Market Integration and Price Discovery in California's Almond Marketing: A Vector Auto-Regressive (VAR) Approach

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Abstract

California almonds production and marketing have been the focus of the state's economy. Since almonds are a high-cost food product facing high market price volatility, reducing price forecasting error increases the likelihood of success (profitability) at the farm level. By focusing on the linkage between the local wholesale inshell price from 2015 to 2021 and international export prices to major trading partners in Europe and Eastern Asian countries, this study contributes to understanding how export prices affect the farm level wholesale price and what causes price shocks in the system. A clear result of this study is farmers can rely on current market price when forecasting local almond price in the short run of upcoming two months.   This study also finds the California local almond wholesale market is integrated into the world almond market, as well as the markets of its trading partners in Europe and East Asia. Specifically, when U.S. export price to the world increase in the current month, its export price to East Asian countries will automatically adjust and decrease in the following months. Lastly, analysis of the sample of prices considered in this study does not establish a long-run equilibrium nor market price integration.

1. Introduction

California leads global almond production by harvesting 80% of the world's total supply in any given year (USDA-FAS, 2022) and the Central Valley is the single largest producer and processor of California almonds. The majority of California's crop is shipped to other parts of the U.S. and the world, including top international destinations of the European Union, India and more recently China, which imports notable quantities of processed almonds (USDA-FAS, 2022). Even though the almond processing industry ships whole kernels around the world, most international shipments are shelled (DERCO, Foods Reports, 2021).

At the farm gate, the price of inshell almonds has a substantial impact on the economic viability of the farm. There exists an intrinsic time lag between production decision making, the harvest and processing of almonds, and the shipments of final products to international markets. To investigate the price differences between local and international markets, this study postulates the local wholesale price of inshell almonds converges to world market price and there may exist nonlinear adjustments in price toward short-run or long-run equilibria. There is a clear gap in the literature regarding the relationships between local and export prices for U.S. grown almonds. This study contributes to the literature by providing advanced scholarly knowledge of this topic. By focusing on the linkage between the local wholesale inshell price and international export prices to major trading partners in Europe and Eastern Asian countries, this study contributes to understanding how export prices affect the farm level wholesale price and what causes price shocks in the system. Since almonds are a high-cost food product facing high market price volatility, reducing price forecasting error increases the likelihood of success (profitability) at the farm level. The results of this study provide important insight to almond producers, marketers, and policy makers with respect to; 1) planning output for the next growing season, 2) forming more accurate price outlooks, and 3) crafting market risk management strategies.

This study seeks to empirically assess the nature of the price relationship among local almond wholesale price, U.S. export price to the world market in general, and export prices to major trading destinations in Europe and newly emerged Eastern Asian markets. Stationarity of four monthly price series from 2015 to 2021 is tested to identify potential short-run and long-run equilibrium between the price series. Johansen's cointegration test (Johansen, 1995) is applied to determine whether the four selected time series show a cointegrating relationship, and if test results support there is no cointegration relationship, then a VAR model is appropriate for further price analysis. Finally, a Granger-causality test is conducted to determine whether there exists a unidirectional causality impact from the world almond market to the local California market.

2. Literature Review

According to Sumner et al. (2014), California's almond industry is an inseparable part of the world almond trade. During any given year, California almonds transition from local producers to international markets after processing which includes cleaning, sizing, sorting, and bulk packaging. This process involves almond handlers, the majority of which manage twenty-four million pounds of almond shipments or less (Sumner et al., 2014). The most important export destinations include Europe, the Middle East, Africa, and Asia Pacific countries. In 2013, the USDA Foreign Agricultural Service reported emerging markets for California almonds included China, India, and the United Arab Emirates, and that demands from these new markets would be major drivers behind growth in export volume and value (USDA Foreign Agricultural Service. Tree Nuts: World Markets and Trade, 2022). The most recent tree nuts world market report expected a 25% increase in exports to the top markets of China and the European Union (USDA, Tree Nuts: World Markets and Trade Report, 2022). Another report showed exports to India and China increased and those to the EU declined from 2008 to 2018. In general, revenues from world markets have become an important source of farm-level profit for California's almond industry and are the corner stone for the Central Valley where most almonds are produced (Matthews, Baratashvili, & Sumner, 2020).

Carefully examining factors affecting the farm level price is not only crucial to establish successful almond marketing strategies, but essential to plan for meaningful cost control. Almonds are an extensively irrigated crop, and water cost is the biggest concern of almond growers. Published studies have examined the water use of almond production (Belmecheri et al., 2016; Fulton, Norton, & Shilling, 2019). Specifically, these studies pointed out that groundwater-related subsidence and decreasing snowpack in the Sierra Nevada Mountain range, are expected to worsen, causing water usage for almond production to become the focus of public concern and water cost a key to farm level planning. In contrast, to examine the economic impact of almond production in California, Fulton, Norton, and Shilling (2019) analyzed twelve years of almond water usage data and compared almond-related water usage to that of other California crops. Their study showed that even though almond production uses more water, when factoring in the nutritional benefits of almonds, the dietary benefits of almond production are higher than California grown rice, olives, and cherries. When factoring in the economic impact of almond production per unit of water used, the study also demonstrated that almond production creates greater economic value than the production of oats. Another study noted the reason almonds gained notoriety as a heavy water user was because of the way water usage is calculated using the gallon per nut method. The study concluded that if an alternative method is applied, water usage for almonds falls to the equivalent of other nut crops (Johnson & Cody, 2015).

Some previous agricultural studies empathized the economics of food production and its impact on food marketing. These studies started the discussion about export marketing, economic expansion to other countries, and industrial development to address the greater linkage between global markets and the world's major food suppliers (Mafimisebi, 2012). Specifically, regarding almonds, one study emphasized the impact of global markets on rising demand for California almonds and pointed out the accelerated demand mostly comes from China (Reisman, 2019). The study affirmed that even though almond exports to the European Union exceed the Asia Pacific Region, California almonds going overseas are fueled by the tastes of China's growing middle class (Krieger, 2015). The study indicates that rising wealth in China and its improved per capita income are major reasons behind their higher willingness-to-pay for California almonds, causing a spike in demand in the international market (Reisman, 2020). Other almond-related international trade debates imply exported almonds represent a loss of control over regional resources. Specifically, these scholars indicated rising demand from China means Chinese consumers may have more power over California's water use than most Californians (Reisman, 2020), suggesting international market demand plays a key role impacting California's water use.

Studies have addressed the importance of farmers forming expectations of market prices when making resource allocation decisions (Just & Rausser, 1981; Zheng et al., 2012; Yan & Reed, 2014; Haile & Kalkuhl, 2016). For instance, Just and Rausser (1981) pointed out that farmers tend to use past market price trends and published market forecasts to make production decisions. Haile and Kalkuhl (2016) reported that grain producers who have access to market information are more likely to have smaller price forecast errors. Even though food production is

randomly determined due to uncertainty caused by unfavorable weather conditions, droughts, pest infestations, and other shocks, farmers that are more successful have access to market information and therefore better understand market price impacts and supply-demand situations (Moschini & Hennessy, 2001). According to economic theories, a rational farmer would pay for market price information to the extent the benefit of having the information exceeds the cost of acquiring or not having it, and the information obtained can improve their price forecasts for the upcoming market season (Orazem & Miranowski, 1986). However, current research has not investigated whether existing price information can help almond producers make decisions in key areas. Specifically, if the international trading price that is updated monthly by the USDA GATS system is an unbiased predictor of the upcoming wholesale price in the local market, then growers can use the signals provided in the international market to adjust their planting, marketing, and price risk management decisions.

3. Research Methods

The vector auto-regression method (VAR) is a popular economic model to estimate the linkage between world market price changes and local food prices (McKenzie et al. 2002; Zheng et al. 2012; Mafimisebi, 2012). Using this model, all collected price series are log transformed to ensure that when the original price series do not follow a bell curve, the transformed format normalizes the curve, and the results are more valid. The natural log of price series thus corrects for any skewness in the distribution of prices that often arises from the non-negativity of market prices. In addition, the differences of the logs can be interpreted as returns to make the explanation of the results more meaningful (Brooks, 2008). Following Motamed, Foster and Tyner (2008), a vector of prices in logarithmic form $P_t = (P_{1t}, P_{2t...} P_{pt})$ is constructed which is assumed to be generated by a kth-order vector auto-regression (VAR) model.

$$P_t = \beta_1 P_{t-1} + ... + \beta_k P_{t-k} + \mu + \varepsilon_t \tag{1}$$

The vector P_t contains the logged local, regional, and world almond prices over the selected time horizon, μ is a vector of constants, and ε_t represents the error term. If the variables are stationary in equation (1) then ε_t has constant first and second moments over time. If the first-order difference $(P_t - P_{t-1})$ is stationary, this time series is said to be integrated of order one, often denoted by $I(1)$. If the local, regional, and world prices are not cointegrated, ε_t is nonstationary and the time series may deviate without bound, thus performing a random walk (Foster, Havenner, & Walburger, 1995) and no long-run equilibrium exists between the price series. Then the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) is conducted to assess stationarity. If the test confirms the selected price series are not stationary, and the first difference of each individual series is stationary, then the time series are integrated of order 1 ($I(1)$) and Johansen's cointegration test is conducted (Johansen, 1995) to find out if the four selected time series show a cointegrating relationship. If there is a cointegration relationship, a VEC model is applied. In this study, the Johansen test supported non-cointegration and the following VAR model was specified:

$$lnlocali_t = \sigma + \sum_{i=1}^{k} \beta_i \Delta lnlocali_{t-i} + \sum_{i=1}^{k} \phi_j \Delta lnworldi_{t-j} + \sum_{j=1}^{k} \varphi_m \Delta lneui_{t-m} + \sum_{m=1}^{k} \xi_n \Delta lneai_{t-j} + \mu_{1t} \tag{2}$$

$$lnworldi_t = \alpha + \sum_{i=1}^{k} \beta_i \Delta lnlocali_{t-i} + \sum_{i=1}^{k} \phi_j \Delta lnworldi_{t-j} + \sum_{m=1}^{k} \varphi_m \Delta lneui_{t-m} + \sum_{n=1}^{k} \xi_n \Delta lneai_{t-j} + \mu_{2t} \tag{3}$$

$$lneui_t = \varrho + \sum_{i=1}^{k} \beta_i \Delta lnlocali_{t-i} + \sum_{j=1}^{k} \phi_j \Delta lnworldi_{t-j} + \sum_{m=1}^{k} \varphi_m \Delta lneui_{t-m} + \sum_{n=1}^{k} \xi_n \Delta lneai_{t-j} + \mu_{3t} \tag{4}$$

$$lneai_t = \varsigma + \sum_{i=1}^{k} \beta_i \Delta lnlocali_{t-i} + \sum_{j=1}^{k} \phi_j \Delta lnworldi_{t-j} + \sum_{m=1}^{k} \varphi_{mi} \Delta lneui_{t-m} + \sum_{n=1}^{k} \xi_n \Delta lneai_{t-j} + \mu_{4t} \tag{5}$$

$lnlocali_t = log\ transformed\ local\ wholesale\ monthly\ price\ series\ 2015 - 2021;$

$lnworld = log\ transformed\ world\ monthly\ export\ price\ series\ 2015 - 2021;$

$lneu = log\ transformed\ East\ Europe\ monthly\ export\ price\ series\ 2015 - 2021;$

$lnea = log\ transformed\ East\ Asian\ monthly\ export\ price\ series\ 2015 - 2021;$

k=the lag length;

$\beta_i, \phi_j, \varphi_m, \xi_n = short - run\ coefficients;$

$\lambda_i = speed\ of\ adjustment\ parameter\ with\ a\ negative\ sign;$

$\mu_{it} = residuals/stochastic\ error\ terms$

After estimating the coefficients for the above VAR models, the Granger Causality test is used to determine

whether one of the selected time series is useful for forecasting another. If the probability value is less than a Prob > chi2 value, then the hypothesis is rejected, meaning there is a causal relationship between the selected time series.

Local almond monthly wholesale prices (in pound) from March 2015 to December 2021 were obtained from a local agricultural management company as well as from local almond wholesalers. International almond trading prices for the same period were gathered from the USDA Global Agriculture Trade System (GATS) data sets. The GATS data set provides unit values of exports from the United States to destination regions in Europe, East Asia, and other parts of the world. Two export destinations were selected for analysis; Europe because it has historically been the top trading partner for California almonds and East Asia because it was the fastest growing export destination during the past decade. To examine the price movement between regional export markets and local California wholesale markets, regional export prices were selected rather than export prices to specific countries in a region. Unit price was computed by converting unit value (in metric tons) to price per pound (in U.S. dollars), and this method was applied to the local, regional, and world price series.

Figure 1 shows trends in monthly prices from 2015 to 2021 for the five selected price series. First, the graph shows a clear trend of correlation among local wholesale almond prices and U.S. export prices to the world market, European region, and East Asian region. Second, compared to 2015, when all price series were above $3 per pound, most market prices dropped below $3 per pound between 2016 and 2020. Third, in the first half of 2021, world and local market prices dropped to the lowest level during the 7-year period, with local wholesale prices dropping below $2 per pound. Finally, after July 2021, local and world prices showed a strong rebound followed by a slight price decrease near year's end for world prices but a sharper price drop for local prices.
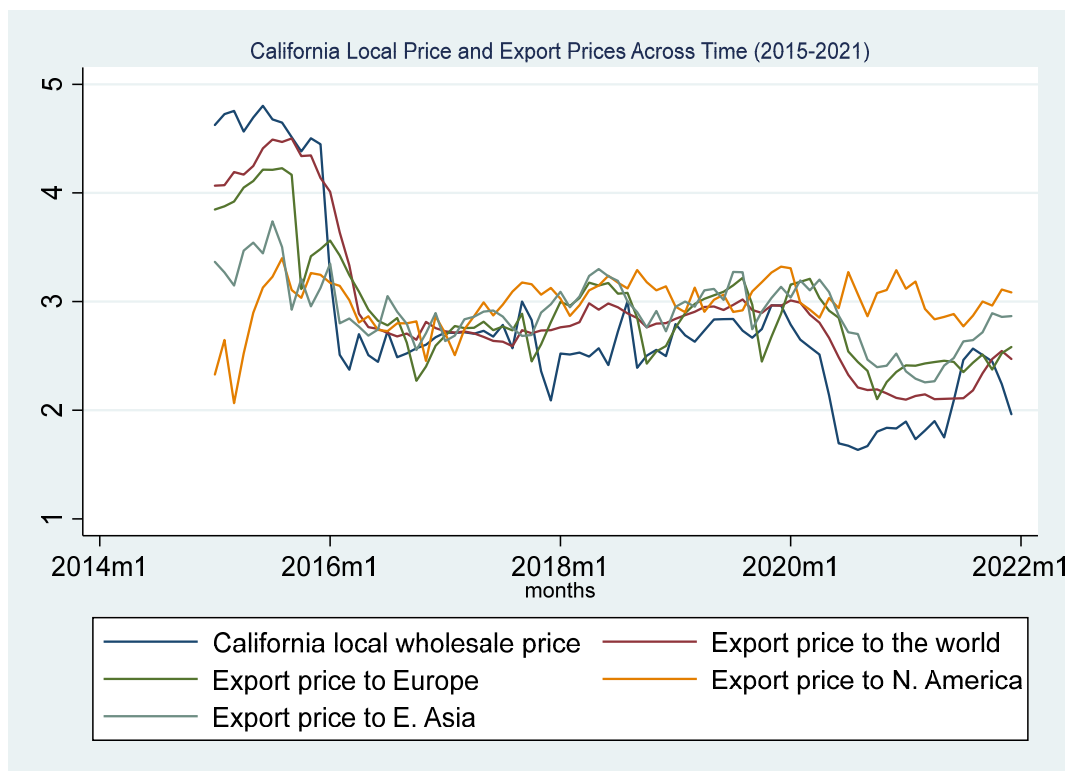

Figure 1. World almond trading prices versus California local wholesale prices, 2015-2021 (Dollar per pound)

4. Results

Before conducting the VAR modeling, a unit root test was conducted to determine if the four price series were stationary or not. Results of the Augmented Dickey Fuller test (1979) appearing in Table 1 show all four of the time series present a trend of non-stationarity, indicating the statistical means of these series are dependent on time. A stochastic trend is presented such that first order transformation of the series is required to further induce stationarity and differences. Thus, a random walk process of first order differentiation was applied. Results indicate the first order differenced series contain a unitary element of a unit root and thus stationarity, confirming the time series are first integrated of order one $I(1)$. These results are consistent with previous findings that food commodity

price series tend to be non-stationary but converge to stationarity after first-order differentiation (Alexander, C., Wyeth, J., 1994; Ogundare, 1999; Franco, 1999; Chirwa, 2001; Mafimisebi, 2001; Okon & Egbon, 2003; Oladapo, 2004; Mafimisebi, 2012). Thus, when examining the price series separately; local wholesale, world, European, and East Asian prices each follow a short-run divergence across months but then converge to a long-term trend of stationarity either because of price inflation, seasonality, or other market reasons.

To select a lag order for the VAR model, four tests were conducted including the final prediction error test (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn Information Criterion (HQIC). According to assorted studies, selection of an appropriate lag order can effectively reduce the mean-square-forecast errors of the VAR model and thus eliminate autocorrelated errors (Lutkepohl, 1993; Hafer and Sheehan, 1989). The test results appearing in Table 2 reveal a lag of two is optimal because the AIC model is the best criterion as its score is the lowest across the selection models. Thus, its result moves much closer to the true impulse response functions than other selection models (Keating, 1995).

Results of the Johansen's cointegration test with maximum eigenvalue and trace statistics appear in Table 3. Results show the null hypothesis of co-integration between selected time series is rejected at the 1% and 5% confidence levels. Thus, the alternative hypothesis that there is no cointegration between the selected time series is accepted. In the case of almond trading, local, world, and regional prices from Europe and East Asia drifted far apart without bounds and no long-run equilibrium exists between them. Assuming the existence of a short-run equilibrium relationship among the selected price series, the remaining analysis employed an unrestricted VAR model with an optimal lag length of two. Thus, the remaining analysis emphasized this short-run price cointegration relationship to identify the magnitude of cointegration and causality of changes.

To fit the VAR model, monthly data from March 2015 to December 2021 were again applied, excluding the first order difference and the optimal lag of 2 (see Table 4). The first parameter of interest is the Root Mean Square Error (RMSE) which measures the spread of the standard deviation of the residuals from the predicted best fit line. Results show the RMSE for each equation are small, meaning changes in the independent variables of each price region can explain its changes in price for up to 2 months. The small P-values show all equations are statistically significant at the 1% confidence level. The R-square values show the percentage of change explained by the past two months' prices. For example, an R-square value of 90.74% means the current local price of almonds is a result of the past two-months' local price adjustments as well as the impact from external price shocks in world, European, and East Asian almond trade prices. Similarly, the current world almond price is a result of the last two-months' world price adjustments as well as the impact coming from external price shocks from the California, European, and East Asian markets.

Estimated coefficients for the VAR model, equations (2) through (5), appear in Table 5. The model reports short-run price variations and interaction of the four selected market prices while providing the direction of the impact, i.e., short-run price causality. First, the selected market prices are statistically significantly affected by variations in their own price patterns from the last month (the first lag). Specifically, California's local almond price at the wholesale level is positively and statistically significantly affected by it's the last month's local almond price (alpha=1%) but negatively affected by the local wholesale price two months' before (the second lag) (alpha=5%). This result indicates an automatic price adjustment in the local market such that when price is low in the previous month, price will improve in the following month to reduce the negative price shocks from the previous month. The previous findings about the optimal number of lags showed the impact was only statistically significant in the short-run of two-months. Second, local price is also positively correlated with current world almond export price (alpha=1%) and negatively affected by the previous month's world price (alpha=1%). The magnitude of the correlation is large, meaning world price shocks affect the U.S. almond export price such that the California local almond price moves in the same direction with the world price at a significant level. Third, the U.S. current almond export price to European countries has a negative impact on world export prices (alpha=5%) and the previous month's U.S. export price to European countries has a positive impact on world price (alpha=5%). Finally, the U.S. export price to East Asian countries is tied to the export price to European countries. The current month's export price to European countries moves in the same direction as the East Asian export price (alpha=1%) and in the opposite direction with the previous month's price (alpha=5%).

Table 6 shows the results of the Granger-causality test which is used to further identify the causality of various price changes on California's local almond market. When two lags are used, the hypothesis that the world price does not have a causal relationship with the California local almond price can be rejected at the 1% confidence level. Further, the hypothesis that the combined almond export price from the world, European, and East Asia markets does not have a causal relationship with California's local price can be rejected at the 10% confidence level. Thus, there exists a unidirectional causality impact from the world almond market to the local California

market. Furthermore, almond prices from major trading partners in European and East Asian countries have a significant and positive impact on the California local price. The results also demonstrate existence of a bi-directional causality relationship among the four price series, meaning the California local wholesale market cannot be separated from the world market as well as from its trading partners in the European Union and East Asia.

Table 1. Augmented Dickey-Fuller (ADF) test

Prices, lags(4) n=79	Z(t) test Statistics	Mackinnon P-values	Inter-poliated DF 5% critical value	First degree differenced Statistics	Mackinnon P-values	Inter-poliated DF 5% critical value
Local prices	-2.197	0.207	-2.905	-4.743***	0.001	-2.906
World prices	-2.439	0.131	-2.905	-3.547**	0.069	-2.906
EU prices	-2.387	0.145	-2.905	-5.718***	0	-2.906
EA	-2.095	0.247	-2.905	5.178***	0	-2.906

Note. Asterisk (***) denotes variables significant at 1% level. (**) at 5% level.

Table 2. Selection order criteria results

Lags	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	183.686				0.000	-4.755	-4.718	-4.663
1	367.233	367.100	9	0.000	0.000	-9.348	-9.201	-8.980*
2*	381.153	27.839	9	0.001	0*	-9.478*	-9.220*	-8.834
3	387.977	13.650	9	0.135	0.000	-9.420	-9.053	-8.500
4	392.109	8.264	9	0.508	0.000	-9.292	-8.814	-8.096
5	397.948	11.678	9	0.232	0.000	-9.209	-8.621	-7.737
6	404.272	12.647	9	0.179	0.000	-9.139	-8.440	-7.391
7	408.393	8.241	9	0.510	0.000	-9.010	-8.201	-6.986
8	419.647	22.508*	9	0.007	0.000	-9.070	-8.150	-6.770

Note. Asterisk (***) denotes variables significant at 1% level. (**) at 5% level.

Table 3. Johansen Cointegration test results

Maximum rank	Parameters	LL	eigenvalue	Trace statistic	5% critical value
0	12	379.525	.	67.480	29.680
1	17	399.127	0.380	28.276	15.410
2	20	411.103	0.253	4.324	3.760
3	21	413.265	0.051		

Table 4. VAR model percentage results

Equation	Parameters	RMSE	R-sq	chi2	P>chi2
Local	9	0.084	0.907	803.657	0
World	9	0.024	0.987	6268.987	0
European	9	0.051	0.906	788.261	0
East Asian	9	0.054	0.757	255.327	0
Sample:	03/2015-12/2021			Observations	82

Table 5. VAR model coefficient estimates

| Variables | Period | Estimated coefficients | | | | |
		Local	World	European	E. Asian	Constant
Local	1	0.960***	1.281***	-0.051	-0.201	0.086
	2	-0.299**	-0.978***	0.262	-0.082	
World	1	0.152***	1.091***	-0.093**	0.013	0.027
	2	0.011	-0.336***	0.078**	0.063	
European	1	0.077	-0.022	0.713***	0.013	0.027
	2	-0.016	0.215	-0.180***	0.063	
E. Asian	1	0.093	0.477	0.026*	0.564	0.261***
	2	-0.043	-0.411	-0.021**	0.076	

Note. * means statistically significant at 10% level, ** at 5% level, *** at 1% level.

Table 6. Granger causality test results

Equation	Excluded	chi2	df	Prob>chi2
Local	World	9.754***	2	0.008
	European	3.088	2	0.214
	East Asian	2.896	2	0.235
	ALL	12.132*	6	0.059
World	Local	37.411***	2	0.000
	European	4.247	2	0.120
	East Asian	2.525	2	0.283
	ALL	43.31***	6	0.000
European	Local	1.584	2	0.453
	World	5.196*	2	0.074
	East Asian	29.986***	2	0.000
	ALL	59.314***	6	0.000
East Asian	Local	1.720	2	0.423
	World	3.613	2	0.164
	European	0.063	2	0.969
	ALL	16.781***	6	0.010

Note. * means statistically significant at 10% level, ** at 5% level, *** at 1% level.

5. Discussion

Local California almond growers have been seeking academic assistance to understand how historical, local, and export prices impact farm-level profitability. In response to this request, the findings of this study provide important policy implications. First, a clear result of this study is farmers can rely on the current market price when forecasting local almond prices in the coming two months. From an economic perspective, farmers believe the current market price includes more information about the supply and demand situation than last month's price. However, this study also verified the current local price of almonds is a result of adjustments to the past two months of local prices. Thus, it is important for almond marketers to consider the automatic price adjustment in the local market such that when the price is low in the previous month, the price will improve in the following month to mitigate the negative price shocks from the previous month. It is also important to know that the local wholesale price before the next production season cannot be used as an indicator for long-run market price expectations. It is also not feasible to use external price shocks from the world, European, and East Asian markets to form long-run price forecasts. Previous research has not addressed this type of price analysis for the almond market and this study is the first to provide results about price relationships to support better decision making for local and international almond growers and marketers.

Second, this study finds the California local almond wholesale market is integrated into the world almond market, as well as the markets of its trading partners in Europe and East Asia. Specifically, California's local wholesale price to a great extent is positively correlated to the current world almond export price and negatively affected by the previous month's world price. If a world market price shock happens, the local wholesale price in California will adjust in the same direction and to a great magnitude. This price response is consistent with expectations since

the U.S. is the dominant producer of almonds and California is the primary producing region.

Third, the world export price for the current month directly impacts the local California almond price and moves in the same direction as export price to the East Asian market. Specifically, when U.S. export price to the world increases in the current month, its export price to East Asian countries will automatically adjust and increase in the following months. Given California supplies 80% of the world's almonds and China is the world's largest consumer market, results of this study may indicate even a slight increase in export price to China may have a large and positive effect on current U.S. export prices, and consequently form a positive ripple effect on the local almond wholesale price. However, this world market price shock with respect to the Chinese market is not sustained and is likely to fall in the following months. Thus, looking solely at world market price when projecting the local price for next season is not appropriate and may result in a large loss for California almond growers.

To address the high price uncertainty in California's almond wholesale market in the past seven years, this study initiated a VAR model to help local growers and marketers develop more accurate price expectations in the short-run period of two months. Analysis of the price series demonstrates a long-run price integration between local wholesale and U.S. export prices does not exist. Based on these findings, regular and wide dissemination of price and market supply information to almond growers and marketers is suggested to facilitate effective price forecasts. Given the USDA publishes almond world export price information monthly in its Global Agricultural Trade Systems (GATS) and the Almond Grower & Processor (RPAC) publishes local monthly market reports, California almond growers may want to refer to these information sources to form their price forecasts for the near future.

Lastly, analysis of the sample of prices considered in this study does not establish a long-run equilibrium nor market price integration. California almond growers should be informed that the world's almond trading markets do not synchronize with each other in the long term. This low market integration in the long run may be a result of a range of factors that impact price convergence between the local and world marketplaces. These factors include trade policy changes in recent years. For example, the Chinese government imposed a 50% almond import tariff in 2018, forcing Chinese importers to look to Australian and Thailand almonds as substitutes for California almonds (Research and Markets, 2020). Other factors such as transportation cost and new trade agreements may also have an impact. For example, the Regional Comprehensive Economic Partnership (RCEP) agreement of 2017, a multilateral Free Trade Agreement, was negotiated among sixteen countries in Southeast Asia, including China, which made China a more influential almond trade partner with the U.S. (California Almond Facts: China (2017). These trade policy changes may explain why price diverges in the long run for selected price series and long-run price integration between California's local market and the major international trade partners does not exist.

This study points to future research to better understand the price linkage between local and international almond markets. Specifically, future studies may address the price relationships between local almond markets and the major trading partners of India, China and emerging buyers from Eastern Asian countries. A limitation of this study is that California does not have a cash market for almond trading and the authors had to use wholesale prices documented by selected wholesalers. Future studies may involve a more comprehensive set of wholesalers to better assess local price movements.

For the seven thousand California almond growers, understanding the linkage between local and world export price provides them an accessible and useful price signal to guide production, marketing, and risk management decisions. California's Almond Board and related programs provide extensive training and educational programs to help local growers understand the mechanisms of trading and how U.S. export prices could impact domestic market prices. This study provides additional details to help local almond growers, marketers, and policymakers better establish reasonable price expectations and help California's almond industry develop into the most efficient, competitive, and successful producer of almonds worldwide.

Acknowledgements

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