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PRICE TRANSMISSION OF MELONS (*CUCUMIS MELO* AND *CITRULLUS LANATUS*) IN MYANMAR – CHINA BORDER TRADE

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Abstract. Border trade is the main export channel for agricultural products from Myanmar (formerly Burma). With an increasing quantity and value of exports during the last few decades, melons have become one of the major crops in the national export strategy of Myanmar. In this paper, the word "melons" is used to represent both watermelon (*Citrullus lanatus*) and muskmelon (*Cucumis melo*) cultivars. No previous research exists on price transmission between these countries, especially for the horticultural produce market. This study aims to measure the magnitude and speed of spatial price adjustment in melons exported from Myanmar to China. Price transmission in the melon export market in Myanmar is analyzed by studying the lead-lag relationship among prices in the border market in Myanmar and the selected wholesale markets in Beijing, China, using a vector autoregressive model (VAR). Prices are transmitted quickly from Myanmar to the selected wholesale markets in Beijing, China. The wholesale market price in Beijing, China lags only one day behind the Myanmar price. In the Myanmar border market, the melon price is affected only by its own lagged price. The adjustment of melon prices in one day suggests that market information is getting passed up the market channel, and there does not appear to be a need for a policy to improve market efficiency.

Keywords: cantaloupe, international trade, marketing channel, vector autoregression (VAR), watermelon

INTRODUCTION

Border trade is the main export channel for most of Myanmar's (Burma's) agricultural products. Compared with overseas trade, border trade is a preferable option for farmers and brokers because it can be carried out using local currency, and it involves lower transportation and documentation processing costs (Kubo, 2018; 2016).

Melons account for Myanmar's largest export by quantity and value as compared to other fresh fruits. In 2016–17, 707,000 metric tons (MT) of watermelon and 124,000 MT of muskmelon were exported, valued at 70.94 million and 23.36 million U.S. dollars, respectively (Myanmar Ministry of Commerce (MOC), 2018). Of this total exported amount, over 90% is exported via border trade, mainly to China (MOC, 2018). According to data from the MOC, approximately 70% of melons produced in Myanmar are exported. Exports have been hampered due to Covid (Zheng 2022) yet remain strong. Because of the high export quantity and the potential to expand the market, melons are a priority crop in Myanmar's export promotion strategy.

The shelf life of fruit and vegetables is shorter than that of cereals. As a result of this shorter shelf life and rapid quality deterioration, the price fluctuates substantially. Like many other perishable products, melons are susceptible to high price fluctuations. There are many reasons for the short shelf life of melons in the study area and the main factors are poor storage and transportation facilities in the producing country. Information on daily prices and the quantity of products traded at the border market is limited. As the sources that provide accurate market information are hard to come by, melon producers from Myanmar try to forecast the prices of

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melons in the border market based on the daily price posted on the border trade companies' Facebook pages. Even though producers try to adjust the date of harvesting based on posted daily prices, farmers frequently fail to get their produce to the border market in time to capture the optimum price. This is because there are still unavoidable delays of up to a few days in harvesting, and there can be traffic jams along the main transportation channels that cause repeated delays in delivery. Since melons are perishable there is limited storage and delays can cause losses of supply, which in turn can cause substantial price fluctuations. Producers can adjust the date of the harvest to seek the best prices possible. Knowing the speed that the price gets transmitted from one market to another can be an important factor in producer decisions.

Factors such as a lack of accurate market information, delays in transportation, and high transaction costs due to the many steps involved in the procurement process cause uncertainties for producers. Weak or inaccurate market information could reduce market efficiency (Ramsey et al. 2021). When trade occurs between countries, the price difference between the importing and exporting country should not exceed the transportation costs (Ramsey et al. 2021). In the short term, the speed of price adjustment is an indicator of the extent of price transmission, and it is expected to indicate the level of integration. In the case of melons in Myanmar, the way the price is transmitted from Chinese buyers to Myanmarese producers as well as the transmission of the price from Muse border market to the import markets is still not well understood. With the goal of providing a better understanding of the Myanmar–China border trade market for melons, this study aimed to understand the price transmission behavior of the melon markets.

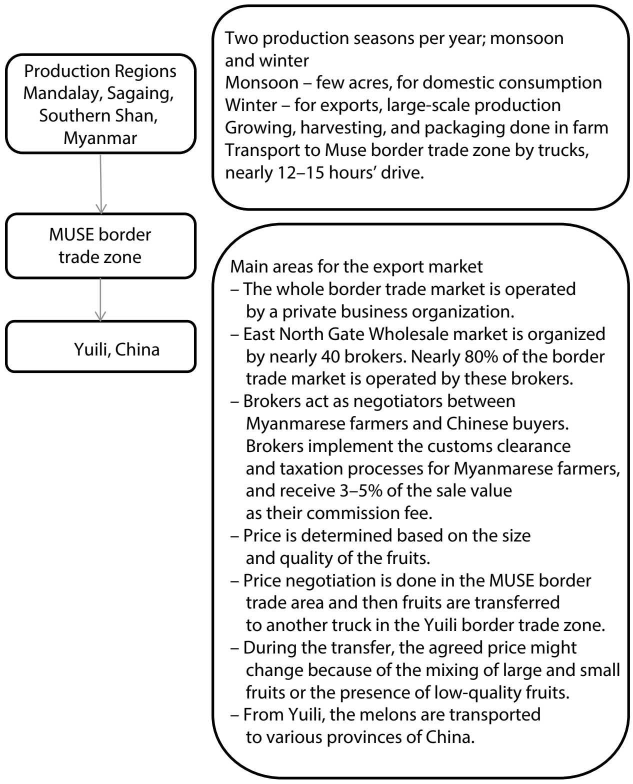

Fig. 1. Flow of Melon Export Market
*The above figure is drawn based on the results of informal interviews with Myanmar melon farmers, representatives from Myanmar Fruit, Flower and Vegetable Producer and Exporter Association (MFVP) and representatives from border trade companies at MUSE border trade zone. The interviews were conducted in 2018.

CHINA-MYANMAR BORDER TRADE MELON MARKET

The peak season for Myanmar's melon exports is from November to April, which is the off-season for melon production in China (Figure 1). Melons are mainly produced in central Myanmar. After harvest, melons are transported directly to the Muse–Yuili border trade area, which is situated near the China–Myanmar border (Yuili is in Yunnan Province of China). It takes twelve to fifteen hours to drive from the major production area in Myanmar to the Chinese border trade zone.

The border trade market is operated by private companies, which in turn serve as brokers connecting producers with Chinese buyers. These private companies also serve as currency exchange centers between Chinese buyers and Myanmar farmers and provide other services to facilitate trade, such as processing taxation and registration for border passes. In addition to providing marketing services, they also serve as the suppliers for the required inputs, including seed and fertilizer. Nearly forty companies currently operate in the border-trade melons market.

Melon prices are mainly determined by buyers from China. Price negotiation and trading are mostly done verbally. Many factors affect the price offered by Chinese buyers to Myanmar brokers. For example, melon prices increase due to unfavorable weather conditions in China, high demand during the Chinese New Year festival, and reduced supplies of melons from Myanmar due to conflicts in the region. After price negotiation, off-loading and repackaging are done on China's side of the border before melons are transported to different Chinese provinces.

PRICE TRANSMISSION

The way the price is transmitted along the supply chain or between different markets provides useful information on the performance of the markets as well as their efficiency. There are two types of price transmission: vertical and spatial. While the price changes along the supply chain of a commodity relate to vertical price transmission (Chavas and Pan, 2019), the way price is transmitted from one market to another relates to spatial price transmission (Wright et al., 2021; Durborow et al., 2020,). While the two markets studied here are in different locations, Myanmar is a supply location and China is a consuming location (at least during the time studied). Thus, vertical price transmission is being studied here even though there is no product transformation.

Many authors point out that asymmetric price transmission is common in markets (Hu and Brorsen, 2017; Han et al., 2016; Gauthier and Zapata, 2006; Peltzman, 2000). For a marketing channel, the general result is that price increases are more quickly reflected at the next level of the marketing channel than price decreases. As a perishable product, vegetables typically show less asymmetry than other commodities (Ahn and Lee, 2015). Many factors can influence the speed and magnitude of price transmission, resulting in asymmetric price transmission. Those factors include market power, political conditions, the flow of market information, and adjustment costs and risks (Han et al., 2016; Meyer and Toubadel, 2004). While asymmetry may exist at some level in the markets studied, data availability is limited and insufficient to identify it.

Recent research has used threshold vector error correction models (Hu and Brorsen, 2017; Greb et al., 2013). Threshold effects are typically expected in the case of horizontal price transmission or when the product flows in both directions. Threshold effects would not be expected here since melons were only shipped from Myanmar to China during the period studied.

The timely flow of price information between markets can help speed price transmission (Hatzenbuehler et al., 2021). Mishra and Kumar (2011) tested the integration of different vegetable markets in Nepal and concluded that improving market information is essential to increasing their efficiency.

A larger number of steps in procurement is expected to increase transaction costs and slow market price adjustment. Factors that can cause changes in the transaction costs in the fresh produce market are improved technology for post-harvest handling practices, shorter procurement systems, and better crop cultivars for extended shelf life (Gokarn and Kuthambalayan, 2019). Regarding the border market of Myanmar, other additional factors can have an adverse impact on the efficient flow of trade. For example, growers' limited knowledge about prices in the destination markets and incomplete knowledge of the quantity demanded because of information lags, as well as non-economic factors, can adversely impact the efficiency of the market.

Most related studies find that information flows up the marketing channel (Chavas and Pan, 2019). This is generally explained by supply shocks being a more important driver of price movements than demand shocks. So here, we expect Myanmarese prices to lead Chinese prices. With very different marketing systems in the two countries and considerable regulations, we would not necessarily expect price transmission to be complete or quick. But the perishability of the product and the fact that we are using prices of a product that is being shipped that day may contribute to relatively speedy price adjustments.

RESEARCH METHODOLOGY

Data

Multiple cultivars of watermelons and muskmelons are exported from Myanmar to China via border trade. Among them, two cultivars of watermelon; 'Taiwang' and 'Seedless', and one cultivar of muskmelon, 'Wu Khone', were selected for this study, as these cultivars are the most popular. Daily prices of these three different cultivars of melons in Muse border market were collected from a wholesale company's Facebook page. The company's Facebook page updates the daily prices (lowest and highest) of melons, and it is the main source of information that producers use to estimate the price. Daily price data (highest and lowest) of Xinfadi market in Beijing were also collected via the wholesale company's website. The prices are sometimes reported as a range of prices. The lowest price represents low-quality fruits and the standards for low-quality fruits are not clear. Thus, the highest daily price was used. The melon export season for Myanmar lasts from November to April and the daily price data were for three crop seasons: Season 1 – November 2015 to April 2016, Season 2 – November 2016 to April 2017, and Season 3 – November 2017 to April 2018. Daily prices were compiled for both the Muse border market and the Xinfadi market in Beijing.

For each crop season, there were 181 potential observations but there were missing values in each season. The missing values could be divided into three categories: 1) consecutive missing values at the beginning of the season, 2) consecutive missing values at the end of the season, and 3) a few missing values during the season. The reasons for missing values are: 1) melons are sometimes not available in the border market as some melon cultivars are late-harvest cultivars, 2) some melon cultivars are harvested earlier than other cultivars so there is no export of these cultivars during the latter part of the export season, 3) the company did not update the price information on the website on some days, and 4) markets are closed during the Chinese New Year Festival, Myanmar New Year Festival, and sometimes due to conflicts along the Myanmar border.

There are methods to impute missing values, such as multiple imputation (MI) and maximum likelihood (ML) methods. But missing value imputation for time-series data is different from missing value imputation for cross-sectional data. Studies have compared the multiple imputation (MI) and maximum likelihood (ML)

Table 1. Summary Statistics of Myanmar Melon Price Data

	Taiwang		Seedless		Wu Khone	
	China	Border	China	Border	China	Border
Season 1 – November 15 to April 2016						
No. of obs.	103	103	103	103	110	110
Maximum	6.6	6	7	6	9	7.5
Minimum	2.8	1.8	3	1.8	6.0	3.0
Mean	4.68	3.46	4.53	3.46	7.97	5.41
SD	1.12	1.17	1.29	1.17	0.98	1.05
Season 2 – November 2016 to April 2017						
No. of obs.	126	126	154	154	181	181
Maximum	7	5.8	7.4	6	10	9
Minimum	3.2	0.80	2.8	1.5	4.8	2.5
Mean	5.24	3.98	5.40	4.20	7.41	5.56
SD	1.21	1.08	1.29	1.1	1.29	1.54
Season 3 – November 2017 to April 2018						
No. of obs.	181	181	167	167	167	167
Maximum	6.4	5	6.4	5.2	11	5.2
Minimum	3.6	2.3	4	1.9	3	1.9
Mean	4.73	3.48	5.19	3.34	7.34	3.35
SD	0.68	0.62	0.88	0.70	2.52	0.70

Source: daily price data of Muse border market was collected from the border trade company's Facebook page; daily price data of Xinfadi market, Beijing was collected from that market website.

methods in imputing missing data (Allison, 2012; Fung, 2006) and recommended the maximum likelihood estimation method for handling missing data. But all these methods estimate the missing values based on previous values in the data set. Thus, consecutive missing values at the beginning of the crop season could not be estimated using any of the above-mentioned methods; therefore, these types of missing values were removed from the data set. The missing values during the season were mostly not consecutive, and only covered a few days (1–4 days). For the latter type of values, the price data from before and after those days were used to impute the missing values. The missing values at the end of the season were also removed since for that period, values were missing in both markets.

Testing time series properties

The first step in modeling the time series was to determine if the data were stationary. The time series properties of each variable were tested. The Augmented Dickey Fuller (ADF) test was used to test the null hypothesis of a unit root. The ADF test (McCarthy, 2015) was conducted using the following model:

$$\Delta y_t = \beta_0 + \beta_1 y_{t\text{-}1} + \beta_2 t + \textstyle\sum^{n}_{i=1} \alpha_i \Delta y_{t\text{-}i} + u_t \qquad (1)$$

where: β_0 is a constant and t is a trend. If the series has a unit root, then $\beta_1 = 0$. The lag length n was determined using the Akaike Information Criterion (AIC) and confirmed with autocorrelation and partial autocorrelation functions.

Method used for the analysis of price transmission

Vector autoregressive models (VAR) and Error Correction Models (ECM) are commonly used in studying price transmission. For stationary time series, vector autoregressive models (VAR) can be used. Error correction models (ECMs) are applied when price series are non-stationary and co-integrated (Onuche, 2021).

Vector autoregressive models specify the price at time t as a function of the lagged prices $t-1$,…, $t-n$, the number n being the lag length (Khofifah et al., 2021; Durburow et al., 2020; Bergmann et al., 2016). To estimate the price transmission between the border market and the Chinese wholesale market, the following vector autoregressive model was used:

$$PMM_t = \alpha_0 + \alpha_1 PMM_{t\text{-}1} + \alpha_2 PCC_{t\text{-}1} + \varepsilon_{1t} \qquad (2)$$

$$PCC_t = \beta_0 + \beta_1 PMM_{t\text{-}1} + \beta_2 PCC_{t\text{-}1} + \varepsilon_{2t} \qquad (3)$$

where: PMM_t is the price in the border market on day t, and PCC_t is the price at the China market on day t. The error terms, ε_{1t} and ε_{2t}, were jointly normally distributed, and the parameters to be estimated were α_0, α_1, α_2, β_0, β_1, and β_2.

FINDINGS

The prices at the border market and the Chinese market are shown in Figure 2 for the Taiwang cultivar, Figure 3 for the Seedless cultivar, and Figure 4 for the Wu Khone cultivar. The prices in the Chinese market are higher than the prices in the border market and the two price series seem to move together. The percentage price differences between the two markets are also shown in the graphs.

Testing time series properties

The ADF test was conducted for each variable. The price data were transformed into natural logarithm form. The lag length selected for the ADF test was one day. The results are shown in Table 2. The results are presented with and without a time trend. All price series reject the null hypothesis of non-stationarity when no trend is included. When the trend variable is included, the null hypothesis can no longer be rejected for the Taiwang cultivar, but this failure to reject could simply be due to the size of the sample. We proceed using the vector autoregressive model and price levels.

Vector autoregressive model (VAR)

The lag lengths for the VAR of the price series were determined, and the price transmission between the border and the Chinese market was determined for each melon cultivar. Based on the autocorrelation and partial autocorrelation functions, the maximum lag length was set at 2. First-order autoregressive models (VAR (1)) were selected for all three cultivars based on the AIC value. The estimated parameters for the VAR model are shown in Table 3.

Melon prices in the border market are significantly related to their own lagged prices. For the ‘Taiwang’ cultivar, the border price is mainly affected by the previous day’s price at the border market, while the Chinese market price during the previous day does not show a significant impact. For the ‘seedless’ cultivar, the previous

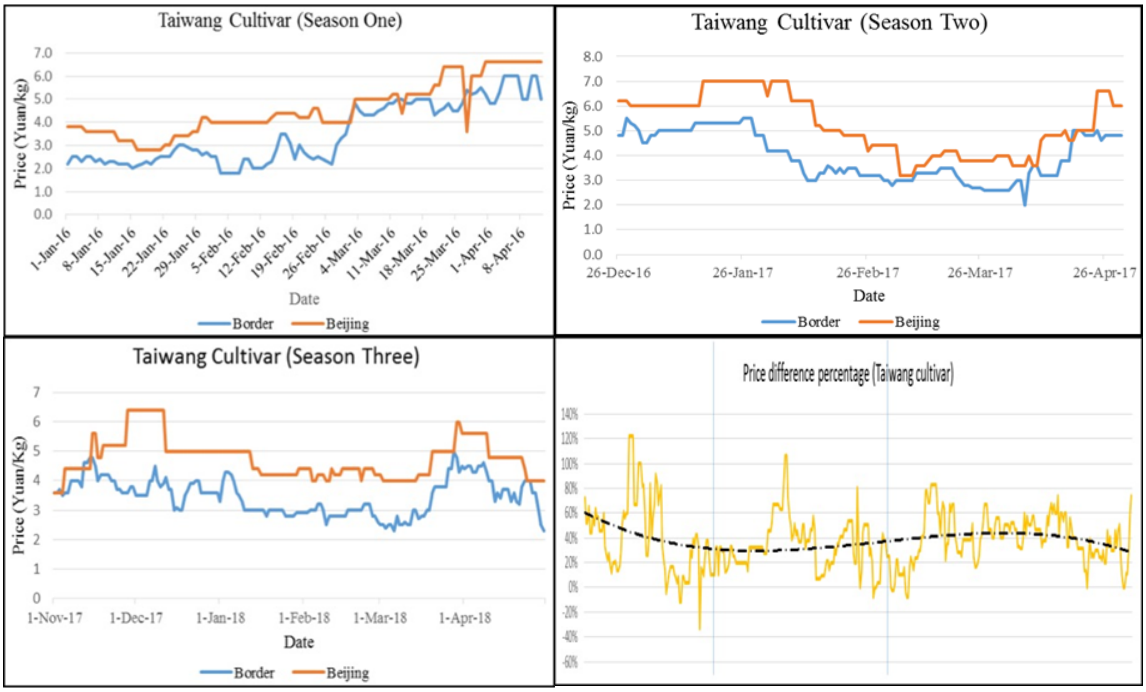

Fig. 2. Price comparison for Taiwang Cultivar
Source: own calculations based on daily price data at MUSE border trade zone and the selected wholesale market, Beijing, China.

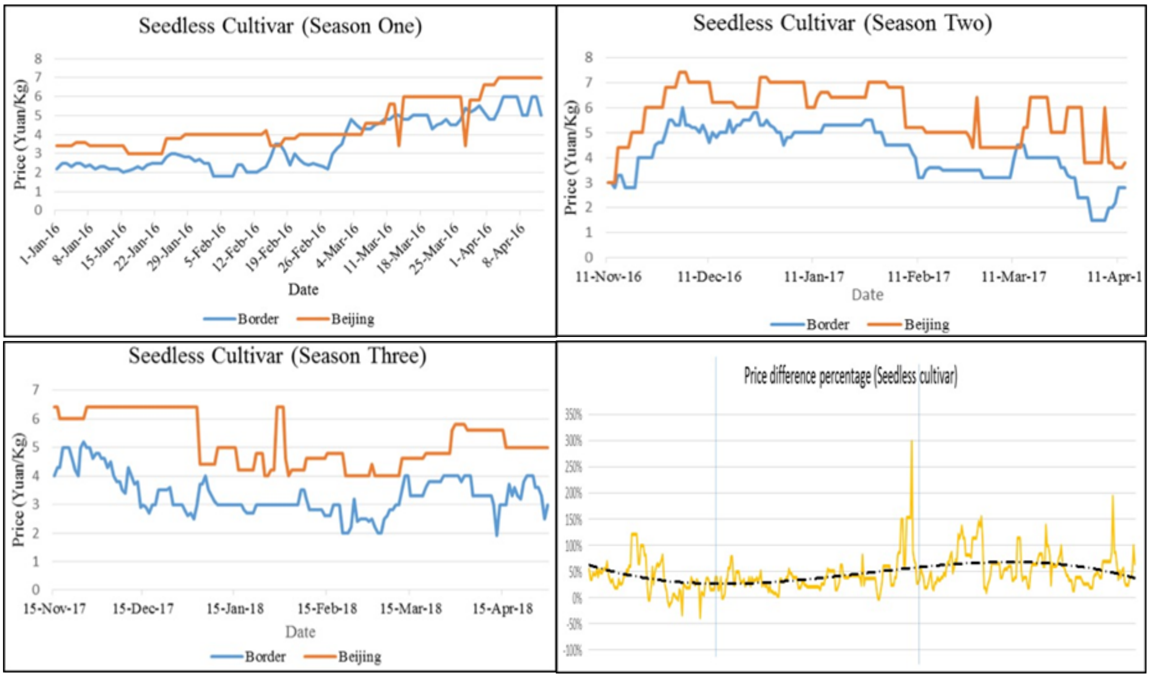

Fig. 3. Price comparison for Seedless Cultivar
Source: own calculations based on daily price data at MUSE border trade zone and the selected wholesale market, Beijing, China.

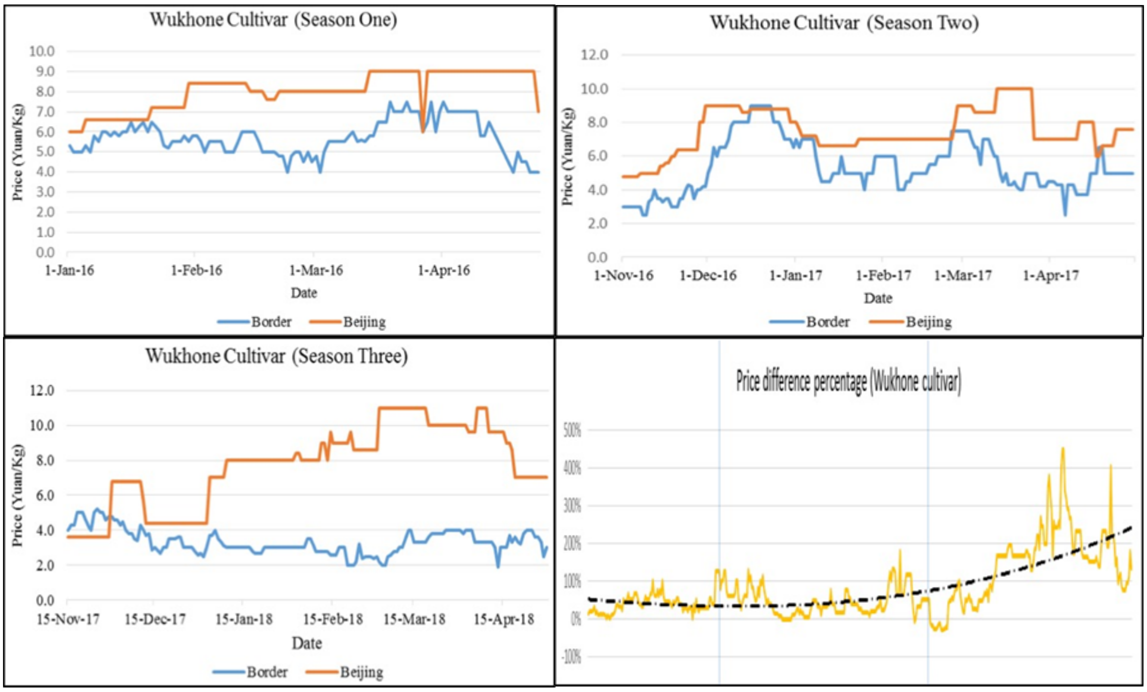

Fig. 4. Price comparison for Wu Khone Cultivar
Source: own calculations based on daily price data at MUSE border trade zone and the selected wholesale market, Beijing, China.

Table 2. Augmented Dickey Fuller Test for Melon Price Level Data

	Taiwang		Seedless		Wu Khone	
	China	Border	China	Border	China	Border
Lags	1	1	1	1	1	1
Single mean	–14.90*	–15.49*	–23.94*	–18.74**	–23.94**	–18.74**
Trend	–14.82	–15.35	–23.27**	–19.40*	–23.27**	–19.40*

*$p < 0.1$, **$p < 0.05$, ***$p < 0.001$.
Source: own calculation based on daily price data at MUSE border trade zone and the selected wholesale market, Beijing, China.

day's prices at both the border and the Chinese market have significant effects. Regarding the 'Wu Khone' cultivar, the price at the border market is mainly affected by the previous day's price at the border market, while the estimated parameter for the price in the Chinese market is not statistically significant. The parameters estimated for the lag period of the border market (PMM_{t-1}) are a little less than one, which suggests the price is stationary but has long memory. In the border market, the company's Facebook page is the main information source and farmers try to harvest and send melons to the border market when the current price is high within the Chinese market. The increase in supplies delivered by trucks during the high price periods leads to a decrease in the border-market price and keeps the price series stationary.

The results for the China price are similar, except that there is a little more evidence of the border price influencing the Chinese price than there is for the reverse direction. All three cultivars show a strong relationship

Table 3. Estimated Parameter of VAR (1) Model of Melon Price Levels

Variable	Taiwang	Seedless	Wu Khone
Border Market			
Intercept	1.14*** (0.12)	1.048*** (0.034)	1.49*** (0.17)
$Border_{t-1}$	0.96*** (0.01)	0.94*** (0.01)	0.95*** (0.01)
$China_{t-1}$	0.05 (0.060)	0.12** (0.049)	–0.002 (0.07)
China Market			
Intercept	1.45*** (0.07)	1.46*** (0.07)	1.94*** (0.09)
$Border_{t-1}$	0.078* (0.042)	0.13* (0.05)	0.04 (0.03)
$China_{t-1}$	0.94*** (0.016)	0.89*** (0.02)	0.96*** (0.01)

*$p < 0.1$, **$p < 0.05$, ***$p < 0.001$.
Source: own calculation based on daily price data at MUSE border trade zone and the selected wholesale market, Beijing, China.

between today's Chinese price and yesterday's Chinese price. Both the 'Taiwang' and 'Seedless' cultivars have a significant positive coefficient for the lagged border price. Past studies have tended to find that price changes are supply driven and thus price changes flow up the marketing channel rather than down. This study finds similar results except there is some evidence of information flowing down for the seedless cultivar.

According to these results, it can be concluded that these three different cultivars show, to a certain extent, that the price impact and the price adjustment are fast. More specifically, the adjustment occurs within only one day. Although the price relationship is noticeable in the graphs, half of the cross-price estimates are not statistically significant. This lack of statistically significant relationships might be due to the relationship between the markets being irregular. This could be due to variable transportation costs, changes in market power, or even variations in price reporting. The prices in these two markets are connected, but not strongly so.

CONCLUSIONS

This study examined the magnitude of price transmission for melons in the China–Myanmar border trade. Two markets were selected for this study: Muse border market in Myanmar and Xinfadi wholesale market in China. The magnitude and the speed of price adjustment between these two markets were estimated using a vector autoregressive model. There is a price relationship between these two markets. Prices in the border market are mainly affected by the previous day's price at the border market. For the selected Chinese market, both the previous day's price in the border market and the Chinese market have an impact on the current price. Given these results, it can be concluded that the price changes in the border market have an impact on both markets. The price adjustment between the two markets is quite rapid, and this suggests that the markets are close to being weak-form efficient.

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