Jiawu DAI*, Xun LI and Xiuqing WANG*****

Food scares and asymmetric price transmission: the case of the pork market in China

This paper investigates the symmetry of impact from three main food scare events on both the upstream and downstream price transmissions in the Chinese pork market through monthly data from 2001 to 2014. Based on a theoretical model, we firstly estimate the VAR systems for pork retail price and price transmissions in different links, and then plot the impulse response function and dynamic multiplier function respectively for endogenous substitute good price and exogenous food scare events. Empirical results indicate the asymmetry of price transmission in the Chinese pork market, and demand and supply shocks from three food scare incidents are found to impact retail price and price transmissions differentially. In addition, shocks from the same incident on price and price transmissions are significantly different. This research provides implications for farmers, business managers and policy makers to make strategies in response to food scare events[1].

Keywords: porcine reproductive and respiratory syndrome, swine influenza, classical swine fever, price transmission

* Hunan Normal University, Hunan Sheng, People's Republic of China.
** College of Economics and Management, Wuhan University, Wuhan, Hubei, People's Republic of China, 430072. Corresponding author: li.xun@whu.edu.cn
*** China Agricultural University, Beijing Shi, People's Republic of China.

Introduction

China is the biggest pork producer in the world with, according to National Bureau of Statistics of China data, a record output of 54.93 million tonnes in 2013, accounting for about 48 per cent of the world pork products. On the other side, pork is the most heavily consumed meat in China. According to USDA World Agricultural Supply and Demand Estimates, the consumption of pork is on average four times as high as that of chicken and nearly eight times as high as that of beef.

The Chinese pork industry is frequently exposed to food scare events such as porcine reproductive and respiratory syndrome (PRRS), swine influenza (SI) and classical swine fever (CSF), which are documented as being the three main porcine diseases in China (Cai, 2002; Yang, 2010; Li and Yang, 2014) and result in an economic loss of RMB 10 billion annually (Ding, 2011). These food scare events directly affect the supply of pork.

PRRS occurs in most major pig-producing areas throughout the world and is characterised by reproductive failure of sows and respiratory problems of piglets and growing pigs. This reproductive failure includes infertility, late foetal mummification, abortions, stillbirths, and 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 the 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 show clinical signs of infection, followed by a rapid recovery of the infected animals. Morbidity rates can reach 100 per cent with SI infections, while mortality rates are generally low. The MAPRC requires farmers to kill and destroy all hogs infected with or died from the SI virus (MAPAC, 2009a).

CSF, formerly known as hog cholera, is a fatal disease in the pig industry. It is among the diseases included in List A of the Office International des Epizooties with mortality up to 80-90 per cent. Similarly, the MAPRC requires farmers to kill and destroy any hogs infected with or died from CSF virus (MAPAC, 2009b).

These food scare events are also deemed as risks for consumers to different extents and usually affect pork consumption. The least risky disease is PRRS as its virus can be killed under high temperature. Though SI is not a real threat for human health in veterinary medicine, for the virus is not easily transmitted from swine to human beings, it does result in scares on pork consumption at the beginning of an outbreak due to ignorance. Conversely, CSF is a substantial threat for pork consumption because pork infected with the CSF virus is inevitably harmful for human health in terms of salmonella food poisoning. In general, outbreaks of porcine diseases are reported simultaneously on websites, television, newspapers and magazines, and consumers could be exposed to this information and aware of the potential risk, thus decreasing pork consumption.

Shocks to supply and demand can cause a volatile market price and price transmission in different links, undermining the profits of farmers and entrepreneurs, as well as the social welfare of consumers. As the biggest pork producer and consumer in the world, China has been perplexed by the frequently-occurring hog diseases and corresponding economic losses. As a consequence, it is of both academic and policy significance to study this phenomenon.

Literature review

Price transmission in food industries has been analysed extensively, but few studies have been conducted on the pork market. Abdulai (2002) applies threshold cointegration tests to examine the relationship between producer and retail pork prices in Switzerland and verifies an asymmetric price transmission between these two links. Using the endogenous break date estimation procedures, Adachi and Liu (2009) identify four breaks in the retail-farm price relationship in the Japanese pork market. Similar empirical results are

[1] An earlier, unreviewed version of this paper was presented at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Francisco CA, 26-28 July 2015.

demonstrated in the U.S. pork market (Boetel and Liu, 2010; Gervais, 2011). Farm-retail price transmission in the Hungarian pork market is found to be symmetric in the long term (Bakucs and Fertő, 2005), but asymmetric in the short term (Bakucs and Fertő, 2009).

Market power is regarded as one of the most important factors inducing asymmetric price transmission in pork markets. For example, Cechura and Sobrova (2008) confirm that oligopsony power in the processing stage is a main cause of asymmetric price transmission in the Czech pork meat agri-food chain. Asymmetric price transmission in the long term in the Swedish pork industry is also deemed to be caused to a great extent by market power (Karantininis *et al*., 2011). Other factors found to be correlated with asymmetric price transmission include menu costs, inflation, government intervention and stock management; see Bakucs *et al.* (2014) for a review.

Although price transmission is empirically tested widely, only a few studies evaluate the effect of food scare events on price transmission, especially in the pork market. Several classic works shed light on examining the cases in beef markets (e.g. Sanjuan and Dawson, 2003; Piggott and Marsh, 2004; Leeming and Turner, 2004; Lloyd *et al.*, 2006; Saghaian, 2007; Marsh *et al.*, 2008; Schlenker and Villas-Boas, 2009; Hassouneh *et al*., 2010). Nevertheless, research on the effects of food scare events such as PRRS, SI and CSF on price transmission in the pork market is still lacking. In addition, almost all of the existing empirical studies paid attention to only one stage between the farm gate and the retailer, or the upstream stage between the purchase of inputs and the sale of agricultural products (e.g. Ward, 1982; Carlton 1986; Kinnucan and Forker, 1987; Hannan and Berger, 1991; Neumark and Sharpe, 1992; Griffith and Piggott, 1994; v. Cramon-Taubadel, 1998; Borenstein *et al*. 1997; Goodwin and Holt, 1999; Abdulai 2000; Peltzman, 2000; Goodwin and Piggott, 2001; Miller and Hayenga, 2001; Chavas and Mehta, 2004; Acharya *et al*. 2011; Shrinivas and Gómez, 2016). It is significant both in theory and policy to calculate the price transmission in the upstream and downstream simultaneously through a systematic framework.

Following Capps *et al*. (2013), the analysis of potential effects of food scare events on the Chinese pork supply chain requires the consideration of certain aspects. Firstly, 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. Secondly, as adjustments in the pork market are not necessarily instantaneous after a food scare event (Schlenker and Villas-Boas, 2009), understanding the time periods lagged of the effects is important for both policymakers and business managers. So here we account for immediate and delayed effects of food scare events on price transmissions. 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. Firstly, 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. Secondly, we jointly model these three food scare events and disentangle their effects on price transmission. Previous studies only centre their attention on some specific food scare event, ignoring that they might occur and affect the market simultaneously and differentially, which could lead to a biased estimation. Thirdly, we attempt to test the price transmissions in both the upstream and downstream of China's pork industry via a systematic framework. Overall, given changes in price transmission may reflect changes in the efficiency and equity of the market system, this study provides valuable information to policymakers about responding to food scare events, to maintain the stability of the market and to minimise welfare loss of consumers.

Methodology

Theoretical and econometric methods

In order to build a theoretical framework for testing price transmission, we firstly assume a pork retail price equation as follows:

$$RP_t = I(X_t) + F(M_t) + N_{Rt} + \epsilon_t \quad (1)$$

where RP_t is pork retail price, $I(X_t)$ represents endogenous variables affecting pork retail price, $F(M_t)$ represents marketing costs such as transportation and wage for processing link, and N_{Rt} represents impact from exogenous demand and supply shocks on pork retail price.

Similarly, the hog price equation is assumed as follows:

$$PP_t = G(X_t) + N_{Pt} + \xi_t \quad (2)$$

where PP_t is hog price, $G(X_t)$ represents endogenous variables affecting hog price, and N_{Pt} represents impact from exogenous demand and supply shocks on hog price.

Subtract equation (2) from (1), we have:

$$RP_t - PP_t = \alpha_H[I(X_t) - G(X_t)] + \alpha_F F(M_t) + \alpha_N(N_{Rt} - N_{Pt}) + \varepsilon_t \quad (3)$$

If $N_{Rt} = N_{Pt}$, then exogenous shocks would exert the same impact on pork retail price and hog price, i.e. the pork-hog price transmission is symmetric under the shock of exogenous shifters.[2] Conversely, if the coefficient of N is significant in equation (3), then asymmetry of price transmission may exist. The deductions are similar for the upstream price transmission equations between hog and piglet prices, and we omit the details.

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

$$X_t = \Phi_1 X_{t-1} + \Phi_2 X_{t-2} + \cdots + \Phi_p X_{t-p} + \Psi_0 w_t + \Psi_1 w_{t-1} + \cdots + \Psi_q w_{t-q} + \epsilon_t \quad (4)$$

where X_t is a $n\times1$ vector of endogenous variables, including pork retail price RP_t, chicken retail price RC_t representing the price of substitute good, and price margin in two different

[2] As implied by the right hand side of equation (3), the significance of endogenous $[I(X_t) - G(X_t)]$, and exogenous $F(M)$ may also indicate the asymmetry of pork-hog price transmission. However, this is not the main point of this study, as we are more interested in the food scares.

links, i.e. the downstream $RPP_t = RP_t - PP_t$ (margin between pork retail price RP_t and hog price PP_t) and the upstream $PPL_t = PP_t - LP_t$ (margin between hog price PP_t and piglet price LP_t). w_t is a $k \times 1$ vector of exogenous variables, which include marketing cost such as oil price O_t, wage W_t, and exogenous demand shocks such as information about porcine diseases (D_PRRS_t, D_SI_t and D_SF_t), supply shocks such as the slaughter and died volume of hogs infected by PRRS (S_PRRS_t) and SCF (S_CSF_t)[3] and net export EXP_t. $\Phi_i (i=1, \ldots, p)$ and $\Psi_j (i=0, \ldots, q)$ 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.

Price margin in two different links are represented as measurement of price transmission. As mentioned above, price margin could not be significantly affected by any other variables except marketing costs, such as wage and transportation, in the intermediate stage. In other words, price transmission would be asymmetric if its explanatory variables except marketing costs are statistically significant.

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

Data

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

Information on diseases such as PRRS, SI and CSF are collected from the www.baidu.com, from which news and information originating from newspapers, websites and television etc. can be gathered. Volumes of information about food scare events are collected as a proxy for consumers' exposure to the negative information. In general, the volumes of news and reports online increase dramatically to a 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 logarithms of the numbers of news. On the contrary, quantities of slaughter and died infected hogs induced from PRRS and CSF are collected from the MAPRC *Official Veterinary Bulletin*, representing the supply shocks of PRRS and CSF respectively.

[3] There were no hogs slaughtered and died in the case of SI, for SI is only a common, mild disease for pigs.

Table 1: Summary statistics of the main variables used in this study (n=163).

Variable	Mean	Std. dev.	Minimum	Maximum
RP	14.64	3.48	9.80	22.70
PP	9.09	2.48	5.62	14.55
LP	17.84	8.92	6.84	38.24
RC	10.70	1.25	8.35	13.30
FP	1.97	0.29	1.54	2.43
W	1,933.17	780.97	778.63	3,808.86
O	397.85	131.18	147.27	766.67
D_PRRS	1.64	2.47	0.00	8.75
D_SI	1.91	2.64	0.00	11.27
D_CSF	2.00	2.15	0.00	6.35
S_PRRS	40,336.20	142,136.40	0.00	1,116,780.00
S_CSF	97,730.80	112,992.70	0.00	608,820.00
LNEXP	9.65	0.46	7.05	10.34

Source: own calculations

Table 1 presents the summary statistics of the main variables in this study. The mean of *D_SCF*, on average, is higher than that of *D_PRRS* and *D_SI*, indicating consumers are exposed to much more negative information on SCF than of the other two diseases.

Figure 1 shows the incidences of three porcine diseases. PRRS outbreaks mainly in 2007 and stays active for nearly three years. SI outbreaks mainly in 2009 and continues in the following years, while CSF outbreaks almost every year since 2004. Figure 2 shows the trends of pork retail price and pork-hog price transmission, corresponding to the outbreaks of PRRS and SI. Both pork retail price and price transmis-

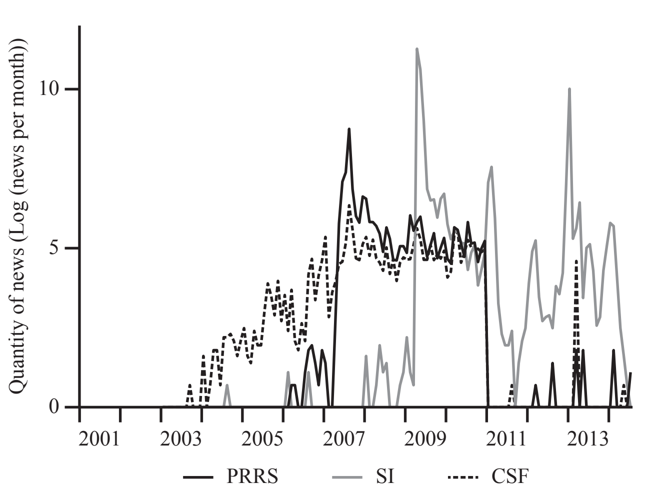

Figure 1: Incidences of the porcine diseases PRRS, SI and CSF, 2001-2014.

Source: own composition

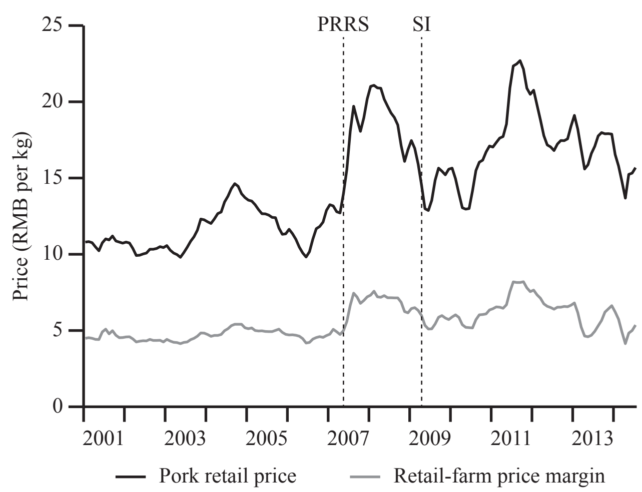

Figure 2: Trends of pork retail price and farm-retail price transmission, 2001-2014.

Source: own composition

sion 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 2, given that it breaks out almost every year.

Results and discussion

Prior to the estimation, variables are tested for the order of integration. Table 2 gives augmented Dickey-Fuller test statistics for all variables, which are all stationary after taking the first-order difference. The lags for endogenous and exogenous variables are selected based on AIC and BIC.

Pork retail price

Pork retail price is directly impacted by exogenous shocks, and selected as the benchmark to distinguish differential effects on different links. For the equation of pork retail price, we find that the values of AIC and BIC reach the minimum and no serial correlation is found for the residuals at the 5 per cent significant level if four lags for both endogenous 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 Annex for simplicity.

Empirical results of the VAR system for pork retail price are reported in Table 3, from which the differential effects from food scares on pork retail price are evident. The coefficients of *D_PRRS* are positive and highly significant in current period and one period lagged, implying that PRRS incidents stimulate the rise of pork retail price. The reason could be that the outbreak of PRRS was not regarded as a serious threat for people's health. On the contrary, the expectation of pork shortage resulting from PRRS would prompt consumers to purchase more pork. In addition, both *D_SI* and *D_CSF* negatively affect retail price significantly in current and one period lagged. As mentioned above, the possible explanation is that SI and CSF could decrease demand as a type of negative information, resulting in a decline of pork retail price.

Table 2: Augmented Dickey-Fuller test statistics of the main variables used in this study.

Variable	Levels (lag)	Differences (lag)	Inference
RP	-2.468 (2)	-8.083*** (1)	*RP* ~ I (1)
PP	-2.564 (2)	-8.097*** (1)	*PP* ~ I (1)
LP	-2.709 (4)	-4.152*** (4)	*LP* ~ I (1)
RC	-1.624 (6)	-2.639* (11)	*RC* ~ I (1)
FP	-2.749 (1)	-5.160*** (4)	*FP* ~ I (1)
W	-1.539 (12)	-4.635*** (11)	*W* ~ I (1)
O	-2.610 (1)*	-7.136*** (1)	*O* ~ I (1)
D_PRRS	-1.911 (1)	-9.406*** (1)	*D_PRRS* ~ I (1)
D_SI	-1.446 (10)	-10.908*** (1)	*D_SI* ~ I (1)
D_CSF	-1.836 (1)	-12.360*** (1)	*D_CSF* ~ I (1)
S_PRRS	-1.658 (10)	-11.992*** (1)	*S_PRRS* ~ I (1)
S_CSF	-1.117 (11)	-4.772*** (12)	*S_CSF* ~ I (1)
LNEXP	-1.514 (12)	-11.241*** (11)	*LNEXP* ~ I (1)

Lag length of the ADF regression was selected according to the SC (Schwarz Criterion) and AIC (Akaike Information Criterion) and is reported in parentheses adjacent to test statistics; ***/**/*: statistically significant at the 1%, 5%, and 10% levels respectively
Source: own calculations

Similarly, the supply shock from PRRS at current and one period lagged positively and significantly impact pork retail price, while supply shock from CSF at current term negatively and significantly impacts the retail price. These empirical results accord with the reality well, because the PRRS would significantly lead to reproductive failure, i.e. reduction of pork supply, and thus raise pork prices, while the death and slaughter resulting from CSF as well as the gloomy expectation would aggravate farmers' and retailers' scares and push them to undersell inventory.

As for the other 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 0.003 and highly significant in the current period, but -0.002 in the two periods lagged. Exports in all the four periods affect pork retail price positively and significantly, where the effect in three periods lagged is largest.

For the endogenous variables, pork retail price in one and three periods lagged have a positive and significant effect on current price, while that in two and four periods lagged negatively impacts current pork retail price. The chicken retail price has a significantly negative effect on pork retail price in one and four periods lagged, and a positive but insignificant effect on pork retail price in two and three periods lagged.

Price transmission

Two links of price transmission will be tested in this study. According to the AIC criterion, VAR(4) is appropriate on testing the pork-hog price transmission. All of the other variables apart from wage and oil price are significant in current and/or lagged periods (Table 4). It means that the pork-

Table 3: Estimation results for pork retail price.

	Current	Lag(1)	Lag(2)	Lag(3)	Lag(4)
Endogenous					
RP	—	0.7741***	-0.2037**	0.1975*	-0.1523*
	—	(0.0857)	(0.1043)	(0.1078)	(0.0847)
RC	—	-0.3739***	0.0959	0.1293	-0.2522**
	—	(0.1225)	(0.1212)	(0.1259)	(0.1239)
Exogenous					
W	-0.0002	-0.0001	0.0007**	0.0008*	-0.0009**
	(0.0003)	(0.0003)	(0.0003)	(0.0005)	(0.0004)
O	0.0030***	-0.0019*	-0.0001	0.0011	-0.0015
	(0.0012)	(0.0012)	(0.0012)	(0.0011)	(0.0011)
D_PRRS	0.1980***	0.1096*	0.0119	0.0625	0.0096
	(0.0574)	(0.0636)	(0.0658)	(0.0634)	(0.0564)
D_SI	-0.0402*	-0.0860**	-0.0012	0.0380	0.0300
	(0.0278)	(0.0294)	(0.0317)	(0.0317)	(0.0308)
D_CSF	-0.1994***	-0.2365***	-0.0969	-0.0423	0.0083
	(0.0561)	(0.0658)	(0.0682)	(0.0651)	(0.0540)
S_PRRS	7.76E-07***	7.87E-07**	-1.86E-07	2.08E-08	1.53E-07
	(2.88E-07)	(3.37E-07)	(3.52E-07)	(3.56E-07)	(3.06E-07)
S_CSF	-7.73E-07*	-2.12E-08	2.17E-07	-4.45E-07	-3.54E-07
	(4.06E-07)	(4.42E-07)	(4.31E-07)	(4.32E-07)	(3.99E-07)
LNEXP	0.2384**	0.4306***	0.5328***	0.3940***	0.1359*
	(0.0985)	(0.1509)	(0.1714)	(0.1475)	(0.0810)
Constant	0.0146	—	—	—	—
	(0.0302)	—	—	—	—

Only the results for equation of pork retail price are reported here, i.e. the dependent variable is pork retail price; standard errors are reported in parentheses
***/**/*: statistically significant at the 1%, 5%, and 10% levels respectively
Source: own calculations

Table 4: Estimation results for pork-hog price transmission.

	Current	Lag(1)	Lag(2)	Lag(3)	Lag(4)
Endogenous					
RP–PP	—	0.2450***	-0.1981**	0.0627	-0.1945**
	—	(0.0923)	(0.0927)	(0.0972)	(0.0829)
RC	—	0.0808	0.1241**	0.1138*	-0.0308
	—	(0.0589)	(0.0576)	(0.0599)	(0.0586)
Exogenous					
W	0.0002*	-0.0003*	0.0003**	0.0006**	-0.0002
	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0002)
O	0.0021***	-0.0002	0.0003	0.0008*	-0.0002
	(0.0006)	(0.0006)	(0.0006)	(0.0005)	(0.0005)
D_PRRS	0.0791***	0.0710**	0.0527*	0.0660**	0.0213
	(0.0269)	(0.0300)	(0.0311)	(0.0302)	(0.0266)
D_SI	-0.0083	-0.0655***	-0.0567***	-0.0158	-0.0065
	(0.0129)	(0.0133)	(0.0148)	(0.0152)	(0.0147)
D_CSF	-0.1017***	-0.1090***	-0.0664**	-0.0543*	-0.0207
	(0.0264)	(0.0315)	(0.0329)	(0.0324)	(0.0259)
S_PRRS	1.810E-07	3.490E-07**	6.130E-08	-2.250E-07	-1.360E-07
	(1.370E-07)	(1.590E-07)	(1.670E-07)	(1.670E-07)	(1.420E-07)
S_CSF	-4.430E-07**	-1.220E-07	-2.560E-07	-3.900E-07	-1.320E-07
	(1.940E-07)	(2.110E-07)	(2.060E-07)	(2.060E-07)	(1.890E-07)
LNEXP	0.0566	0.1267*	0.1756**	0.1269*	0.0336
	(0.0468)	(0.0714)	(0.0807)	(0.0685)	(0.0374)
Constant	-0.0061	—	—	—	—
	(0.0143)	—	—	—	—

Only the results for equation of farm-retail price transmission are reported here, i.e. the dependent variable is price transmission; Standard errors in parentheses
***/**/*: statistically significant at the 1%, 5%, and 10% levels respectively
Source: own calculations

hog price margin and then welfare distribution are affected not only by marketing costs, but also by some other factors such as price of substitute good, food incidents and export, verifying the obvious asymmetry of pork-hog price transmission in China's pork market.

Coefficients of three demand shocks are almost significant. *D_PRRS* affects pork-hog price transmission significantly lasting for four periods (i.e. from three periods lagged to current period), indicating that outbreaks of PRRS widens pork-hog price margin, which means pork retailers will be more profitable under the PRRS shock.[4] In contrast, both SI and CSF narrow the price margin. Specifically, SI negatively affects price transmission in one and two periods lagged, and CSF has a negative effect on price transmission in the first four periods. In addition, the effect of CSF is more enduring and powerful than that of SI. This is because CSF is a much more severe animal disease compared to SI. These estimated results also imply the porcine diseases have a differential impact on retailers and producers.

Meanwhile, shocks of diseases from supply side are less significant. Only the one period lagged of *S_PRRS* is significant and similar situation also exists in the supply shock of CSF. Not surprisingly, pork export and two kinds of marketing costs tend to enlarge the price margin (except in two periods lagged of wage). In other words, it means these variables increase pork retail price more than hog price.

The VAR(2) are selected on testing the upstream hog-piglet price transmission (PPL_t) based on the AIC criterion. Compared to the pork-hog price transmission, coefficients in the hog-piglet system are less significant (Table 5). In three food scares, only the demand shock of SI in one period lagged is significant and positive. While in two supply shocks resulted from food incidents, only PRRS in one period lagged is significant and negative.

Table 5: Estimation results for hog-piglet price transmission.

	Current	Lag(1)	Lag(2)
Endogenous			
RP–PP	—	0.6137***	-0.0487
	—	(0.0840)	(0.0811)
RC	—	-0.0880	-0.2112
	—	(0.1840)	(0.1852)
Exogenous			
W	0.0018***	0.0003	-0.0005
	(0.0004)	(0.0005)	(0.0004)
O	-0.0045**	0.0006	0.0004
	(0.0021)	(0.0021)	(0.0020)
D_PRRS	-0.0891	-0.0100	0.1452
	(0.1018)	(0.1079)	(0.0987)
D_SI	0.0365	0.1689***	0.0080
	(0.0501)	(0.0501)	(0.0540)
D_CSF	0.0861	0.1309	-0.0530
	(0.0970)	(0.1070)	(0.0944)
S_PRRS	2.260E-07	-1.230E-06**	-4.590E-07
	(4.970E-07)	(5.660E-07)	(5.140E-07)
S_CSF	3.550E-07	-2.690E-07	-4.300E-07
	(7.250E-07)	(7.760E-07)	(7.100E-07)
LNEXP	-0.3661***	0.0331	0.1500
	(0.1295)	(0.1655)	(0.1237)
Constant	-0.0458	—	—
	(0.0565)	—	—

According to the AIC criterion, VAR (2) is the best choice; only the results for equation of farm-retail price transmission are reported here, i.e. the dependent variable is price transmission; standard errors in parentheses
***/**/*: statistically significant at the 1%, 5%, and 10% levels respectively
Source: own calculations

Furthermore, only current period of the other three exogenous variables are significant, of which wage is positive but oil price and export are negative. The endogenous chicken price is insignificant in all periods. These results indicate that price transmission from hog to piglet market cannot be easily

[4] The authors consulted several Chinese butchers who experienced the 2007 PRRS crisis and get conclusions that are completely consistent with our empirical results.

impacted by food incidents, especially by PRRS and CSF. In other words, the pork-hog price transmission is more asymmetric than the hog-piglet one, which means more attention should be paid to the former facing porcine disease shocks.

Dynamic simulations

The impulse response function (IRF) proposed by Koop *et al*. (1996) and Pesaran and Shin (1997) is applied to observe the dynamic effects from endogenous variables on pork price and price transmissions. Figure 3 illustrates the IRF as there is an endogenous shock from chicken retail price. The minimum negative effect on pork retail price and two upstream price transmissions happen at one or two periods lagged, followed with fluctuations to zero until period 8. On the other side, the effect on pork-hog price transmission reaches the peak after the first three periods, declines from period 3 to period 7, then returns to zero gradually.

Unlike Lloyd *et al.* (2006), we use the Dynamic Multiplier Function (DMF) to test the impact of a unit increase in exogenous shocks on the endogenous price transmission, which is recognised to be more appropriate (Lütkepohl, 2005).

Figure 4 illustrates the effects of *D_PRRS* on pork retail price and price transmissions, which follow very similar patterns. All the three kinds of effects of *D_PRRS* rise at the beginning periods, and then decline dramatically until period 5, followed with fluctuations and decay to zero. The difference is that effects of *D_PRRS* on hog-piglet price transmission at the first two periods are negative, while effects on others are always positive, which is very meaningful for policy implications.

The effect processes of *D_SI* on pork retail price and pork-hog price transmissions are very analogous, i.e. drop to a minimum negative value at the first period, and then bounce back to horizon (Figure 5). Although patterns of them are similar, the impact on pork retail price is larger than those on price transmissions, suggesting that the pork retailer is more profitless than swineherds under the shock of SI. On the contrary, the effect on hog-piglet price transmission reaches a maximum positive value at the first period, followed with continuous decrease to zero. It means an amplifying hog-piglet price transmission existing in the upstream under the shock of SI. Therefore, it is not difficult to conclude that in the case of SI shock, swineherds in the middle of the chain

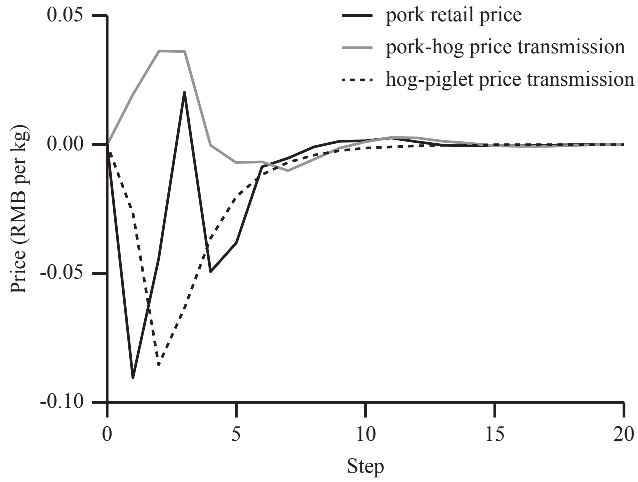

Figure 3: The simulated dynamic effect of a (one standard error) shock from chicken retail price (impulse response function).
Source: own composition

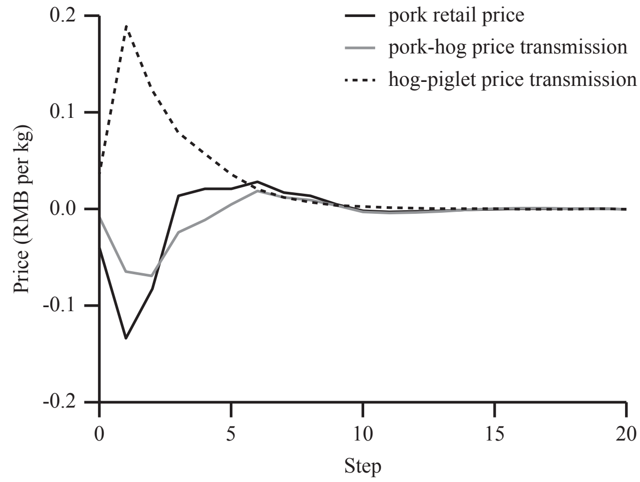

Figure 5: The simulated dynamic effect of a (one standard error) shock from SI (dynamic multiplier function).
Source: own composition

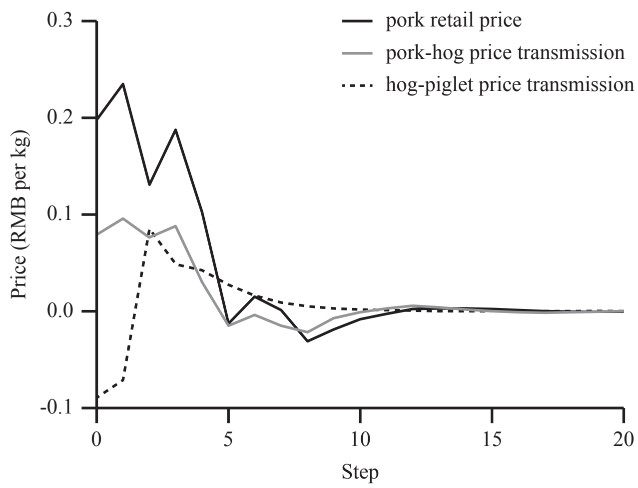

Figure 4: The simulated dynamic effect of a (one standard error) shock from PRRS (dynamic multiplier function).
Source: own composition

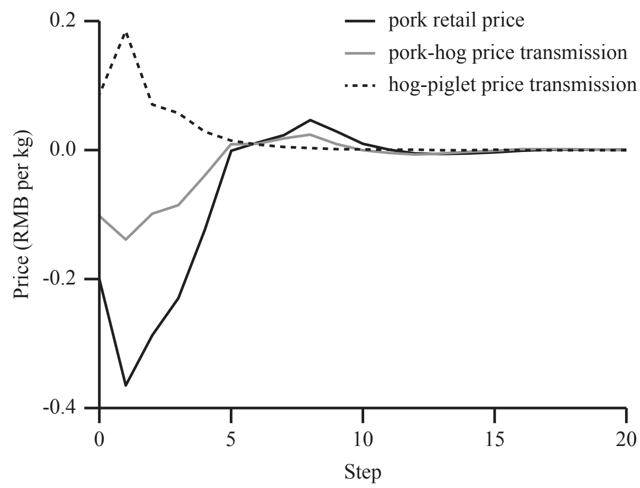

Figure 6: The simulated dynamic effect of a (one standard error) shock from CSF (dynamic multiplier function).
Source: own composition

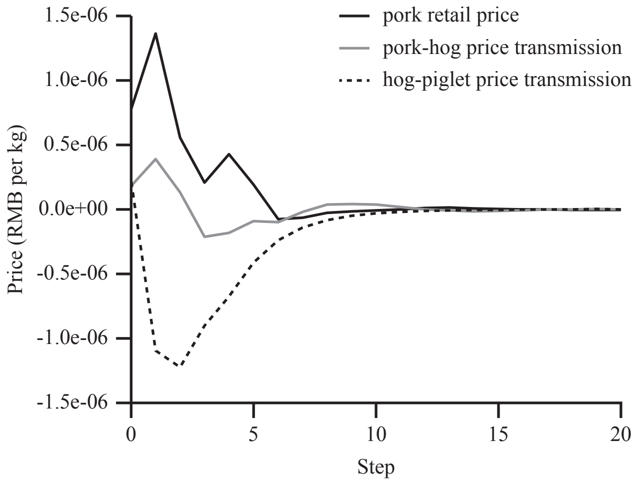

Figure 7: The simulated dynamic effect of a (one standard error) shock from S_PRRS (dynamic multiplier function)

Source: own composition

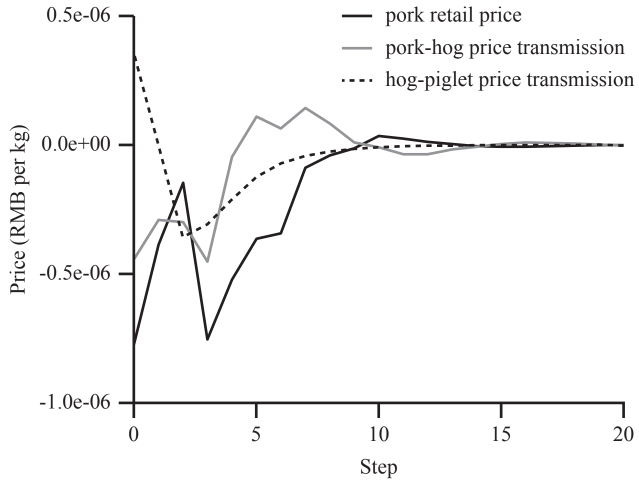

Figure 8: The simulated dynamic effect of a (one standard error) shock from S_CSF (dynamic multiplier function).

Source: own composition

are profitable as they can get a positive margin, while piglet farmers and pork retailers are very likely loss-making.

Figure 6 describes the impacts of *D_CSF* on pork retail price and price transmissions. Similarly, the impacts on pork price and pork-hog price transmission bottom out during the first period, and then recover to zero quickly. It is notable that the negative shock on pork retail price is much deeper than that on the pork-hog price transmissions. In addition, the effect process of *D_CSF* on hog-piglet price transmission tends to be totally opposite, which peaks at the first period and then drops quickly. Its implications are very similar with those for SI.

The effects of two exogenous supply shocks from PRRS and CSF are described in Figures 7 and 8. The increase of slaughter and death resulting from PRRS would push up the pork price and pork-hog price transmission to the maximum values at the first period, and then pull them down to zero gradually (Figure 7). The positive effect on pork price is significantly larger than that on pork-hog price transmission. On the contrary, impact on hog-piglet price transmission is negative and bottoms out at the second period and finally goes back to zero. Apparently, in the case of supply shock of PRRS, swineherds are loss-making, while both piglet farmers and pork retailers are winners with price margins. In comparison, the dynamic effects from the supply shock of CSF are more complicated and irregular (Figure 8).

Conclusions

This paper investigates the symmetry of impact of three main food scare events on farm and retail prices in the Chinese pork market, with national monthly data from 2001 to 2014. Based on a simple theoretical model, we estimate the VAR systems for pork retail price and price transmissions in different links, as well as plot the impulse response function and dynamic multiplier function respectively for endogenous substitute good price and exogenous food scare events.

Compared with previous studies, this paper jointly models three main food scare events and disentangles their effects on price transmission between both the upstream and downstream stages in the Chinese pork market. Empirical results correspond well with the reality and provide implications for farmers, business managers and policy makers to make strategies in response to food scare events. The biggest enlightenment is to respond differentially and flexibly for different market participants under different shocks. Future research can be fruitful in two ways. The first is obtaining higher quality data, for example, data for a longer time period. The second is to improve theoretical models and empirical procedures.

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Annex

Test for equation of pork retail price

Table A1: Lagrange-multiplier test for serial correlation for the equation of pork retail price.

lag	chi^2	df	Prob > chi^2
1	0.405	4	0.982
2	1.861	4	0.761
3	3.776	4	0.437
4	2.324	4	0.676
5	6.817	4	0.146

H0: no autocorrelation at lag order.
Source: own calculations

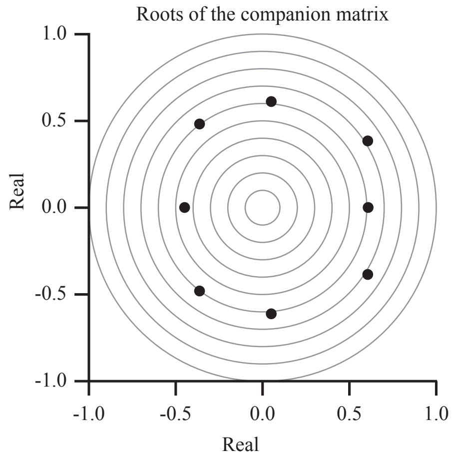

Figure A1: Test for stationary of VAR system of pork retail price.
Source: own composition

Test for equation of pork-hog price transmission

Table A2: Lagrange-multiplier test for serial correlation.

lag	chi^2	df	Prob > chi^2
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
Source: own calculations

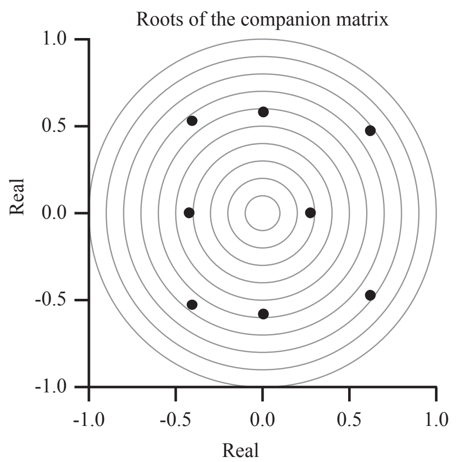

Figure A2: Test for stationary of VAR system.
Source: own composition

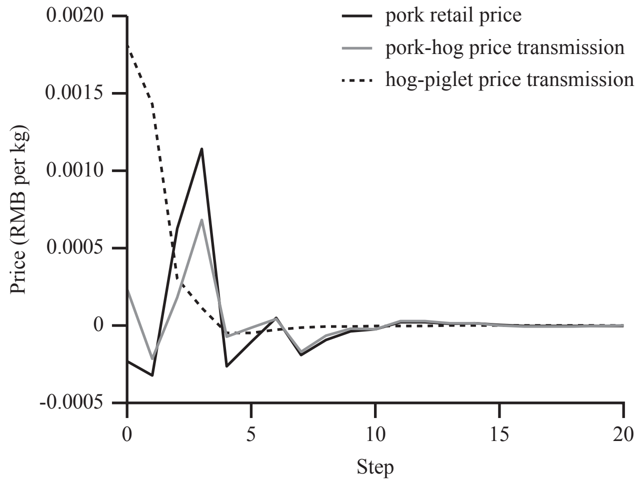

Figure A3: The simulated dynamic effect of a (one standard error) shock from wage (dynamic multiplier function).
Source: own composition

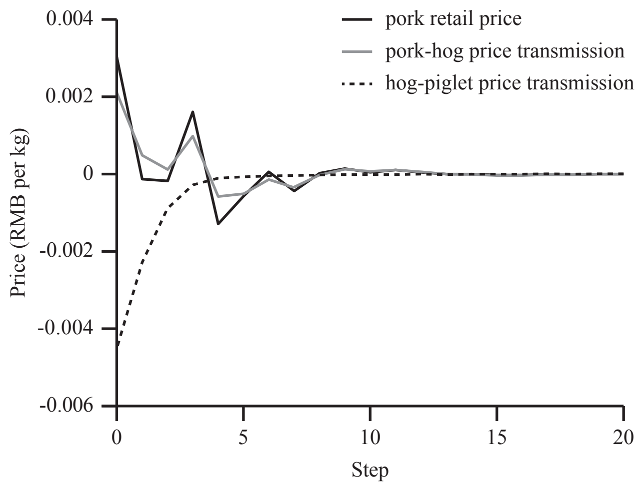

Figure A4: The simulated dynamic effect of a (one standard error) shock from oil price (dynamic multiplier function).
Source: own composition

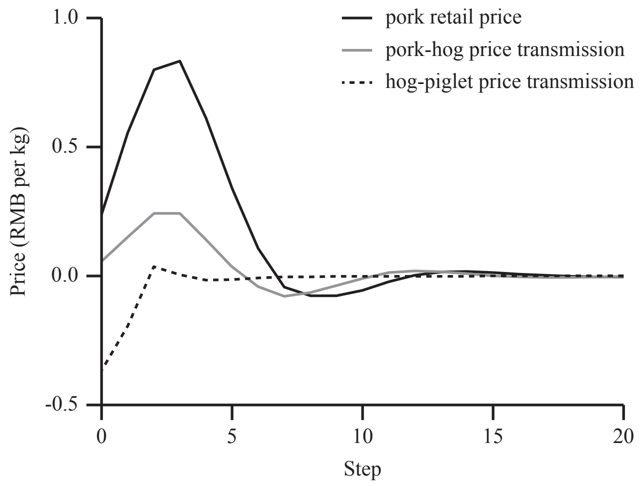

Figure A5: The simulated dynamic effect of a (one standard error) shock from LNEXP (dynamic multiplier function).
Source: own composition