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ARTICLE

Price volatility and price transmission in perishable commodity markets: evidence from Chinese lychee markets

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Q2

ABSTRACT

This paper examines price volatility and price transmission in lychee markets in China. The empirical results provide strong evidence of price volatility clustering in farm and retail markets, and the farm prices exhibit negative asymmetric volatility. We find a bi-directional Granger causal relationship between farm prices and retail prices. The impulse analysis shows that the retail price responses to farm price shocks reach the maximum value faster than the farm price responses to retail price shocks. Retail price shocks cause larger short-run positive effects on farm prices. The variance decomposition indicates that the long-run effects of retail price shocks on farm price changes are larger than the effects of farm price shocks on retail price changes.

KEYWORDS

Lychee market; perishable commodity; price volatility; price transmission

JEL CLASSIFICATION

Q11; Q13; C22

I. Introduction

This paper provides an empirical assessment of price dynamics regarding price volatility and price transmission in farm and retail lychee markets. While focusing on China, which is the largest lychee producer worldwide, we discuss the roles of market power and product perishability in explaining lychee market dynamics.

Our research topic is relevant to three research streams in the literature. First, existing studies using monthly and weekly data suggest that price adjustments and asymmetry patterns between different markets are closely related to the intensity of product perishability (Ward 1982). However, a potential shortcoming of these studies is that monthly and weekly data may be inappropriate to reflect price adjustment processes because perishable products require short price transmissions that often occur within days (Meyer and Von Cramon-Taubadel 2004). The second set of studies is related to the cause of asymmetric price transmission. In addition to product perishability, several other theories are also useful in explaining asymmetric price transmission, such as market power (Griffith and Piggott 1994), adjustment costs (Peltzman 2000), etc. The studies belonging to the third stream are concerned with empirical methods used to measure price volatility in agricultural commodities (e.g. Buguk, Hudson, and Hanson 2003; Gutierrez, Piras, and Paolo Roggero 2014).

Although previous studies have investigated price dynamics in many perishable agricultural commodity markets, lychee price dynamics have not been analyzed to date. Using unique survey data, we adopt a series of econometric models, including generalized autoregressive conditional heteroskedasticity (GARCH) family models, the Granger causality test, the impulse response function (IRF), and the forecast error variance decomposition (FEVD), to investigate farm and retail prices in Chinese lychee markets. Our work contributes to the literature investigating price dynamics in perishable agricultural commodities (Michelson, Reardon, and Perez 2012). To the best of our knowledge, this paper is the first to study lychee price dynamics in farm and retail markets. Section II describes the data and methodologies. Section III presents the results, and Section IV concludes the paper.

II. Data and methodologies

The data on daily farm and retail prices come from the Lychee and Longan Industry Survey of

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China. All prices are adjusted to real values using the monthly national-level consumer price index with May 2012 as the base month. Due to planting cycles and seasonal characteristics, lychee data are available during harvest seasons from May to July each year. The final sample consists of 343 observations from 4 May 2012 to 25 July 2016. The summary statistics of the key variables are reported in Table 1.

We adopt GARCH family models to measure price volatility. The mean equation in a GARCH(1,1) model is given by $y_t = \alpha_0 + \sum_{i=1}^{T} \alpha_i y_{t-i} + \epsilon_t$, where y_t is the price at time t, and T is the lag length. Given that $\epsilon_t = \sigma_t e_t$ and $e_t \sim N(0,1)$, the conditional variance is given by $\sigma_t^2 = \beta_0 + \beta_1 \epsilon_{t-1}^2 + \gamma \sigma_{t-1}^2$, where $\beta_0 > 0, \beta_1 \geq 0$ and $\gamma \geq 0$. The GARCH-in-mean (GARCH-M) model is given by $y_t = \alpha_0 + \sum_{i=1}^{T} \alpha_i y_{t-i} + \phi \sigma_t^2 + \epsilon_t$, where ϕ captures the effect of the conditional variance on the price in the mean equation. Because the GARCH and GARCH-M models cannot capture asymmetric performances, we consider asymmetric volatility models. In a Threshold GARCH (TGARCH) model, the conditional variance is specified as $\sigma_t^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \gamma \sigma_{t-1}^2 + \lambda \epsilon_{t-1}^2 \cdot 1(\epsilon_{t-1} > 0)$, where $1(\cdot)$ equals 1 if $\epsilon_{t-1} > 0$ and 0 otherwise. λ captures the asymmetric volatility effects. $\lambda < 0$ implies that negative shocks increase price volatility more than positive shocks. In an Exponential GARCH (EGARCH) model, which relaxes the parameter restrictions, the conditional variance is given by $ln(\sigma_t^2) = \beta + \theta(\epsilon_{t-1}/\sigma_{t-1}) + \eta|\epsilon_{t-1}/\sigma_{t-1}| + \kappa ln(\sigma_{t-1}^2)$. θ captures the asymmetric volatility effects. $\theta < 0$ implies that negative shocks increase price volatility more than positive shocks of the same magnitude. To test the conditional correlation between farm and retail prices, we modify the GARCH model from univariate to bivariate settings based on Bollerslev (1990). In the bivariate GARCH (1,1) model, the mean equation is given by $y_{it} = \mu_i + \epsilon_{it}$, where μ_i is a conditional mean. The conditional variance is specified as $\sigma_{iit}^2 = \omega_i + \alpha_{i1} \epsilon_{it-1}^2 + \beta_{i1} \sigma_{iit-1}^2$. $\sigma_{ijt}^2 = \rho_{ij} (\sigma_{iit}^2 \sigma_{jjt}^2)^{1/2}$, where i and j represent the farm and retail prices, respectively. ρ_{ij} measures the constant conditional correlation between farm and retail prices.

To investigate price transmissions, we adopt a vector autoregression (VAR) model as follows: $Y_t = A + \Pi_1 Y_{t-1} + \ldots + \Pi_p Y_{t-p} + \mu_t$, where Y_t is a 2×1 vector of lychee prices at time t. A is a 2×1 vector of constants. Π_p is a 2×2 matrix of coefficients. p is the lag length. μ_t is a 2×1 vector of random errors (innovations) assumed to be uncorrelated with their lagged values and past prices. Based on the VAR framework, we employ the Granger causality test, the impulse response function, and the forecast error variance decomposition.

III. Results

Table 2 reports the results of the unit root tests. The null hypothesis results of the Dickey-Fuller test, the Augmented Dickey-Fuller test, and the Phillips Perron test are rejected, suggesting that all variables are stationary at the log levels. In Table 3, we perform the Lagrange Multiplier test to investigate the time-varying patterns of price volatility. The results show strong evidence of price volatility clustering in both farm and retail markets. Table 4 reports the estimation results of the volatility models. In the GARCH(1,1) model, the sums of β_1 and γ are close to 0.8 in farm and retail prices, suggesting high levels of persistent price volatility. Additionally, as ϕ is significant at the 1% level, the GARCH-M(1,1) model confirms the presence of GARCH-M effects on both prices. We employ the TGARCH(1,1) and EGARCH(1,1) models to detect asymmetric volatility effects. The results of both models provide strong evidence of negative asymmetric volatility in farm prices but minimal asymmetric volatility in retail prices. Our results are consistent with the view presented in some studies, such as Rezitis and Stavropoulos (2010), stating that negative shocks

Table 1. Summary statistics.

Variable (RMB/kg)	Sources	Mean	Std. Dev.	Min	Max	Obs
Real Farm Prices	Test Stations	8.15	3.08	1.91	17.58	343
Real Retail Prices	Fixed Survey Sites	22.04	8.18	8.89	55.44	343

Table 2. Unit root tests.

	Log Farm Prices	Log Retail Prices
Test Types	(1)	(2)
Dickey-Fuller Test	−5.345***	−6.795***
Augmented Dickey-Fuller Test	−3.874***	−3.937***
Phillips-Perron Test	−4.802***	−6.256***

All tests include the constant term. *** denotes significance at the 1% level.

Table 3. Lagrange multiplier tests.

Test Statistics	p = 1		p = 5		p = 10	
	nR^2	F-test	nR^2	F-test	nR^2	F-test
Panel A: Log Farm Prices						
k = 1	10.35***	10.62***	24.06***	5.09***	44.57***	4.98***
k = 2	9.21***	9.41***	25.76***	5.48***	37.29***	4.06***
k = 3	9.3***	9.5***	25.79***	5.49***	37.19***	4.05***
Panel B: Log Retail Prices						
k = 1	9.06***	9.25***	26.69***	5.69***	26.69***	2.96***
k = 2	3.45*	3.46*	25.03***	5.31***	27.6***	2.91***
k = 3	3.24*	3.25*	22.18***	4.67***	24.22***	2.53***

The models of the log farm prices and log retail prices follow the autoregressive process order of k = 1, 2, 3. p is the lag length of the squared fitted residuals. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

increase farm price volatility more than positive shocks of the same magnitude. This phenomenon is reasonable in the Chinese lychee farm market. Farmers who face positive shocks tend to slowly increase prices since they fear sales losses to their competitors. Because lychees are highly perishable products and cannot be stored easily or well on farms, farmers facing negative shocks tend to sell lychees at lower prices to avoid greater sales losses. Compared to relatively stable demands, the increased farmers' supply lowers farm prices, further stimulating farmers to sell their lychees at low prices. It is worth noting that the estimates of the above GARCH family models are invalid if both price volatilities are strongly interdependent. To address this concern, we adopt a bivariate GARCH(1,1) model to examine the conditional correlation between farm and retail price volatilities. Table 5 reports that the conditional correlation coefficient ρ_{ij} (0.019) does not significantly differ from zero, suggesting that our GARCH results are applicable. Table 6 reports the results of the Granger causality tests. We find the existence of bi-directional causality between farm and retail prices. In Figure 1, we adopt an IRF analysis to investigate dynamic price transmissions. The results shown in both panels suggest that (1) the responses of retail prices to farm price shocks react faster to the maximum value than do the responses of farm prices to retail

Table 4. Estimation results of the volatility models.

Coefficient	GARCH(1,1)	GARCH-M(1,1)	TGARCH(1,1)	EGARCH(1,1)
Panel A: Log Farm Prices				
Mean Equation				
α_0	0.1761 (0.0499)***	0.1168 (0.0593)**	0.2001 (0.0618)***	0.2233 (0.0538)***
α_1	0.6096 (0.0600)***	0.6162 (0.0596)***	0.6186 (0.0547)***	0.6276 (0.0472)***
α_2	0.3031 (0.0611)***	0.3059 (0.0586)***	0.2783 (0.0535)***	0.2582 (0.0466)***
ϕ		1.2631 (0.4725)***		
Variance Equation				
β_1	0.2151 (0.0502)***	0.2541 (0.0583)***	0.3808 (0.0977)***	
γ	0.6031 (0.056)***	0.4825 (0.0581)***	0.6741 (0.0526)***	
λ			−0.3624 (0.1036)***	
θ				−0.2291 (0.0362)***
Observations	341	341	341	341
Log Likelihood	90.8529	93.6341	99.2428	97.2317
Diagnostics				
AIC	−169.7057	−173.2682	−184.4856	−180.4635
BIC	−146.7144	−146.4450	−157.6624	−153.6403
Panel B: Log Retail Prices				
Mean Equation				
α_0	0.3374 (0.1107)***	0.1598 (0.0989)	0.2598 (0.1086)**	0.4172 (0.1201)***
α_1	0.5358 (0.0756)***	0.4731 (0.0683)***	0.5685 (0.0648)***	0.4971 (0.0477)***
α_2	0.2002 (0.0696)***	0.2299 (0.0603)***	0.1888 (0.0664)***	0.2099 (0.0509)***
α_3	0.1463 (0.0569)***	0.2144 (0.5336)***	0.1494 (0.0484)***	0.1515 (0.0455)***
ϕ		1.8441 (0.4452)***		
Variance Equation				
β_1	0.3227 (0.1182)***	0.4621 (0.1169)***	0.3217 (0.1815)*	
γ	0.4198 (0.1446)***	0.2374 (0.0870)**	0.2471 (0.1056)**	
λ			0.3511 (0.2679)	
θ				0.0588 (0.0307)*
Observations	340	340	340	340
Log Likelihood	70.3547	78.8112	70.4676	54.201
Diagnostics				
AIC	−126.7095	−141.6223	−124.9351	−92.4021
BIC	−99.9068	−110.9908	−94.3036	−61.7705

For each price, the lag length of the autoregressive process in the mean equation is determined by the AIC's minimum value. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 5. Bivariate GARCH(1,1) model.

Coefficient	Log Farm Prices	Log Retail Prices
μ_i	−0.003(0.009)	−0.022(0.010)**
ω_i	0.009(0.002)***	0.014(0.003)***
α_{i1}	0.362(0.088)***	0.566(0.133)***
β_{i1}	0.492(0.078)***	0.275(0.083)***
ρ_{ij}	0.019(0.052)	

*** and ** denote significance at the 1% and 5% levels, respectively.

price shocks and (2) retail prices have larger short-run positive shocks on farm prices than vice versa. These findings are consistent with some studies, such as Abdulai (2002), stating that the imperfect competition in the retail market allows retailers to utilize market powers, which affects asymmetric price transmission in terms of speed and extent. Table 7 presents the FEVD results to assess the economic significance of price shocks. We find that variability in farm (retail) price changes can be minimally explained by retail (farm) price shocks on the first day, but the explained proportion increases to more than 10% after six weeks. These results suggest that there is a certain degree of linkage between farm and retail prices in the short run and that retail price shocks tend to cause larger long-run effects on farm price changes.

IV. Conclusions

This paper investigates Chinese lychee markets to improve the understanding of price dynamics in terms of price volatility and price transmission in the perishable commodity market. We find strong evidence of price volatility clustering in both farm and retail prices. The results also suggest that ignoring the leverage effect may lead to misleading inferences about price volatility in farm prices. In the analysis of price transmission, we find that the causality between farm prices and retail prices is bi-directional in the Granger sense. We also show that retail price shocks have larger impacts on farm prices in the IRF and FEDV analysis, which is

Table 6. Granger causality tests.

Null Hypothesis	Log $P_{retail} \neq>$ Log P_{farm}		Log $P_{farm} \neq>$ Log P_{retail}	
Day Lag	F statistic	χ^2 statistic	F statistic	χ^2 statistic
1 day lag	9.7***	9.78***	17.51***	17.67***
2 day lags	3.3**	6.7**	7.47***	15.16***
3 day lags	2.16*	6.6*	4.49***	4.49***

The symbol "≠>" means 'does not Granger cause'. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

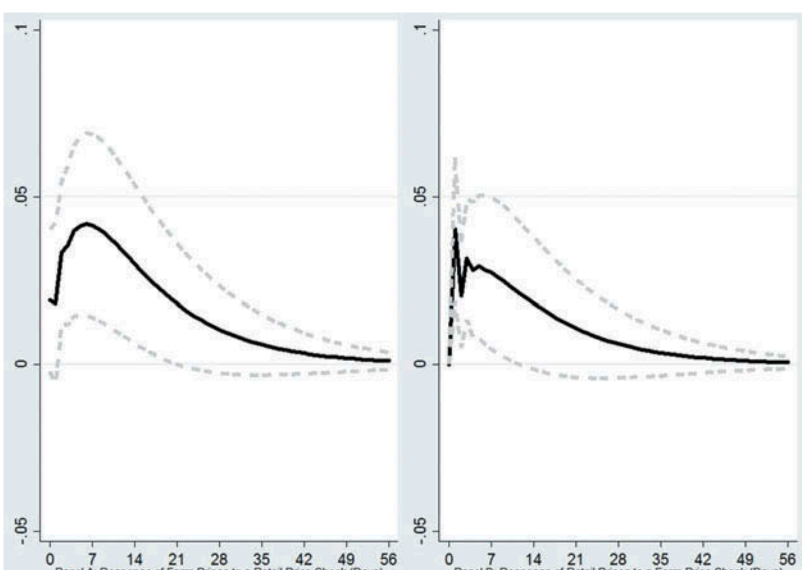

Figure 1. Impulse response results.

Notes: The optimal lag length of the VAR system is 2, which is determined by the AIC's minimum value. The thick black lines represent the simulated responses of lychee prices to one standard deviation price shock. The gray dashed lines indicate the 95% confidence intervals.

Table 7. Variance decomposition estimations.

Response	Panel A: Log Farm Prices		Panel B: Log Retail Prices	
Day Lag	Farm Prices	Retail Prices	Retail Prices	Farm Prices
1 day lag	99.10%	0.90%	100%	0%
8 day lags	91.31%	8.69%	93.77%	6.23%
15 day lags	86.37%	13.63%	91.27%	8.73%
57 day lags	83.70%	16.30%	89.87%	10.13%

The reported percentage in the cell denotes the percentage of the forecast error in each variable that can be attributed to innovations in other variables at 57 horizons.

consistent with the view that retailers have strong market powers to influence farmers' pricing behaviors. Our work offers a valuable addition to empirical studies on investigating price dynamics of perishable commodities.

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