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Spatial and Varietal Price Analysis of Dry Edible Bean Markets

ABSTRACT: Dry bean prices, as received by the grower and the dealer, were analyzed for four different production regions, and for two of the major varieties grown in the US. The dry bean price series were not stationary. Prices for each variety were cointegrated across the production regions and between grower and dealer markets. However causality tests failed to show the dominant regional variety as the price leader. Further, prices of the two varieties were not cointegrated, which indicated that growers would benefit from growing more than one variety at the same time.

The US dry edible bean industry has unique structural features such as a concentration at processing levels, lack of a futures market, and volatile international demand that impair the ability of the market to signal prices for efficient production and distribution. Before analyzing dry bean prices with the goal of increasing production and marketing efficiency, we must first outline the market structure of the dry bean industry.

Dry edible beans are grown in geographically separated production regions: southern Idaho, northeast Colorado, eastern North Dakota, Michigan, and western Nebraska-eastern Wyoming. Each production region has become dominated by one or at most two varieties. Pinto is the major variety grown in the US and the most disperse dry bean variety with production occurring in Colorado, Idaho, western Nebraska-eastern Wyoming, and North Dakota. In contrast to Pinto, the Great Northern variety is primarily grown in the region of western Nebraska-eastern Wyoming. This region accounts for approximately 80 to 85% of the total Great

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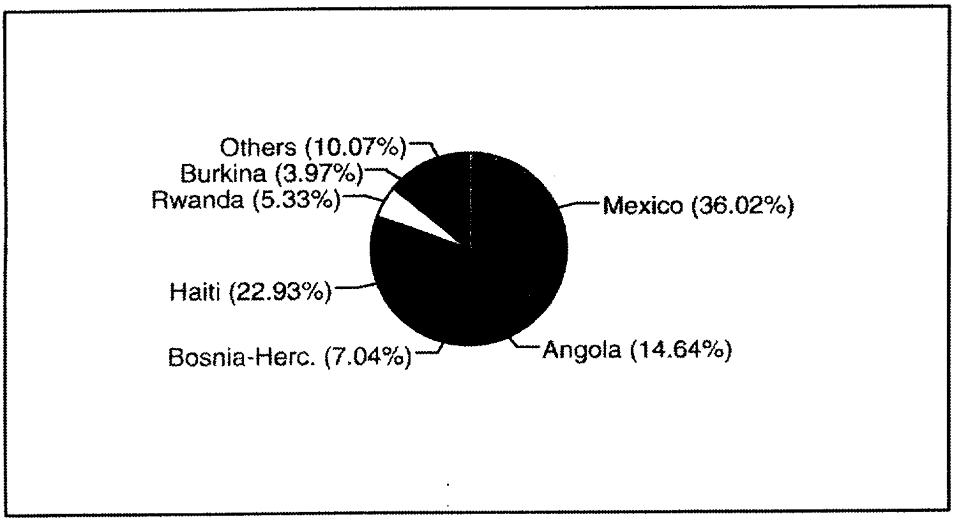

Figure 1. Major Destinations of 1997 U.S. Pinto Exports

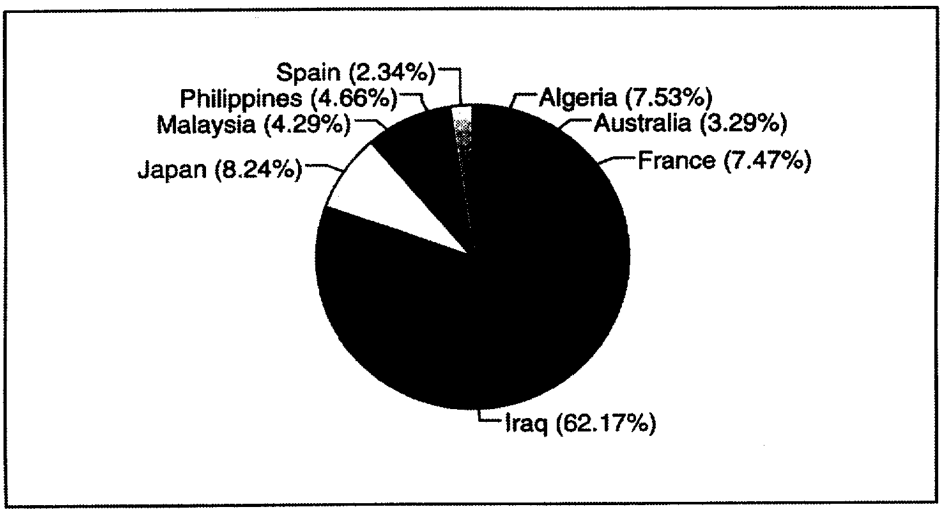

Figure 2. Major Destinations of 1997 Great Exports

Northern production in the US. These two varieties are the focus of this paper and offer a contrast of a variety with several production regions and markets to a variety with predominantly one production region and market.

From the production point of view, Pinto and Great Northern beans can be planted and managed by almost identical production practices. Farmers can switch varieties without changing any management practices. However Pinto and Great Northern beans face quite different demands at the market level. A large portion of Pinto and Great Northern beans are exported to the international market, and each variety has different destinations. Figure 1 and Figure 2 show the countries that are major buyers for Pinto and Great Northern beans. In 1997, Iraq was the major buyer of Great Northern beans, followed by Japan, Algeria and France. For Pinto beans, Mexico was the largest importer in 1997, followed by Haiti and Angola. Some of these importing nations do not have stable political and economical situation. This creates greater price uncertainty to the US dry bean growers and dealers.

In each production area, there are a large number of farmers selling to highly concentrated bean processors. Bean processors clean, package, store, and transfer sales, i.e., serve as the "middleman" between farmers and domestic users and export markets. A majority of dry beans are contracted with local elevators (processors), and most of these elevators are privately owned. Small bean processors and small grower cooperatives are confined to single production regions, while a number of large processors have multi-regional operations.

USDA reports the prices of transactions for the major varieties in each major production region. However, price information gaps occur when the markets lack sufficient transactions to establish a price. Furthermore, there are no future markets for dry edible beans, so neither growers nor processors are able to hedge for price protection. A significant proportion of beans are cash forward contracted prior to harvest to a specific local processor and contract prices are not reported. Farmers thus have difficulty in determining current and future prices for different bean varieties to make production and marketing decisions. The general objective of this paper is to analyze spatial and varietal prices for dry edible beans. The specific objective are: 1) analyze the relationship of the dry bean prices for the same variety in different production regions, 2) examine the relationship of prices for different bean varieties in the same market, and 3) determine the relationship between grower and dealer prices for the same variety in the same production region.

Spacial market integration necessarily implies a unique long-run equilibrium relationship in which deviations from regional price parity are forced to zero (Goodman and Schroeder, 1991). In the dry bean market, the conditions that force regional parity are competition and production substitutability. As mentioned before, dry bean growers can apply the same planting schedule, the same fertilizing schedule, the same irrigation schedule and water supply, as well as the same harvesting time to either Pinto or Great Northern beans, and there is little costs to growers when shifting between Pinto and Great Northern beans. Differences in Pinto or Great Northern prices in different markets should be less than or equal to transportation costs plus other constant costs. As for the two varieties in the same market, growers might expect the two price series to follow each other closely since they act like production substitutes. Dealers and growers in different markets would also expect their prices to move closely together or to reach a long run equilibrium in different markets, assuming dry bean prices are affected by the same force in different markets. Profits to dry bean growers and dealers could be improved and some of the uncertainty related to the dry bean prices could be reduced if there were information available on (1) how dry bean prices vary over time; and (2) how dry bean prices compare across production areas and among different varieties.

To achieve the objectives of this paper, the following hypotheses will be empirically tested using price series for Pinto and Great Northern bean varieties in the principle markets for those varieties. The first hypothesis is that edible bean prices for the same variety will be cointegrated across the different production regions. If this hypothesis is substantiated, it implies that grower prices, as well as dealer prices, for the same variety in different production regions should follow each other closely. It would also imply that farmers could use price quotes in other production regions if there is no price quote for their local market.

The second and related hypothesis is that dealers' prices and growers' prices for Pinto or Great Northern move in the same direction over time, regardless the size of the marketing margins and the factors which influence the size of the marketing margins.

The third hypothesis states that Pinto and Great Northen prices will be cointegrated in the same production region, which also implies that Pinto prices and Great Northern prices reach a long term equilibrium relationship. If this hypothesis is substantiated, it means that prices for the two varieties should follow each other and move in the same direction over time. This also implies that dry bean growers could expect Pinto prices to go up if they see Great Northern prices go up, or Pinto prices to go down if they see Great Northern prices go down. Furthermore, it should not make any difference to growers if they decide to plant Pinto or Great Northern in any year, and growing more than one varieties would not diversify growers profit portfolio.

The last hypothesis is that the dominant production region for each variety will be the price leader for that variety. Specifically, Colorado will be the price leader for Pinto beans, while western Nebraska-eastern Wyoming will be the price leader for Great Northen beans.

PRICE ANALYSIS: DATA, METHODS AND RESULTS

Methods to examine spatial and varietal linkages are divided into three sections; price stationarity, cointegration analysis, and causality. Stationarity must be determined before cointegration hypothesis can be tested. Each of the following price analysis sections outlines the relevant theory, sets forth the method of analysis, and summarizes the empirical results of the hypothesis tests. Prerequisite to the discussion of the methods and subsequent results is a description of the data.

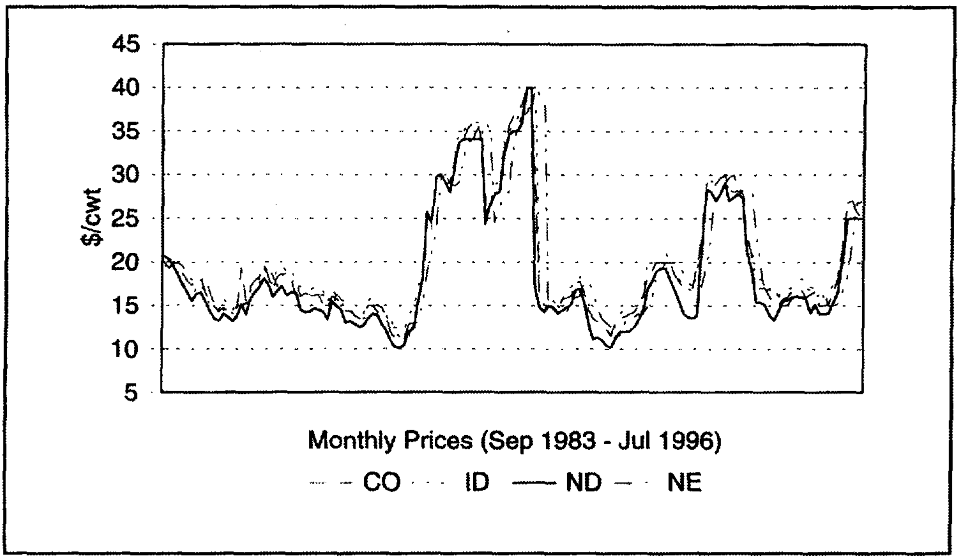

Figure 3. Pinto Historical Grower Prices in Four Regions—Colorado (CO), Idaho (ID), North Dakota (ND), and Western Nebraska & Eastern Wyoming (NE)

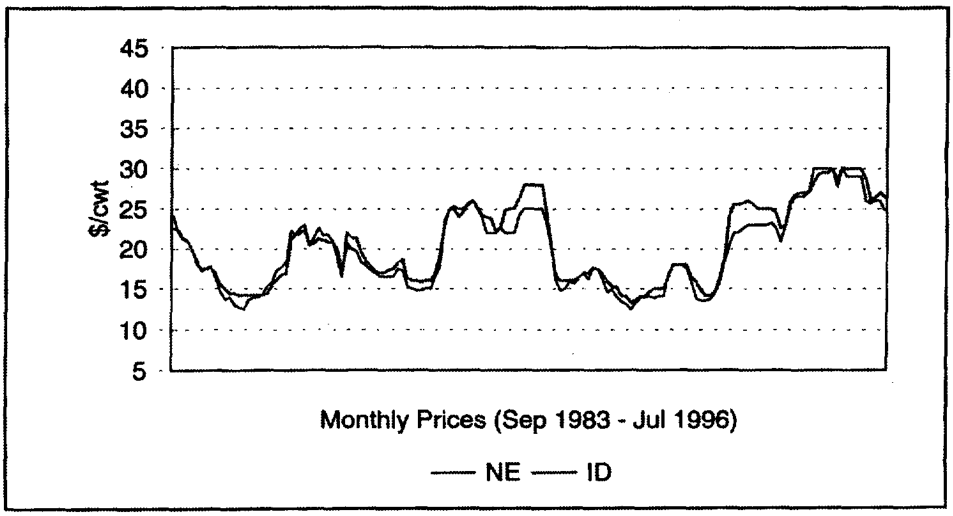

Figure 4. Historical Great Northern Grower Prices in Two Regions—Western Nebraska & Eastern Wyoming (NE) and Idaho (ID)

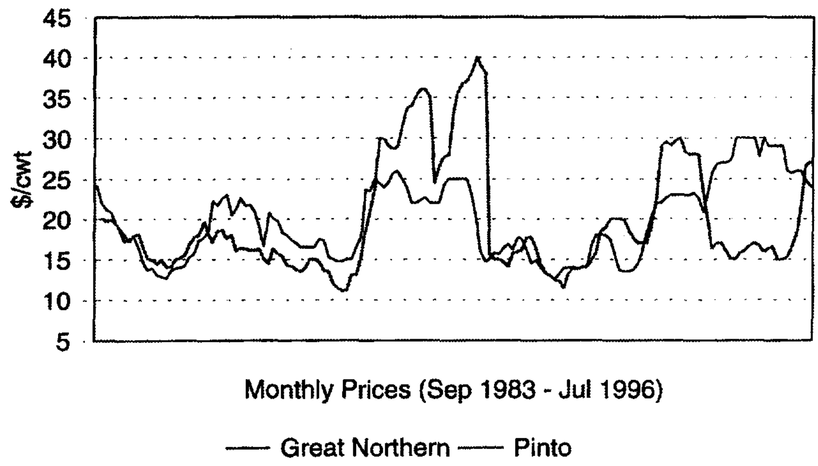

Figure 5. Historical Pinto and Great Northern Grower Prices in Western Nebraska & Eastern Wyoming

Price Data

Monthly grower and dealer prices for Pinto and Great Northern beans are investigated in different regions. USDA Livestock and Seeds Division reports weekly grower prices and dealer prices for Pinto and Great Northern beans in different markets. However, this weekly series contains many missing data points, as there is not always sufficient trade in a week in a specific market to establish a price. Therefore, the weekly prices are averaged to calculate monthly prices. Prices for the Pinto variety were collected from four major production regions: Colorado, North Dakota, Idaho, and combined region of western Nebraska-eastern Wyoming. Prices for the Great Northern variety were collected from two production regions: Idaho and the combined region of western Nebraska-eastern Wyoming. The price series are recorded monthly from September 1983 to August 1996 (153 months). Figures 3 to 5 contain plots of the two variety prices. The most significant data caveat is that this price data is tallied by USDA agents, and may not represent actual prices paid to growers or dealers. A common practice by dealers is to negotiate discounts or bonuses for bean characteristics (tare, discoloration, splits etc.) to vary price while reporting only the base price.

Price Stationarity

With dry bean price data being recorded as a time-series, stationarity tests are a prerequisite to further price analysis. A time series is stationary if the mean, variance, and autocovariances are independent of time (Rao, 1994). Suppose y_t is a

Table 1. P-value of Unit Root Test on Dealer and Grower Prices by Variety and Market (Significance Level is Set at 1%)

Variety	*Market*	*Dealer Price*	*Grower Price*
Pinto	Colorado	0.053	0.039
	Idaho	0.067	0.050
	North Dakota	0.043	0.055
	Neb. - Wyo	0.054	0.040
Great Northern	Neb. - Wyo.	0.233	0.182
	Idaho	0.248	0.160

time series (or stochastic process) defined for $t = 1,2,\ldots,$ and for $t = 0,-1,-2,\ldots.$ Formally, y_t is (weakly) stationary if the following conditions are satisfied for all t (Rao, 1994):

$$E(y_t) = \mu$$

$$E[(y_t - \mu)^2] = var(y_t) = x(0)$$

$$E[(y_t - \mu)(y_{t-\iota} - \mu)] = cov(y_t, y_{t-\iota}) = x(\iota), \iota = 1, 2, 3,\ldots \qquad (1)$$

where μ is the mean of the time series, $x(0)$ is the variance of the time series, and $x(\iota)$ is the autocovariance of the time series. Equation (1) requires the process to have a constant mean and variance, while the covariance between any two values from the series depends only on the time interval between those two values (ι) and not on the point in time (t).

Stationarity identifies the impact of a "shock" on a time-series variables. For a stationary series estimated autocorrelations fade over time, and the opposite for a non-stationary series (Rao, 1994). Thus, a "shock" or "innovation" has a sustained effect in the unit root case, and an effect that diminishes with time in the stationary case (Rao, 1994). The shock for dry bean price series could be the annual harvest, when newly harvested beans flood the market and depress prices. The long term sustained effects are the genetic and farming innovations that increase production and thereby dampen price.

The Dickey-Fuller (DF) unit root test for a univariate time series was applied to the price series using SAS/ETS macro procedure for DF tests (Hamilton, 1994 and SAS/ETS User's Guide). The null hypothesis tests the existence of a unit root for each series and the alternative hypothesis states the series is stationary. The unit root test for dealer prices and grower prices for each variety in each market were not statistically significant at 1% (Table 1). The null hypothesis of an existence of a unit root for each price series can not be rejected. Thus neither dealers' prices or growers' prices in any of the markets is stationary; i.e., mean, variance, and autocovariances of the price series are time dependent. However, while the series are not stationary, there is no consistent seasonal pattern (Liang, Feuz and Taylor) which is typical of many agricultural commodity prices.

Cointegration Analysis

Given that dry bean prices are not stationary, what other price relationship exist to guide marketing or planting decisions of farmers, processors, and domestic and international purchasers of dry beans? The price relationships that can be examined are prices for the same variety between different markets; prices between grower and dealer level for the same varieties in the same market; and prices between the two varieties in the same market.

The specific hypotheses to be tested are (1) dealers' prices for Pinto or Great Northern in different production regions move consistently in the same direction regardless of exogenous factors affecting the markets; i.e. dealer prices are cointegrated, (2) growers' prices for Pinto or Great Northern in different production regions move consistently in the same direction in different production region; i.e., grower prices are cointegrated, (3) dealers' prices are expected to be cointegrated with growers' prices for each variety in each production region, i.e., dealers' prices and growers' prices move in the same direction over time regardless the size of the marketing margins and the factors which influence the size of the margins, and (4) if Pinto and Great Northern varieties can be treated as production substitutes like growers usually believe, Pinto growers' prices should be cointegrated with Great Northern growers' prices, or the two price series should reach a long run equilibrium relationship and move in the same direction over time. Past studies have used cointegration analysis to look at spatial price linkages in regional fed cattle markets (Goodwin and Schroeder, 1991), to determine if the international wheat market was following the "Law of One Price" (Goodwin, 1992), and to study commodity arbitrage (Karbuz and Jumah, 1995). In this study, the cointegration analysis is primarily used to analyze spatial price linkages, but the impact of the international market is also observed on dealer prices for different varieties.

Granger (1981, 1991), Granger and Weiss (1983), and Engle and Granger (1987) have shown that, even though a given set of series may be non-stationary, there may exist various linear combinations of the individual series that are stationary. Cointegration is a statistical framework to test for long-run or steady-state equilibrium relationships among several non-stationary series.

The formal definition of cointegration (Engle and Granger, 1987) of two variable time series x_{1t} and x_{2t} are cointegrated of order d, b, where $d \geq b \geq 0$ written as $x_{1t}, x_{2t} \sim CI(d,b)$ if; (1) both series are integrated of order d, and (2) there exists a linear combination of these variables, say $\alpha_1 \times x_{1t} + \alpha_2 \times x_{2t}$, which is integrated of order $(d - b)$. The vector $[\alpha_1, \alpha_2]$ is the cointegrating vector. If there is a long-run relationship between two (or more) non-stationary variables (all integrated of the same order), the idea is that deviations from this long-run path are stationary if the variables are to be cointegrated. Consider two price series in the following regression:

$$p^1{}_t - \alpha - \beta p^2{}_t = v_t \tag{2}$$

where p_t^1 and p_t^2, as an example, represent Pinto prices in two markets and v_t is the random error term. Existence of perfectly spatially integrated markets (where price changes in one market are fully reflected by equilibrating changes in alternative market) necessarily requires the estimated parameter of the cointegrating regression, β, have a value of one. However, because the price series p_t^1 and p_t^2 are non-stationary in a cointegrated system, conventional t-test cannot be used to provide reliable hypothesis tests regarding the value of β.

Four tests for cointegration were used as suggested by Engle and Granger (1987). These tests provide critical values for sample sizes of 100 observations which was exceeded with our sample size of 153 months. The null hypothesis for each test is "no cointegration"; i.e., rejection of null hypothesis affirms integrated prices in regional markets. For a two prices series y_t and x_t relationship:

$$y_t = \hat{\alpha}\ x_t + c + \hat{e}_t \tag{3}$$

The null hypothesis of no cointegration is rejected for values of the Durbin-Watson (*DW*) test significantly different from zero. With the Dickey Fuller (DF) regression:

$$\Delta\,\hat{e}_t = -\,\phi\,\hat{e}_{t-1} + \hat{\varepsilon}_t \tag{4}$$

(where $\hat{e}_t$ is defined in equation (4) and Δ is the first difference) the test statistic is, τ_ϕ(t statistic for ϕ). The DF testing procedure considers whether the autoregressive parameter for the estimated residuals from the cointegrating regression (ϕ) is significantly different from one. If there is a unit root of the residuals, then the two series are not cointegrated. The null hypothesis of no cointegration is rejected for values of ϕ which are significantly different from zero. Critical values are provided by Engle and Granger (1987). The restricted VAR (RVAR) formulation is:

$$\Delta y_t = \hat{\beta}_1 \hat{e}_{t-1} + \varepsilon_{1t}\ \mathit{and}\ \Delta\,x_t = \hat{\beta}_2 \hat{e}_{t-1} + \gamma\,\delta\,y_t + \varepsilon_{2t} \tag{5}$$

The test statistic for the VAR is; $\tau^2{}_{\beta 1} + \tau^2{}_{\beta 2}$ (the sum of two t-statistics for $\hat{\beta}_1$ and $\hat{\beta}_2$). The VAR test involves the estimation of a vector error correction mechanism for the cointegrating regression. VAR tests are based on the joint significance of the estimators of the error correction coefficients ($\hat{\beta}_1$ and $\hat{\beta}_2$). This test

Table 2. Cointegration Tests on Dealer and Grower Prices Across Market Regions

			Dealer			Grower		
Variety	*Market*	*Test*	*Test Statistic*	*Critical Value*	*Decision*	*Test Statistic*	*Critical Value*	*Decision*
Pinto	Colo. vs. Idaho	DW	1.669	0.511	Reject	1.294	0.511	Reject
		DF	10.407	4.070	Reject	8.528	4.070	Reject
		RVAR	108.056	18.300	Reject	110.203	18.30	Reject
		UNRVAR	835.308	23.400	Reject	599.436	23.40	Reject
	Colo. vs. N.Dak.	DW	0.780	0.511	Reject	1.658	0.511	Reject
		DF	6.278	4.070	Reject	10.514	4.070	Reject
		RVAR	45.404	18.300	Reject	130.033	18.30	Reject
		UNRVAR	991.052	23.400	Reject	410.364	23.40	Reject
	Colo. vs. Neb.	DW	2.028	0.511	Reject	2.015	0.511	Reject
		DF	12.475	4.070	Reject	12.383	4.070	Reject
		RVAR	171.195	18.300	Reject	252.836	18.300	Reject
		UNRVAR	19051.684	23.400	Reject	1109.706	23.400	Reject
	Idaho vs. N. Dak.	DW	0.960	0.511	Reject	1.759	0.511	Reject
		DF	7.043	4.070	Reject	11.059	4.070	Reject
		RVAR	51.368	18.300	Reject	169.798	18.300	Reject
		UNRVAR	433.450	23.400	Reject	222.458	23.400	Reject
	Idaho vs. Neb.	DW	1.634	0.511	Reject	0.757	0.511	Reject
		DF	10.228	4.070	Reject	5.989	4.070	Reject
		RVAR	95.472	18.300	Reject	36.341	18.300	Reject
		UNRVAR	27471.768	23.400	Reject	2202.996	23.400	Reject
	N. Dak. vs. Neb.	DW	0.778	0.511	Reject	1.947	0.511	Reject
		DF	6.275	4.070	Reject	12.056	4.070	Reject
		RVAR	45.334	18.300	Reject	247.192	18.300	Reject
		UNRVAR	1124.528	23.400	Reject	274.156	23.400	Reject
Great Northern	Idaho vs. Neb.	DW	1.058	0.511	Reject	0.496	0.511	Not Reject
		DF	7.417	4.070	Reject	4.952	4.070	Reject
		RVAR	63.317	18.300	Reject	26.610	18.300	Reject
		UNRVAR	746.018	23.400	Reject	264.242	23.400	Reject

Note: Significance level is set at 1%.

Table 3. Cointegration Tests on Dealer versus Grower Prices by Variety and Market

Variety	*Market*	*Test*	*Test Statistic*	*Critical Value*	*Decision*
Pinto	Colorado	DW	1.05	0.51	Reject
		DF	7.53	4.07	Reject
		RVAR	56.42	18.30	Reject
		UNRVAR	685.83	23.40	Reject
	N. Dakota	DW	2.06	0.51	Reject
		DF	12.81	4.07	Reject
		RVAR	153.03	18.30	Reject
		UNRVAR	307.16	23.40	Reject
	Nebraska	DW	1.02	0.51	Reject
		DF	7.39	4.07	Reject
		RVAR	75.91	18.30	Reject
		UNRVAR	730.28	23.40	Reject
	Idaho	DW	1.54	0.51	Reject
		DF	9.82	4.07	Reject
		RVAR	103.78	18.30	Reject
		UNRVAR	452.04	23.40	Reject
Great Northern	Idaho	DW	0.52	0.51	Reject
		DF	4.81	4.07	Reject
		RVAR	38.27	18.30	Reject
		UNRVAR	289.88	23.40	Reject
	Nebraska	DW	0.32	0.51	Not Reject
		DF	4.09	4.07	Reject
		RVAR	25.81	18.30	Reject
		UNRVAR	295.39	23.40	Reject

Note: Significance level is set at 1%.

explains that a cointegrated set of variables can be equivalently expressed as an error correction model in (5). If $\hat{\beta}_1$ and $\hat{\beta}_2$ are jointly significantly different from zero, the null hypothesis of no cointegration is rejected (Engle and Granger, 1987). The unrestricted VAR (UNRVAR) formulation is:

$$\Delta y_t = \hat{\beta}_1 y_{t-1} + \hat{\beta}_2 x_{t-1} + \hat{c}_1 + \hat{\varepsilon}_{1t} \textit{ and}$$

$$\Delta x_t = \hat{\beta}_3 y_{t-1} + \hat{\beta}_4 x_{t-1} + \gamma \Delta y_t + \hat{c}_2 + \hat{\varepsilon}_{2t} \tag{6}$$

The test statistic for the unrestricted VAR is: $2[F_1 + F_2]$ where F_1 is the F-statistic for testing $\hat{\beta}_1$ and $\hat{\beta}_2$ both equal to zero in (6), and F_2 is the F-statistic for testing $\hat{\beta}_3$ and $\hat{\beta}_4$ both equal to zero in (6). The unrestricted VAR test procedure utilizes a vector autoregression which is not constrained on satisfying the cointegration constraints. The null hypothesis of no cointegration is rejected if parameters $\hat{\beta}_1$ and $\hat{\beta}_2$, and $\hat{\beta}_3$ and $\hat{\beta}_4$ from (6) are jointly significantly different from zero. A failure to reject the null hypothesis indicates the lack of a statistically sig-

Table 4. Cointegration Tests on Pinto versus Great Northern Prices in the Same Region

	Market	*Test*	*Test Statistic*	*Critical Value*	*Decision*
Dealer Price	Idaho	DW	0.09	0.51	Not Reject Null
		DF	1.82	4.07	Not Reject Null
		RVAR	4.17	18.30	Not Reject Null
		UNRVAR	32.04	23.40	Reject Null
	Nebraska	DW	0.07	0.51	Not Reject Null
		DF	1.62	4.07	Not Reject Null
		RVAR	3.81	18.30	Not Reject Null
		UNRVAR	39.64	23.40	Reject Null
Grower Price	Idaho	DW	0.09	0.51	Not Reject Null
		DF	1.81	4.07	Not Reject Null
		RVAR	4.33	18.30	Not Reject Null
		UNRVAR	37.47	23.40	Reject Null
	Nebraska	DW	0.07	0.51	Not Reject Null
		DF	1.77	4.07	Not Reject Null
		RVAR	3.58	18.30	Not Reject Null
		UNRVAR	36.97	23.40	Reject Null

Note: Significance level is set at 1%.

nificant relationship between current changes and past values of the economic variables, implying a general failure of cointegration between variables (Goodwin and Schroeder, 1991; Engle and Granger, 1987).

Results of the pair-wise comparisons of dealers' prices and growers' prices for two varieties (Table 2) in different regions are consistent for all four tests and all comparisons. Dealers' prices for Pinto and dealers' prices for Great Northern beans are cointegrated across regional market areas, and the same conclusion holds for growers' prices. Dry edible bean prices are spatially cointegrated. Domestic and export demand shocks likely impact each production region in a similar manner, and supply shocks in one region impact all production regions general price equilibrium.

Cointegration tests results on dealer versus grower prices are presented in Table 3. The tests are all consistent for Pinto beans to accept the alternative hypothesis of cointegration between dealer and grower prices. The results for dealer versus grower prices for Great Northern beans also suggest the existence of cointegration between dealer and grower prices in the Idaho market. Cointegration tests for the Great Northern variety in western Nebraska-eastern Wyoming are ambiguous: three of the tests reject the null hypothesis of no cointegration, but the DW null hypothesis can not be rejected. According to Granger, 1991, the DW test is weaker than the other three tests. It is therefore likely that grower and dealer prices for Great Northern beans are cointegrated in western Nebraska-eastern Wyoming. The fact that grower and dealer prices are cointegrated implies a long-run stable marketing margin. However, no conclusions can be drawn about the size of the marketing margin and its underlying components: processing costs, risk, market power, etc. This is an area that needs additional research.

Pinto prices are not cointegrated with Great Northern prices for either dealer or grower prices. The results of the tests for cointegration of Pinto prices versus Great Northern prices in the same region are somewhat ambiguous (Table 4). Three of the four procedures suggest the two price series are not cointegrated. Even though Pinto and Great Northern beans are production substitutes, the two varieties have distinct domestic and international markets. The market segregation thus transmits independent shocks into the series thereby terminating the cointegration in both dealer and grower prices for the two varieties. It appears that in the export market, Pinto and Great Northern beans are viewed as separate commodities and thus do not converge to one price.

To summarize the cointegration test results: (1) Dealer and grower prices are cointegrated across spatial markets for both Pinto and Great Northern bean prices; (2) Dealer prices are cointegrated with grower prices for both bean varieties; and (3) Pinto prices are not cointegrated with Great Northern prices for either dealers' prices or growers' prices. These results imply that while there are geographically isolated production regions for dry beans across the U.S., there is one national market for each variety. However, each variety is viewed as a separate commodity in the international export market and the price is independently determined in each of these markets. Producing more than one bean variety would therefore diversify a producers portfolio and could reduce market risk.

Causality

Cointegration analysis explains the integrated relationship of price series for Pinto and Great Northern beans in different regions, but cointegration fails to signal spatial price leadership. Does one market lead other markets in establishing dry bean prices? If price leadership is evident, then the production dominant region should lead prices in minor markets. Further, if leadership in dealer prices is identified in a selected market, then grower price in that market will likely be the price leader as well. The best example of production dominance is the Nebraska-Wyoming region which produces over 80% of the total U.S. Great Northern beans. But does the Nebraska-Wyoming market lead or signal the Idaho market to follow in price?

Granger-causality theorem can be applied to examine lead-lag relationship in dealer prices for each variety in different markets. Granger causality tests have been widely applied in previous studies to determine the lead-lag relationship between different series. Examples of previous applications have been the real-trade-weighted agricultural exchange rate and monthly real prices and export sales of crops (Bradshaw and Orden, 1990), economic growth and defense spend-

Table 5. Partial *F*-Tests of Causality for Dealer Prices

Variety	*Assumed Leader*	*Assumed Follower*	*Test Statistic*
Pinto	Nebraska	Colorado	16.39*
	Idaho	Colorado	2.36
	N. Dakota	Colorado	1.41
	Colorado	Nebraska	13.53*
	Idaho	Nebraska	5.58
	N. Dakota	Nebraska	0.12
	Colorado	Idaho	8.19*
	Nebraska	Idaho	13.84*
	N. Dakota	Idaho	10.40*
	Colorado	N. Dakota	1.08
	Idaho	N. Dakota	3.74
	Nebraska	N. Dakota	0.02
Great Northern	Idaho	Nebraska	0.18
	Nebraska	Idaho	1.08

Note: *Significant at 1% significance level.

ing (Joerding, 1986), two wholesale beef price quotes (Faminow, 1981), and the exchange value of the dollar and the U.S. trade balance (Mahdavi and Sohrabian, 1993).

Since the dry bean price series are not stationary, as shown in the first section, a transformation is necessary to set the series stationary. Taking the first difference of each price series results in stationary series as verified by unit root tests.

Results indicate no lead-lag relationship between the Pinto dealer prices in Nebraska and Colorado because these two series both rely on own lagged prices to predict the future dealer prices (Table 5). There is also no significant lead-lag relationship between North Dakota and Colorado Pinto dealer prices since they both failed to reject the null hypothesis. Idaho appeared to be the only leader in Pinto dealer price based on the Granger test. For the Great Northern variety, no significant lead-lags were evidenced (Table 5). Overall these results do not support the hypothesis of the dominant production region being the price leader for either of the bean varieties.

The fact that the dominant production regions are not price leaders and that generally no consistent lead-lag relationships exist substantiates the notion that there is in fact a national market for each dry bean variety. There are large bean processors that operate in more than one production region that may facilitate one national market. It would also be a reasonable assumption that information from the international export market would flow to all regions simultaneously, and thus demand shocks would be simultaneously observed in each production region. The results would also imply that producers of a variety in the dominant production region do not enjoy a marketing advantage over producers of that same variety in other regions. Furthermore, producers and processors cannot look to other regions as price leaders to signal price changes that will occur in their region as it appears that the price changes occur simultaneously.

CONCLUSIONS AND IMPLICATIONS

The US dry edible bean industry has unique structural features that may impair this market's ability to signal prices efficiently:

- Prices reported by the USDA are dealer reported prices and may not reflect actual negotiated transaction prices that are frequently adjusted for various quality standards;
- Within a region a large number of farmers sell to a few bean dealers with a substantial portion of the crop contracted to a specific dealer;
- There is no futures market; and
- Price are volatile due to the volatile international markets into which a large portion of the beans are exported.

Bean producers and processors make production, marketing, and inventory decision in an environment of very limited price information. Current prices may or my not be reported and known, and there is no futures market to hedge production or storage decisions to reduce risk. If producers and processors were aware of how bean prices were spatially related, how variety prices compared, and how prices at different market levels compared (grower and dealer), then some of the uncertainty regarding edible bean prices could be reduced. This study undertakes a price analysis of edible bean prices to determine these relationships.

Each of the dry edible bean price series were found to be non stationary, i.e., mean, variance, and autocovariances of the price series are time dependent. However, while the series are not stationary, prior research has shown that there is no consistent seasonal price pattern. Grower prices as well as dealer prices were cointegrated for each variety in each market. This result implies that prices tend to move in the same direction for each variety in different regions. Such information would be helpful to growers and processors in different production regions, because they would be able to expect changes in local prices by watching other markets. Thus, when a price quote for local market in a certain week is lacking dealers and growers can quote prices in other markets to establish local prices. Growers would also be able to expect a consistent movement of local prices compared to other production regions.

Grower prices for both Pinto and Great Northern were cointegrated with dealer prices in four major markets. Thus there is a consistent relationship between dealers' prices and growers' prices for Pinto and Great Northern beans in each market. The fact that grower and dealer prices are cointegrated implies a long-run stable marketing margin. However, no conclusions can be drawn about the size of the marketing margin and its underlying components: processing costs, risk, market power, etc.

Pinto and Great Northern prices are not cointegrated in production regions where both varieties are grown. Producers may treat Pinto and Great Northern varieties as production substitutes, but lack of market substitutability was manifested by lack of cointegration between the two varieties. There are periods of time when Pinto prices are considerably higher/lower than Great Northern prices. Growers may consider planting both varieties to diversify their portfolio of crops and spread the risks of an adverse price fluctuation in one bean variety.

In addition to the markets being spatially cointegrated, it was hypothesized that the dominant production region for a variety would lead prices in other regions. Causality tests failed to substantiate this hypothesis. The dominant production region for each variety did not exhibit any price leadership. The results of the cointegration analysis and the causality tests imply that there is one national market for each dry bean variety. Production occurs in regionally isolated markets, but price is primarily determined in a national supply and international demand framework.

This price analysis of dry edible bean prices as provided new insights into dry bean price relationships. Growers and dealers should be able to compare prices across regions for the same variety and in the absence of a grower or dealer reported price should be able to assume a stable margin to estimate the missing price. However, it would be incorrect to assume that prices for Pinto and Great Northern beans will always move in the same direction. It is also incorrect to assume that prices in the dominant production region for a variety will lead prices for that variety in other regions.

This analysis has focused on the U.S. dry bean market with particular emphasis on two bean varieties. However, the results may be applicable to other regionally produced commodities, such as regional fruit and vegetable markets. This type of analysis is particularly applicable to those markets that do not have an associated futures market which industry participants can look to for expected price changes. With current U.S. farm policy allowing for greater flexibility in the crops that are planted, producers may consider growing more of some of these regionally produced crops. If the markets are national, then increases in supply from one region will have less of an impact on price than if the market was a regional market. Therefore, this type of analysis could be very beneficial to industry participants for a number of different crops.

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