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Factors Impacting Alfalfa Hay Prices in Seven Western States: An Explanatory Model Used for Extension Forecasting

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Abstract
Alfalfa is an important crop for the seven western states in the U.S. However, price reporting is inconsistent across the states and there is no futures market for alfalfa hay. This creates price uncertainty within these hay markets. This paper looks at how closely alfalfa hay prices in one state track with hay prices in another state. Further, the paper seeks to determine what factors have influenced alfalfa hay prices over time. Alfalfa prices for the last 30 years, 1992-2021, for each of the seven western states of Arizona (AZ), California (CA), Idaho (ID), Nevada (NV), Oregon (OR), Utah (UT), and Washington (WA) were analyzed and compared. The hay prices between the states are correlated between 0.85 and 0.96. California and Oregon had the highest prices over time and Idaho and Utah had the lowest prices. A regression model was developed to explain what factors influence western state alfalfa hay prices. The findings indicate that larger May 1 hay stocks for the seven-state total leads to lower alfalfa hay prices. Additionally, increased hay exports increase hay prices. Higher corn, feeder cattle and milk prices all positively impact alfalfa hay prices with corn having the biggest impact and milk prices having the smallest impact.

Key Words: Alfalfa Hay Prices, Western States, Regression Model

JEL code: Q13

Introduction

Alfalfa is the number one valued crop for Nevada, Oregon, and Utah and is the number two valued crop in Arizona and Idaho. In Washington and California, respectively, alfalfa is the 4th and 5th highest valued crop (USDA-NASS). Despite alfalfa's crop value in AZ, NV and UT, the USDA-Agricultural Marketing Service (USDA-AMS) does not provide a weekly *Direct Hay Market* report for these states. Even in the states where a weekly market report is provided, prices often go unreported due to lack of sales. As a result, long periods of time pass where either no price is reported, or where the reported price remains unchanged. For example, the USDA-National Agricultural Statistics Service (USDA-NASS) monthly *Agricultural Prices* report lists the same price for three, four, and even five months in a row on multiple occasions in the last ten years for these seven western states.

No futures market exists for alfalfa hay, and with limited or no price reporting of alfalfa sales, this creates price uncertainty within these hay markets. Often buyers and sellers of alfalfa must rely solely on "coffee shop" talk to inform their expectations of current and future alfalfa hay prices.

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How closely do alfalfa hay prices in one western state track prices in another western state? If prices are not reported in Utah, for example, can a Utah producer follow the Idaho or Washington hay market reports? Tejeda, Kim and Feuz (2015) analyzed monthly alfalfa prices for the seven western states from 2000-2014 and concluded that prices between states were all co-integrated and endogenous. Simply stated, the prices all seem to respond to the same market information and the markets are all interrelated. They also found that California prices led the other states, and that Oregon, Idaho and Utah prices also seemed to follow Washington prices. A more recent study by Tejeda, Kim and Feuz (2017) examined the impact of increased alfalfa hay exports on California alfalfa and milk prices. They concluded that structurally the markets changed in 2009 as a result of increasing alfalfa hay exports. They also suggest that there is a need for additional research to determine what factors other than exports and milk prices may be impacting alfalfa hay prices.

The objectives of this paper are: 1) to determine what factors have influenced alfalfa hay prices in the seven western states, and 2) to construct a model which might be adopted by Cooperative Extension personnel to improve their ability to make alfalfa market outlook predictions/forecasts.

Data and Methods

Annual crop year (i.e., May-April) alfalfa prices for the last 30 years, 1992-2021, for each of the seven western states of AZ, CA, ID, NV, OR, UT, and WA were obtained from the USDA-NASS Agricultural Prices reports. Table 1, contains summary statistics for those marketing year average prices converted to real dollars using the GDP Price Deflator with 2015 as the base (Federal Reserve Bank of St. Louis, 2023), and Figure 1 is a plot of those real prices over the 30-year time period. The complete price data set is in Appendix Table A1. The seven different price series means are tested to determine if the mean hay price varies by state. A t-test for Paired Sample Means is used to test these differences. A correlation analysis of all the seven different price series is also performed.

What are the underlying supply and demand factors that could be expected to influence alfalfa prices? Most of the alfalfa grown in the West is grown under irrigation, and, as such, annual production is less variable than in areas that rely more heavily on rainfall. USDA-NASS releases two hay stocks reports annually: for December 1 and May 1. The May 1 stocks report is essentially the carryover stock from the prior hay marketing year into the new hay marketing year. Both Arizona and California begin harvesting hay prior to May 1 each year, but May 1 is regarded as the new crop year by industry analysts. The May 1 Hay Stocks for the seven western states will be used as a measure of annual changes in supply at the start of each new marketing year.

On the demand side, most alfalfa hay in the seven western states is fed to the dairy and beef cattle industries. Milk prices and feeder cattle prices will be used as proxy variables to reflect potential profitability changes in those industries and the implied potential changes in demand for feed. Grain and grain silage, mainly corn, are also major ration components for dairies and feedlots. There is not 100% substitutability between alfalfa hay and the amount of grain and grain silage in a ration due to the nutrients required by the cattle and the nutrients supplied by the feed. However, at the margin, one would expect lower grain and grain silage prices, relative to alfalfa hay prices, to result in more grain and silage being fed and less alfalfa hay and alfalfa haylage being fed. Hoyt (2017) documented, since 2009, the amount of alfalfa fed per day per cow in California dairies has decreased from over 11.5 pounds to less than 7.5 pounds. Perhaps this is a result of increased relative alfalfa hay prices due to increased hay exports since 2009. The price of corn grain will be used to capture these price differentials between feed grains/silages and alfalfa hay.

In 1992, very limited alfalfa hay was exported. By 2015, Tejeda, Kim and Feuz (2015) indicated that likely 20% of U.S. alfalfa hay was being exported and Putnam et al. estimated that more than 95% of those alfalfa hay exports originate from the seven western states. Therefore, annual alfalfa hay exports will also be expected to influence the demand and price for alfalfa hay in the seven western states.

The following ordinary least squares (OLS) regression model was estimated for the annual average of the seven western states' alfalfa prices from 1992-2021 and for each of the individual seven western states:

$$\text{Hay Price} = b_0 + b_1{*}\text{May Stocks} + b_2{*}\text{Exports} + b_3{*}\text{Milk Price} + b_4{*}\text{Feeder Cattle Price} + b_5{*}\text{Corn Price} + e$$

where Hay Price is state level in real dollars per ton, May Stocks is the seven-state total hay stocks in 1,000 tons, Exports is total U.S. alfalfa hay exports in 1,000 metric tons, Milk Price is the CME Class III milk futures in dollars per cwt., Feeder Cattle Price is the CME Feeder Cattle futures in dollars per cwt., Corn Price is the CBOT Corn Futures in dollars per bushel, and e is the unexplained error term. All futures prices are the annual average of the monthly nearby contract as calculated by the Livestock Market Information Center. Summary statistics for these variables are presented in Table 2.

Results

Figure 1 shows that prices in each of the states appear to respond in a similar manner to changes in supply and demand conditions as Tejeda, Kim and Feuz (2015) document. Tejeda, Kim and Feuz (2019) also document a structural break in hay prices in 2009 because of increased alfalfa hay exports. From Figure 1, it appears that prices have become more variable since that time period and possibly a little higher as well.

Results of the Paired Means Test are displayed in Table 1. California and Oregon have the highest real alfalfa hay prices statistically over the last 30 years at $169 per ton. Arizona, Nevada and Washington prices are statistically equivalent at approximately $157-159 per ton. Idaho's alfalfa prices are significantly lower at $148 per ton and Utah's are statistically the lowest at $137 per ton.

A correlation analysis was also conducted on these alfalfa prices and the correlation coefficients ranged from 0.85 to 0.96 with AZ and CA having the highest correlation and CA and UT having the lowest correlation. Apparently, alfalfa prices in the seven western states respond to the same supply and demand information, but transportation and other local supply and demand conditions result in different price levels.

A correlation analysis was conducted with the average of the seven western states' alfalfa hay price and the five independent or potential explanatory variables listed in Table 2. Results of the correlation analysis are displayed in Table 3. Chicago Board of Trade (CBT) corn futures price has the highest correlation with alfalfa hay price at 0.71. CME feeder cattle futures and alfalfa prices had a correlation of 0.62 and CME milk class III futures were correlated with alfalfa price at 0.38. Alfalfa hay exports were correlated at 0.52 with alfalfa hay price. May stocks were negatively correlated with alfalfa price, which would be expected.

The results of the regression analysis are presented in Table 4. Each of the seven western states' annual alfalfa hay price, as well as the seven-state average annual alfalfa hay price for 1992 through 2021 was regressed against the five explanatory variables. For the seven-state average annual price model, all of the independent variables were statistically significant, and each had the anticipated sign. The independent variables accounted for 83% of the annual price variability in the seven-state average price series.

The five independent variables were also all statistically significant in explaining California and Nevada alfalfa prices. For each of the other western states, one or two of the independent variables were not statistically significant for each state. An increase in May 1 hay stocks of 100,000 ton would lead to a range of expected decreases in alfalfa prices from $1.36 per ton in Oregon to $2.17 per ton in Washington. An increase of 100,000 metric tons of exports would result in an insignificant increase for alfalfa hay prices in Idaho and a significant price increase in the other six western states of anywhere from $.089 per ton in Washington to $2.20 per ton in Utah.

CME feeder cattle futures and CBOT corn futures had a positive and significant impact on alfalfa hay price in all seven western states. A $10/cwt increase in the price of feeder cattle would result in an expected increase of alfalfa hay prices ranging from $3.53 (UT) to $5.30 (NV) per ton. A $1.00 per bushel increase in the price of corn would be expected to increase the price of alfalfa hay by anywhere from $9.48 (UT) to $16.37 (WA) per ton.

The explanatory variables are all in different units, making it difficult to determine which variables may have the largest impact on alfalfa hay prices. The estimated regression parameters for the seven-state average price model were multiplied by the standard deviation of each of the independent variables and are displayed in Table 5. Over the thirty-year time period estimated, these standardized betas provide the relative impact from each independent variable on alfalfa prices. A one standard deviation increase in May Stocks would result in a decrease in alfalfa price of $9.91 per ton. A one standard deviation increase in each of the other independent variables would result in an increase in alfalfa price of $10.23 per ton for Exports, $5.44 per ton for Milk Price, $11.78 per ton for Feeder Cattle Price, and $15.41 per ton for Corn Price.

Frequently, Extension Farm Management/Marketing Specialists are asked to provide alfalfa market outlook for hay growers and/or cattle or dairy producers. The authors of this paper have been using this alfalfa pricing model for several years. The problem with the market outlook provided at one point in time for price forecasts of several months into the future is that all the independent variables change over time, and thus the forecasts need to change. The advantage of this alfalfa hay pricing model is that producers and users of alfalfa hay can readily observe changes in milk, feeder cattle and corn futures prices and based on the estimated regression parameters, they can make their own predictions of how much alfalfa hay prices are likely to change. While no statistics are provided here, the authors have found this to be a more accurate method of forecasting than last year's price.

Conclusions

Alfalfa hay is the dominant crop in many western states, and yet market price reporting is almost non-existent in several of these states. Thirty years of real, inflation adjusted, annual hay prices were compared across the seven western states of AZ, CA, ID, NV, OR, UT and WA to determine how closely annual hay prices are related to each other in these states. If prices are closely related, then a producer in a state where prices may be infrequently reported could look to another state's market report to get an estimate of the market in their state.

We find that over the thirty-year period of 1992-2021, mean average prices were significantly different across these seven states. Furthermore, alfalfa hay prices in each state are highly correlated with the other six states. The correlation coefficients ranged from 0.85 to 0.96. Seemingly, the implication is that alfalfa hay prices in the seven states are closely related, and, at minimum, producers should be able to observe direction of price movement in one state and assume prices will likely move in the same direction in their state.

The price of alfalfa hay in each state is influenced by the May 1 hay stocks for the combined seven-states with an increase in those stocks leading to a decrease in hay prices. Hay exports positively impact hay prices, but the magnitude of that impact varies across states. Corn price and feeder cattle price both have a positive and significant impact on alfalfa hay prices in the western states. While milk price is positively correlated with alfalfa hay price, in the regression model, milk price is only significant in explaining alfalfa hay price for two of the individual western states. This result may be because prices of milk, feeder cattle, and corn are all positively correlated with one another.

Alfalfa hay does not have a traded futures market contract, making it difficult to have an idea of the direction of hay prices in the future. However, given that corn, feeder cattle and milk are all traded futures contracts, producers can readily observe changes in these markets. Based on the parameters estimated and presented, producers can make more educated estimates of future changes in alfalfa hay prices.

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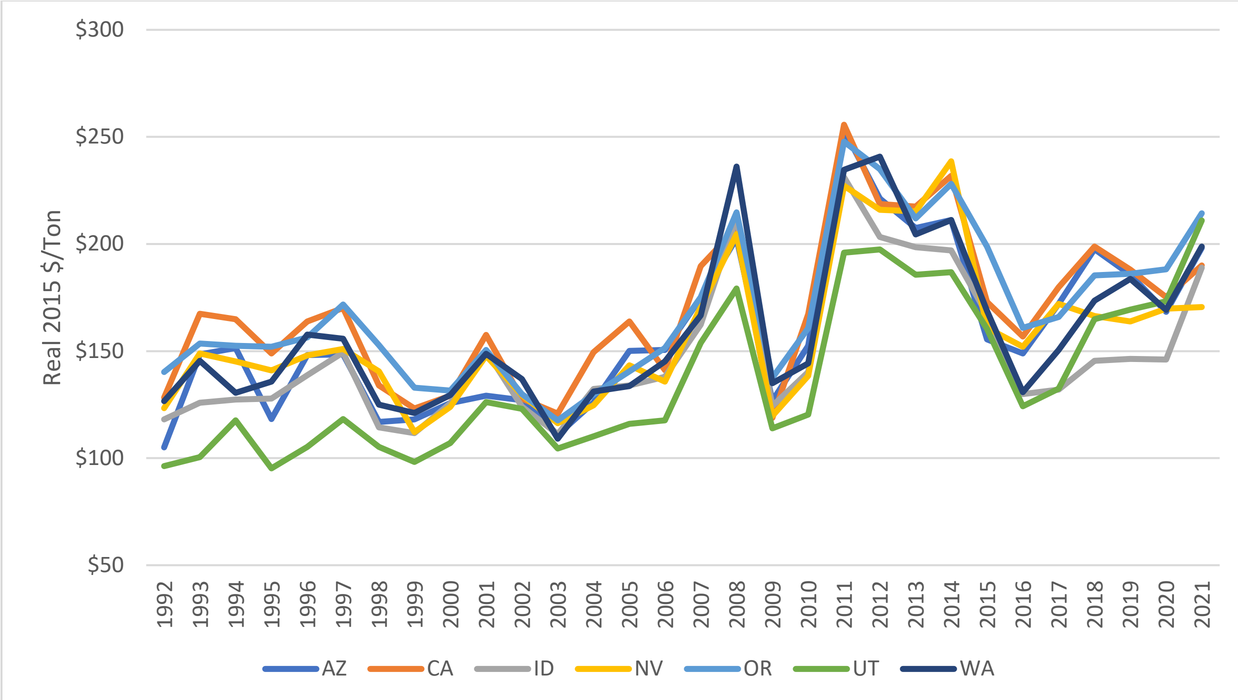

Figure 1. Seven Western States Annual Alfalfa Prices, 1992 to 2021, Real 2015 Dollars/Ton

Table 1. Descriptive Statistics for the Seven Western States Market Year (May-April) Annual Average Alfalfa Hay Price, 1992-2021 (Real 2015 Dollars per Ton)

	7-State Avg	AZ	CA	ID	NV	OR	UT	WA
Mean	156.88[b]	158.34[b]	168.62[a]	148.47[c]	157.24[b]	169.13[a]	137.00[d]	159.34[b]
Standard Deviation	33.66	37.21	34.79	32.29	33.56	34.72	35.70	36.32
Minimum	112.92	118.80	118.80	111.18	112.17	117.62	95.23	109.07
Maximum	235.10	255.69	255.69	231.16	238.61	247.78	210.96	240.79

Means with different superscripts are significantly different at the .05 level, with "a" being the highest and "d" being the lowest

Table 2. Descriptive Statistics for May Stocks from Seven Western States, U.S. Annual Hay Exports, CME Milk Futures Average Price, CME Feeder Cattle Future Average Price, and CBOT Corn Futures Average Price for May 1992-April 2021 (Futures Prices are Real 2015 Dollars)

	Stocks (1,000 tons)	Exports (1,000 M Tons)	Corn ($/bushel)	Feeder Cattle ($/cwt.)	Milk ($/cwt.)
Mean	1,811	1,274	4.06	128.71	16.96
Standard Deviation	519	867	1.23	26.78	2.13
Minimum	983	0	2.57	90.98	12.69
Maximum	2,810	2,862	7.48	219.15	21.54

Table 3. Correlation of 7-State Average Alfalfa Price with Other Variables (All Price in Real 1982-84 Dollars)

	Alfalfa Price	May Stocks	Hay Exports	Corn Price	Feeder Cattle Price	Milk Price
Alfalfa Price	1					
May Stocks	-0.33	1				
Hay Exports	0.52	0.11	1			
Corn Futures	0.71	-0.14	0.24	1		
Feeder Price	0.62	0.02	0.49	0.21	1	
Milk Futures	0.38	-0.07	0.19	0.38	0.22	1

Table 4. Regression Results for the 7-State Average and for each of the Individual Seven Western States Annual Alfalfa Hay Price

	7-State Avg	AZ	CA	ID	NV	OR	UT	WA
Intercept	25.5069	35.6786	14.6956	34.0407	4.6050	20.0753	22.8504	46.6028
	(24.5033)	(30.6782)	(28.3983)	(27.9209)	(27.7596)	(26.6827)	(28.7513)	(31.6896)
May Stocks, 7-State Total,	-0.0191***	-0.0210***	-0.0207***	-0.0186***	-0.0189***	-0.0136**	-0.0189***	-0.0217***
1,000 ton	(0.0050)	(0.0063)	(0.0058)	(0.0058)	(0.0057)	(0.0055)	(0.0059)	(0.0065)
Exports Total U.S.	0.0118***	0.0156***	0.0113**	0.0039	0.0090**	0.0117***	0.0220***	0.0089*
1,000 Metric ton	(0.0039)	(0.0048)	(0.0048)	(0.0044)	(0.0044)	(0.0042)	(0.0045)	(0.0050)
CME Milk Class III,	2.5554*	1.8509	4.4479**	1.4714	4.0216**	2.5815	2.1480	1.3669
Annual Average Nearby Contract, $/cwt	(1.4797)	(1.8526)	(1.7149)	(1.6860)	(1.6763)	(1.6113)	(1.7362)	(1.9136)
CME Feeder Cattle,	0.4400***	0.4157***	0.4627***	0.4668***	0.5304***	0.4545***	0.3530**	0.3956**
Annual Average Nearby Contract, $/cwt	(0.1179)	(0.1476)	(0.1366)	(0.1343)	(0.1336)	(0.1284)	(0.1383)	(0.1525)
CBT Corn Annual	12.5288***	13.7628***	10.3601***	14.2520***	9.5840***	13.9009***	9.4761***	16.3660***
Average Nearby Contract, $/bu	(2.4508)	(3.0684)	(2.8404)	(2.7926)	(2.7765)	(2.6688)	(2.8757)	(3.1696)
ADJ R^2	0.83	0.82	0.79	0.76	0.78	0.82	0.79	0.76

, **, and * denotes significance at the 0.10, 0.05 and 0.01 level, respectively*

Table 5. The Relative Price Impact from a One Standard Deviation Increase of each of the Independent Variables on the Seven-State Average Annual Alfalfa Price, Dollars per ton

	Regression Parameter	Standard Deviation	Relative Alfalfa Price Impact
May Stocks	-0.0191	519	-$9.91
Exports	0.0118	867	$10.23
Milk Price	2.5554	2.13	$5.44
Feeder Cattle Price	0.4400	26.78	$11.78
Corn Price	12.5288	1.23	$15.41

Appendix

Table A1. Market Year Average (May-April) Annual Alfalfa Prices, 7-State Average and Each Seven Western State, May 1992 - April 2022, Nominal Dollars per Ton

Year	7-State Average	AZ	CA	ID	NV	OR	UT	WA
1992-93	76.92	67.50	82.42	75.92	79.25	90.08	61.92	81.33
1993-94	93.05	97.67	110.17	82.83	97.92	101.00	66.08	95.67
1994-95	94.98	101.75	110.75	85.58	97.50	102.50	79.08	87.67
1995-96	90.06	81.08	102.17	87.67	96.67	104.33	65.33	93.17
1996-97	101.60	103.50	114.50	96.92	103.33	109.25	73.50	110.17
1997-98	108.10	105.50	120.83	106.17	107.33	122.08	84.08	110.67
1998-99	91.24	84.00	96.25	82.17	101.00	109.75	75.67	89.83
1999-00	85.10	86.08	89.75	81.42	81.75	96.83	71.58	88.25
2000-01	92.88	93.67	96.25	93.58	92.33	98.00	79.83	96.50
2001-02	109.98	98.42	120.08	114.42	112.67	114.75	96.17	113.33
2002-03	99.35	98.33	98.92	96.08	100.25	100.58	95.25	106.00
2003-04	89.12	87.58	95.33	87.75	91.75	92.83	82.50	86.08
2004-05	104.63	102.17	121.17	107.25	101.08	105.17	89.33	106.25
2005-06	117.18	125.50	136.92	112.00	119.83	117.42	96.92	111.67
2006-07	120.58	129.75	121.58	118.92	116.92	130.50	101.42	125.00
2007-08	150.83	154.75	167.83	143.67	150.92	155.00	136.17	147.50
2008-09	187.74	182.75	187.08	191.58	184.58	193.67	161.58	212.92
2009-10	113.60	115.00	107.83	112.92	108.75	124.83	103.33	122.50
2010-11	134.33	140.00	153.58	128.83	127.17	147.67	110.58	132.50
2011-12	220.44	237.50	239.75	216.75	213.08	232.33	183.67	220.00
2012-13	209.10	211.25	208.92	194.17	206.25	224.42	188.67	230.00
2013-14	200.05	201.67	211.42	192.92	209.17	206.00	180.42	198.75
2014-15	212.86	209.17	229.58	195.00	236.25	225.83	185.00	209.17
2015-16	169.17	155.42	172.92	167.08	160.83	198.75	160.42	168.75
2016-17	144.79	150.42	158.33	131.25	153.50	162.50	125.42	132.08
2017-18	162.44	177.08	185.00	135.83	177.08	170.83	136.25	155.00
2018-19	185.54	208.33	209.58	153.33	175.42	195.42	173.75	182.92
2019-20	187.44	199.17	201.67	157.08	175.83	199.58	181.67	197.08
2020-21	184.79	182.92	190.42	158.75	184.58	204.58	188.33	183.92
2021-22	222.56	225.00	215.83	214.58	193.75	243.33	239.58	225.83

Source: USDA-NASS "Agricultural Prices" multiple reports

Table A2. May Stocks for Seven Western States, U.S. Hay Exports, CME Milk III Futures Price, CME Feeder Cattle Futures Price, and CBOT Corn Futures Price

Year	Stocks 1,000 ton	Exports 1,000 MT	Corn $/bu.	Feeder Cattle $/cwt.	Milk $/cwt.
1992	2,682	0.00	2.25	83.68	11.56
1993	983	0.00	2.59	84.43	11.80
1994	2,177	303.35	2.35	73.51	11.27
1995	1,087	435.50	3.31	62.42	11.85
1996	2,255	535.41	3.42	64.68	13.34
1997	1,217	532.67	2.68	77.85	12.34
1998	2,489	575.00	2.20	71.31	14.32
1999	2,496	640.18	2.11	80.48	11.91
2000	1,568	651.36	2.05	87.05	10.15
2001	1,226	602.43	2.05	85.73	13.12
2002	1,379	897.87	2.38	79.14	9.83
2003	1,847	929.13	2.53	91.88	12.93
2004	2,047	941.81	2.24	107.71	15.37
2005	1,849	859.22	2.15	110.71	13.26
2006	1,542	808.77	3.16	106.53	12.78
2007	1,364	748.51	4.22	108.22	19.06
2008	1,241	918.88	4.75	101.47	14.94
2009	2,045	1,546.89	3.70	99.48	12.42
2010	2,522	1,452.23	5.35	118.25	15.32
2011	1,300	1,618.56	6.62	141.88	18.03
2012	2,068	1,759.01	7.14	145.23	17.85
2013	1,705	1,975.41	5.02	161.39	19.74
2014	1,340	1,682.80	3.88	216.98	19.70
2015	2,565	1,955.01	3.71	184.13	15.18
2016	2,810	2,485.43	3.58	134.03	15.70
2017	1,990	2,662.86	3.62	147.13	15.40
2018	1,725	2,532.69	3.68	147.41	15.31
2019	1,510	2,654.43	3.81	136.92	17.32
2020	1,895	2,665.84	4.29	137.46	18.24
2021	1,420	2,861.95	6.28	156.89	11.56

Source: All data were obtained from Livestock Market Information Center – annual price series files