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Forecasting Organic Wheat Prices: Do Conventional Prices Play a Role?

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Abstract

Organic wheat production is generally profitable in the West, but farmers considering organic conversion or maintaining current organic fields face uncertainty due to significant price variations over time. The ability to predict price movements in this market is complicated by the limited availability of pricing data as well as missing observations. This study evaluates three methods to impute missing price observations. Additionally, we investigate short- and long-run relationships between organic and conventional wheat prices to understand whether conventional prices can help to predict organic wheat prices. Results indicate that conventional wheat prices influence organic prices, but only in the short run.

Keywords: cointegration, market integration, missing observations, organic, pricing, wheat

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Introduction

Organic wheat prices have changed rapidly in the past few years, leading to an overall increase in excess of 140% between 2010 and 2017. Generally, current organic wheat prices allow organic wheat production to be profitable in the West. But farmers face uncertainties regarding the length of favorable market conditions, which affects their decision to begin or continue dryland organic wheat farming. Lags in conversion contribute to on-going supply deficiencies that cannot keep up with growing demand. The organic premium, the difference between organic and conventional wheat prices, is one factor that plays a role in the profitability of the organic wheat production (McBride et al., 2012) and thus affects its attractiveness to farmers.

In this study, we investigate both long- and short-run relationships between conventional and organic wheat prices, using the concepts of market integration and price transmission. These relationships are used to determine whether conventional wheat prices can be used to forecast organic wheat prices. By examining the long-run relationship between organic and conventional wheat prices, we also aim to gain understanding about how organic premiums develop over time. However, our analysis is complicated by the limited availability of historical organic pricing data as well as missing observations in available pricing data.

We have three objectives for this study. First, we aim to recover missing organic wheat pricing observations through three different methods used to impute missing values. Second, we will examine price transmissions between organic and conventional wheat markets in both the long run and the short run. We investigate the presence of a long-run relationship by testing whether these two markets are cointegrated. Third, we develop a model to forecast organic wheat prices. As no cointegration between organic and conventional wheat market was found, we estimate a structural vector autoregressive (SVAR) model. In addition to forecasting, this model will be used to identify any short-run relationships between organic and conventional wheat prices.

Background and Literature Review

If the same information is used to form expectations about supply and demand in two different markets, these markets and their prices become linked. The strength of the link between prices can be examined by investigating their long- and short-run relationships. If prices share a stable long-run equilibrium, then the markets are said to be cointegrated. In this case, if one of the prices deviates from this equilibrium due to a shock in the market, an adjustment will take place to re-establish the equilibrium relationship that allows prices to move together over time. In the absence of market cointegration, prices are likely to diverge over time. In the context of this study, cointegration between organic and conventional markets plays a role in keeping the organic premium stable over time. In addition, both prices may influence each other in the short run, regardless of whether the two markets are cointegrated.

Several studies have examined price transmissions and market integration between organic and conventional commodities, which are qualitatively differentiated but can potentially act as substitutes. Kleemann and Effenberger (2010) found that price transmission occurs from the conventional to organic pineapple market in the short run, even though the markets for conventional and organic pineapple are not integrated.

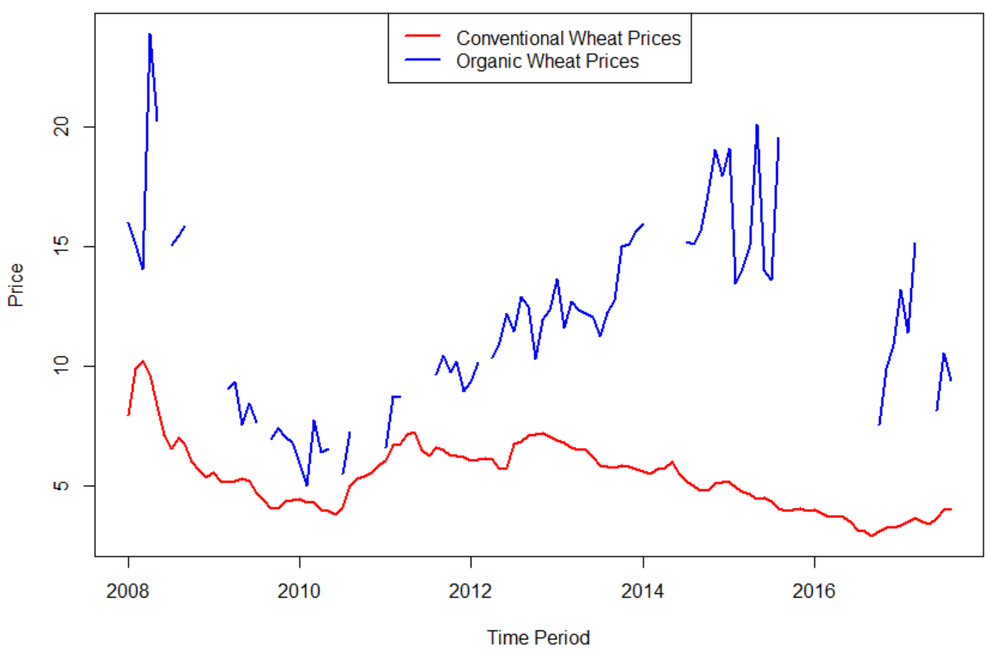
Singerman, Lence, and Kimble-Evans (2014) found no evidence of long- or short-run price relationships between organic and conventional corn and soybeans. Würriehausen, Ihle, and Lakner (2015) and Nemati and Saghaian (2016) found evidence of asymmetric price transmission and market integration between organic and conventional wheat and apples, respectively. Ankamah-Yeboah, Nielsen, and Nielsen (2017) found market integration between organic and conventional salmonids, at both the farm and retail levels. Conventional prices were found to influence organic prices clearly at the farm level only.

This study builds on the previous literature by investigating the dynamic short- and long-run relationships between organic and conventional wheat prices using standard vector autoregression methods. Examining such relationships will allow us to determine whether conventional wheat prices can be used to predict organic prices. We find that conventional wheat prices affect organic prices in the short run and thus can be used to predict recent organic prices. In the long run, however, these two markets are independent.

Data

The data used in this analysis are monthly farm-gate organic and conventional food-grade wheat prices between January 2008 and August 2017, obtained from the U.S. Department of Agriculture Agricultural Marketing Service (AMS) and Economic Research Service (ERS). Figure 1 plots observed organic and conventional wheat prices, with 116 observations for conventional wheat and 85 for organic. Values for the missing organic prices are imputed using i) spline interpolation, ii) an exponential moving average, and iii) an expectation maximization with bootstrapping (EMB) algorithm.

Figure 1. Observed Monthly Conventional and Organic Wheat Prices, January 2008–August 2017 (USD/bushel)



These three methods add robustness to our analysis, but the third method is most statistically sound and thus preferred. While the first two methods consider only observations proximate to missing values, the third uses the whole distribution of data in the imputation process and, additionally, accounts for the time series nature of the data. Figure 2 depicts observed organic prices as well as prices obtained using the three imputation methods. The organic wheat prices used in our analysis are the average of prices for soft red winter, hard red winter, and hard red spring wheat varieties. All prices were deflated using the seasonally adjusted consumer price index for cereals and bakery products and transformed into natural logarithms. Table 1 reports summary statistics for all price series used in this analysis.

Figure 2. Observed Monthly Organic Prices Compared to Complete Organic Prices Obtained Using Three Imputation Methods (USD/bushel)

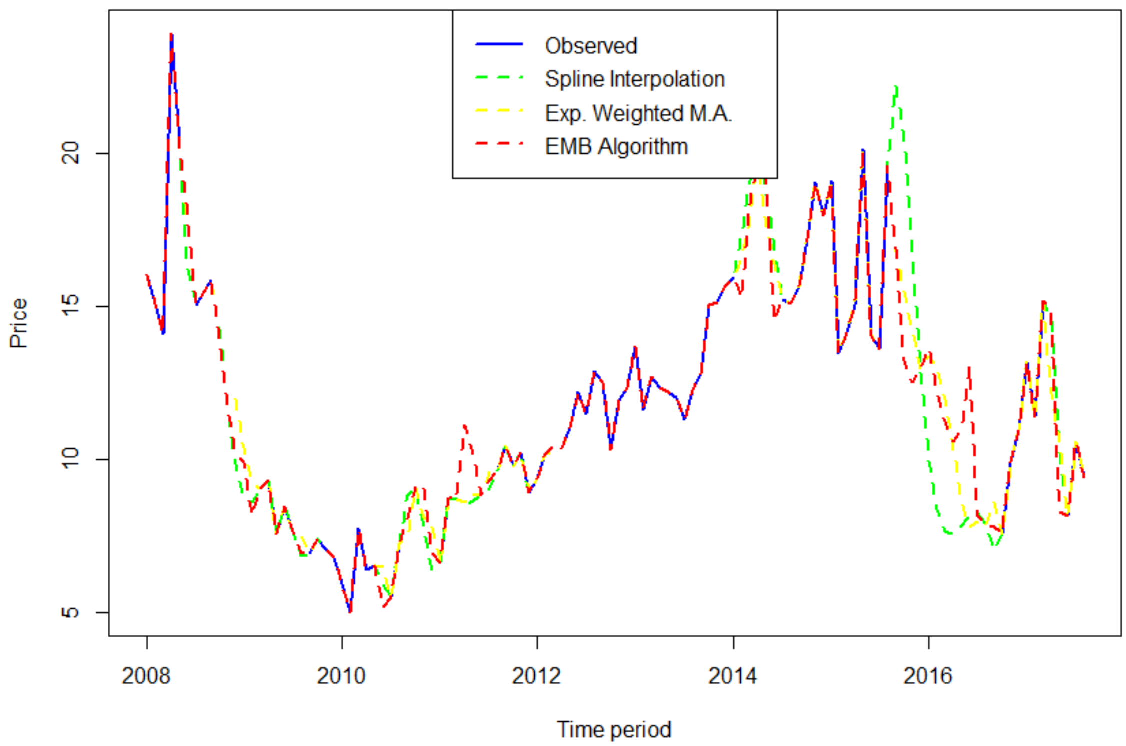


Table 1. Summary Statistics for Conventional and Organic Prices (USD/bushel)

	N	Mean	St. Dev.	Min.	Max.
Conventional price	116	5.38	1.44	2.93	10.19
Organic price – observed	85	11.96	3.96	5.02	23.91
Organic price – spline interpolation	116	11.80	4.18	5.02	23.91
Organic price – exponential moving avg.	116	11.85	3.85	5.02	23.91
Organic price – EMB algorithm	116	11.86	3.86	5.02	23.91

Methods

Markets are cointegrated when the corresponding price series follow a non-stationary process, a linear combination of prices results in a stationary process. Therefore, the first step is to apply unit root tests to individual price series to test for stationarity. We apply three tests, including Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS).

Next we test for the presence of cointegration on each pair of organic and conventional prices using the method developed by Johansen (1988). In general, given two non-stationary series, x and y, the series are said to be cointegrated if a unique β_1 exists that renders the difference $y - \beta_0 - \beta_1 x$ stationary. The Johansen cointegration test determines whether such β_1 exists. The cointegrating parameter, β_1, measures the long-run relationship. The Akaike information criterion (AIC) is used to determine the best number of lags to be used in the test.

Depending on whether we find evidence of cointegration, we then proceed to estimate either a structural vector error correction (SVEC) model or a structural vector autoregressive (SVAR) model to further examine dynamic relationships between prices. The bivariate SVEC model with k lags is specified as:

$$(1)\quad \begin{bmatrix} \Delta p_{1,t} \\ \Delta p_{2,t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \left(p_{1,t-1} - \beta_0 - \beta_1 p_{2,t-1}\right) + A_0 \begin{bmatrix} \Delta p_{1,t} \\ \Delta p_{2,t} \end{bmatrix} + \sum_{i=1}^{k} A_i \begin{bmatrix} \Delta p_{1,t-i} \\ \Delta p_{2,t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix},$$

where $p_{1,t-1} - \beta_0 - \beta_1 p_{2,t-1}$ is the lagged error correction term and its coefficients α_1 and α_2 measure the percentage of deviation from equilibrium that is adjusted in the next period. A_0 is a 2 x 2 matrix with three coefficients restricted to 0 for identification purposes, and the remaining non-zero coefficient measures the contemporaneous effect between the two prices. A_i for $i = 1,2,\dots,k$ is 2 x 2 matrix with the coefficients measuring short-run effects. The number of lags k is determined using the AIC, and $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are *i.i.d.* error terms with 0 mean and constant variance. In addition, all log-transformed prices are in the first differences (Δ is the first-difference operator). If cointegration between organic and conventional wheat prices is not found, then a SVAR model is estimated similarly to equation (1) but with the error correction term removed.

Results

The unit root tests results reported in Table 2 show unambiguously that all log-transformed prices are non-stationary in level form and stationary in first differences. The results of the Johansen cointegration test reported in Table 3 show that there is no cointegration between the prices within each pair of organic and conventional wheat prices. That means that there is no stable long-run relationship between organic and conventional prices. As a result, we estimate a SVAR model. The best-fitting SVAR model is estimated on the pair of conventional and organic wheat prices obtained using the EMB algorithm. The AIC selected 2 lags as the best number of lags for the model. The results reported in Table 4 show that current organic prices are influenced by conventional prices in the current period and in the last two months. In addition, as expected, current organic prices are affected by both lags of organic prices.

Results also show that current conventional wheat prices are mainly influenced by conventional prices 1 month ago and weakly influenced by conventional prices 2 months ago and organic prices 1 month ago. The magnitude of the estimated coefficients is not interpretable in the usual way, as an impulse response function (IRF) analysis needs to be employed to assess the short-run dynamics more accurately. In our analysis, we also consider the possibility that the interactions between organic and conventional prices may change over time, meaning that the estimated coefficients would not be stable over the entire studied period. The test for the presence of structural breaks reveals that the stability condition of our estimates holds, meaning that no structural breaks occurred during the studied period. Thus our model, which assumes constant coefficient estimates over the entire studied period, is appropriate.

Table 2. Results of Unit Root Tests for Log Transformed Prices in Levels and First Differences

	Levels			**First Differences**		
	ADF	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
Drift only						
Conventional	-1.46	-	1.62***	-6.55***	-	0.10
Org – spline interp.	-2.20	-	0.70*	-7.31***	-	0.08
Org – exp. m. avg.	-1.67	-	0.77***	-7.38***	-	0.10
Org – EMB algorithm	-1.73	-	0.82***	-9.99***	-	0.08
Trend and drift						
Conventional	-1.76	-6.52	0.48***	-6.55***	-74.2***	0.10
Org – spline interp.	-2.35	-10.85	0.35***	-7.29***	-100.3***	0.07
Org – exp. m. avg.	-1.90	-9.99	0.37***	-7.35***	-136.9***	0.10
Org – EMB algorithm	-1.94	-12.15	0.37***	-9.97***	-109.9***	0.08

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 95%, 99%, and 99.9% confidence levels, respectively. H_0 for ADF and PP tests: Series are non-stationary. H_0 for KPSS test: Series are stationary.

Table 3. Results of Johansen Cointegration Tests for Each Pair of Log Transformed Prices

		Test	**Critical Values**		
	Rank	**Statistic**	**10%**	**5%**	**1%**
Conventional and organic	$r \leq 1$	5.32	7.52	9.24	12.97
(spline interpolation)	$r = 0$	17.47	17.85	19.96	24.6
Conventional and organic	$r \leq 1$	4.17	7.52	9.24	12.97
(exponential moving average)	$r = 0$	16.59	17.85	19.96	24.6
Conventional and organic	$r \leq 1$	2.74	7.52	9.24	12.97
(EMB algorithm)	$r = 0$	15.66	17.85	19.96	24.6

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 95%, 99%, and 99.9% confidence levels, respectively. H_0: There are r ($r = 0$ or $r \leq 1$) cointegrating relationships.

Table 4. Regression Results of the SVAR Model Using Organic Prices Obtained Using the EMB Algorithm

	$\Delta price_{conv}$		$\Delta price_{org}$	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**
Conventional price, current period	-	-	0.871**	0.292
Conventional price, 1st lag	0.524***	0.097	0.108	0.331
Conventional price, 2nd lag	-0.178	0.092	0.880**	0.283
Organic price, 1st lag	-0.051	0.029	-0.261**	0.091
Organic price, 2nd lag	-0.005	0.030	-0.307***	0.090
Intercept	-0.536	0.461	0.773	1.410
Prob > F	0.000		0.000	
Adjusted R^2	0.189		0.219	

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 95%, 99%, and 99.9% confidence levels, respectively.

Conclusions

As organic wheat prices and, more specifically, their premium over conventional wheat prices play a role in the attractiveness and profitability of organic wheat farming, this study seeks to understand the relationships between organic and conventional wheat prices. We find that in the long run, organic and conventional prices behave independently of each other. But we find that conventional wheat prices do affect organic prices in the short run and thus can be used to predict recent organic wheat prices. We conclude that price transmission occurs between these two markets to some extent, but there are factors that cause prices to diverge over time. Shortages in the organic wheat market may contribute to the independent development of organic wheat prices.

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