Housing prices, labor market, and agricultural commodity prices: new evidence from California San Joaquin Valley

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Abstract

This paper studies the impacts of housing prices and labor markets on agricultural commodity prices. In particular, we focus on almonds and walnuts, two major agricultural commodities in the San Joaquin Valley of California. Cointegration analysis and the Granger causality test were used to investigate the relationships among monthly data of housing markets, labor market, and agricultural commodity prices. Both national and local level data of housing and labor market variables are analyzed. The empirical results suggest that, while most of the housing and labor market-related indicators have significant long-term cointegration relationships with agricultural commodity prices, local economic variables, especially local housing prices and employment data have the most prominent causalities on the commodity prices under study. The results provide new insights regarding the relationship between asset prices, commodity markets, and regional economic volatility.

Keywords: Commodity price; housing market; regional economy; asset pricing; granger causality.

1. Introduction

One of the most economically influential industries in the state of California is agriculture and few commodities are more important to this industry than tree nuts such as almonds and walnuts. California is the number one producer of tree nuts in the United States, and produces over 80% of the world's almonds; in addition, almonds and walnuts exports over $5.8 billion accounting for nearly 80% of the California crop.1 In 2012, California tree nut production (in conjunction with California fruit production) was valued at $18.7 billion (California Agricultural Statistics Review, 2014). In particular, California Walnuts and Almonds production was more than $7.3 billion in 2019.[2] Thus, tree nut prices are very important variables to not only farmers but also to the economy of California. In this research, we investigate the key factors that affect the price volatilities of tree nut prices in California using an up-to-date dataset.

[1] https://aic.ucdavis.edu/california-agricultural-exports-year-2000-through-latest-available-2/
[2] https://www.cdfa.ca.gov/Statistics/

The prices of agricultural commodities often change due to different factors in the industry and the economy. Important factors that impact tree nut prices are international trade, land values, and the local labor markets. The U.S. dollar exchange rate relative to the currencies of our major trading partners are a key indicator for trade relationships, and this has been suggested to have direct impacts on commodity exports. The local land value and the labor markets measure the costs of two important input factors for the production of any agricultural commodity. Our research investigates how these different variables correlate with the tree nut industry in California and what effect they may have on tree nut prices.

This research focused primarily on California's San Joaquin Valley, as this area arguably represents the most tree nut production in the state. We use cointegration tests and the Granger Causality test to study the relationships amongst the main variables under study. Our main hypothesis is that prices of tree nut commodities are influenced by exchange rates and trade, the value of agricultural land, and the labor market-related variables. While our results suggest that economic variables such as local employment, earnings, and housing prices do have significant causalities to the value of agricultural prices, we find that the U.S. exchange rate is not an influencing factor on the prices of walnuts and almonds in the San Joaquin Valley. These results not only help us better understand the price dynamics of tree nut commodities, but also provide insights for agribusiness and policy practitioners to more efficiently make business and policy decisions.

The rest of this paper is organized into five sections. Section two reviews relevant literature pertaining to this research. Section three details our data and lists the variables under study. In Section four, we explain the methodology of cointegration test and Granger causality test which are used to interpret the data and investigate our hypothesis. Section five is a discussion of the implications of the economic variables being studied on agricultural prices. Section six summarizes the findings and discusses future research directions and policy suggestions.

2. Literature Review

This research investigates the factors that can influence agricultural commodity prices in California's San Joaquin Valley. In particular, we focus on the price volatilities of walnuts and almonds, both of which are major agricultural commodities for this region, and study the economic variables that can affect their prices. The importance of agricultural price stability for the economy and society has been widely discussed in recent years. For example, it has been noted that price instability not only impacts food safety but also food security for poorer communities around the world, especially those in lesser developed countries. Volatile agricultural prices also contribute to a negative change in the standard of living of producers, especially when considering low prices (Lanfranchi et al., 2019). Price volatilities can be translated to a much greater scale and affect the economic vulnerability of entire countries, not just families or producers. This is especially pertinent when considering international commodity prices and their consequences on export and import markets (Combes & Guillaumont, 2002). Besides, the price dynamics of almonds and walnuts may also provide important information about the markets of other commodities. The U.S. tree nut industry is unique in that most nuts can serve as substitutes for one another except in a handful of cases (for example, walnuts cannot be used in a pecan pie). This special quality requires a more thorough investigation of the relationships among prices of different nuts which could be applied to other commodity industries (Ibrahim & Florkowski, 2009). In addition, knowledge about the relationships between commodity prices and other economic variables are also highly valuable for business and financial investments. It has been observed that owning walnut land in the central valley of California can be a better investment than the stock market. The production and price of this commodity, as well as the labor involved, only add to the value of the farmland (Cai et al., 2018). Although scholars have pointed out the importance of the volatility of agricultural commodity prices, the literature focused on the California tree-nut industry is still very limited. In this research, we seek to fill this gap and provide new empirical results about the walnut and almond markets.

Drawing on recent literature, we identify some important economic factors that may influence the tree-nut prices and empirically investigate their actual impacts. The first is market conditions, especially that of foreign demand. To appeal to foreign markets, the United States must remain competitive as compared to other countries. In research done on the export demand for U.S. pistachios, Zheng et al. (2012) suggest that the U.S. is encroaching on its main competitors, such as Iran's position as the top pistachio producer, by adopting advanced technology to increase yield and utilizing more skilled labor. They also found that providing superior quality relative to competitors in terms of flavor, packaging, and food safety can contribute to greater foreign demand for the U.S. commodities they studied. Trade tariffs is a closely related market condition worth considering. Along with stronger competition, tariffs are barriers to trade that can have a noticeable impact on commodity prices (Sumner & Hanon, 2018). As an important variable for international trade, the exchange rate and relevant policies are also relevant. A decrease in the value of the U.S. dollar lowers the actual costs for importing U.S. commodities, including agricultural goods, which ultimately leads to an increase in demand (Hatzenbuehler et al., 2016). Conversely, a strong U.S. dollar almost always results in a decrease in exports (Amatov & Dorfman, 2017). Some studies highlight the roles of national-level macroeconomic conditions and policies affecting agricultural prices. For example, variations in interest rates and money supplies can consequently increase or decrease commodity prices. These prices, which are often relatively flexible, can respond very quickly to changes and adjustments in macroeconomic policy (Henderson, 2018). However, on the other hand, it is also suggested that commodity prices have strong connections with local economic variables. Variables worth considering for small, rural communities include population, wages, housing market prices and investments. These considerations are applicable to this research as the San Joaquin Valley is primarily rural (Grimes & Hyland, 2013).

The economic connections between agricultural commodity prices and local economic performance have been widely discussed in recent years. For commodities, like walnuts and almonds, that are highly concentrated in specific regions like the San Joaquin Valley, such price volatilities are typically ever-present and unavoidable (Liang et al., 2021). Furthermore, it has been noted that relationships between economic variables and agricultural prices can be bilateral, having consequences and causalities in both directions. A regional economy that is overly saturated by the same few commodities may have economically cyclical characteristics that are repeating and therefore, potentially damaging (Liang, 2017; Liang & Goetz, 2016). However, as the San Joaquin Valley is an agriculturally-rich region with a variety of commodities produced, this may only be relevant for certain, smaller communities in the area. In this research, we will consider all of the above issues and empirically test them using the most recent data of the San Joaquin Valley tree-nut industries.

3. Data

The variables used in this study are summarized in Table 1. Our dataset covers the period from January 2000 to September 2018, and it includes variables of monthly agricultural commodity prices, local and national house prices, local and regional labor market variables, U.S. dollar exchange rate, and world food price index. For agricultural commodities, we study the two major agricultural products of the California Central Valley – almonds and walnuts. Their monthly price indices are obtained from the USDA Economics, Statistics and Market Information System3. All of these price data are already seasonally adjusted with ARIMA (Autoregressive integrated moving average) method4. National and local housing prices are obtained from the House Price Indexes (HPI) which is provided by the Federal Housing Finance Agency (FHFA)5. Specifically, for local house price, we calculated the weighted average of HPI of the four Metropolitan Statistical Areas (MSA) of California Central Valley. Employment and earnings data and U.S. dollar exchange rate index are from U.S. Bureau of Economic Analysis. Food price index is from the FAO6. When a variable's monthly price return is needed, it is calculated as 100 times the monthly difference of its natural logarithm.

Tab. 1.* - *List of variables (monthly data from 2000/1 to 2018/9)

Variable Name	Description
alm	Almond price
wal	Walnut price
hp_us	National housing price index
hp_l	Housing price index for the local area[†]
emp_us	Total private employment of the US
emp_l	Total private employment of the local area
earning_us	National average hourly earnings of private sectors
earning_l	Local average hourly earnings of private sectors
usd	U.S. dollar exchange rate index
fpi	Food Price Index

Note: [†] the local area refers to the four MSAs of the Central Valley area in California: Bakersfield, Fresno-Madera, Sacramento-Roseville-Arden-Arcade, and Stockton-Lodi.

In Table 2, we test the unit root of the above variables using DF-GLS test, as proposed by Elliott, Rothenberg, & Stock (1996). The results suggest that none of the logarithmic variables studied here are stationary, while their first difference variables are all stationary. That means these logarithmic variables are all integrated of order one, or ***I(1)*** processes.

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[3] https://usda.library.cornell.edu/

[4] For more details about the ARIMA method and seasonal adjustment of price data, please refer to United States Census Bureau: Seasonal Adjustment. https://www.census.gov/data/software/x13as/seasonal-adjustment-questions-answers.html#Q2

[5] https://www.fhfa.gov/

[6] http://www.fao.org/worldfoodsituation/foodpricesindex/en/

***Tab. 2.* -** *Unit Root Test*

Variable	DF-GLS test statistics	
	Logarithm	1st difference of logarithm
alm	-2.340	-5.862***
wal	-1.569	-7.517***
hp_us	-0.299	-1.858*
hp_l	-0.523	-1.982**
emp_us	-1.604	-3.006**
emp_l	-1.289	-6.698***
earning_us	-1.294	-2.664*
earning_l	-1.157	-7.304***
usd	-1.312	-4.293***
fpi	-1.582	-5.388***

Note: *H0*: Unit root exists. Optimum lags are chosen by modified akaike information criterion (MAIC).
*** p<0.01; ** p<0.05; * p<0.1

4. Method and Results

4.1 Cointegration Test

Cointegration means that two ***I(1)*** variables have some long-term interaction relationships. As shown in Table 2, the logarithms of the variables are all ***I(1)*** processes, and thus we can use cointegration test to investigate whether there exist long-term correlations between the agricultural commodity prices and the other economic variables under study. A widely used method for testing cointegration is the two-step EG-ADF test proposed by Engle & Granger (1987), where the cointegration equations are as below:

$$X_t = a_1 + b_1 * Y_t + e_{1t}$$

$$\mathrm{Y}_t = a_2 + b_2 * X_t + e_{2t} \quad (1)$$

In (1), *Xt* and *Yt* are two time-series variables, and e1t and e2t are the respective error terms of the two regressions. If ADF tests suggest that both e1t and e2t are stationary, then we can argue that there exists cointegration relationship between Xt and Yt. Here we use the maximum likelihood estimation (MLE) method proposed by Johansen (1995) to estimate the cointegration equations between the agricultural commodity prices and other economic variables.

Table 3 shows the results of cointegration tests between walnut prices and various economic variables. We can see that the hypothesis of the cointegration relationship is rejected for national employment and U.S. dollar index, while we cannot significantly reject the hypothesis that walnut prices have long-term cointegration relationships with the other six economic variables. Because all variables studied in the cointegration equations (1) are logarithmic variables, the regression coefficient b can be interpreted as the elasticity from the independent variable to the dependent variable. Thus, the results in Table 3 also suggest that, first, both national and local housing prices have long-term cointegrations with walnut prices, but the impacts of local housing prices on walnut prices is almost 50% stronger than that of national housing prices (elasticities of 3.450 vs 2.364). The same pattern is also found in the labor market variables: employment at the local level has significant cointegration with walnut prices while national employment does not; local average earnings have an elasticity of 6.295 on walnut prices, while national average earnings only have 2.820. Lastly, the U.S. dollar index's cointegration relationship with walnut prices is rejected, and in addition the direction of its coefficient does not meet economic expectations. Because a weaker U.S. dollar is expected to make U.S. commodities more economical in other countries, which boosts exports. That means ***b*** should be negative. Lastly, FPI has a positive cointegration relationship with walnut prices, which suggests walnut prices follow the general movement patterns of world food prices in this period.

Tab. 3. - *Cointegration tests: walnut prices*

Independent variables:	**Cointegration equation** *a*	*b*†	**Prob > Chi2 for e_t** †
hp_us	-3.195	2.364 (0.000)	0.626
hp_l	-9.184	3.450 (0.001)	0.342
emp_us	-27.848	3.061 (0.173)	0.000
emp_l	-28.548	5.134 (0.023)	0.227
earning_us	-10.303	2.820 (0.000)	0.286
pearning_l	-33.840	6.295 (0.000)	0.364
usd	-149.886	33.810 (0.019)	0.040
fpi	-7.281	3.204 (0.003)	0.502

Note: All variables are in logarithm. Number of lags in the cointegration equations are selected by Akaike information criterion (AIC).
† p-values are in parenthesis.
† Lagrange-multiplier test for *H0*: No autocorrelation in e_t.

Table 4 shows the results of cointegration tests between almond prices and the various economic variables, and the results are very similar to those of walnut prices as discussed above. First, although both national and local housing prices have long-term cointegrations with almond prices, the elasticity of local housing prices on almond prices is much greater – almost 50% greater than that of national housing prices. The cointegration relationship between the national total employment and almond prices is rejected, while the relationship with local employment and almond prices is not. The effect of local average earnings on almond prices is also much stronger than that of national average earning. The U.S. dollar index's cointegration relationship with almond prices is significant, and its elasticity is negative, which is consistent with our expectation that a stronger U.S. dollar discourages exports. Lastly, FPI has a positive cointegration relationship with almond prices.

Tab. 4. **-** *Cointegration tests: almond prices*

Independent variables:	Cointegration equation		Prob > Chi2 for et ☨
	a	b†	
hp_us	-2.091	2.090 (0.000)	0.497
hp_l	-8.488	3.317 (0.002)	0.907
emp_us	27.863	-1.637 (0.553)	0.000
emp_l	-23.686	4.455 (0.060)	0.106
earning_us	-3.516	1.835 (0.000)	0.312
earning_l	-22.22	4.586 (0.001)	0.261
usd	47.552	-8.379 (0.019)	0.969
fpi	0.054	1.698 (0.001)	0.272

Note: All variables are in logarithm. Number of lags in the cointegration equations are selected by AIC.
† p-values are in parenthesis.
☨ Lagrange-multiplier test for H0: No autocorrelation in et.

4.2 Granger Causality Test

The Granger Causality test between two stationary time-series variables R_X_t and R_Y_t are based on the following VAR (Vector Autoregression) model:

$$R\_Y_t = \beta_{10} + \sum_{i=1}^{p} \beta_{11i} R\_Y_{t-i} + \sum_{j=1}^{p} \beta_{12j} R\_X_{t-i} + \varepsilon_{1t}$$

$$R\_X_t = \beta_{20} + \sum_{i=1}^{p} \beta_{21i} R\_X_{t-i} + \sum_{i=j}^{p} \beta_{22j} R\_Y_{t-i} + \varepsilon_{2t}$$

(2)

The maximum lag numbers in (2) are determined by information criteria such as AIC. For the first equation in (2), if the null hypothesis that $\beta_{12j}=0$ $(j=1,2, \ldots, p)$ is rejected, then we can argue that the change in R_X_t Granger causes the change in R_Y_t. Likewise, we may say the change in R_Y_t Granger causes the change in R_X_t if the null hypothesis that $\beta_{22j}=0$ $(j=1,2, \ldots, p)$ is rejected.
The results of the Granger causality tests between the agricultural commodity prices and other economic variables are reported in Table 5 and 6. The prefix "R_" means return of the economic variable. As shown in the Unit Root Test Table 2 above, all the return data are stationary.
Table 5 reports the Granger causality results between walnut price returns and the returns of the various economic variables under study. We can see that, first, changes in the return of local housing prices, indicated by Granger results, cause the change in the return of walnut prices, while the causality from the return of national housing prices to walnut price returns is not significant. Second, both national and local employment can, as indicated by the Granger test, cause the change in walnut price returns, while the causalities from average earnings to walnut prices are not significant. The return of U.S. dollar index does not, as indicated by the Granger test, cause change in walnut price returns, which suggests that the exchange rate does not have a decisive effect on walnut trade in this period. Lastly, the change in walnut price return is influenced by the variability of the World Food Price Index.
Table 6 shows similar results of Granger causalities for almond price return. Local housing prices return are significant, as indicated by the Granger test, in relation to almond price return, while national housing price return does not. Employment data at local and national levels show mixed results in Table 6. The U.S. dollar index return is still not a significant with respect to the Granger test for almond price return, while the Food Price Index return is.

Tab. 5. - *Granger Causality Tests: return of walnut prices*

Null Hypothesis	**F statistics**	**Probability**
R_wal ⇏ R_hp_us	5.899	0.435
R_hp_us ⇏ R_wal	2.958	0.814
R_wal ⇏ R_hp_l	10.092	0.608
R_hp_l ⇏ R_wal	28.802	0.004
R_wal ⇏ R_emp_us	19.857	0.070
R_emp_us ⇏ R_wal	25.599	0.011
R_wal ⇏ R_emp_l	11.974	0.448
R_emp_l ⇏ R_wal	20.878	0.052
R_wal ⇏ R_earning_us	27.050	0.008
R_earning_us ⇏ R_wal	13.983	0.302
R_wal ⇏ R_earning_l	0.629	0.730
R_earning_l ⇏ R_wal	3.437	0.179
R_wal ⇏ R_usd	19.845	0.006
R_usd ⇏ R_wal	5.550	0.593

R_wal ⇏ *R_fpi*	2.704	0.259
R_fpi ⇏ *R_wal*	5.930	0.052

Note: ⇏ means no Granger causality from the left variable to the right variable.

Tab. 6. **-** *Granger Causality Tests: return of almond price*

Null Hypothesis	F statistics	Probability
R_alm ⇏ *R_hp_us*	7.608	0.179
R_hp_us ⇏ *R_alm*	4.437	0.488
R_alm ⇏ *R_hp_l*	11.756	0.068
R_hp_l ⇏ *R_alm*	11.646	0.070
R_alm ⇏ *R_emp_us*	44.931	0.000
R_emp_us ⇏ *R_alm*	20.378	0.060
R_alm ⇏ *R_emp_l*	18.396	0.104
R_emp_l ⇏ *R_alm*	18.001	0.116
R_alm ⇏ *R_earning_us*	15.889	0.238
R_earning_us ⇏ *R_alm*	15.889	0.044
R_alm ⇏ *R_earning_l*	13.707	0.008
R_earning_l ⇏ *R_alm*	4.836	0.305
R_alm ⇏ *R_usd*	22.491	0.000
R_usd ⇏ *R_alm*	7.878	0.163
R_alm ⇏ *R_fpi*	7.597	0.055
R_fpi ⇏ *R_alm*	25.639	0.000

Note: ⇏ means no Granger causality from the left variable to the right variable.

5. Discussion

The empirical results above reveal some important facts about the price dynamics of the agricultural commodities under study. First, local economic variables have strong associations with almond and walnut prices. The cointegration tests show that their elasticities with local employment, earnings, and housing prices are much stronger than their elasticities with those at the national level. The Granger causality tests suggest that there are significant causalities from local earnings and housing price values relative to agricultural commodity prices. These results are consistent with many recent studies of asset pricing and regional economies that emphasize the importance of localized economies on regional commodity production operations (Hu & Liang, 2018; Liang & Goetz, 2018). Specifically, California San Joaquin Valley accounts for most of the almond and walnut production in the United States, and the related ancillary industries and supporting services are also highly agglomerated in this area. As a result, the local economic

indicators like employment, wage level, and (housing) asset prices can significantly affect the costs and production schedules of these commodities, hence influence their global prices.
Another important finding of our empirical analysis is that the U.S. dollar exchange rate is not a strong predictor for the changes of almond or walnut prices during this period. This result is slightly different from traditional beliefs that exchange rates and trade relationships are closely associated with the global demand of commodities and their prices. Many possible factors exist that can explain this weak relationship between the U.S. dollar index and commodity prices as we find here, such as the elasticity of demand in international markets, non-exchange rate related issues in trade, and the relative importance of domestic versus overseas markets for the commodities. A more detailed analysis of these issues is beyond the scope of this paper, which can be possible topics for future research. Considering the highly unstable trade relationships between the United States and rest of the world in the recent years, our findings that almond and walnut prices are relatively immune to exchange rate turbulences provides some good news, and supports optimistic expectations for tree nut farmers in the United States.

6. Conclusion

In this study, we investigated correlations and causalities between exchange rates, land values, labor markets, local economic factors and agricultural prices of walnuts and almonds in California's San Joaquin Valley. Drawing on recent literature focusing on price volatilities and important economic variables, we empirically investigate the relationships between the economic and asset price variables understudy and the agricultural prices using cointegration and Granger causality tests. We find that employment, wage, and housing price variables, especially at the local level, have significant cointegration and causality relationships with almond and walnut prices, while the influence of U.S. dollar exchange rate is not significant. These results provide new insights on the price dynamics of walnuts and almonds, which are widely grown in the San Joaquin Valley of California and are highly influential on the local economy.
Our findings in this paper also point to a number of future research topics and policy suggestions. First, we studied two important agricultural commodities with very large commercial production in the United States, almonds and walnuts, but it is not clear whether the price dynamics and causality patterns of agricultural commodities and other economic variables we found here also apply to other commodities. Second, as we mentioned in Section 5, several factors can possibly explain why exchange rate volatilities in this period did not have significant causalities to the agricultural commodities prices, and future research can further study these issues when data are available; this would provide more insights about the relationship between international trade and agricultural commodity prices. Third, for farmers and farm advisors, our research suggests it is important to keep close track of local labor markets and asset prices, which can strongly influence the costs and hence prices of their agricultural commodities. Fourth, local policy practitioners should be aware of the associations between agricultural commodity prices and the local economy as suggested by this research. In particular, the price stability and competitiveness of agricultural commodities significantly relies on the predictability of local labor and asset markets.

Acknowledgements

The authors gratefully acknowledge USDA-NIFA funding that supports this research (Grant # 2018-51181-28437) as well as the Jordan College of Agricultural Sciences and Technology at California State University, Fresno. The authors are also grateful for constructive comments from the editor and anonymous referee(s). The usual disclaimers apply.

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