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# **Price Transparency in the Voluntary Price Reporting System for Live Cattle: Theory and Empirical Evidence**

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By

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# **Price Transparency in the Voluntary Price Reporting System for Live Cattle: Theory and Empirical Evidence.**

## **ABSTRACT**

Interregional spatial linkages between South Dakota and Nebraska cash markets for slaughter cattle are investigated. Econometric procedures are used to test whether a thinning market effect or strategic price reporting behavior by packers has degraded market transparency under the voluntary price reporting system. Empirical evidence suggests transparency was not degraded.

# Price Transparency in the Voluntary Price Reporting System for Live Cattle: Theory and Empirical Evidence.

## Introduction

Recent passage of mandatory livestock price reporting legislation at the federal level is the direct result of concerns raised over the reliability of the voluntary price reporting system to promote price discovery.<sup>1</sup> This legislation ended individual state mandatory livestock price reporting regimes and discontinued the voluntary reporting of slaughter cattle sales occurring in regional markets by the Agricultural Marketing Service (AMS).<sup>2</sup>

Structural change occurring in the livestock industry over the last fifty years has often been cited as the reason for the need to reform the price reporting mechanism for livestock markets. Specific issues raised are: 1) price and market transparency have been degraded as a result of industry participants failing to report an estimated 35 to 40 percent of all cattle transactions (USDA-AMS 2000) because the AMS reported only confirmed transactions to the public; 2) there is a propensity for buyers and sellers in the cash market to behave strategically when voluntarily reporting market transactions,<sup>3</sup> and 3) captive supply inventories have a

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<sup>1</sup> Increased concentration in both the packing and feedlot industries, the use of alternative marketing arrangements (marketing agreements, forward contracts, etc.), has resulted in the movement away from terminal market transactions by market participants over the last 30 years. In the spot market for cattle, the use of terminal markets has declined from 30% in 1977 to 13% in 1999 (GIPSA 2002). Furthermore, the four largest packers control 82% of steer and heifer slaughter but only purchase 3.7% of total slaughter from terminal markets. A number of economists have concluded that these structural changes in the cattle industry have resulted in thinning markets. Possible consequences include, hampering price discovery, reducing market transparency, and degrading the effectiveness of the voluntary price reporting system. See for example Bastian et al. (2001) or Azzam (2003).

<sup>2</sup> National mandatory livestock price reporting legislation was passed in October 1999 and superseded state legislation. The first federal publicly issued mandatory price report was released on April 2, 2001, ending individual state reporting activity. Regional AMS voluntary livestock reports also ended at this time, e.g. Montana Direct, Washington/Oregon Direct, etc.

<sup>3</sup> Koontz (1999) suggested that packers and feedlots are more likely to withhold transaction information during periods of sharp price movements. This type of behavior would increase price uncertainty during these periods.

propensity to create thin markets upon which public voluntary price reports are based.<sup>4</sup> These concerns have raised doubts about the ability of the voluntary price reporting system to engender market efficiency and promote competition in livestock markets. However, the robustness of the voluntary price reporting system, as a price transmission mechanism, has not been empirically investigated in the literature. This issue is addressed in this study.

Efficient price transmission implies the provision of timely and accurate price information to market participants and is vital to maintaining efficient livestock markets. Our objective is to investigate the AMS voluntary price reporting system to determine if it was an efficient mechanism for the transmission of price information to live-cattle cash markets in South Dakota and Nebraska. We develop a descriptive theoretical framework identifying the potential spatial linkages between South Dakota and Nebraska cash markets. The hypothesized spatial linkages allow us to empirically test if the Agricultural Marketing News Service regional voluntary price report for Nebraska (AMS 1999-2001) was an efficient conduit for price transmission between Nebraska and South Dakota cash markets based on the criteria presented in a recent paper by Barrett and Li (2002).

The findings of this empirical investigation will contribute to the public discourse on the decision to eliminate all federal voluntary public price reports in the slaughter cattle industry. A key issue is whether the former voluntary livestock price reporting system did provide timely and accurate market price information to cash market participants. Currently, the states of New Mexico, Nebraska, and Texas have voluntary price reports being issued. The existence of these state voluntary price reports indicates a perceived need for additional public information that

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<sup>4</sup> The concept of a thin market in this context refers to the decline in cash transactions as a percentage of total transactions (Tomek 1980).

could be provided on a voluntary basis and disseminated by the AMS in conjunction with the current mandatory price reporting series. However, the robustness of a voluntary system is still a point of contention. Public discourse on this issue should intensify because legislative authorization for federal mandatory price reporting expires in October, 2004.

### **Price Transparency in Livestock Markets**

Market transparency refers to a market environment where all relevant information on market conditions is publicly available to all market participants. One important component of market transparency is the concept of price transparency. Price transparency is defined as a market condition where all relevant information on transaction prices are publicly available to all market participants. The goal of public price reporting is to provide accurate and timely market price reporting Lawrence et. al (1996). Accurate and timely market price reports are necessary for adequate price discovery, and the promotion of market efficiency Ward (1987).

A number of studies in the literature on mandatory and voluntary price reporting have questioned the accuracy of the former AMS voluntary public price reporting system relative to a mandatory livestock price reporting regime (Anderson et al 1998, Bastian et al 2001, Azzam 2003). These studies assert that moving to a mandatory price reporting system will improve the availability of public information dramatically.<sup>5</sup> A common theoretical linkage in this literature is that by reducing price uncertainty, you increase market efficiency. These studies basically assume Tomek's thinning market phenomenon was occurring in the voluntary price reporting mechanism and increased price uncertainty. They demonstrate that a full information system is

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<sup>5</sup> The implementation of mandatory price reporting in the market for slaughter cattle has dramatically improved the public information set for non-spot market transactions. However, the focus in this study is only on cash transactions in South Dakota and Nebraska, and if the AMS voluntary price reporting system provided accurate and timely price information to South Dakota producers marketing live slaughter cattle in the cash market.

more efficient because it reduces price uncertainty relative to an incomplete information system. The implication of a thinning market phenomenon is that price transparency is degraded in that market and this will affect economic behavior. However, to empirically verify their hypothesis of a thinning market, actual market transaction data collected simultaneously from a mandatory and voluntary price reporting agency would have to be compared to establish increasing price dispersion occurring, over time, in the voluntary price reporting system. That data does not exist.

Recent literature on the relationship between competitive spatial equilibrium and market integration (Barrett and Li 2002, McNew 1996, McNew and Fackler 1997) provides an alternative methodology for analyzing the robustness of price transparency within the context of mandatory versus voluntary price reporting. When interregional trade is nonnegative, Barrett and Li note that a long-run competitive spatial equilibrium condition holds when marginal profit from arbitrage activity is equal to zero. Under this condition, when trade is positive, regional price differentials move “one-for-one with the costs of spatial arbitrage” in the long-run. On the other hand, market integration, as discussed in the contestable market literature “implies the transfer of Walrasian excess demand from one market to another, manifest in the physical flow of a commodity, the transmission of price shocks from one market to another, or both ,” (Barrett and Li p.293).

Market integration requires an efficient short-run market adjustment mechanism restoring a market to its long-run equilibrium condition. In the framework developed below for investigating the relationship between mandatory and voluntary price reports, the test for market integration will be based on if there is evidence of the efficient transmission of price shocks from one market to another. We contend that Barrett and Li’s definition of market integration implies price



transparency. Next, a theoretical framework is developed incorporating the two different types of price reporting regimes.

### **Regional Mandatory Price Reporting Regimes**

The purpose of regional (state) mandatory livestock price reporting laws (now defunct) is to require all livestock transactions to be reported to the designated government agency. In theory, this implies complete price transparency in cash markets. The price revealed in a mandatory public price report ( $P_t^{MA}$ ) for region (state) A, in period t, equals the actual weighted average market price ( $P_t^A$ ) for direct sales in period t for the reporting region plus a random error:

$$(1) P_t^{MA}(I_t^A) = P_t^A + \epsilon_t.^6$$

The symbol I denotes the information set containing all transaction data generated in region A and collected by the price reporting agency. The variable ( $\epsilon$ ) denotes random error occurring in the data collection and reporting process. If one assumes full industry compliance (complete information), then:  $E(\epsilon_t | I_t^A) = 0$ ,  $VAR(\epsilon_t | I_t^A) = \sigma_{\epsilon_t}^2$ , and  $E(P_t^{MA} | I_t^A) = P_t^A$ .<sup>7</sup> Assuming the government's data collection procedures adhere to standardized collection and evaluation practices, then Barrett and Li's definition of an integrated relationship between  $P_t^A$  and  $P_t^{MA}$  exists in the context of a price reporting relationship.

### **Voluntary Price Reporting Regimes**

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<sup>6</sup> This assumption assumes full compliance with price reporting regulations by all market participants. The assumption that the expected value of collected transaction prices is an unbiased estimate of equilibrium price is consistent with Tomek (1980). It is assumed transaction costs associated with price reporting are zero and so the intercept term is dropped.

<sup>7</sup> Note that the mathematical operators E and VAR are conditional expectation and variance operators, respectively.

The information set ( $I_t^B$ ) contains transaction price information, for region B, voluntarily reported to the price reporting agency. The information set determines the price revealed in the public voluntary price report ( $P_t^{VB}$ ), at time t, plus a random error:

$$(2) P_t^{VB}(I_t^B) = P_t^B + \epsilon_t.$$

$P_t^B$  is the actual market weighted average transaction price in region B, and  $\epsilon_t$  is the random error term resulting from random error in the data collection and reporting process. Next, let it be assumed that the voluntary price reporting system draws a large enough sample when constructing  $I_t^B$  that the sample is representative of the market and therefore the voluntary price reports are an efficient conduit for the transmission of market information on slaughter cattle transactions in region B.<sup>8</sup> This implies:  $E(P_t^{VB} - P_t^B) = 0$ , given that  $E(\epsilon_t) = 0$  and  $VAR(\epsilon_t) = \sigma_{\epsilon}^2$ . Assuming the government's data collection procedures adhere to standardized collection and evaluation practices, then Barrett and Li's definition of an integrated relationship between  $P_t^B$  and  $P_t^{VB}$  exists in the context of a price reporting relationship.

With respect to  $E(\epsilon_t) = 0$  and  $VAR(\epsilon_t) = \sigma_{\epsilon}^2$  assumptions, if one or both are false, this implies that either  $E(\epsilon_t) \neq 0$  or  $VAR(\epsilon_t)$  changes as the content of the information set changes or both.<sup>9</sup> These types of potential flaws in the AMS public voluntary price reporting

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<sup>8</sup> Azzam (2003, p.388) discusses transparency in terms of reduced uncertainty over livestock prices under a mandatory system relative to voluntary price reporting as a result of increased market information. The underlying premise of Azzam's assumption is that increased uncertainty is the result of fewer transactions being reported under a voluntary system resulting in increased price dispersion relative to actual dispersion of market transaction prices. In simple terms, Azzam refers to the issue as analogous to a sampling issue.

<sup>9</sup> The implication of  $E(\epsilon_t) \neq 0$  is  $E(P_t^{VB}) \neq P_t^B$ , the voluntary price report is biased. If there are transactions not reported, then the content of the information set declines as the proportion of transactions reported declines (thinning markets), causing the variance of the estimated equilibrium transaction price ( $VAR(\epsilon_t)$ ) to increase (Tomek 1980). The thinning market assumption is the unifying behavioral assumption linking together the earlier studies found in this literature. If the missing information is nonrandom, then the distribution of the information set may be skewed relative to the distribution of actual transactions occurring in the market. This may result in bias voluntary public price reports.

system have been alluded to by the proponents of federal mandatory price reporting. For example: 1) If buyers and sellers of slaughter cattle are behaving strategically when reporting transaction prices, then  $\pi_t$  will not have a constant mean over time, and 2) if the volume of transactions being reported is diminished to the point of affecting the distribution of the voluntary price report then  $\pi_t$  will experience an increase in its variance over time. If either one of these conditions or both are present, then the relationship between  $P_t^{VB}$  and  $P_t^B$  will not be stationary. This implies the voluntary price report will not have a long-run equilibrium relationship with actual market transactions. In this case, it is not possible for the two price series to be integrated and price transparency is nonexistent. This implies the voluntary price reporting system is fundamentally flawed as implied in the earlier literature.

### **Interregional Slaughter Cattle Production and Interregional Spatial Equilibrium**

Assume regions A and B are two spatially related regions for the production of slaughter cattle. Assume the production capacity of slaughter cattle in region A is defined as being small relative to B. Assume region B is defined as a centralized market, and region A as a decentralized market.<sup>10</sup> The difference between the two regions is slaughter cattle production capacity and: a) region B has processing facilities and a voluntary public price reporting regime, and b) region A has a mandatory public price reporting regime and no processing facilities. Assume region A produces an excess supply of slaughter cattle because of a lack of processing facilities. Assume region B has excess demand for slaughter cattle due to processing facilities having excess capacity. Producers in region A have a choice of selling their live cattle to a field representative of a processing firm located in region B or selling their cattle in region A to an intermediary

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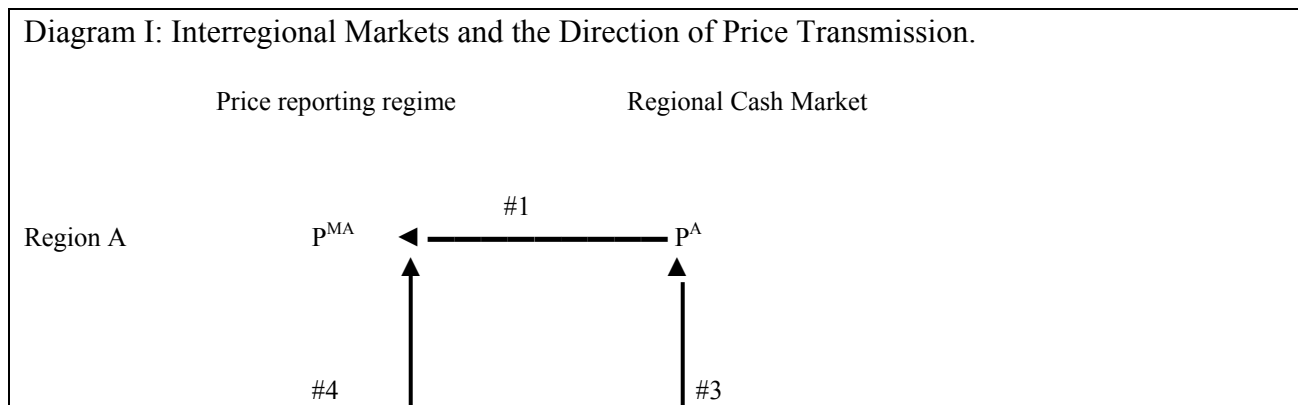
<sup>10</sup> The term centralized infers the ability of a region to produce, market, and process slaughter cattle internally.

(independent order buyer). The intermediary will assume the risk of delivering the cattle to the processing facility in region B and profit from any short-run arbitrage activity. Therefore, all slaughter cattle flow from region A to region B.<sup>11</sup>

Next, assume the market for slaughter cattle is competitive in regions A&B. This implies that opportunities for interregional arbitrage dissipate quickly.<sup>12</sup> This infers that the cash markets for slaughter cattle in regions A&B are spatially integrated and this relationship can be defined as:

(3)  $P_t^A = \alpha + P_t^B + \psi_t$ , where  $\alpha$  is the intercept term capturing transactions cost and  $\psi_t$  is the random error term and  $E(\psi_t) = 0$  and  $Var(\psi_t) = \sigma^2_{\psi_t}$ .

Diagram I depicts the spatial relationships between interregional markets and between regional price reports and actual marked transactions as discussed above.



<sup>11</sup> The discussion reflects the production and marketing of slaughter cattle in South Dakota. There are no modern commercial beef packing plants in South Dakota. A large majority of South Dakota slaughter cattle are shipped out of state for processing.

<sup>12</sup> This implies the long-run competitive spatial equilibrium is consistent with marginal profit from arbitrage activity being equal to zero. This assumption is consistent with Barrett and Li, and Mc New and Fackler.

Region B  
(NEB)



The line #1 represents the spatial relationship and direction of price transmission between actual and reported transactions resulting from government enforcement of mandatory price reporting regulations in region A: eq. 1. The line #2 represents the possible spatial relationship between actual and voluntary reported transaction prices released by the reporting agency in region B: eq 2. The line #3 represents the assumed spatially integrated relationship between regions A&B due to spatial arbitrage: eq 3. The line #4 represents the possible interregional spatial relationship between the mandatory price report in region A and the voluntary price report in region B eq 4.

The spatial relationships defined by equations 1, 2, and 3 are unobservable. The spatial relationship between actual market transaction prices and published mandatory price reports as defined in eq. 1, and depicted in diagram I, is assumed to adhere to the conditions necessary for spatial equilibrium to occur because of government enforcement of mandatory price reporting regulations in region A. The spatial relationship between actual market transaction prices and published voluntary price reports as defined in eq. 2, and depicted in diagram I, is assumed to adhere to the conditions necessary for spatial equilibrium to occur because the government collection of voluntarily reported transaction data is assumed to be accurate and hence government voluntary price reports are an accurate reflection of actual market conditions in region B. The interregional spatial relationship defined in eq. 3, and depicted in diagram I is assumed to attain spatial equilibrium because competitive spatial arbitrage and one-way trade exists between regions A&B.<sup>13</sup>

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<sup>13</sup> The Barrett and Li necessary conditions for long-run spatial competitive equilibrium to exist between regions A&B are one-way trade and zero marginal profits to arbitrage in the long-run.

The interregional spatial relationship between region A's mandatory price report and region B's voluntary price report depicted in diagram I is defined as follows:

(4)  $P_t^{MA} = a + P_t^{VB} + e_t$ , where "a" denotes the intercept term, and  $e_t$  is the random error term.

The existence of a long-run spatial equilibrium for the interregional spatial relationship defined in eq. 4 is solely dependant on what is assumed about the nature of the spatial relationships defined by equations 1, 2, & 3. If any of the spatial relationships defined by equations 1, 2, & 3 fail to yield a long-run spatial equilibrium condition, then it is not possible for an interregional spatial equilibrium relationship to exist between the mandatory price report in region A and the voluntary price report in region B.

We assert that the interregional spatial relationships developed above reflect the relationship between the Nebraska and South Dakota cash markets before federal mandatory price regulations went into effect. The above discussion allows the first testable hypothesis to be introduced: *If the spatial relationships defined by equations, 1, 2, & 3 are consistent with the conditions necessary to sustain long-run spatial equilibrium, then the mandatory price report in South Dakota and the voluntary price report in Nebraska have a long-run spatial equilibrium relationship.*

Empirically, spatial equilibrium is a long-run concept which requires certain conditions to be present in the spatial relationship of two time series variables. Empirically, for the condition of long-run spatial equilibrium to occur in the spatial relationship defined by equation

4, statistical evidence of a cointegrated relationship between  $P_t^{MA}$  and  $P_t^{VB}$  is necessary.<sup>14</sup> If a cointegrated relationship between  $P_t^{MA}$  and  $P_t^{VB}$  is not present, then a long-run spatial equilibrium relationship does not exist for the spatial relationships defined by equations 2&3.

To develop this point further, assume competitive spatial arbitrage between South Dakota and Nebraska markets is robust, and that the South Dakota Mandatory price reporting regime was accurate. Given the absence of cointegration, we can draw a conclusion from rejecting the null hypothesis that the voluntary price reporting mechanism for public reporting of Nebraska live cattle cash transactions was flawed before federal mandatory price reporting was implemented.

### **Interregional Spatial Integration and Price Transparency**

According to the recent literature (e.g. Barret and Li), market integration is defined as the ability of linked markets to transfer changes in market supply and demand conditions from one market to another via the transmission of price shocks. Efficient transmission of price shocks is consistent with the definition of price transparency requiring the market mechanism to provide accurate and timely price information to market participants.

Long-run spatial equilibrium is a necessary but not sufficient condition for the existence of price transparency. In the last section it was postulated that if an interregional long-run spatial equilibrium relationship exists between  $P_t^{MA}$  and  $P_t^{VB}$ , then a long-run spatial relationship must also exist for the other three spatial relationships (diagram I). Applying the same logic to

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<sup>14</sup> The literature (Barrett and Li, McNew, McNew and Flacker, etc) indicates that linear cointegration techniques are inadequate when transactions cost are not stationary, trade is bidirectional, or trade is discontinuous. Only the issue of nonstationary transactions costs poses a potential problem. The other two potential problems are not relevant to the theoretical framework developed in this paper. However, empirical results discussed later indicate that transactions costs are stationary.

test if the spatial relationships (as illustrated in diagram I) are spatially integrated leads us to the second testable hypothesis: *If the spatial relationships defined by equations, 1, 2, & 3 are spatially integrated, then the mandatory price report in South Dakota and the voluntary price report in Nebraska are spatially integrated.*

To test if the AMS voluntary price reporting system did fully transmit price shocks from one region to another in a timely fashion, an error correction model (ECM) is constructed to test the robustness of the short-run equilibrium interregional price shock adjustment mechanism to determine if the mandatory price reporting series in region A (South Dakota) and the voluntary price reporting series in region B (Nebraska) are spatially integrated.

Adopting the ECM framework to model the price transmission process in the interregional cash market will allow us to define the price transmission process (eq. 5). According to Granger (1981, 1983), two cointegrated series (eq. 4) can be expressed as a simple error correction model:

$$(5) \Delta P_t^{MA} = \gamma_0 + \gamma_1 \Delta P_t^{VB} + \gamma_2 e_{t-1}.$$

The change in the equilibrium price of slaughter cattle from period t-1 to t in region A is reflected in  $\Delta P_t^{MA}$ . The change in the equilibrium price of slaughter cattle from period t-1 to t in region B is reflected in  $\Delta P_t^{VB}$ . The intercept term  $\gamma_0$  ( $\gamma_0 = \Delta a$ ) reflects changes in the long-run equilibrium relationship due to the effect of the price shock on transaction cost levels.<sup>15</sup> The slope parameter  $\gamma_1$  ( $0 \leq \gamma_1 \leq 1$ ) captures the transmission of the price shock occurring in region B, in time period t, to region A. If  $\gamma_1=1$ , then this would indicate “instantaneous perfect integration” as defined by Barrett and Li. However, a weaker condition discussed by Barrett and Li is “perfect integration” which only requires that the entire price shock be transmitted, without a

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<sup>15</sup> Barrett and Li discuss the effect of nonstationary transaction costs on the robustness on linear ECM models. We assume  $\gamma_0=0$ , and empirical evidence presented later in the paper supports this assumption.



specific duration-of-time constraint. The variable  $e_{t-1}$  reflects the deviation from parity remaining to be transmitted from region B to region A as a result of the price shock at time  $t$ . The deviation from parity adjustment parameter  $\gamma_2$  ( $0 \leq \gamma_2 \leq 1$ ) captures the transmission of the price shock residual to region A.

The interregional ECM modeling of the price shock transmission process is done in a discrete time framework to determine if the time-path of the adjustment process is consistent with Barrett and Li's definition of perfect integration. First, assume that the spatial relationships outlined in diagram I are integrated and assume a fixed proportion of the price shock ( $\gamma_1 = \gamma_2$ ) is transmitted from region B to region A each period, and  $\gamma_0 = 0$ .<sup>16</sup> Next, assume a price shock at time  $t$  occurs in region B. The price shock disrupts the long run equilibrium between regional transaction prices  $P_t^A$  and  $P_t^B$ . This disruption will be reflected in the respective price reports;  $P_t^{MA}$  and  $P_t^{VB}$ . In period  $t$ , the proportion of the price shock transmitted to region A and reflected in  $P_t^{MA}$  is:

$$(6) \Delta P_t^{MA} = \gamma_1 \Delta P_t^{VB}.$$

In period  $t+1$ , the proportion of the price shock transmitted to region A is the residual  $e_{t-1}$  multiplied by  $\gamma_1$ . Where  $e_{t-1} = \Delta P_t^{VB} - \gamma_1 \Delta P_t^{VB}$  is the residual of the price shock not yet transmitted to region A. The transmission process continues until the entire shock is transmitted to region A. Rewriting the price shock transmission process in a compact form allows us to define the *spatial price transmission equation*:

$$(7) \sum_{i=0}^n \Delta P_{t+i}^{MA} = \Delta P_t^{VB} \sum_{i=0}^n \gamma_1 (1 - \gamma_1)^i.$$

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<sup>16</sup> We assume the market mechanism for the transmission of price shocks across regions is time invariant. Empirical evidence presented later indicates the fixed proportion assumption is robust.

Equation 7 confirms that the proposed ECM framework is consistent with Barret and Li's definition of perfect integration occurring between regions A and B whenever  $\gamma_0=0$ , and  $0 < \gamma_1 < 1$ .<sup>17</sup> Instantaneous perfect integration occurs whenever  $i=0$ ,  $\gamma_0=0$ ,  $\gamma_1 = \gamma_2$ , and  $\gamma_1 = 1$ . This type of integration is the type one would associate with financial markets. Barret and Li's segmented equilibrium would occur if  $\gamma_0=0$ ,  $\gamma_1 = 0$ , and no movement of slaughter cattle from region A to B.

Empirical estimation of parameters  $\gamma_1$  and  $\gamma_2$  in eq. 5 will provide statistical evidence of whether spatial integration existed between  $P_t^{MA}$  and  $P_t^{VB}$ . If both  $\gamma_1$  and  $\gamma_2$  are statistically significant then we can conclude all of the spatial relationships in diagram I are integrated. The implication under this scenario is that the AMS Nebraska voluntary price report did engender price transparency in Nebraska and South Dakota cash markets.

## Methodology

For South Dakota and Nebraska, we intend to empirically investigate the spatial relationships hypothesized in diagram I for the time period just before federal mandatory price reporting rules went into effect. A test for the presence of cointegration will provide empirical evidence on the possible existence of long-run spatial equilibrium relationships discussed above (diagram I). If a long-run equilibrium relationship is found, then an error correction

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<sup>17</sup> Given that  $\lim_{i \rightarrow \infty} \sum_{i=0}^n \gamma_1 (1 - \gamma_1)^i = 1$ , and thus  $\lim_{i \rightarrow \infty} \sum_{i=0}^n \Delta P_{t+i}^{MA} = \Delta P_t^{VB}$ . Therefore, Barret and

Li's requirement for perfect integration is met.

mechanism (ECM) modeling approach will be used to investigate the short-run disequilibrium adjustment process to determine if there is empirical evidence of spatial integration.

First, unit root tests will be conducted to determine which of the selected price series are non-stationary.<sup>18</sup> Engle and Granger (1987) state that if two series are I(1) then it is possible that a linear combination of the two series is I(0). Engle and Granger propose a *cointegrating regression*: regressing one I(1) series on another I(1) series. The residual series generated by the cointegration regression will be tested for the existence of a unit root to determine if the two price series are cointegrated. Next, based on the work by Granger (1981, 1983), the Granger Representation Theorem states that if two time series variables are cointegrated, then the relationship between them can be expressed as an error correction mechanism (ECM).

## **Data**

In July of 1999 South Dakota Codified Law: Chapter 40-15B (SDCL 2000) required mandatory livestock price reporting in South Dakota to begin on Sept 1, 1999. The legislation required that all private livestock transactions were to be reported to the South Dakota Department of Agriculture. The Department of Agriculture collected data until federal mandatory price reporting began. The Secretary of Agriculture's office supplied all of the collected mandatory reporting data used in this study. The South Dakota mandatory price reporting data was used to construct a daily price series for all live weight steer transactions

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<sup>18</sup> For a discussion of unit root testing procedures and testing for cointegration between non-stationary time series variables see Gujarati (2003).

occurring in the state during the 19-month period prior to implementation of federal mandatory price reporting. This data provides a unique opportunity to test if voluntary public price reporting system reflected actual market conditions during the period just prior to the implementation of federal mandatory price reporting.

The South Dakota Mandatory Price Reporting data set contains 80 weeks of daily weighted average price data (142 transaction days) for the direct sale of live steers in South Dakota. The data set contains 59,614 head and 300 recorded transactions.<sup>19</sup> The AMS voluntary price series selected is the Nebraska Daily Direct Weighted Average report. The two price series were matched with respect to transaction dates.

### **Empirical Results: Testing for Unit Roots and Cointegration**

Table I presents the Dicky-Fuller (DF) and Augmented Dicky-Fuller (ADF) test statistics, the associated p-values for the unit root tests, for each of the price series. The test statistic for detecting the presence of serial correlation is either the Durbin-Watson d or Durbin's t, depending on if a lagged dependent variable was needed to whiten the error structure of the unit root test. Lagged terms were added to the ADF equation until the error structure was empirically verified as whitened. The unit root tests are based on the null hypothesis that a price series has a unit root and is non-stationary versus the alternative that the

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<sup>19</sup> The mandatory price reporting data set supplied to the Dept. of Economics at SDSU by the State of South Dakota contains transaction data on over 600,000 head of cattle. Dressed weight sales, grid sales, forward contract sales, marketing agreement transactions, heifer and Holstein transactions were excluded from the sample. Voluntary price report data collected from various issue of the AMS Livestock, Meat and Wool Weekly Summary and Statistics report (1999-2001).

series does not have a unit root and is stationary.<sup>20</sup> The unit root hypothesis test results indicate that both price series are non-stationary (Table I). The cointegration results are presented in Table II.

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<sup>20</sup> If serial correlation was not detected in the initial DF test, then the autoregressive order is zero. If serial correlation was detected then the appropriate ADF test was used.

**TABLE I**  
**UNIT ROOT TEST RESULTS**

Price Series	Obs.	Tau Statistic	P-Value
Nebraska Daily Direct Weighted-Average report. <sup>1</sup>	142	-0.80	0.81
South Dakota Mandatory Price Reporting Data. <sup>2</sup>	142	-1.34	0.61

1. The order of the autoregressive model selected for the ADF test is AR(0). DW d test stat=1.68  
 2. The order of the autoregressive model selected for the ADF test is AR(1). Durbin's t= -1.27

**TABLE II**  
**SDMPR COINTEGRATION TEST RESULTS**

Price Series Cointegrating Regressions	Number Of Obs. <sup>21</sup>	Cointegrating Intercept Estimate	Regression Parameter Estimate	Tau Statistic	P-Value
SDMPR & Nebraska Daily Dir. Wt. Avg. <sup>1</sup>	142	5.14	0.917	-9.27	0.001

1. The order of the autoregressive model selected for the ADF test is AR(0). DW d test stat = 2.025.

The empirical evidence suggests a long-run spatial equilibrium relationship did exist between the South Dakota Mandatory price report series and the Nebraska Direct series. We concluded there is empirical evidence to support hypothesis 1, and that the long-run spatial equilibrium relationships outlined in diagram I did exist in the period just prior to implementation of federal mandatory price reporting.

<sup>21</sup> Statistical analyses were conducted using SAS (1993).

Empirical evidence of the existence of long-run equilibrium relationships, however, does not tell us anything about short-run deviations away from equilibrium. Short-run divergence from the long-run equilibrium relationship may result from the alleged flaws in the former voluntary price reporting system. The literature clearly indicates that interregional integration occurs only if price shocks are completely transmitted from one region to another. To investigate this issue, an error correction mechanism (as discussed earlier) will be employed to investigate the effect of short-run anomalies on the empirically established long-run relationships discussed above.

### **ERROR CORRECTION MODEL**

In the last section we established empirically that there is statistical evidence of long-run spatial equilibrium conditions present among the South Dakota and Nebraska interregional spatial relationships as defined in diagram I. While the estimated long-run equilibrium relationships are statistically significant, there is still the question of whether price integration exists across these spatial relationships. The literature indicates that sustained short-run deviations from the long-run equilibrium relationship could degrade price (integration) transparency and hinder price discovery. Sustained short-run deviations would be evidence of the failure of the voluntary price reporting system to act as an efficient mechanism or conduit for the transmission of changing market conditions to the public.

An error correction modeling procedure is therefore utilized with the following set of premises concerning price determination in the cash market for slaughter steers. It is assumed here that the equilibrium cash price of slaughter steers is determined by regional market conditions outside of South Dakota. Packers engaged in the direct cash purchase of live

slaughter steers in South Dakota are aware of the current regional market conditions for beef and the transaction costs associated with placing South Dakota steers into the supply channel. It is also assumed here that the trends in transaction and transport costs were relatively flat during the time period covered by this study.<sup>22</sup> Given these assumptions, a price shock to the live slaughter steer cash market at the regional level will eventually be reflected in the direct price paid to South Dakota producers. Simply stated, a price shock of  $x$  dollars per cwt. at time  $t$  at the regional level will disrupt the long-run equilibrium between the regional market price and the price paid to South Dakota producers. The disequilibrium condition will persist until the South Dakota market fully adjusts to the price shock in some future period  $t+n$ , where  $n$  is the number of periods (transaction days) needed for full adjustment to take place (eq.7). It is during this period of disequilibrium that price transparency can be effected.<sup>23</sup> The length of time ( $n$ ) it takes for the transmission of a price shock opens a window of opportunity for profitable arbitrage activities to occur in smaller decentralized markets like South Dakota.<sup>24</sup>

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<sup>22</sup> During the time period covered by this study the average Midwest retail weekly #2 diesel price per gallon was \$1.41 and the standard deviation was 12 cents (U.S. Dept. Of Energy, Energy Information Administration).

<sup>23</sup> Koontz (1999) reported that packers and feedlots are more likely to withhold transaction information during periods of sharp price movements. However, empirical evidence does not support this type of market disrupting behavior affecting the interregional spatial relationship in this study.

<sup>24</sup> The possibility of excess profit potential arising in this type of situation has been alluded to by Goodwin and Schroeder (1991) and Tomek (1980).



Based on the work by Granger (1981, 1983), the Granger Representation Theorem states that if two time series variables are cointegrated, then the relationship between them can be expressed as an error correction mechanism (ECM). The ECM defined in eq.5 is estimated using OLS:

$$8) \Delta P_t^{MA} = \gamma_0 + \gamma_1 \Delta P_t^{VB} + \gamma_2 e_{t-1} + z_t,$$

where  $z_t$  is the random error term, and the empirical estimates are provided in Table III.<sup>25</sup>

**TABLE III**  
**ERROR CORRECTION MODEL OLS ESTIMATES**

Price Series ECM Regressions	Number Of Obs.	ECM Intercept Est.	Regression Estimates <sup>1</sup> Slope Est.	Speed of Adjustment Est.
ΔSDMPR & ΔNebraska Daily Dir. Wt. Avg.	142	0.03 (0.29)	0.752 (6.62)	-0.755 (-9.16)

1. Student t test statistics are given in parentheses below the respective parameter estimate.

Table III indicates that the intercept estimate is statistically zero. This result implies that transaction costs were stationary during the period investigated in this study.

Empirical evidence presented in Table III indicates the slope parameter estimate is highly significant and has a p-value of less than .001. The “speed of adjustment” parameter estimate is also highly significant and has a p-value of less than .001. The “speed of adjustment” parameter coefficient estimates indicate the proportion of the price-shock-residual remaining after period t that will be transmitted to the SDMPR series in period t+1. The slope and speed of adjustment parameter estimates and their respective standard errors are very consistent with the modeling assumption made earlier that  $\pi_1$

<sup>25</sup> The first difference variables used to estimate the ECM were screened for serial correlation (DW: 2.042) and stationary, and no diagnostic problems were detected.

$= \beta_2$ . This implies the institutional structure of the price transmission mechanism is stable. The empirical estimates are consistent with Barret and Li's definition of perfect integration.

Robust price integration needed for market transparency and price discovery occurs when a price shock completely passes through from one market to another in a timely fashion. Table IV provides empirical estimates for the speed of adjustment process.

**TABLE IV**  
**SOUTH DAKOTA MANDATORY PRICE REPORTING SERIES:**  
**“SPEED OF ADJUSTMENT” OVER TIME TO A PRICE SHOCK AT TIME t**

Cointegrating Regressions	TIME		
	t	t+1	t+2
SDMPR & Nebraska Daily Dir. Wt. Avg.	75.2%	93.98%	98.52%

The ECM estimates indicates that 94% of a price shock occurring in the Nebraska cash market was transmitted to the South Dakota cash market by the next transaction day and 98.5% by day two. The empirical evidence indicates that while the AMS voluntary price reporting system did not provide instantaneous price transparency, price transparency did exist and was robust.

### **Conclusions and Summary**

For the period when South Dakota required mandatory livestock reporting, all hypotheses tests associated with the cointegration and error correction analysis indicate that: a) South Dakota's cash market for slaughter cattle was spatially integrated with the Nebraska cash market, and b) South Dakota's mandatory price reporting system and the AMS voluntary price reporting system for Nebraska's direct cash sales were robust price reporting mechanisms. The conclusion from the empirical evidence presented is that in the case of South Dakota and Nebraska, the former voluntary price

reporting system did foster price transparency and was a robust mechanism for promoting market transparency and price discovery.

The debate over whether the former voluntary price reporting system engendered price transparency and promoted price discovery is an important question. The uniqueness of the transaction data collected under South Dakota's mandatory price reporting regulations provides an opportunity to empirically gauge the robustness of the former AMS voluntary price reporting system before federal mandatory price reporting rules came into existence. All previous studies looking at the reliability of the voluntary price reporting system assumed a mandatory price reporting system would reduce price uncertainty and thus would eliminate market inefficiency caused by increased uncertainty. Empirical evidence of interregional spatial price transparency suggests that increased uncertainty did not exist at a level necessary to negatively affect the cash markets in SD and NE. Therefore, the potential negative consequences discussed in the previous literature were minimal in the SD and NE cash markets.

While our study only covers one small corner of the livestock sector, it raises the question that if the former voluntary price reporting system was an efficient mechanism for promoting market transparency and price discovery in the cash market for live steers in South Dakota, what about other regions and other types of livestock? We are not advocating that the former voluntary price reporting system is more robust than the new federal mandatory system, but we are saying there is ample evidence that the former system was not as flawed as previous research has suggested. Therefore, it is not necessarily valid to justify the need for mandatory price reporting based on the assertion that the former voluntary price reporting system degraded price transparency.

We conclude that additional research is needed to answer these questions: 1) What are costs and benefits associated with the new federal mandatory price reporting system and should they be identified before the renewal issue is debated on the floor of Congress, 2) Should voluntary public price reports be resumed in regional markets where regional voluntary price reports were discontinued, and 3) Are there

other regional cattle markets or other types of livestock markets where the former voluntary price reporting system was an efficient mechanism for promoting market transparency and price discovery? Answers to these questions are needed before an informed debate on the current structure of the federal mandatory livestock price reporting system can begin. The question is, are Nebraska and South Dakota the exceptions to the general consensus that the former AMS voluntary price reporting regime was fundamentally flawed when reporting cash market prices.

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