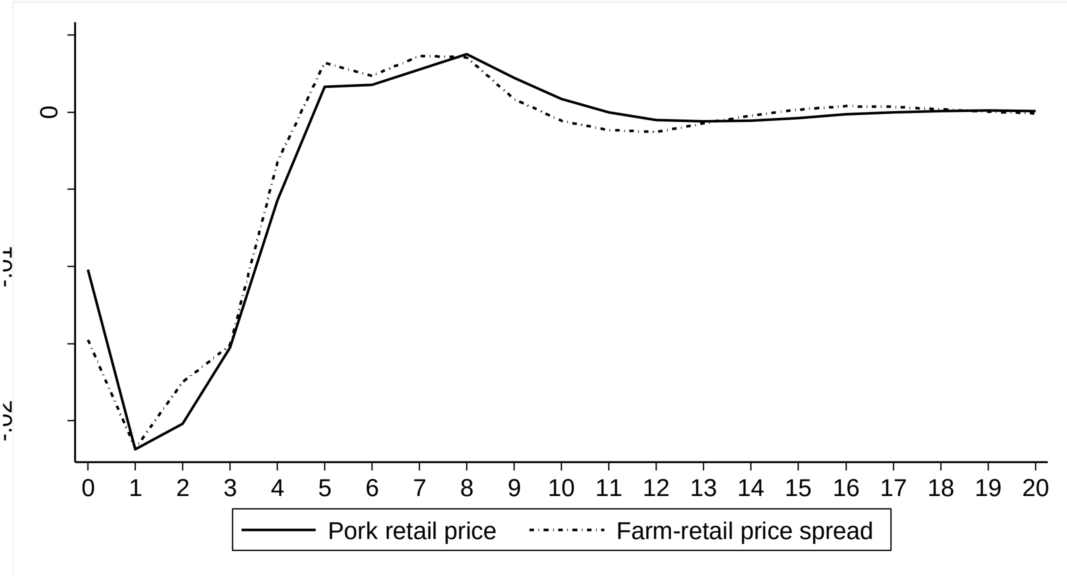

Figure 7. The simulated dynamic effect of a (one standard error) shock from CSF (dynamic multiplier function)

Appendix

Test for equation of pork retail price

Table A1. Lagrange-multiplier test for serial correlation

lag	chi2	df	Prob>chi2
1	0.999	4	0.910
2	0.653	4	0.957
3	3.651	4	0.455
4	2.203	4	0.698
5	4.911	4	0.297

H0: no autocorrelation at lag order

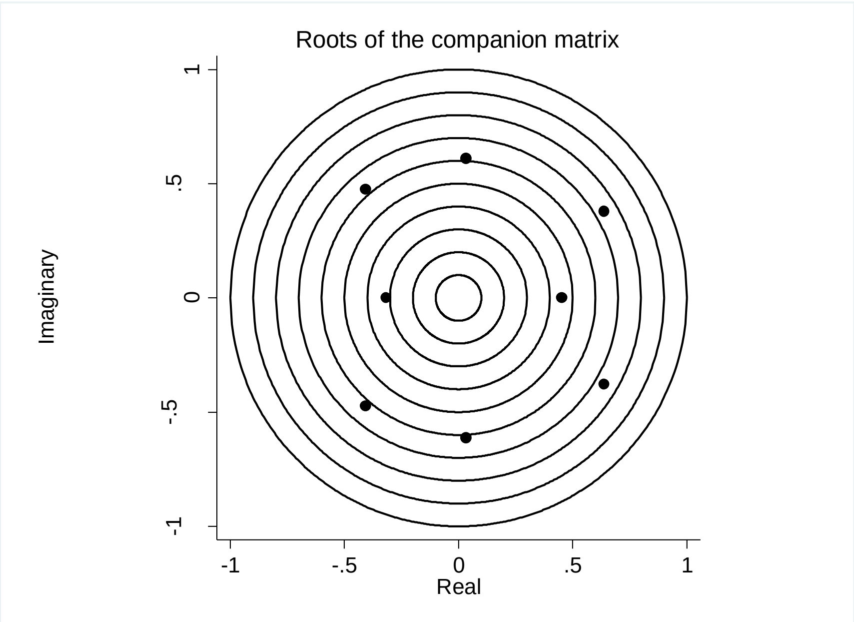

Figure. A1. Test for stationary of VAR system

Test for equation of farm-retail price spread

Table A2. Lagrange-multiplier test for serial correlation

lag	chi2	df	Prob>chi2
1	7.110	4	0.130
2	0.440	4	0.979
3	1.286	4	0.864
4	4.707	4	0.319
5	6.969	4	0.138

H0: no autocorrelation at lag order

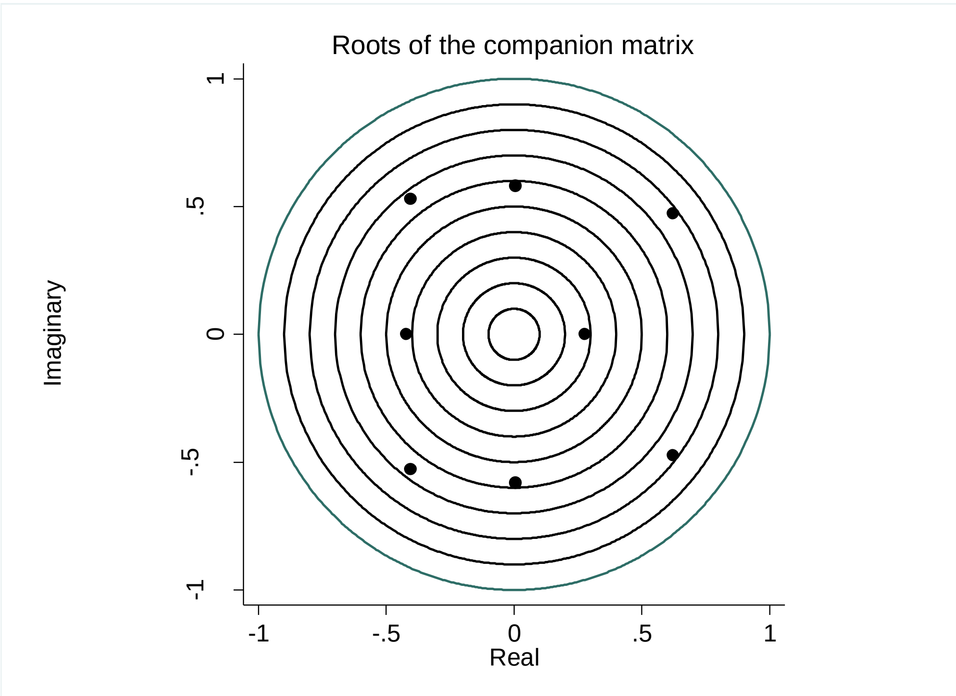

Figure. A2. Test for stationary of VAR system