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in regional cattle markets**

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Abstract

This paper analyzes non-competitive market conduct in the U.S. cattle procurement markets. Rather than relying on estimation of conduct parameters or measures of market concentration the analysis is based on the dynamics of price adjustment across regional markets. A VAR model is estimated using a multiple co-integration technique as a test for spatial market integration. The results are then related with hypotheses about pricing conduct in spatial markets.

Resumen

Este trabajo analiza la conducta no competitiva en los mercados estadounidenses de ganado. El análisis está basado en la dinámica de los ajustes de precio entre los mercados regionales, en lugar de descansar en la estimación de los parámetros de conducta o en las medidas del grado de concentración del mercado. Se estima un modelo VAR usando una técnica de co-integración múltiple como una prueba de la integración espacial del mercado. Los resultados están, por lo tanto, relacionados a la conducta de precios en los mercados espaciales.

¹ The author thanks Janet Netz and Kenneth Foster for their readings and comments of this article at earlier stages of its development.

1. Introduction

Market power in the meatpacking industry has been a source of public concern since the emergence of the “Big Three” (IBP, ConAgra and Excel) during the 1970s and 1980s. The decline in the consumption of red meat in the 1970’s left the industry with excess slaughter capacity, triggering a wave of mergers and acquisitions that led to concentration in the number of firms and plants. The result was a drastically changed industry structure. The industry’s top four firms in 1977 held together about 30 percent of total beef slaughter capacity. By 1989 concentration measured by the C4, increased to 70 percent. In 1992 these values were further increased to 78 percent and to 82 percent in 1994.

Concern about market power and competition in the industry generated several studies about the cattle procurement markets in the past years. However, the results are not definite. Azzam and Anderson (1996) arrive at the conclusion that “the body of empirical evidence from both Structure-Conduct-Performance (SCP) and New Empirical Industrial Organization (NEIO) studies is not persuasive enough to conclude that the (meatpacking) industry is not competitive.” According to these authors, problems of market definition and data availability at the regional level affect the results of most of these studies. One of the suggestions for further research made by Azzam and Anderson is the need to develop empirical pricing conduct models not affected by problems of market definition, as are the SCP and NEIO models reviewed. “Rather than relying on estimation of conduct parameters or measures of market concentration, inferences on coordination could be made from evaluation of price changes between spatially dispersed locations.”

The approach chosen in this work assumes that the phenomenon of spatial interaction is central to the spatial economic analysis of imperfect competition. Packers and livestock producers are spatially distributed and the cost of transporting cattle from producers to packinghouses is significant. The empirical challenge is to deduce non-competitive conduct from the dynamic price adjustments across the regional cattle markets. There are two different approaches to this problem in the literature. One is to formulate hypotheses about pricing conduct consistent with particular price reactions and feedbacks. This is what Faminow and Benson (1990) do for an analysis of hog prices in Canada. They assume that both buyers and sellers are spatially dispersed and intra-regional transport costs are significant. These assumptions imply that the market is a linked oligopsony. Market integration tests allowed certain predictions of various spatial pricing systems that may underly oligopsony price formation. Non-competitive pricing, in the form of a basing-point pricing system for hogs, was detected for a subgroup of Canadian hog markets between 1965 and 1970.

An alternative approach is structural, where the degree of cointegration between markets is correlated with concentration. This is the approach adopted by Goodwin and Schroeder (1991). Their analysis evaluates spatial linkages in cattle markets using cointegration tests of regional price series. Markets are found to be not fully integrated but the degree of integration increased with increased concentration. The significant relationship between increased concentration and increased cointegration is attributed to either informational economies due to multiplant operations across regions, or increased coordination among packers because of increased concentration.

These studies have some features that limit their contribution to understanding conduct in a spatially linked oligopsony. The work by Faminow and Benson does not make a complete use of the time series properties of the data. Specifically there are no considerations about cointegration of the price series used in the study. Also, the hypotheses about pricing conduct are formulated using tests for market integration that do not allow for multiple interactions between markets because they assume that there is a central market (exogenous) with which all other markets relate (Ravallion, 1986).

Goodwin and Schroeder use cointegration tests to consider long-run price relationships among regional cattle markets. One of the limitations of this analysis is that when measuring the relationship between cointegration and concentration, the concentration variable is national and, hence, out of correspondence with concentration in the pairs of markets assessed for cointegration. Another limitation is that separate bivariate analysis, as was used to test for cointegration between regional markets, is a source of misspecification.

The goal of this paper is to deduce non-competitive market conduct from the dynamic of price adjustments across the regional cattle procurement markets. This is achieved by using Johansen's multiple cointegration technique as a test for spatial market integration. This technique overcomes the problems of the bivariate analysis used by Goodwin and Schoeder. It also allows the estimation of a VAR model of market prices corrected by the cointegration relationship that can be used to test for Granger causality. This test determines lead-lag relationships and short-run dynamics across markets. The results will be related with hypotheses about pricing conduct in spatial markets based in the work by Faminow and Benson and related literature.

2. Price Relationships and Competitive Behavior in Spatial Markets

The purpose of this section is to show how prices are linked in spatial markets and also to relate these linkages to different pricing systems. Faminow and Benson (1990) use the idea of regional markets being linked through oligopolistic interdependence. The point is that spatial markets where both buyers and sellers are dispersed and transport costs are significant should not be characterized as perfectly competitive. Market integration, that is, the process by which price interdependence occurs, can be directly deduced by developing a model of spatial oligopolistic competition. The main results presented by Faminow and Benson are replicated here. Also, references are made to Scherer (1980). The only differences are in notation. The model refers to oligopoly relationships, but the relevant conclusions for these study can easily be extended to oligopsonistic markets.

Figure 1 represents a spatial market where the geographic distance between points is shown in the horizontal axis. There are two firms in the market: a firm located at point X charging price P_x , and a second firm located at Y charging price P_y . Firm i has cost function

$$(1) \quad C_i = F_i + c_i Q_i \quad i = x, y$$

where Q_i is firm i 's output.

Consumers are evenly distributed along the horizontal axis. Assuming for simplicity that the transportation cost is \$1 per unit of distance, the delivered price to any buying point is

$$(2) \quad P = p + u$$

where p is the mill price charged by the firm and u is distance. The individual consumer demand function is defined as

$$(3) \quad p + u = a + \frac{b}{v} q^v$$

where q is demand per consumer, a , b and v are constants. Parameter v can be varied to get a wide range of demand function. If $v=1$, the demand function is linear. If $v>1$ the function is convex upwards. With $v<1$, the function is concave upwards. If $-1<v<0$ and $a=0$, the function is a constant elasticity demand curve (Benson, 1980).

The total demand faced by each firm is obtained by integrating the individual quantities demanded by the consumers located over the distance G for firm X and $(D-G)$ for firm Y.

$$(4) \quad Q_x = \int_0^G \left[\frac{v}{b} (a - p_x - u) \right]^{1/v} du$$

$$(5) \quad Q_y = \int_0^{D-G} \left[\frac{v}{b} (a - p_y - u) \right]^{1/v} du$$

Finally, profits for firm i are given by

$$(6) \quad \pi_i = (p_i - c_i)Q_i - F_i$$

Using this model we can derive price relationships in spatial markets assuming different pricing systems. In particular, we need to show how prices are related under spatial competition (FOB pricing) and compare this with price relationships under collusion (Basing Point Pricing).

FOB pricing

As defined in Scherer (1980), the FOB pricing system implies that “producers announce a price at which customers can buy, paying their own freight bills. Or if delivery by the producer is preferred, then actual charges for transportation from the producing point to the buyer’s destination will be added onto the producer’s price.” As highlighted by Scherer “this is the only system that entails no geographic price discrimination, since the price paid by buyers increases in direct relation to shipping costs, while the seller receives a uniform net price after freight expenses are covered.”

Figure 1 represents competition under FOB pricing. Firm X charges price p_x and consumer pays p_x plus transport cost according to the line p_x+u . The boundary for firm’s X market is at G. To the right of this point, consumers will buy from firm Y. The oligopolistic nature of the FOB pricing model is represented by the boundary conjecture. The boundary between two FOB pricing firm sales areas occurs where delivered prices are equal, so G arises where

$$\begin{aligned} p_x + G &= p_y + (D - G) \\ (7) \quad \text{or} \\ G &= \frac{1}{2}(p_y - p_x + D) \end{aligned}$$

The boundary conjecture depends on X’s expectations regarding Y’s price response:

$$(8) \quad \frac{dG}{dp_x} = \frac{1}{2} \left(\frac{dp_y}{dp_x} - 1 \right)$$

The problem of firm X is then to maximize profit, using price as the decision variable.

$$\text{Max} \quad \pi_x = (p_x - c_x)Q_x - F_x$$

Substituting Q_x by (4) and taking derivatives with respect to p_x , the profit maximizing decision is:

(9)

$$\frac{d\pi_x}{dp_x} = \left[\frac{v}{b}(a-p_x) \right]^{(v+1)/v} - \left[\frac{v}{b}(a-p_x-G) \right]^{(v+1)/v} + \frac{v+1}{b}(p_x-c_x) \left[\frac{v}{b}(a-p_x-G)^{1/v} \left(1 + \frac{dG}{dp_x} \right) - \frac{v}{b}(a-p_x)^{1/v} \right] = 0$$

From (9) we can derive an expression for p_x

$$(10) \quad p_x = p_x \left(a, b, v, c_x, G, \frac{dG}{dp_x} \right)$$

If a firm maximizes profits choosing price, the value of p_x depends on demand and cost parameters as well as on the size of firm X's sales area (G) and the boundary conjecture.

A similar expression can be derived for p_y

$$(11) \quad p_y = p_y \left(a, b, v, c_y, G, \frac{dG}{dp_y} \right)$$

For given values of the parameters and defining the conjectures, the equilibrium for the market can be found using equation (7), (10) and (11). This system of equations shows that the price set by X is, through G, a function of the price at Y. In the same way p_y is a function of p_x . Any change in one of the prices will lead to a reaction of the other firm, even in the very short run depending on the information available to the firms.

If firms X and Y are located at very distant points in space, we can think of a new firm selling to consumers in a region between X and Y. Firm Z will sell to an area with boundary G with firm X and boundary H with firm Y. The price set by Z will have an expression similar to that of p_x and p_y

$$(12) \quad p_z = p_z \left(a, b, v, c_z, G, H, \frac{dG}{dp_z}, \frac{dH}{dp_z} \right)$$

Even though X and Y are distant markets, the price set by X is a function of the price of Y through G, p_z and H. If firm Y lowers price p_y , the boundary of its sales area would expand. But this change will shrink the areas of firms Z and X in the market, which will also reduce prices. The price set by X is impacted by the cost and demand conditions that Z faces and vice versa. This shows that under FOB competition all markets are related, but the effect of a price change on other markets will depend on the distance. The larger the number of intermediate selling sites between two specific sellers, the weaker the price linkage. Initial price reactions and their feedback can lead to additional price changes as the market adjusts toward a new equilibrium but in this case the full price adjustments can take time.

Basing Point Pricing

This pricing system has been used by oligopolist selling physically standardized products whose transportation costs are high relative to the product value and whose marginal production cost is low relative to total unit cost at less than capacity operation. The BPP is the result of an oligopoly arrangement, either price leadership or collusion. In the single basing point system one production point is accepted by common consent as the basing point, and all prices are quoted as the announced mill price at that point plus freight to destination (Scherer, 1980).

Figure 2 represents a collusive arrangement between firms X and Y, where Y is the basing point. Consumers at any point can buy to firm X or Y, because they will be paying the same price no matter where the product is coming from. Firm Y will charge $P_y + u$ to any consumer in D. But in this case X will also charge $P_y + u$. On nearby

shipments, say at point F, X charge consumers the high freight from Y and consumers will pay AF. Firm Y can sell all the way up to X, and X can sell at Y if its costs are low enough to absorb the freight costs that it will incur when selling in the area to the right of G.

The implications for the relationships between prices of different selling areas are clear. Prices will move following changes in the basing point and price changes in other areas will not affect the price in the basing point. So, we can expect that price determination between markets will go in one direction from the basing point to the rest of the regions. Also, price relationships between distant markets will be stronger than in FOB pricing because they will be determined by the leader-follower relationship rather than being the consequence of reactions between firms in different locations. Under BPP, producers systematically adhere precisely to pricing rules that enable each to quote identical delivered prices to buyers at every destination no matter the distance between the markets. Through such adherence, they avoid independent initiatives that could threaten pricing discipline. Considering that integrated markets are those where prices are determined interdependently, we should expect that areas using the BPP will have a higher degree of integration than areas using the FOB pricing system.

3. Implications for empirical analysis

Based in the previous analysis, two tests will be used to infer behavior in the cattle spatial markets. The first empirical test measures the degree of market integration. The existence, degree and evolution of market integration will be an indicator of firm behavior. As discussed before, markets will be integrated either under FOB pricing or

BPP². However, the degree of market integration will give important information to identify the different pricing systems. Collusive price arrangements like BPP imply higher market integration than is the case in FOB pricing.

The second empirical test is the Wald test of Granger causality. This test uses price relationships to determine “causality” between prices in different markets. A price from market X is a Granger cause of price from Y, if present Y can be predicted with better accuracy by using past values of X rather than not doing so, other information being identical. In terms of the different pricing systems, we expect that under BPP, Granger causality will go in one direction, from the basing point market to the other markets. These effects should be noticed in the very short run, e.g. when testing for prices lagged one period. Also, there should be strong determination of the leading market over all markets, including distant markets. In the FOB pricing system, Granger causality will not have a clear pattern as in BPP. The price adjustment between markets could take longer, and short run relationships between distant markets are not necessarily expected. Short-run price adjustment will likely show a regional pattern going from the larger markets to the smaller markets. Table 1 summarizes the contrasting results expected for the FOB pricing and BPP.

4. The model

A general VAR model of the form presented in equation (13) is used. The model consists in the regression of each current (non-lagged) price series on all prices in the

² Faminow and Benson (1990) also discuss the case of spatial price discrimination where the firm set prices equating marginal revenue to marginal cost. They show that discrimination may break market integration. A complete breakdown requires constant marginal costs.

model, lagged a certain number of times. In equation (13), X_t is a $p \times 1$ vector of prices at time t ; μ is a $p \times 1$ vector of intercept terms; D_t are seasonal dummies; A_i are $p \times p$ matrices of parameters; e_t is a $p \times 1$ vector of independently and normally distributed disturbances and k is the lag length required to whiten the noise term e .

$$(13) \quad X_t = \sum_{i=1}^k A_i X_{t-i} + \mu + \Phi D_t + e_t$$

Each equation of the system represents the relationship between the price of one market and the lagged price of all the markets. These equations can be estimated separately using ordinary least squares given that the VAR model involves only lagged variables on its right-hand side, and that we assume that these variables are not correlated with the error term.

The VAR model in equation (13) is used here to determine cointegration between price series. Among the cointegrating techniques, Johansen and Juselius (1990) presented a multiple cointegration analysis that enables the testing and estimation of more than one cointegrating relationship. The model also permits testing for the validity of any restrictions on cointegrating relationships implied by economic theory. A reparametrization of the model in (13) assuming all series are integrated of order 1 leads to:

$$(14) \quad \Delta X_t = \sum_{i=1}^k B_i \Delta X_{t-i} + \Pi X_{t-k} + \mu + \Phi D_t + e_t ,$$

where $D = \sum_{i=1}^k A_i - I$ and $B_i = -\sum_{j=i+1}^k A_j$.

The operator Δ denotes first differencing of all the variables in a vector of variables X_t . The equalities of models (13) and (14) can be checked by adding X_{t-1} , X_t .

X_{t-k} and $A_1X_1, A_2X_2, \dots, A_{t-k}X_{t-k}$ to both sides in (13) and rearranging. Equation (14) represents the cointegrating transformation model. The special feature of this model is the inclusion of a term in levels (ΠX_{t-k}) among the variables in first difference. The estimation of the matrix of coefficients Π will give the cointegrating relationships between the different price series. The determination of the rank of Π is equivalent to finding whether any cointegration relationship exists between the prices at separate markets. Rank of 0 means no cointegration. If $\text{rank}(\Pi) = r < p$, then there are r cointegrating relationships and $(p-r)$ common trends. In this case matrix Π can be represented as:

$$(15) \quad \Pi = \alpha \cdot \beta'$$

where α and β are both $r \times p$ matrices. Matrix β is the cointegrating matrix and has the property that $\beta' X_t \sim I(0)$, while $X_t \sim I(1)$. This means that the variables in X_t are cointegrated, with cointegrating vectors $\beta_1, \beta_2, \dots, \beta_5$ being particular columns of the cointegrating matrix β . In a VAR model explaining n variables there can be at most $r=n-1$ cointegrating vectors.

For empirical analysis, the essential problems are in the determination of r , the rank of matrix Π , that is, in identifying the number of cointegrating vectors and in estimating the cointegrating matrix β . The procedure for this estimation was developed by Johansen and is used here for the estimation of the model in (14). Its precisely the possibility of determining multiple cointegration relationships that makes this method specially suited for the analysis of price relationships between spatial markets where we expect multiple price relationships in the long run between the different prices.

The term ΠX_{t-k} giving the long-run price relationships between markets is used as an error correction term of the VAR model and the model is estimated by maximum likelihood.

The estimation of the VAR model as explained before, allows the analysis of the short-run dynamics between the markets (the term $\sum_{i=1}^k B_i \Delta X_{t-i}$ in the model) by the use of a Wald test to check for Granger causality between prices. The test implies three steps. First the optimal order of the VAR system must be determined using conventional criteria (Akaike's information criterion or the Schwartz-Bayesian criterion). After determining the optimal order, an additional lag is added to the model. Finally, the Wald statistic is calculated using parameter estimates for the optimal number of lags. The restriction that the price of market i does not affect the price of market j is tested for all i and j . If the restriction is valid, the chi-square value of the Wald test will not be significant.

5. An application to the cattle procurement markets

In this section, the model presented in section IV is estimated and conclusions are derived from the results, based on the theoretical discussion of section II. The data used are weekly price series for Choice Yield grade 2-4, 1100-1300 pound slaughter steers from the U.S. Department of Agriculture's *Livestock, Meat, and Wool Market News*. The period covered is January 1989-December 1998, yielding a total of 522 observations. The analysis of this period is relevant given that this is the period of historically highest concentration. Also, most of the studies reviewed in this industry used data for the 70's and 80's and no studies were found covering this period.

Prices were collected for most of the relevant cattle markets: Kansas, Texas-Oklahoma, Iowa, California, Colorado, Illinois, Omaha, Sioux City, St. Paul. Figure 3 shows the size of these markets in terms of cattle volumes.

The VAR model using the Johansen's methodology imposes a restriction in the number of markets to include because Johansen developed the tables for critical values for the test statistics of the number of cointegrating vectors for only five variables. Because of this, the model is estimated for the markets of Texas and Iowa as the largest and most important markets of the sample, Colorado as a "marginal" market distant from the centers of Texas and Iowa, and Omaha and St. Paul, as smaller markets, close to Iowa. Although Kansas is one of the largest markets, it was not considered because of an important number of missing observations³.

Basic statistics for the price series are presented in table 2. Figure 4 shows the evolution of cattle price in Texas during the period 1989-1998. All other markets show the same pattern.

A drastic change in price behavior can be seen in the last period, if we compare it with the first years of the series (1989-1992). Prices are on average 11% lower in the last period in all markets. Moreover, there is a clear trend in the series showing that prices are decreasing with respect to the price levels in 1989-92. Prices in 1998 are 17% lower than prices in 1989.

The data suggest that a significant change took place in price behavior in the last seven years. Given this information, the model is estimated separately for the periods 1989-1992 and 1993-1998. The results are compared to see if the differences in price

³ The other markets have a small number of missing observation and they were proxied by the mean value of the prices on the week before and the week after the missing value.

behavior can be explained by differences in price relationships and integration between markets.

6. Results

The first step in the estimation of the model is the application of the Dickey-Fuller unit root tests to the individual price series. The tests are reported with a trend but similar results are obtained without trend (Table 3). Strong evidence of a single unit root is revealed. Price data when considered in levels are non stationary. However, first-differenced prices are stationary in every case. Only for Iowa and Colorado in the second period the null hypothesis of the existence of a unit root can be rejected, although the values are close to the critical value. The same test applied on the first differences of the prices, show clearly that this series are integrated of order one ($I_{(1)}$).

The optimal number of lags for the VAR model was determined using three different tests: the Akaike information criterion, the Schwarz Bayesian criterion, and the adjusted R-squared. All of the three methods indicate that the number of lags for the model is 2. Given this, k is set equal to 2 in equation (2), and the model is estimated following Johansen's procedure.

The results of the multivariate cointegration test are presented in the next table. The maximum eigenvalue test confirms the presence of four cointegrating relationships in both periods. It is important to notice that cointegration between the price series in these markets was increased in the last period.

Finally, the Granger causality tests are presented in tables 5 and 6. Important differences in price determination and causality can be found between the two periods. In the first period, the results agree with what we can expect from a FOB pricing system as discussed before. Prices in all markets in the short-run react to price changes in Texas and Iowa, the larger markets in the sample. Also, there is evidence (at the 5% level of significance) that Texas (the largest market) is affecting Iowa's price. In conclusion, for the period 1989-1992, the cattle procurement markets analyzed show a high degree of integration with causality relationships going mainly from Texas and Iowa to all other markets.

There is a significant change in the causality relationships in the second period, where causality effects appear to be moving from Iowa to all other markets, including Texas. Also, the Chi-square values of the Wald test corresponding to the effect of Iowa's price on other markets are all higher than any value for this test in the first period. Omaha appears to be integrated to Iowa given the very high values of the Granger test. This can also explain why is Omaha having an effect on Texas prices.

Contrasting the results from both periods, we can conclude that a significant change in the degree of market integration, price behavior, and causality relationships between prices from different regions had taken place during the period 1992-1998. Considering the price causality from Iowa to all other regions and relating this to the price reduction and increasing concentration during this period, we conclude that there is evidence of increasing collusive behavior in the cattle procurement markets.

7. Summary and Conclusions

The objective of this work is to deduce non-competitive market conduct from the dynamic of price adjustments across the regional cattle procurement markets. Johansen's multiple cointegration technique is used as a test for spatial market integration and Granger's causality test is applied to determine the direction of causality between prices in the different markets. Conduct is inferred relating the results of these tests with hypotheses about pricing conduct in spatial markets.

A VAR model is estimated for prices from Texas, Iowa, Colorado, Omaha and St.Paul. The model is estimated separately for the periods 1989-1992 and 1993-1998. The results are compared to see if the differences in price behavior between periods can be explained by differences in price relationships and integration between markets.

The results show that a significant change in the degree of market integration, price behavior and causality relationships between prices from different regions had taken place during the period 1992-1998. Considering the price causality from Iowa to all other regions and relating this to the price reduction and increasing concentration, there is evidence of increasing collusive behavior in the cattle procurement markets.

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Table 1--Empirical implications of different pricing systems

FOB Pricing	BPP
<ul style="list-style-type: none"> Markets less integrated than in BPP Price interaction will not have a clear pattern as in BPP. The price adjustment between markets could take longer, short run relationships are not necessarily expected short-run price adjustment between distant markets should be weaker. Short-run price adjustment will likely show a regional pattern going from the larger markets to the smaller markets. 	<ul style="list-style-type: none"> Markets more integrated than in FOB Price interaction should go in one direction, from the basing point market to the other markets. These effects should be noticed in the very short run Strong determination of the leading market over all markets, including distant markets

Table 2--Prices basic statistics, weekly data 1989-1998 (\$ per 100 pounds)

	Mean		Standard Deviation	
	1989-92	1992-98	1989-92	1992-98
Texas	75.84	67.90	3.64	6.06
Omaha	75.14	67.06	3.87	6.02
Iowa	75.22	67.37	3.83	5.86
Colorado	75.71	67.81	3.66	6.06
St.Paul	73.66	66.09	4.06	6.05

Source: *Livestock, Meat, and Wool Market News*, USDA

Table 3—Augmented Dickey-Fuller test for Non-Stationarity.

	Period 1/1989-11/1992		Period 12/1992-12/1998	
	Test	Critical	Test	Critical
	Statistics	Value (10%)	Statistics	Value (10%)
Texas	-2.53	-3.13	-3.09	-3.13
Omaha	-9.08	-18.2	-2.66	-3.13
Iowa	-3.02	-3.13	-3.31	-3.13
Colorado	-13.61	-18.2	-3.32	-3.13
St.Paul	-2.55	-3.13	-3.07	-3.13

Table 4--Cointegration tests

		1/1989-11/1992	12/1992-12/1998	Critical value
Ho:	HA:	Lmax	Lmax	5%
r=4	r=5	3.131	2.544	8.1
r=3	r=4	35.386	33.401	14.6
r=2	r=3	40.084	67.663	21.3
r=1	r=2	59.019	94.963	27.3
r=0	r=1	86.047	132.186	33.3

Table 5--Wald Test of Granger Causality with cointegration restriction. Period 1/1989-11/1992

Dependent Variable	Explanatory Variable				
	Texas	Omaha	Iowa	Colorado	St.Paul
Texas	0.11	4.23	3.37	0.3	2.53
Omaha	6.88	50.55	12.4	0.21	8.42
Iowa	5.82	0.55	8.94	0.17	4.43
Colorado	13.58	4.77	12.99	62.5	1.92
St.Paul	2.65	0.01	3.16	0.39	8.61

Critical values (5% 3.84) (1% 6.63)

Note: Numbers in bold represent significant values at the 1% level

Table 6-- Wald Test of Granger Causality with cointegration restriction. Period 12/1992-12/1998

Dependent Variable	Explanatory Variable				
	Texas	Omaha	Iowa	Colorado	St.Paul
Texas	1.7	8.17	17.66	3.75	1.99
Omaha	3.33	85.92	50.49	0.78	0.56
Iowa	2.58	1.52	0.17	1.15	1.2
Colorado	11.37	8.82	27.46	32.03	2.29
St.Paul	0.5	0.74	23.86	0.22	134.36

Critical values (5% 3.84) (1% 6.63)

Note: Numbers in bold represent significant values at the 1% level

Figure 1—A spatial market representation

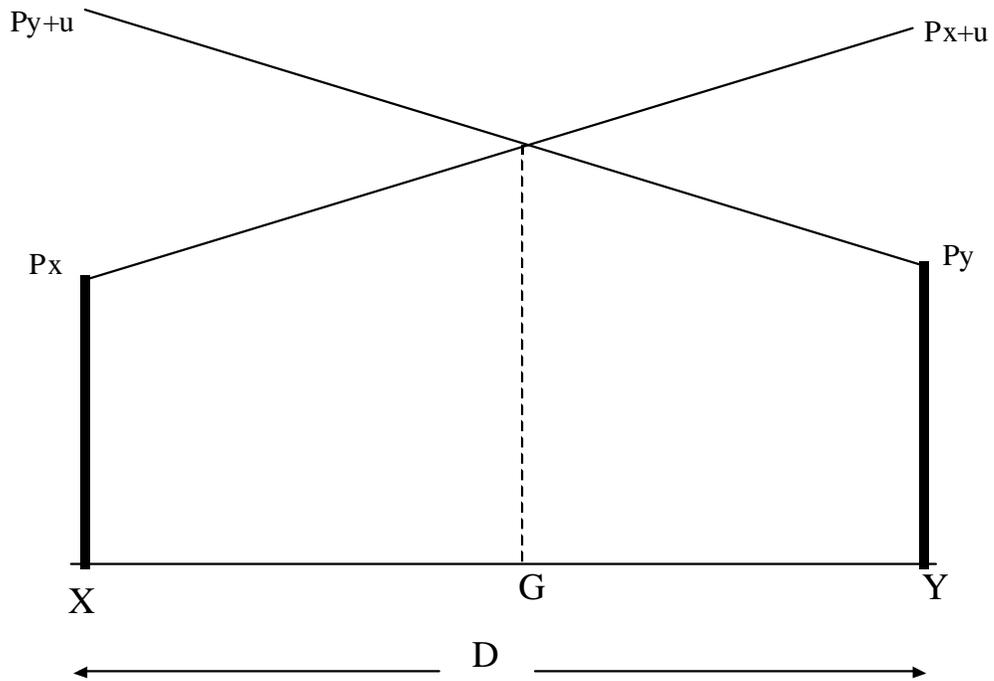


Figure 2—Basing Point Pricing (BPP)

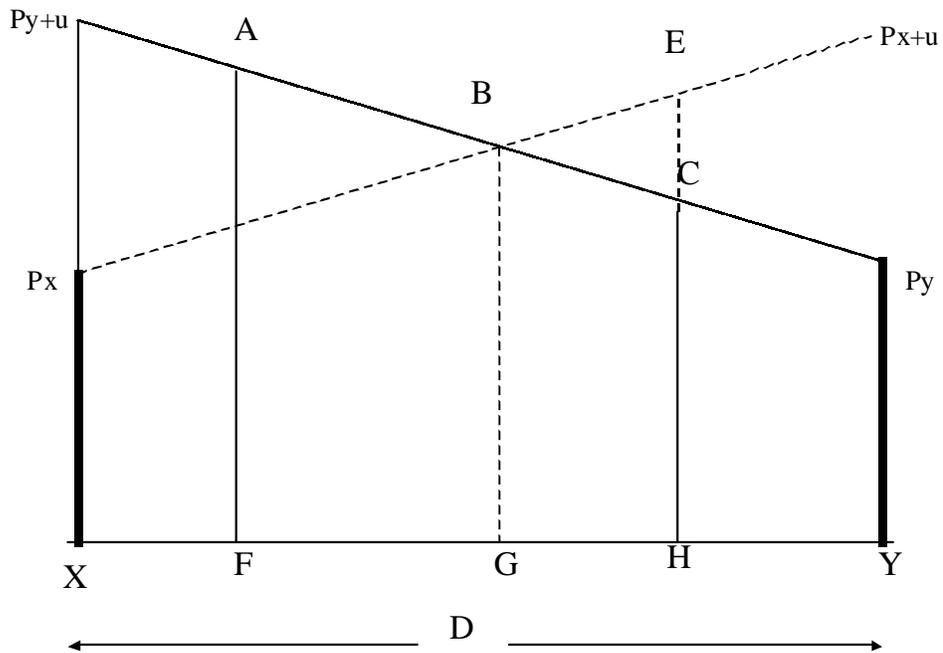
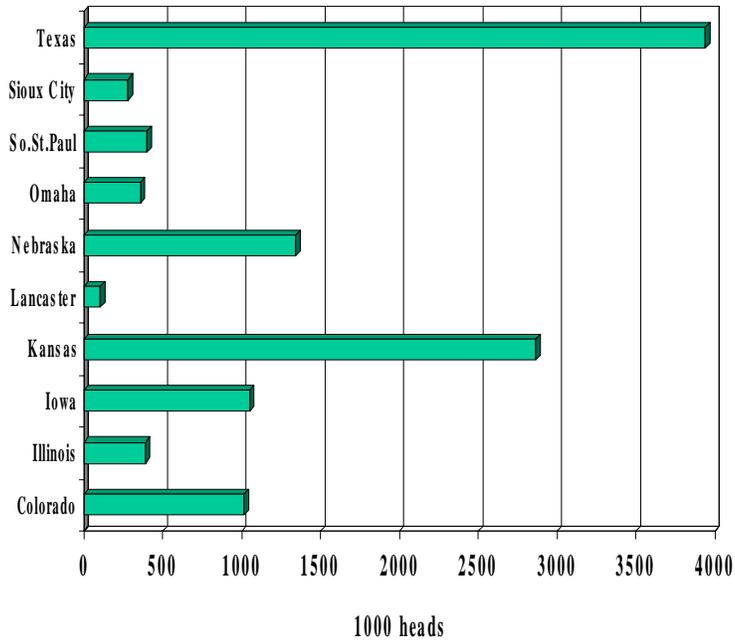


Figure 3—Average annual cattle volumes (1984-1987)



Source: Schroeder and Goodwin, 1990

Figure 4—Slaughter steer: weekly prices from Texas (dollars per 100 pounds)

