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Impact of Alfalfa Exports Surge on Dairy and Feed Markets in California

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Abstract

Alfalfa hay exports have surged considerably since 2000, with 95% of shipments being supplied from seven western states. Many of these states are major US dairy and alfalfa hay producers, and in particular California is the nation's largest producer for both commodities. We investigate whether the spike in alfalfa exports has caused a structural break in its dynamic evolution from the year 2000 until present and find a significant break for the years 2007-2008. Just as important, we also find significant evidence of California dairy and alfalfa markets having undergone structural breaks, and investigate whether there has been a change in the dynamic long run relationships among these two markets for the periods' pre and post-break. We identify significant differences among the two periods, in particular for the speed of adjustment following a shock to either market. Implications are of effects in risk management and policy analysis.

Key words: Alfalfa Exports, California Dairy and Alfalfa markets, structural break, reference price, co-integration.

Impact of Alfalfa Exports Surge on Dairy and Feed Markets in California

There has been a steady growth in alfalfa exports (Figure 1), which proceed mainly from the western states, especially from the beginning of 2000 and going forward. The initial alfalfa hay export uptick occurs in 2002 but more prominently after 2008 (dotted line in Figure 1). Putnam et al. (2013) note that 99% of alfalfa exports are shipped from western ports and there has been a substantial surge in exports from 2008 up to date. Putnam et al. (2015) also note that "…more than 95% of these exports originate from the seven western states of Arizona, California, Idaho, Nevada, Oregon, Utah and Washington," and, in particular, California and Idaho are the two largest alfalfa producing states in the U.S. (NASS, 2016). Alfalfa hay is the main feed element of the dairy industry, especially in the West, covering a bit less than half of the ration components for dairy cow consumption. The seven western states produced just over 33% of total US milk production in 2017 (U.S. Dairy Statistics, 2017). As a result, this increase in alfalfa export operations opens a new growing market for alfalfa hay, having an unexplored effect on the pricing process in alfalfa hay and its relationship with the milk markets in the West.

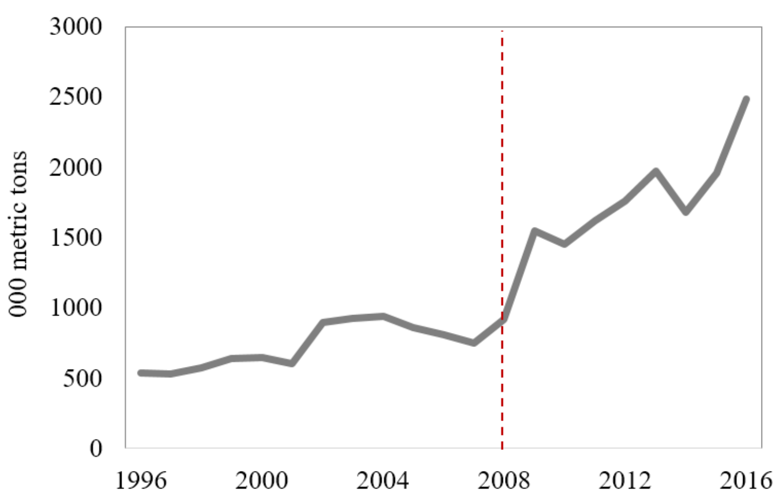

Figure 1: Alfalfa Hay Export from Seven Western States.

Source: FAS – USDA

Note: dotted line indicates the potential structural break in alfalfa hay export in 2008

Alfalfa is a main feed component for the dairy industry and the concentration and scale of dairy producers varies considerably by state. Unlike other major feed components such as corn and soybean meal, alfalfa hay markets do not have a presence in the futures markets. This latter plays a critical role in providing information for the commodity markets' price discovery process (Leuthold et al., 1989). Price discovery is about determining which market is more informative for fundamental valuation when similar commodities or inter-connected commodities like alfalfa hay and milk are traded in different markets. A number of different methods have been used to study price discovery. One of methods is to use bivariate time series analysis with the error correction term and compare the speed of adjustment between the two series (Gonzalo and Granger, 2005). A detailed description of these methods is presented in the following sections.

This study investigates the dynamic relationships between alfalfa hay and milk markets in California. In particular, the study determines whether these markets underwent structural changes following a surge of alfalfa hay exports. More importantly, it identifies possible implications from these growing alfalfa hay exports on the interrelationship between the California alfalfa and dairy markets; specifically, changes in the price discovery process among these two markets. California is both the country's largest dairy producer and alfalfa producer and exporter, with their industries valued at about 6.07 billion dollars (milk production, 2016 State Ag Overview) and 1.13 billion dollars (value of hay and haylage production, 2016 State Ag Overview), respectively. Results of this study provide insightful information to risk managers as well as policymakers in the alfalfa and milk industry in California, in addition to the surrounding western state alfalfa exporting markets.[1]

[1] California currently has its "own" Milk Marketing Order system to determine the milk prices. This system is unrelated to those prevalent in neighboring western states. A new Milk Marketing Order is under review for implementation.

Unfortunately, to the authors' best knowledge, there are no previous studies which have investigated the interrelationship between alfalfa hay and milk markets even though there have been numerous studies about price discovery across various commodities. Regarding alfalfa hay, Tejeda, Kim and Feuz (2015) investigated the dynamic price relationships among alfalfa markets in seven western states including California. They conclude that California has a dominant effect on the price movements of the other alfalfa hay producing regions.

We proceed by describing the data and methodology applied. We then present the results followed by discussion and implications. We conclude with final remarks and future lines of study.

Data and Methodology

Monthly milk and alfalfa hay prices (obtained from NASS-USDA) from January 2000 to December 2016 are tested for structural break(s) by using a dynamic programming approach from Bai and Perron (1998 and 2003). Because there is a structural break in alfalfa hay export in 2008 (Figure 1 and from Bai and Perron test on annual export data), we anticipate structural break(s) in milk and alfalfa hay markets during 2007 or 2008. Vector Error Correction Models (VECM) are then estimated with California monthly price series of alfalfa and milk taking into consideration the periods of pre and post structural break. That is, two VECM models are estimated considering the period prior to and period post structural break.

Figure 2 shows the evolution of the California milk and alfalfa hay prices. As shown in Figure 2, it is not clear whether both prices are non-stationary and cointegrated. Unit root tests are applied by using Augmented Dickey Fuller (Dickey and Fuller, 1981) and KPSS (Kwiatkowski et al., 1992) tests. In addition, the Johansen (1991) co-integration test is used to verify the existence of co-integration or long-run relationship between two markets.

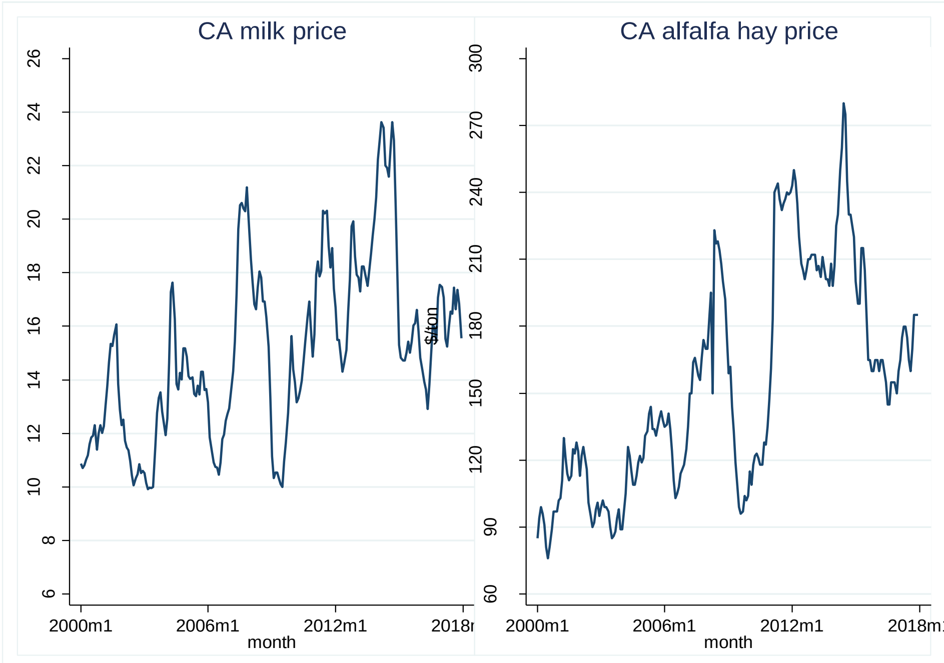

Figure 2: Monthly California Milk and Alfalfa Hay Prices.

Source: USDA-NASS

Since price discovery is about an identical/similar or inter-connected commodities traded in different markets, a cointegration framework is typically adopted. The conventional price discovery measure used in the literature simply compared the speed of adjustment coefficients in the (bivariate) VECM as a share of the total adjustment. As explained Arnade and Hoffman (2015) estimates of (absolute) adjustment rates are related to market efficiency. The long-run equilibrium between alfalfa hay and milk prices can be written as follows:

(1) $$p_{milk,t} = \beta_{alf} p_{alf,t} + c + u_t \quad \Leftrightarrow \quad u_t = p_{milk,t} - \beta_{alf} p_{alf,t} - c$$

where $p_{milk,t}$ and $p_{alf,t}$ represent milk and alfalfa hay prices at time t, respectively. The term c (constant term) account for differences in these two markets. The term u_t is the (long-run) error, which equals zero in equilibrium.

The bivariate VECM contains this long-run equilibrium in equation (1) as follows:

(2) $$\Delta y_{i,t} = \alpha_i\left(\beta' y_{i,t-1} + c\right) + \sum_{l=1}^{L}\sum_{j=1}^{2} a_{i,j,l}\Delta y_{j,t-l} + \sum_{m=1}^{11} b_m x_{m,t} + e_{i,t}, \quad (i = \text{milk}, \text{alf})$$

where $\Delta y_{i,t} = y_{i,t} - y_{i,t-1}$ are the price differences of alfalfa hay and of milk for month t, β is the co-integrating parameter among the two markets, and α_i are the "speed of adjustment" parameters. The coefficients α_{milk} and α_{alf} in the VECM determine the permanent effect that a shock to one of the variables has on the system (Theissen, 2002). The parameters b_m are the coefficients for monthly dummies as shown in Figure 2 where monthly seasonality exists.

We investigate the reference price among milk and alfalfa markets, prior and post the (potential) structural break, identifying whether there have been substantial changes in this process. To determine the reference market (price discovery)[2], we calculate the relative ratio of the speed of adjustment coefficients following Schwarz and Szakmay (1994), Foster (1996), and Theissen (2002). In effect

(3) $$\theta_{milk} = \frac{|\alpha_{alf}|}{|\alpha_{milk}|+|\alpha_{alf}|}, \quad \theta_{alf} = \frac{|\alpha_{milk}|}{|\alpha_{milk}|+|\alpha_{alf}|}, \quad \text{and} \quad \theta_{milk} + \theta_{alf} = 1$$

where a high (low) θ_i ($i = milk, alf$) indicates a low (high) α_i, which in turn implies that market i slowly (quickly) responds to an unpredicted shock in the system; therefore market i is (not) the price discovery reference market. If $\theta_{milk} = \theta_{alf} = 0.5$, both markets contribute rather equally to the price discovery process; i.e. both markets move at a roughly similar rate toward the long-run equilibrium. We examine and contrast results obtained for the two periods estimated.

[2] Other measures of price discovery used in the literature are the Information Share (IS) of Hasbrouck (1995) and the Component Share (CS) of Booth et al. (1999), Chu et al. (1999), and Harris et al. (2002). The IS measures each market's relative contribution to the variance of the efficient price, while the CS decomposes the common efficient price into a weighted average of observed market prices (similar to relative ratio of the speed of adjustment), and measures each market's contribution to the common efficient price. Both IS and CS are based on the reduced-form "forecasting errors" in a Vector Error Correction Model (VECM) (Kim, 2011).

Results

The structural break test (Bai and Perron, 1998 and 2003) applied to monthly milk and alfalfa hay prices from January 2000 to December 2016 delivered somewhat similar results. In the case of milk price, three structural breaks are identified; one in February 2007, another in January 2011, and lastly one in December 2014. Among them, the February 2007 break has the largest F-statistics, which is consistent with the structural break in alfalfa hay export in 2008. There were four structural breaks in alfalfa hay price; these where in March 2004, February 2007, February 2011, and April 2015. Among them February 2011 had the largest F-statistic and February 2007 had a close second largest F-statistic. In accordance with these results, February 2007 was selected as the month and year of the structural break considering jointly these two markets. We proceeded to partition the monthly price series accordingly, i.e. Pre-2007 (2000 M1-2007 M2) and Post-2007 (2007 M3-2017 M12).

Unit root tests are performed on each price series (Table 1). In both pre-2007 and post-2007, milk and alfalfa hay prices are identified as being non-stationary even though the results are mixed as shown in Table 1. The Schmidt-Phillips test (Schmidt and Phillips, 1992) is also performed to circumvent mixed results from ADF and KPSS tests. Schmidt and Phillips (1992) have proposed a non-stationarity test with a deterministic trend. The Schmidt-Phillips test confirms that both prices are non-stationary for both Pre-2007 and Post-2007 periods. We then apply Schwarz criteria to estimate the number of lags in the VAR models with monthly dummies and find the optimal lag length for VECM (Enders, 2004; pg. 358). From this, VECM (1) with monthly dummies are estimated for both periods. The Johansen test for co-integration (Johansen, 1991) results in one long-run relationship between milk and alfalfa prices, in each period (Table 2).

Table 1: Unit Root Tests

	All (N = 216)		Pre-2007 (N = 86)		Post-2007 (N = 130)	
Raw data	ADF (non-zero mean)					
	Milk	Alfalfa	Milk	Alfalfa	Milk	Alfalfa
Test statistics	-3.185	-1.926	-3.002	-2.401	-3.21	-1.678
Lags[a]	1	0	1	1	1	0
5% critical value			-2.86			
Decision[a]	S	NS	S	NS	S	NS
	KPSS test (level stationarity)					
	Milk	Alfalfa	Milk	Alfalfa	Milk	Alfalfa
Z(t) statatistics	1.866	2.716	0.238	0.842	0.257	0.429
Lags[a]	4	4	3	3	4	4
5% critical value			0.463			
Decision	NS	NS	S	NS	S	S
	Schmidt-Phillips test					
	Milk	Alfalfa	Milk	Alfalfa	Milk	Alfalfa
Z(rho) statistics	-21.579	-14.084	-10.416	-11.025	-12.463	-8.101
Lags[a]	4	4	3	3	4	4
5% critical value			-18.1			
Decision[a]	S	NS	NS	NS	NS	NS

[a] Lags for ADF test is determined by minimizing Schwarz Criterion and for KPSS test is given by Newey-West lags, $\text{int}\left\{4(T/100)^{\frac{2}{9}}\right\}$, where T is the number of observations

[b] ADF test - testing the null hypothesis of nonstationarity, thus the series is stationary by rejecting null hypothesis; KPSS test - testing the null hypothesis of stationarity, thus the series is stationary by failing to reject null hypothesis; Schmidt Phillips test – testing the null hypothesis for a unit root in the presence of deterministic trends; and NS = nonstationary, S = stationary

Table 2: Trace Test on Order of Co-integration

Pre-2007						
Rank	Trace*[a]	C*[a]	Decision	Trace[b]	C[b]	Decision
r = 0	20.83	20.16	Reject	26.18	25.73	Reject
r ≤ 1	8.29	9.14	Fail to Reject	11.75	12.45	Fail to Reject
Post-2007						
Rank	Trace*	C*	Decision	Trace	C	Decision
r = 0	31.55	20.16	Reject	31.54	25.73	Reject
r ≤ 1	4.57	9.14	Fail to Reject	4.61	12.45	Fail to Reject

[a] Trace* and C* refer to the values of trace statistic and critical values at the 5% significance level with an intercept.

[b] Trace and C refer to the values of trace statistic and critical values at the 5% significance level with a time trend and an intercept

[c] The first "fail to reject" the null hypothesis occurs for r ≤ 1. Thus, there are 1 cointegrating vector in each sub-period.

Upon modeling our pre- and post-2007 VECM, we obtain the α_i coefficients from the error correction vectors. For the pre-2007 period, they are $\alpha_{milk} = -0.121$ and $\alpha_{alf} = 0.120$ which results in a ratio of speed adjustment $\theta_{milk} = 0.498$ and $\theta_{alf} = 0.502$. Conversely, for the post-2007 period, the α_i coefficients are -0.065 and 0.204; resulting in a speed adjustment θ_i of 0.758 and 0.242 for milk and alfalfa, respectively. We therefore find that prior to the structural break that occurred in February 2007, the long run relationship between California milk and alfalfa hay - following shocks to either market - was quite symmetrical in its responding speed to return to their long-term equilibrium. In other words, if either milk or alfalfa was subject to an external shock, these markets returned to their long-run equilibrium at a very similar pace. This, however, is not the case after February 2007, where the speed of adjustment coefficient for milk price is almost four times higher than that of alfalfa price. This implies that, after a shock to either market, the alfalfa market will return to the long-run equilibrium at a much quicker pace. The long-run equilibrium also changed. The slope parameter, β, in the long-run equation, $y_{milk,t} = \beta y_{alf,t} + c$, is estimated to be $\beta^{pre} = 0.350$ and $\beta^{post} = 0.521$, which implies that the impact of alfalfa hay has been increased. Figure 3 illustrates these results.

We examine more closely the changes in the pre and post slope (β) of the long-run equilibrium equations. In the pre-2007 period, milk price increased by about 0.35 dollars when alfalfa hay price increased by 1 dollar. In the post-2007 period, however, milk price increased by 0.52 dollars when alfalfa hay price increased by 1 dollar, meaning that the impact of alfalfa hay increased considerably after the structural break. The different speed of adjustments have more interesting implications. Suppose that milk price is increased from p_{milk}^0 to p_{milk}' after an (unexpected) shock to the milk market as shown in Figure 3. In the pre-2007 period, both milk and alfalfa hay markets respond to this change. Milk price decreases to p_{milk}^1 (but higher than

p^0_{milk}) and alfalfa hay price increases to p^1_{hay}. The relative price adjustments in milk market and alfalfa hay market are somewhat similar. In the post-2007 period, however, the milk market would not respond much to the change. Milk price decreases only slightly, conversely alfalfa hay price moves quite extensively (Post-2007 panel, Figure 3).

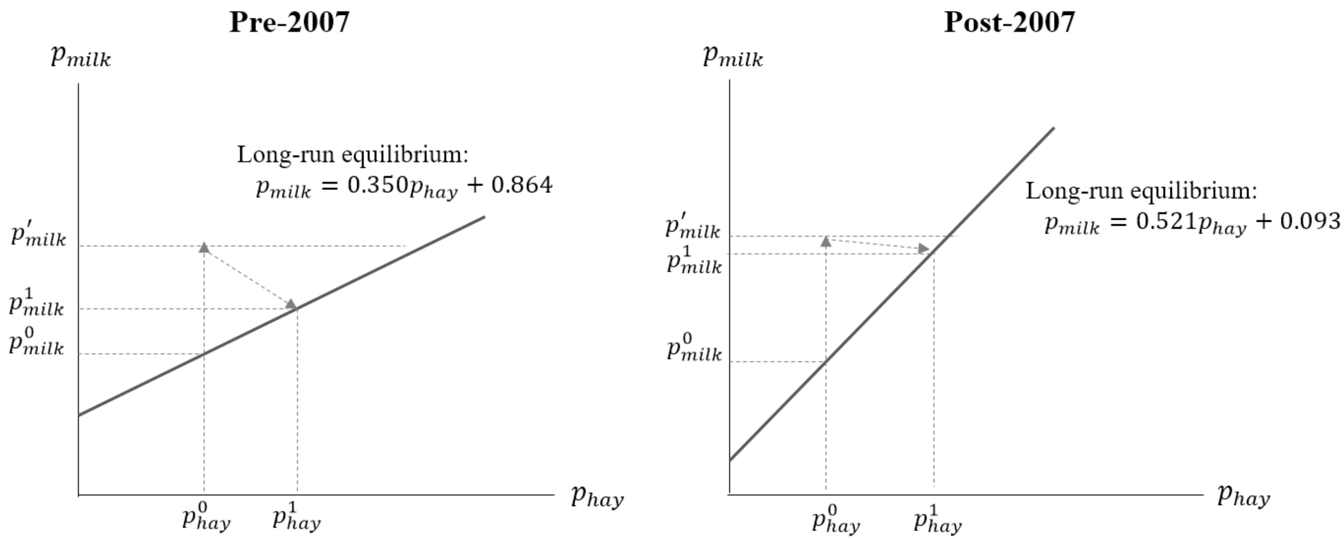

Figure 3: Illustration of Long-run Equilibrium and Speed of Adjustments

Conclusions

This study investigates the dynamic relationships between alfalfa hay and milk markets in California. In particular, the study determines whether these markets underwent structural changes following a surge of alfalfa hay exports; and more importantly, it identifies possible implications from these growing alfalfa hay exports on the interrelationship between the alfalfa and dairy markets in California.

The surge in alfalfa hay exports in 2007~8 has resulted in a new long run relationship between California milk and alfalfa prices in comparison to the era prior to 2007, as shown in

Figure 3. A main finding of this new relationship is that following an external shock, the speed of adjustment towards long run equilibrium is no longer similar among the two markets, since alfalfa hay now adjusts much quicker. This result indicates that California milk prices would now serve as reference in comparison to California alfalfa hay prices. A natural question is what drivers are behind this, perhaps partly because of changes in the relationship between dairy farms, alfalfa hay production and exports, and partly because of technological changes in both the dairy sector and alfalfa hay sectors. Government policies might also be a source of this change. These are relevant matters of future study.

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