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Dynamic Price Discovery of U.S. Fed Cattle Markets:

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This study re-examines the price discovery process of fed cattle markets by taking into account the dynamic effects from unexpected shocks to fed cattle markets. That is, we investigate whether ensuing shocks to the industry, specifically from BSE outbreaks, resulted in any temporal or permanent changes in the reference market(s) (futures market) obtained from the price discovery process. Using weekly weighted average fed cattle cash prices for Nebraska and weekly average live cattle CME futures prices, from May 2001 to January 2017, we construct forward growing samples. The first sample is from May 2001 until four weeks before the first BSE outbreak, and the second sample onwards sequentially incorporates four more weeks of data until January 2017. We model these samples as rolling bivariate Error Correction Models (ECM) and test whether the futures prices hold as the reference market during the three U.S. BSE outbreaks (December 2003, June 2005, and March 2006). Findings are that during and following the first and second BSE outbreaks, the cash market price became the (new) reference price. During this period, the U.S. experienced a ban of beef exports, in particular to its largest markets Japan and South Korea. The futures market became the reference price (again) only a month before the export ban was partially lifted. In addition, we found no changes to the reference market in the thirdBSE outbreaks; when no export bans occurred. Thus unexpected shocks that produced significant impacts, for example, export bans on the market, were accompanied by a change in reference market.

Key Words: price discovery process, fed cattle market, short run shocks, bivariate ECM models

Introduction

Determining the price discovery process among regional fed cattle markets and live cattle futures markets can provide valuable information to different market participants, since they can learn more about the fundamental value of the commodity by observing the price on this dominant market. The dominant market where information is first discovered may play the role of price leader or serve as reference, providing substantial information to the other markets (price followers), which may have insufficient activity to generate much new information (Schroeder, 1996). In this sense, the live cattle CME futures market also plays a critical role in providing price information for the commodity markets' price discovery process (Leuthold et al., 1989).

Price discovery is about determining which market is more informative for fundamental valuation, such as in the case of similar commodities or inter-connected commodities like fed cattle being traded in different markets. A number of different methods have been used to study price discovery. One of methods is to use a bivariate time series analysis with an error correction term and compare the speed of adjustment between the two series (Gonzalo and Granger, 2005). Price discovery in this context refers to a process whereby the relative contributions of interrelated submarkets to the overall market price can be determined. The submarket with the larger contribution is called the "price discovery market." Numerous studies have investigated price leadership and identification of the relevant geographic market for fed cattle. Koontz, Garcia, and Hudson (1990) used weekly fed cattle prices from four separate regions spanning 1973 through

1984, identifying lead/lag relationships among them and found that price changes in the Nebraska direct market responded fastest to new information. Schroeder and Goodwin (1990) applied a vector autoregression (VAR) model to 11 regional weekly fed cattle prices from 1976 through 1987, and found that Iowa/Southern Minnesota and Eastern Nebraska and Omaha tended to be the leading price discovery regions, with the western Kansas market becoming more dominant towards the end of the considered time period.

A more recent study by Joseph, Garcia, and Peterson (2013) emphasized that "effective price discovery is critical as it facilitates pricing quantity and quality of a commodity at a specified time and place". Joseph, Garcia and Peterson (2013) investigated the fed cattle market discovery process using live cattle futures settled prices, fed cattle cash prices – specifically the five area weighted average prices of 35 to 65% choice live steers, and also considered weekly boxed beef cutout prices. They applied Vector Error Correction models, with Directed Acyclic Graph (DAG) methods to identify non-time causality among the three prices, and used innovation accounting techniques to identify the market reference. The five area weighted average prices takes jointly into account the feedlot transactions from five distinct regions: Texas/Oklahoma/New Mexico, Kansas, Nebraska, Colorado, and Iowa/Minnesota. Despite being comprehensive in its coverage, the transaction prices from each of these markets is not considered separately. In addition, the study is not able to elucidate the contribution from each regional cash market in the price discovery process. Wright, Kim and Tejeda (2017) also investigated price discovery using the ECM approach. They grouped the regional fed cattle prices using the cluster analysis, and ran a series of bivariate ECM to find the reference market. They reaffirmed that futures fed cattle price is the reference price.

This study re-examines the development and price discovery process of fed cattle markets in a more comprehensive manner, by taking into account the dynamic effects (on the reference market(s)) from shocks that these markets experienced. That is, we investigate whether ensuing shocks to the industry resulted in any temporal or permanent changes in the reference market(s) obtained from the price discovery process. The price discovery measure from the literature that is applied here compares the speed of adjustment coefficients in a (bivariate) Vector Error Correction Model (VECM) as a share of the total (market) adjustment, as developed by Gonzalo and Granger (1995) and expanded in Theissen (2002). This method is used by Foster (1996), Eun and Sabherwal (2003), Figuerola-Ferretti and Gonzalo (2010), and Plato and Hoffman (2011), among others to identify price discovery among related markets.

The objective of this study is to determine if the identified reference price - from the price discovery process among fed or live cattle markets - maintains its "reference" characteristics following a shock to the industry, e.g., for unexpected news in the market or livestock disease such as a BSE finding or outbreak. In other words, we examine whether after unexpected shock(s) impacted the fed cattle market, the long run reference market that served as the price discovery (market) is maintained or whether there is a change. In particular, we investigate the case of BSE incidents. We study sub-periods of the full time frame considered (from 2001 to 2016) where news of BSE outbreaks affected the markets, seeking to identify the reference market during the time periods when these unanticipated market shocks occurred. We proceed by describing the data used and methods applied. Followed by results, discussion as well as conclusions and avenues of further study.

Data

Nebraska fed cattle weekly weighted average cash prices from May 2001 to January 2017 (obtained from NASS-USDA) are used, based on prior literature results having found Nebraska fed cattle cash prices as being the reference spot price for fed cattle markets (Koontz et al, 1990; Schroeder and Goodwin, 1990; Wright et al., 2017). May 2001 corresponds to the date when the Livestock Mandatory Price Reporting (LMPR)[1] was initially implemented. Also weekly average futures prices for live cattle are used for the same period and obtained from the CME, in response to futures markets having a major role in the price discovery process (Leuthold et al, 1989; Joseph et al., 2013; Wright, Kim and Tejeda, 2017).

We expressly study sub-periods of this time frame considering when news of BSE outbreaks impacted the markets, seeking to identify and/or verify prior findings (i.e. futures markets being the reference price discovery market) for these cases where unanticipated market shocks occurred. We consider different series, taking into account the specific BSE outbreaks in Washington State (December 2003), Texas (June 2005), Alabama (March, 2006).[2] Figure 1 shows the evolution of the two prices series, including when the BSE outbreaks occurred.

The series studied evolve by initially considering data up to four weeks prior to the first outbreak, and then sequentially incorporating four more weeks of data until January 2017. The 1st sample has 135 observations, from May 6, 2001 to November 30, 2003. The 2nd sample has 139 observations by ending on December 28, 2003. The 3rd sample has 143 observations, ending on January 25, 2004. The 4th sample has 147 observations, ending on February 22, 2004 and so on.[3] We estimate a total of 77 (growing) samples by taking into account the effect from arrival of new information, specifically the BSE outbreaks.

Methodology

Each data sample is treated with the same methods. We begin by conducting unit root tests to the two series in a given sample. Tests applied for this are the Augmented Dickey Fuller Test (Dickey and Fuller, 1981) and the KPSS (Kwiatkowski et al., 1992) test. We also verify the existence of co-integration or a long-run relationship between the two sample series by applying the Johansen (1991) co-integration test. We then apply a bivariate vector error correction model (VECM) to each sample, in order to identify the price discovery measure among the two sample series by comparing their speed of adjustment coefficients.

[1] LMPR was a policy requiring meat packers to provide the public with complete livestock (cattle, hogs, lamb and products) price and transaction information. For detailed information, see Koontz and Ward (2011)

[2] California BSE case (April 24, 2012) was found in a dairy cow. More details are available at: www.centerforfoodsafety.org/issues/1040/mad-cow-disease/, thus we do not include this event in the actual analysis.

[3] We also estimated results from samples of equal size, which were formed by not just incorporating four more weeks of data to the initial sample but also 'eliminating' its 1st four observations. Results from these samples were quite similar.

As explained Arnade and Hoffman (2015), estimates of (absolute) adjustment rates are related to market efficiency. The long-run equilibrium between the cash and the futures prices can be written as follows:

$$y_{csh,t} = \beta_{fut} y_{fut,t} + c + u_t \;\Leftrightarrow\; u_t = y_{csh,t} - \beta_{fut} y_{fut,t} - c \tag{1}$$

where $y_{fut,t}$ and $y_{csh,t}$ represent live cattle futures and fed cattle cash prices at time t, respectively. The term c (constant term) account for differences in these two markets. The term u_t is the (long-run) error, which equals zero in equilibrium.

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

$$\Delta y_{i,t} = \alpha_i \left(y_{csh,t} - \beta_{fut} y_{fut,t} - c\right) + \sum_{l=1}^{L} \sum_{j=1}^{2} \gamma_{i,j,l} \Delta y_{j,t-l} + e_{i,t}, \;\; (i,j = fut, csh) \tag{2}$$

where $\Delta y_{i,t} = y_{i,t} - y_{i,t-1}$ are the price differences of futures and cash values for week t, β_{fut} is the co-integrating parameter among the two price series, and α_i are the "speed of adjustment" parameters. The coefficients α_{fut} and α_{csh} in the VECM determine the permanent effect that a shock to one of the variables has on the system (Theissen, 2002).

To determine the reference market (price discovery) we calculate the relative ratio of the speed of adjustment coefficients following Schwarz and Szakmay (1994), Foster (1996), and Theissen (2002). Other measures of price discovery used in the literature are the Information Share (IS) of Hasbrouck (1995) and the Component Share (CS) of Booth et al. (1999), Chu et al. (1999), and Harris et al. (2002). The IS measures each market's relative contribution to the variance of the efficient price, while the CS decomposes the common efficient price into a weighted average of observed market prices (similar to relative ratio of the speed of adjustment), and measures each market's contribution to the common efficient price. Both IS and CS are based on the reduced-form "forecasting errors" in a Vector Error Correction Model (VECM) (Kim, 2011). The relative ratio of speed adjustment applies as follows,

$$\theta_{fut} = \frac{|\alpha_{csh}|}{|\alpha_{fut}| + |\alpha_{csh}|}, \;\; \theta_{csh} = \frac{|\alpha_{fut}|}{|\alpha_{fut}| + |\alpha_{csh}|}, \;\text{and}\; \theta_{fut} + \theta_{csh} = 1 \tag{3}$$

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

Results and Discussion

In every one of the time series investigated, unit root test results found it had level non-stationary and first differenced stationary properties (tests results are available, but for brevity not reported here). Moreover, each of the samples where co-integrated, at least at the 5% confidence level (test results are available, but for brevity not reported here). After modeling each bivariate VEC model and calculating its relative coefficient of speed adjustment, we found that right after the first BSE outbreak and following many weeks ahead, the fed cattle cash price became the reference market from the price discovery process. Figure 2 illustrates the value of the futures price relative coefficient of speed adjustment (θ_{fut}) for futures price calculated using equation (3) from the estimated bivariate VECM for each sample (i.e. 1st sample, 2nd sample, etc.) - previously defined in the Data section.

In effect we observe that for sample 1, which included data up to four weeks prior to the first BSE outbreak, the futures price is the market reference for the fed cattle market. This however changes once the sample size incorporates data following this first BSE incident. Results for the 2nd sample, which considers data up until the BSE finding, shows that the reference price between futures and cash markets has practically faded. That is, the futures price no longer is the clear price discovery market for fed cattle. More importantly, for the following sample size that includes four weeks (observations) weeks after the first BSE incident, the Nebraska cash market has become the actual reference price or the fed cattle market for price discovery.

The Nebraska cash market continues being the (new) reference price in comparison to the futures prices until approximately sample number 26. This sample considers data up to October 30, 2005 which is almost two years after the first incidence and four months after the second BSE incidence reported in June, 2005. The first BSE outbreak produced an immediate ban on beef exports to many countries, in particular to Japan, the U.S. largest beef importer. This ban was partly lifted by the end of 2005 (Fackler, 2005), opening up the beef trade to its previous (and current) largest buyer. Though the trade ban was lifted a month after the futures price was once again found to be the price reference, trade negotiations had been undergoing for quite a few months back and the market may have been anticipating this decision.

The following BSE outbreaks of 2006 and 2012 did not have an effect on the price discovery process of fed cattle, as we find that futures prices remained the price reference for that market. This may respond to the notion that neither incident produced a ban on beef exports, and thus the markets responded accordingly. We can infer that (unexpected) shocks that have a decisive effect in the market, as in the case of a ban of exports, produces a (transitory) change in the reference market of the price discovery process, where it is no longer the futures market. This change to being a cash price the reference market is not permanent, as the market evolves to consider all the new information and thus changes back to futures prices being the reference market. For future study, we investigate the effects from other unexpected shocks such as FMD, or consider a different fed cattle cash market such as the five area weighted average.

Conclusions

This study re-examines the development and price discovery process of fed cattle markets by taking into account the dynamic effects on the reference market, from unanticipated shocks that these markets experienced. That is, we investigate whether ensuing shocks to the industry resulted in any temporal or permanent changes in the reference market obtained from the price discovery process. We use Nebraska fed cattle weekly weighted average cash prices from May 2001 to January 2017, and live cattle futures market for the same time period. We expressly study sub-periods of this time frame considering when news of BSE outbreaks impacted the markets taking into account the specific BSE outbreaks in Washington State (December 2003), Texas (June 2005), Alabama (March, 2006). The series studied evolve by initially considering data sample of up to four weeks prior to the first outbreak, and then sequentially incorporating four more weeks of data to each sample until January 2017. This produces a total of 77 samples.

After modeling each bivariate VEC model as a rolling ECM and calculating each relative coefficient of speed adjustment, we found that right after the first BSE outbreak and following many weeks ahead, the fed cattle cash price became the reference market from the price discovery process. That is, the futures price was no longer the reference market but the cash market became the new reference price after the 1st BSE incidence in late December, 2003; and this phenomena continued until late October 2005. This was just a month before beef exports to the U.S. largest international market, Japan, was partially re-opened for business. Subsequent BSE shock from 2006 did not produce a change in the reference market for fed cattle, as it remained being the futures price. We believe that the cattle market experienced a certain (transitory) break during this period, mainly caused by the interruption of beef export. For the latter/last cases, there were no impacts on the international trade markets. This study provides insightful information for cases where unexpected shocks result in having substantial impacts on the market versus cases where there is no market effect from the shocks.

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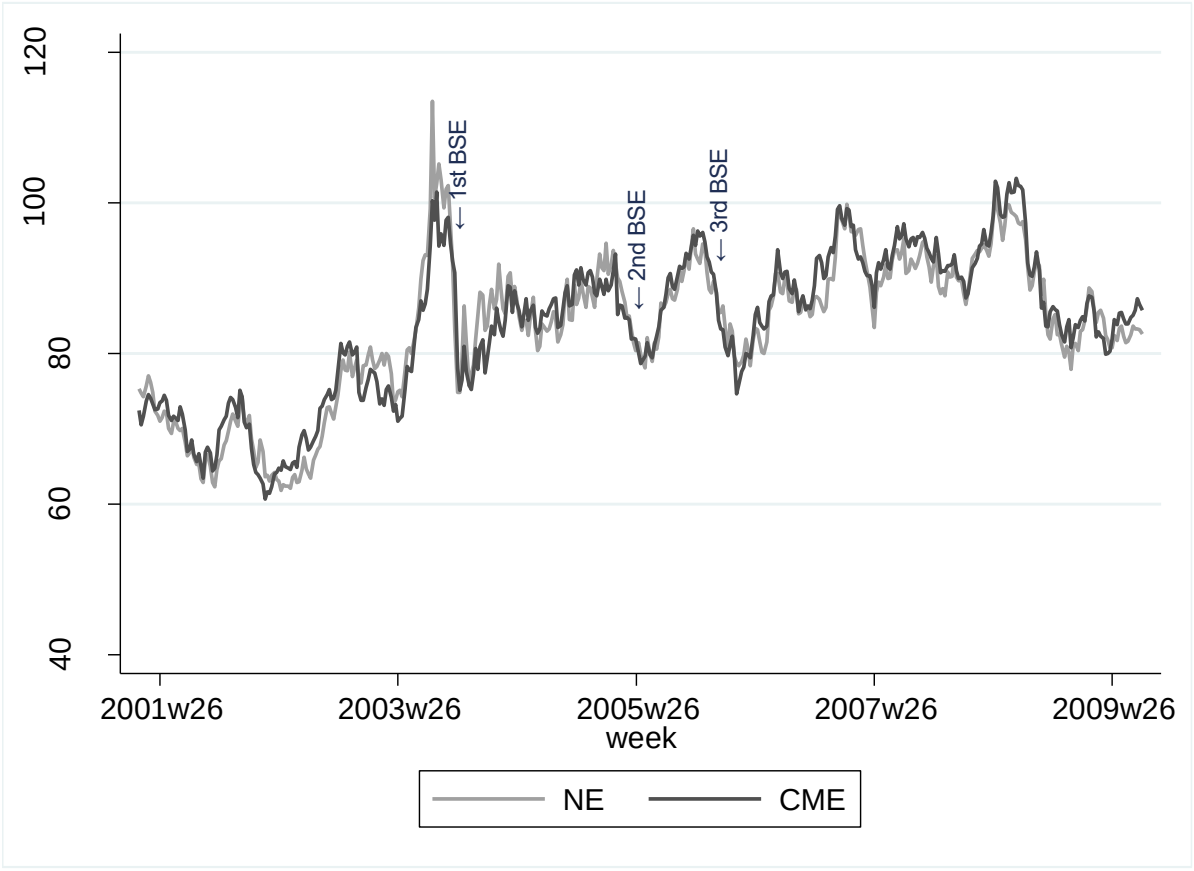

Figure 1: Weekly weighted average fed cattle cash prices from NE (NE) and weekly average live cattle futures prices from CME (CME)

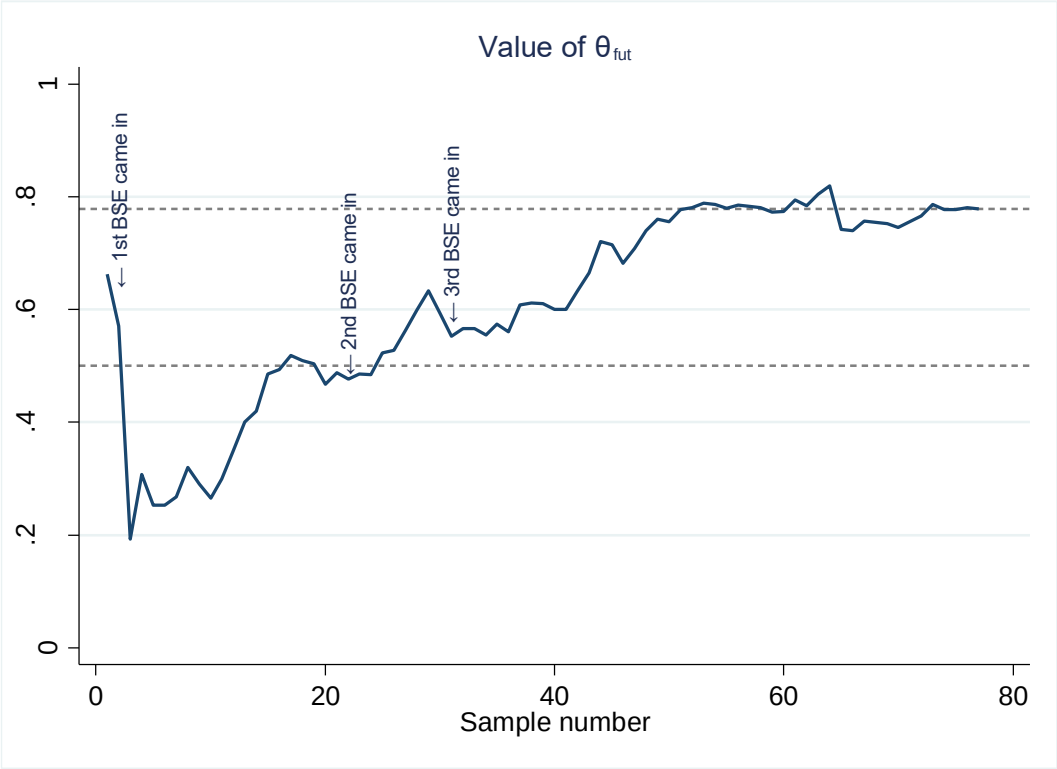

Figure 2: Coefficient of relative ratio of speed adjustment for futures prices θ_{fut} as a function of the sample number.