Implementation of the Event Study Methodology to Agricultural Markets : An Evaluation of the BSE Impact on Cattle Prices in Italy

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Application de l'approche événementielle aux marchés agricoles : évaluation de l'impact de l'ESB sur les prix du bétail en Italie

Mots-clés :
crise de l'ESB, risques alimentaires, économétrie, approche événementielle, marché du bétail, prix des bovins

Résumé – L'objectif de cet article est d'illustrer comment l'approche *« Event Study »*, traditionnellement réservée aux applications financières, peut être transposée aux marchés agro-alimentaires pour évaluer l'impact de chocs dus à des crises spécifiques (intoxications alimentaires) ou à d'autres facteurs (modifications législatives ou politiques). L'intérêt de cette approche est de permettre d'évaluer la persistance du choc en termes de comportement anormal du marché, en approfondissant la simple étude d'impact sur la variable d'objectif.

L'approche *« Event Study »* est appliquée au cas particulier de l'impact de l'apparition de la crise de l'ESB sur le principal marché bovin d'Italie, *i.e.* celui de Modène. Cette application permet de mettre en relief certains des principaux avantages et inconvénients de l'approche en question. Elle permet également de mettre en évidence les effets de la crise de l'ESB sur l'évolution des prix des différentes espèces bovines sur le marché de Modène. Les résultats montrent que l'apparition de la crise de l'ESB en mars 1996 a affecté négativement les prix de toutes les espèces bovines sur le marché de Modène, les catégories les plus touchées étant les génisses et les jeunes bovins. Après le printemps, les prix montrent des signes de reprise, excepté ceux des génisses et des jeunes bovins qui conservent leur comportement anormalement déprimé, imprimé par la crise.

Implementation of the Event Study Methodology to Agricultural Markets: an Evaluation of the BSE Impact on the Cattle Prices in Italy

Key-words :
BSE shock, food scares, econometrics, event study analysis, cattle market, bovine prices

Summary – *This article aims to illustrate the application to agricultural markets of the event study methodology, by exploring the impacts of the March 1996 BSE news on the Modena cattle market prices. This method is based on an analysis of forecast residuals during an event window which is defined outside the model estimation period. Through the application on cattle prices, some of the main advantages and limits of the event study approach are underlined. Using this method we find that the BSE crisis negatively affected market prices, particularly in the first three months, with a stronger impact on trading prices for steers and heifers. After the spring other species showed sign of recovery, whereas steers and heifers' prices continued in their abnormal, negative behaviour.*

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THE aim of this paper is to illustrate how the Event Study (ES) analysis may be applied to agri-food markets in order to assess the impact of food scares and other factors (i.e. regulations, policies). Event study methodology has been widely used in finance to analyse the behaviour of securities affected by specific shocks such as the news or the introduction of new regulations. The recent availability of frequent data in agricultural and food markets now allows to test the analysis on non-financial data. Starting from this consideration and from the prominence and consequences of the Bovine Spongiform Encephalopathy (BSE) scare, an event study analysis, with the appropriate adjustments, has been carried out using data on cattle prices, supplied by the Modena cattle market, the most representative Italian cattle market.

There are several methodologies that could be used to evaluate the market reaction to the occurrence of an external event. Traditional econometric techniques aim to adjust the model to the event, analysing the impact in terms of changes in the parameters. These include methods of testing for model stability (Chow, 1960; Greene, 1997 and references therein) and methods of adjusting the model specification once a structural change has been detected (such as the intervention analysis introduced by Box and Tiao, 1975, or the time-varying parameter approach used by Chow, 1984, and Harvey, 1989, for example). Event Study has as its objective the evaluation of the impact of the event on the modelled dependent (target) variable, without assessing any structural change in the model's parameters. It is in practice a method of statistical analysis on prediction residuals generated by an external shock. Hence, the logic behind the ES analysis is similar to that of the Chow forecast test (Fisher, 1970). However there is a relevant difference: the ES method does not rely on the specification and estimation of a model for the post-event period, avoiding potential sources of errors. On the other hand, classical methods for testing structural change allow some consideration on the pattern of structural change after the shock, by explicitly modelling the post-event behaviour.

The clear identification of the time period when the shock first occurred and the absence of other relevant factors acting in the same period are basic conditions for applying the event study methodology.

THE EVENT STUDY ANALYSIS

Event studies began with the work of Ball and Brown (1968) and Fama *et al.* (1969). Binder (1998) and Strong (1992) offer comprehensive reviews of the methodology and its developments. This approach has been rarely applied to agricultural and food markets. Only few studies used the Event Study approach for indirectly analysing agro-food markets, through the performance in the Stock Exchanges of securities related to the agricultural and food sector. Johnson *et al.* (1992) applied the technique to the meat-packing sector in the United States for evaluating the impact of regulatory changes. Henson and Mazzocchi (1997) assessed the reaction of food companies listed in the London Stock Exchange to the news of a possible link between BSE and the human Creuzfeld-Jakob disease (CJD).

The event study method is quite simple. Once a specific exogenous event of interest has been identified, the target variable is modelled over a period which does not include the exogenous event. The model should be independent from any other shock influencing the market behaviour [(1)]. Prediction residuals are calculated over the forecast or event window and are tested for statistical significance under the standard hypothesis that their mean is zero.

Figure 1.
Example of Excess Residuals in Event Study Analysis

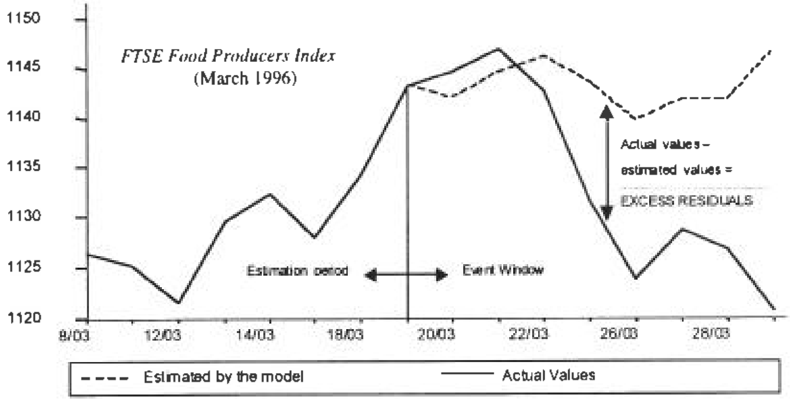


Figure 1 presents an example of excess (forecast) residuals obtained by event study analysis. This example is borrowed from the Henson and Mazzocchi (1997) study focusing on the reaction of the FTSE Food Producers Index in the London Stock Exchange to the release of the news about a possible linkage between BSE and human disease CJD on 20th March 1996. Here the target variable is the food producers index of the London Stock Exchange. The analysis investigates the effects of the BSE news announcement on 20th March 1996 *(event date)*, through an *event window* of 7 trading days from 20th to 29th of March. A *benchmark model*

[(1)] In financial literature, Strong (1992) identifies five alternative specifications of the benchmark model for event studies. Some corrections were proposed by Scholes and Williams (1977), Dimson (1979), Cohen *et al.* (1986) and Henson and Mazzocchi (1997), but the basic assumption of these models can be still ascribed to the cases listed by Strong.

was estimated with the 150 daily observations preceding the shock date and represents the "normal" behaviour of the target variable.

The benchmark model is then used to forecast the target variable over the event window (dotted line). The excess or forecast residuals are the result of the difference between the actual values and the forecasted values. The final aim is to test with the appropriate tools whether the excess residuals are significantly different from 0 or not.

The most important steps of the analysis are the specification and estimation of the benchmark model, since it will affect both the computation of the residuals and the precision of any statistical test. The explanatory variables of the model should be independent from the event, in order to allow reliable forecasts of the benchmark model over the event window. Two conditions to be respected by the independent variables: they must not be affected by the event and must be highly correlated with the target variable over the estimation period. One would then expect that the correlation between the target variable and the exogenous one(s) should decrease after the event. The benchmark model however should perform well in forecasting in the absence of structural change.

Once the model has been estimated and forecasts are computed, the forecast residuals are calculated. As seen, for hypothesis testing purposes, the changes in the model parameters after the event are not taken into account. Instead, tests focus on changes in the expected value of the target variable, that is on the forecast residuals over the event window.

Let X_{it} be the target variable, observed on statistical unit i at the time period t and E_l the event occurring at time $t = l$. The first hypothesis to be tested will be

$$H_0: E(X_{it}/E_l) - E(X_{it}) = E(u_{it}/E_l) = 0$$

against $$H_1: E(X_{it}/E_l) - E(X_{it}) = E(u_{it}/E_l) \neq 0 \quad (1)$$

with $$u_{it} = X_{it} - E(X_{it}) \quad (2)$$

where $l \leq t \leq L$, and L is the last time period of the event window. The expected value of the target variable conditional to the event is in fact the actual observed value of the target variable in a single month (X_{it}). On the other hand, the expected value of the target variable unconditional to the event $E(X_{it})$ is returned by the benchmark model, that was estimated over a period unaffected by the event. Under the hypothesis that these forecast residuals are normally distributed over the event window, tests on standardised forecast residuals are carried out. These are referred to as Patell Standardised Residuals and they are defined as follows (Patell, 1976):

$$PSR_{it} = \frac{u_{it}}{s_i \sqrt{C_{it}}} \sim t(T_i - 2) \quad (3)$$

with $$C_{it} = 1+\frac{1}{T_i}+\frac{(Z_{it}-\overline{Z}_i)^2}{\sum_{\tau=1}^{T_i}(Z_{i\tau}-\overline{Z}_i)^2} \tag{4}$$

where: T_i is the number of time periods included in the estimation period (EP) of the benchmark model for the target variable X_i

Z_i is the exogenous variable in the benchmark model for the target variable X_i

$\overline{Z}_i = \frac{1}{T_i}\sum_{\tau=1}^{T_i} Z_{it}$ is the mean of the exogenous variable over the EP

$s_i = \sqrt{\frac{\sum_{\tau=1}^{T_i} u_{i\tau}^2}{T_i-2}}$ is an estimate of the standard error of the residuals (σ_i) of the benchmark model for the target variable X_i

Correction (4) reflects the increase in variance due to prediction outside the estimation period. If a lagged dependent variable appears in the model and dynamic forecasts are computed, then the test should also take into account the increase in the prediction variance due to the inclusion of the forecast lagged dependent variable.

It might be interesting to aggregate the individual residuals through time and statistical units. Given an event window with L time periods and a group g of statistical units, the following tests can thus be built:

$$PSR_{i0} = \sum_{t=1}^{L}\frac{u_{it}}{s_i\sqrt{L.C_{it}}} \sim t(T_i-2) \tag{5}$$

$$PSR_{gt} = \frac{\sum_{i\in g}\frac{u_{it}}{s_i\sqrt{C_{it}}}}{\sqrt{\sum_{i\in g}\frac{T_i-2}{T_i-4}}} \sim N(0,1) \tag{6}$$

$$PSR_{g0} = \frac{\sum_{i\in g} PSR_{i0}}{\sqrt{\sum_{i\in g}\frac{T_i-2}{T_i-4}}} \sim N(0,1) \tag{7}$$

Standard statistical conditions, such as normality of residuals, lack of heteroskedasticity and autocorrelation, must be respected in order to well-specify the above tests. In the same way, when some statistical units are aggregated, cross-sectional independence across residuals of these variables is required. Jaffe (1974) and Mandelker (1974) propose a correction to take into account cross-sectional dependence across residuals of aggregated statistical units.

In that case, cumulating the grouped abnormal returns over the event window and taking into account Patell's results leads to the test:

$$PSR_g = \sum_{t=1}^{L} \frac{u_{gt}}{SE(u_g)\sqrt{LC_{gt}}} \sim t(L-2) \qquad (8)$$

with $S.E.(u_g) = \sqrt{\frac{1}{L-1}\sum_{t=1}^{L}(u_{gt} - \bar{u}_g)^2}$

where $\bar{u}_g = \frac{1}{L}\sum_{t=1}^{L} u_{gt}$

THE CASE STUDY OF THE MODENA CATTLE MARKET

To illustrate the event study methodology, we evaluate the BSE impact on monthly cattle prices in the Modena cattle market. These prices are defined as the target variables. The Modena cattle market is the most important in Italy and provides prices for a large number of species, that is prices are highly disaggregated by commodity.

Data

The prices on the Modena cattle market are recorded by a Technical Committee, composed of the representatives of the main interest groups (breeders, slaughtering and processing firms, meat packaging firms etc.), on the basis of interviews and sample surveys on the market. These prices might not exactly coincide with the actual average prices applied by the traders on the Modena market, however once published, they are a basis for transactions outside the Modena market. For example, some contracts, especially at firm and industry level, explicitly set their prices at the "Modena cattle market level"(2).

(2) Most of the cattle trade in Italy (around 60 % of the trading volume) takes place outside the cattle markets, as a result of direct agreements among market operators (breeders, slaughtering firms, meat processing firms, etc.). The prices on the Modena cattle market are widely publicised each week, to be used as a landmark for those transactions. This function has become so significant that the Modena cattle market is now planning to turn into a telematic auction market. For a more comprehensive discussion of the price formation mechanism and the representativeness of the Modena cattle market see Cazzola, Forti and Gatti (1997).

The database includes 28 time series of bovine prices, classified by species and breeds (see annex 1), with weekly observations from January 1991 to June 1997 (76 observations). Maximum and minimum prices are recorded for each breed, from which weekly average prices were derived. The prices used in the analysis are monthly averages of corresponding weekly average prices for each breed.

The estimation period of the benchmark model is January 1992 to February 1996 (50 observations). Where lagged dependent variables are used, the estimation period begins in 1991, in order to keep 50 observations available. The event date (release of the information of a possible linkage between BSE and the human disease CJD) is 20th March 1996. Hence, March is defined as the first month of the event window. However, as only one of the four March trading weeks was concerned by the news on the BSE scare, the impact of the event is expected to be lower on this first month.

Two event windows were defined. In the first case all post-event available observations (from March 1996 to June 1997) were included. In the second case, the event window was restricted to the period March-December 1996. As a matter of fact, in January 1997 there was a major change in the bovine market regulation: the Italian Ministry of Health restricted the access of foreign cattle to the domestic market. This mainly led to the exclusion of French bovines, which accounted for more than 30 % of the cattle traded on the Italian market in 1996. This regulation change may be considered as a an "event" itself, or as a further consequence of the initial event, *i.e.* the BSE crisis.

The benchmark model for the analysis is specified as follows (see annex 2):

$$P_{it} = \alpha_{i0} + \alpha_{i1} P_{i,t-1} + \alpha_{i2} Z_t + e_{it} \qquad (9)$$

where P_{it} is the price of cattle breed i at month t

Z_t is the Lira/Ecu exchange rate at month t

α_{ij} $(j = 0,1,2)$ are the parameters to be estimated for each cattle breed i

Several explanatory variables Z were considered in specifying the benchmark model (namely, the number of heads of cattle breed i entering the market, the producer price index for animal products and the Lira/Ecu exchange rate). The Lira/Ecu exchange rate appeared as the most suitable explanatory variable for two main reasons. Firstly it displayed the highest correlation with target variables. Secondly one may safely assume that the exchange rate is not significantly affected by the considered event, *i.e.* the BSE crisis, whereas this is probably not the case for both other considered variables.

Results: Computation and Analysis of Forecast Residuals

Once the models have been estimated (see annex 3), the forecast residuals for each species in each event window can be computed. Either dynamic or static forecasts may be used in the analysis though the interpretation of results will differ. Using dynamic forecasts relies on the assumption that the shock is temporary. Indeed, in each time period of the event window, the lagged price used to forecast the corresponding current price is the lagged forecasted price and not the lagged observed price. Therefore, apart from the initial shock on the considered price, dynamic forecasts embody only pre-event information (*i.e.* data used to estimate the benchmark model).

In contrast, in the static forecast case, the lagged price used to forecast the current price over the event window is the actual lagged price. The shock is therefore assumed to be permanent, in the sense that post-event information is embodied in static forecasts. One may underline here that neither case considers any structural change in the benchmark model's parameters.

The choice of the convenient forecasting method mainly depends on the nature (temporary or permanent) of the considered event. Obviously, in some cases, the nature of the shock is not clearly identified, and it may be useful to carry out both analyses.

In our case study, price series clearly show that the prices of the various considered cattle breeds observed on the Modena market did not recover their previous levels in the months following the BSE shock. This suggests that our considered event would rather correspond to a permanent shock. As a consequence, static forecasts were retained and the excess residuals were computed as $u_{it} = P_{it} - E(P_{it})$ where $E(P_{it})$ is the forecast value. Of course we agree that dynamic forecasts could have been carried out in addition, at least because the dynamic approach may constitute itself a test for identifying structural breaks. However, we consider that identifying such structural breaks is far beyond our empirical purpose which is mainly directed at quantifying the BSE shock effects across time and among bovine categories.

Table 1 reports the computed values of Patell Standardised Errors (PSR_{i0}) and the results of test (5) for each considered cattle breed i, and for both event windows (March 1996-December 1996 and March 1996 and June 1997). Cattle breeds are sorted according to their PSR_{i0}'s respective values obtained for the first event window. One may emphasise that the Patell's statistics operate a standardisation on the excess residuals, so that the PSR_{i0} are not influenced by any factor of scale due to differences in price levels. Hence it is possible to compare the residuals across the different cattle breeds.

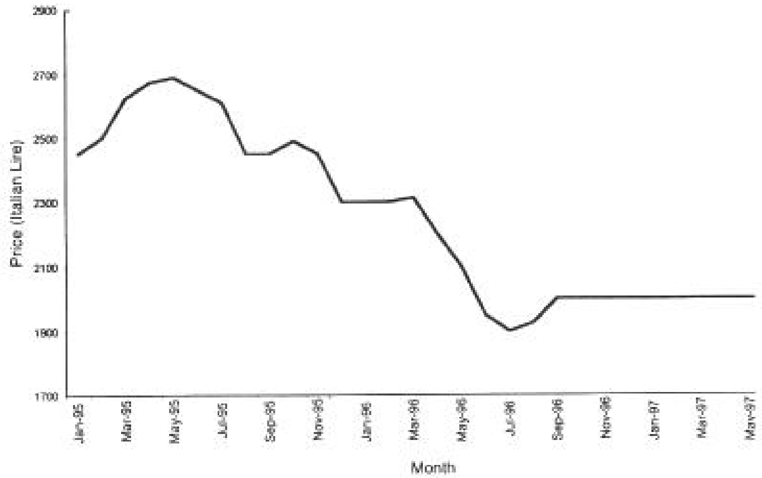
Table 1. **Patell Standardised Residuals per Species over the Event Windows (PSR_{i0})**

Species	Breed	Event Window 1 Mar 96-Dec 96	Event Window 2 Mar 96-Jun 97
Steers	Charolaise 1st Quality	-16.29 **	-15.07 **
Heifers	French and crossbreeds	-11.48 **	-12.89 **
Heifers	Valuable for beef Extra	-9.75 **	-8.98 **
Heifers	Limousine	-8.31 **	-8.13 **
Steers	Simmenthal 2nd Quality	-7.55 **	-8.75 **
Steers	Limousine	-7.51 **	-8.69 **
Heifers	Simmenthal	-7.20 **	-7.68 **
Heifers	Black Spotted	-7.08 **	-7.74 **
Steers	Simmenthal 1st Quality	-5.84 **	-6.90 **
Steers	Black spotted 1st Quality	-5.05 **	-9.03 **
Steers	Valuables for beef Extra	-4.86 **	-5.38 **
Steers	Charolaise 2nd Quality	-4.57 **	-3.39 **
Steers	Polish Black Spotted	-4.45 **	-6.33 **
Calves <3 months	Valuable Extra	-3.90 **	-4.60 **
Calves <3 months	Rearing 1st Quality	-3.90 **	-4.19 **
Calves <3 months	Rearing 2nd Quality	-3.78 **	-3.97 **
Bulls	French and crossbreeds	-3.78 **	-2.75 **
Repl. Calves	Crossbreeds	-2.92 **	-3.51 **
Repl. Calves	Limousine	-2.86 **	-3.81 **
Steers	Black spotted 2nd Quality	-2.14 *	-3.18 **
Repl. Calves	Charolaise	-2.07 *	-2.93 **
Slaughter Calves	2nd Quality	-1.97 *	-1.78
Slaughter Calves	1st Quality	-1.89	-2.05 *
Cows	Simmenthal 2nd Quality	-1.79	-0.34
Bulls	Piedmontese	-1.35	-0.17
Cows	Black spotted 1st Quality	-1.17	0.54
Cows	Piedmontese	-0.37	1.83
Bulls	Simmenthal	3.89 **	7.18 **

*** Significant at 1% level* ** significant at 5% level*

In very general terms, table 1 shows that, in average, the BSE crisis affected negatively the prices of nearly all cattle breeds on the Modena market. Results indicate that steers and heifers suffered the largest loss in prices. On the other hand, an unexpected result emerges from the cows' and bulls' excess residuals. They suggest that both these species would have not been significantly affected by the crisis. According to obtained results, Simmenthal bulls'price showed a significant positive behaviour through the two event windows. This may be explained by the event study methodology itself, which rather analyses price trends than price levels in absolute terms. As shown by figure 2, the Simmenthal bulls' price had been experiencing a negative trend since long before the BSE crisis. In March 1996, it actually suffered from the general crisis and reached its lowest historical level. The Simmenthal Bulls' price did not recover after March 1996, but was steady at a very low level after October 1996. Hence, while the model's forecasts continued on a negative trend, the actual prices were steady at their minimum level, so that the prediction residuals became positive. Hence, the analysis leads to the conclusion that the Simmenthal bulls'price suffered less than prices of other species on the Modena cattle market essentially because, even before the BSE crisis, it was already reaching very low levels. This conclusion also applies, to a lesser extent, to other bulls and cow species.

Figure 2.
Simmenthal Bulls Price (Jan 95-June 97)



In a following step, excess residuals are aggregated across homogenous species (see Table 2) and tests (6) and (8) are performed. This step is necessary when working with non-normally distributed excess residuals (Brown and Warner, 1985). In the present case study, the Jarque-Brera test, applied to each single excess residual series, never led to the rejection of the normality hypothesis. However, such an aggregation is useful for drawing some more general conclusions about the prices' behaviour of homogenous species.

Generally, the behaviour of cattle prices on the Modena market has been greatly affected by the crisis, as emerges from the last column of table 2. Considering the market as a whole, the computed PSR is negative and significantly different from 0 in each month of the event window. April 1996 was by far the month where the BSE had the largest negative impact on cattle prices (– 40.69). The negative value of May (– 8.87) is less marked, but still significant, and in June the average shock impact on the market is still very relevant (– 34.63). From July to the end of the year, the excess residuals remain significantly negative, even though the loss appears to become lower than in the first months. Only in January 1997, the PSR shifts to be significantly positive

(+ 11.42), but in February and the months later it becomes again significantly negative and the cattle prices' behaviour does not actually show signs of recovery.

Some further considerations may be stemmed from the analysis of the prices' behaviour for the different species. As already pointed out, steers and heifers' prices suffered the most from the crisis. In fact, excess residuals for these species are negative through all the event window but January 1997. In addition, they are almost constantly significantly different from 0. The analysis on veal calves'prices show a different pattern. After a significant loss in April and June 1996, they started to recover through the summer months. The news of the import ban at the end of December resulted in a positive effect on January prices. Finally, from April 1997 onwards veal calves'prices showed some signs of recovery from the crisis, with positive and significant excess residuals. As already underlined, the response of the prices of bulls and cows to the BSE crisis was somewhat different. The prices of both species were also significantly negatively affected during the first months of the crisis. But from July 1996 to the end of the event window, the actual prices were constantly above the expected value, resulting in positive excess residuals. However, as already explained, this result is mainly due to the fact that actual price levels of bulls and cows were around their lowest historical values.

To sum up, our results suggest that on the Modena cattle market, the period April-June 1996 was marked by a significant global price decrease with respect to the usual situation. From July to November 1996, price behaviours started to differentiate across bovine species. Veal calves' prices started to recover, consistently with the fact that the risk of BSE is considered to be minimum for bovines aged under 30 - months[(3)]. According to the model, other calves' prices exhibited a "normal" behaviour although they did not recover from the losses of the first period. In the same time, heifers and steers'prices were still showing a negative abnormal behaviour. Between December 1996 and January 1997 the Modena market experienced clear signs of recovery for all species, probably because of the decision of the Italian Ministry of Health to ban imports of foreign animals. As already mentioned, this raises the issue of whether this decision should be considered as an event itself. The case of cows and bulls'prices is specific. From July 1996 to June 1997 they seem to be on a recovery path, independently from the general price behaviour on the Modena cattle market.

[(3)] Less than 0.2% of the total cases of BSE (about 170,000) registered in the UK between 1985 and 1997 occurred in cattle younger than 30 months. During 1997, the youngest animal with BSE in UK was 37 months of age (*Source*: MAFF).

The last two rows of table 2 return some indications on the overall impact of the BSE crisis through the whole event windows. A fall in prices that was not recovered emerges for steers, heifers and other calves through both event windows. Whereas prices of veal calves, bulls and cows do not show abnormal behaviour on both event windows considered as a whole. Instead, bulls and cows' prices resulted to be higher than expected, considering the event window from March 1996 to June 1997.

Table 2. **Grouping Across Species: Values and Significance of Patell Standardised Residuals** *(PSR_{gt})*

	Species					
Month	Veal Calves	Other Calves	Steers	Heifers	Bulls and cows	Whole market
Mar-96	0.00	-2.12 *	-2.95 **	-4.05 **	1.20	-7.63 **
Apr-96	-8.21 **	-6.69 **	-12.55 **	-13.44 **	-4.80 **	-40.69 **
May-96	0.88	1.28	-4.62 **	-3.26 **	-2.55 *	-8.87 **
Jun-96	-2.12 *	-11.82 **	-9.64 **	-8.72 **	-4.98 **	-34.63 **
Jul-96	0.67	0.35	-7.46 **	-7.37 **	0.36	-13.82 **
Aug-96	2.95 **	-0.34	-3.87 **	-5.01 **	2.17 *	-5.53 **
Sep-96	2.47 *	-0.41	-4.68 **	-3.34 **	4.22 **	-2.92 **
Oct-96	-1.89	-0.63	-7.50 **	-4.48 **	0.95	-12.52 **
Nov-96	-1.01	-1.40	-6.64 **	-7.00 **	1.85	-13.51 **
Dec-96	-2.22 *	-2.79 *	-0.23	-4.01 **	3.17 **	-4.59 **
Jan-97	0.81	-0.88	4.18 **	4.57 **	3.02 **	11.42 **
Feb-97	-3.53 **	-2.64 *	-5.68 **	-4.07 **	2.55 *	-11.25 **
Mar-97	-5.50 **	-3.36 **	-3.98 **	-4.25 **	3.70 **	-10.18 **
Apr-97	0.29	-1.28	-7.61 **	-8.59 **	3.04 **	-14.12 **
May-97	2.59 *	-3.46 **	-5.98 **	-1.65	4.20 **	-5.12 **
Jun-97	3.18 **	-0.63	-7.92 **	-4.86 **	3.39 **	-8.35 **
Event windows						
Mar 96-Dec 96	-0.83	-2.92 **	-5.33 **	-5.71 **	0.73	
Mar 96-Jun 97	-0.83	-2.09 *	-5.68 **	-5.21 **	2.68 **	

*** Significant at 1% level* ** significant at 5% level.*

CONCLUSIONS AND FURTHER WORK

The event study application to the Modena cattle market proposed in this article provides some indication about the potential uses of this approach in agricultural economics. The advantages of the event studies lie in the possibility to evaluate the persistence of a shock in terms of abnormal behaviour exhibited by target variables, deepening the simpler study of the level of these target variables. An interesting issue emerging from our application of the event study methodology to a non-financial market results from the introduction of a lagged dependent variable among the regressors. This creates the choice between two alternative forecasting methods: static and dynamic. Each method relates to a specific assumption on the nature of the shock and gives the opportunity to evaluate whether it is temporary or permanent. In the present case study the shock appeared to have some permanent effects or – more cautiously – evident medium-term impact, since cattle prices on the Modena market were still showing negative abnormal behaviour after 15 months from the beginning of the BSE crisis. Hence, the static forecast method was chosen. However, further work is needed in order to better analyse the «static» versus «dynamic» forecast issues. Hence a further development to this article would be to perform dynamic forecasts and to compare obtained results with those presented here. In addition, as emphasised by the discussion in the previous sections, testing with dynamic forecasts could be considered as an alternative approach to Chow forecast test, as the Patell tests do not rely on model estimation after the structural break.

Through the analysis of the excess residuals over time, it has also been possible to identify different patterns in the prices behaviour after the crisis, according to cattle breeds. For our case study, data on the number of heads actually traded during each month of the considered time period were not available. Otherwise it could have been possible to estimate the total monetary loss due to the BSE crisis for breeders trading on the Modena market. Event studies have already been applied in damage assessment in the case of legal-liability for specific events, like the Tylenol-poisoning case of 1982 (Mitchell, 1989). A further potential application of the event study methodology to BSE-like cases could be for example to contribute to assess the levels of compensatory payments (differentiated by cattle species) which would be necessary if policy makers decided to compensate breeders for the loss induced by the price fall.

The present work also highlights some limits to the application of the event study analysis to agricultural data. The most evident is probably the need for numerous data series in order to have well-specified tests, especially when working with weekly or daily data.

On the other hand, modelling is a decisive step. The explanatory variable(s) must be chosen very carefully, but this choice is often conditioned by data availability. Moreover, the respect of the residuals' econometric properties here mentioned deserves a deeper discussion. Other issues not discussed here regard the data frequency and the length of the event window.

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ANNEX 1

List of species and breeds for bovine prices considered in the analysis

Calves < 3 months (3 breeds)
Valuable Extra, Rearing 1st Quality, Rearing 2nd Quality

Slaughter calves (2)
1st and 2nd Quality

Replacement calves (3)
Limousine, Charolaise, Crossbreeds

Steers (9)
Valuables for beef Extra, Limousine, Charolaise 1st Quality, Charolaise 2nd Quality, Simmenthal 1st Quality, Simmenthal 2nd Quality, Black spotted 1st Quality, Black spotted 2nd Quality, Polish Black Spotted

Heifers (5)
Valuable for beef Extra, French and crossbreeds, Simmenthal, Black Spotted, Limousine

Bulls (3)
Piedmontese, French and crossbreeds, Simmenthal

Cows (3)
Piedmontese, Simmenthal 2nd Quality, Black spotted 1st Quality

Data are available at the following Internet address :
http://phobos.comune.modena.it/cgi-bin/mercato/mb-query

ANNEX 2

The partial adjustment structure for the benchmark model

Starting from the consideration that the adjustment of cattle prices to change in the Lira/Ecu exchange rate is not complete, the benchmark model for each breed was defined as a partial adjustment model (see for example Hallam, 1990) as follows:

$$P_{it} = \alpha_{i0} + \alpha_{i1} P_{i,t-1} + \alpha_{i2} Z_t + e_{it} \qquad \text{(a1)}$$

Model (a1) means that in each period the price of breed i partially adjusts to its desired level. So the change in P_{it} over one period is a proportion of the desired complete change:

$$P_{it} - P_{i,t-1} = \delta_i (P^*_{it} - P_{i,t-1}) + u_{it} \qquad \text{(a2)}$$

where $P_{it}*$ is the desired level, *i.e.* the level the price would reach if the market were frictionless and the adjustment to changes in the exogenous variables was instantaneous;

δ_i is the the adjustment parameter (ranging from 0 to 1) for price i

In a frictionless market with instantaneous adjustment, we have:

$$P^*_{it} = \beta_{0i} + \beta_{1i} Z_t \qquad \text{(a3)}$$

Merging (a2) with (a3) we obtain the partial adjustment model:

$$P_{it} = \delta_i \beta_{0i} + (1 - \delta_i) P_{i,t-1} + \delta_i \beta_{1i} Z_t + u_{it} \qquad \text{(a4)}$$

Equation (a4) can be estimated by OLS in the form (a1). As a lagged dependent variable is included among the regressors, the model's residuals might be serially correlated. When this was the case, estimation was carried out through nonlinear least squares using the Marquardt Algorithm, which is asymptotically equivalent to maximum likelihood (Harvey, 1990, pp. 136-137). The data were not seasonally adjusted previously to the estimation, as this would induce further serial correlation in the series and in the residuals. Instead, seasonal (monthly) dummies were added to the model in order to take into account and evaluate seasonality. The tests for the presence of serial correlation were based on the Ljung-Box statistic. As mentioned, the serial correlation patterns in the residuals were modelled when the uncorrelation hypothesis was rejected. A Wald test on the coefficient of the lagged dependent variable was used to detect whether it was significantly different from (less than) one, for ensuring stationarity. The estimation results are summarised in annex 3, omitting the non-significant explanatory variables.

ANNEX 3

The benchmark models: Significant parameter estimates

Breed	Equation	Adj. R^2
1. Calves < 3 mths	$P_{it} = 0.88\, P_{i,t-1} + 0.76\, Z_t - 595.8\, \text{Jul} - 694.5\, \text{Aug} - 297.3\, \text{Dec} + 0.44\, \text{MA(1)} + u_t$	0.97
2. Calves < 3 mths	$P_{it} = 0.71\, P_{i,t-1} + 0.98\, Z_t + 623\, \text{May} + 928.4\, \text{Jun} - 501.1\, \text{Aug} + 0.59\, \text{MA(1)} + u_t$	0.90
3. Calves < 3 mths	$P_{it} = 0.68\, P_{i,t-1} + 0.89\, Z_t + 637.8\, \text{May} + 968.6\, \text{Jun} - 495.7\, \text{Aug} + 0.54\, \text{MA(1)} + u_t$	0.89
4. Slaughter Calves	$P_{it} = 0.79\, P_{i,t-1} + 0.70\, Z_t + 369\, \text{Sep} + 242.7\, \text{Oct} + u_t$	0.97
5. Slaughter Calves	$P_{it} = 0.80\, P_{i,t-1} + 0.53\, Z_t + 162.4\, \text{Jun} + 314.6\, \text{Sep} + 182.9\, \text{Oct} + 0.36\, \text{AR(1)} + u_t$	0.97
6. Repl. Calves	$P_{it} = 0.88\, P_{i,t-1} + 0.34\, Z_t + 237.5\, \text{Sep} + 0.39\, \text{MA(1)} + u_t$	0.98
7. Repl. Calves	$P_{it} = 0.90\, P_{i,t-1} + 0.24\, Z_t + 263.2\, \text{Sep} + u_t$	0.95
8. Repl. Calves	$P_{it} = 0.86\, P_{i,t-1} + 0.34\, Z_t + 121\, \text{Sep} + 0.57\, \text{MA(1)} + u_t$	0.97
9. Steers	$P_{it} = 894.9 + 0.76\, P_{i,t-1} + 0.16\, Z_t - 109.3\, \text{May} - 172.11\, \text{Jun} + u_t$	0.84
10. Steers	$P_{it} = 688.6 + 0.63\, P_{i,t-1} + 0.49\, Z_t - 98.8\, \text{May} - 175.4\, \text{Jun} + u_t$	0.93
11. Steers	$P_{it} = 878.2 + 0.61\, P_{i,t-1} + 0.38\, Z_t - 112.7\, \text{May} - 173.7\, \text{Jun} - 102.5\, \text{Jul} + u_t$	0.87
12. Steers	$P_{it} = 304.5 + 0.63\, P_{i,t-1} + 0.54\, Z_t - 92.3\, \text{May} - 158\, \text{Jun} + u_t$	0.93
13. Steers	$P_{it} = 340.1 + 0.67\, P_{i,t-1} + 0.43\, Z_t - 138.1\, \text{May} - 182.7\, \text{Jun} - 104.5\, \text{Jul} + u_t$	0.90
14. Steers	$P_{it} = 340.8 + 0.67\, P_{i,t-1} + 0.36\, Z_t - 102.4\, \text{May} - 147.2\, \text{Jun} - 95.5\, \text{Jul} + u_t$	0.90
15. Steers	$P_{it} = 0.54\, P_{i,t-1} + 0.69\, Z_t + 81\, \text{Jan} - 112.4\, \text{May} - 139\, \text{Jun} - 114\, \text{Jul} + 0.77\, \text{AR(1)} + u_t$	0.89
16. Steers	$P_{it} = 0.47\, P_{i,t-1} + 0.71\, Z_t + 0.74\, \text{AR(1)} + u_t$	0.88
17. Steers	$P_{it} = 461.9 + 0.67\, P_{i,t-1} + 0.35\, Z_t - 190.9\, \text{May} - 183.6\, \text{Jun} - 149.4\, \text{Jul} + u_t$	0.90
18. Heifers	$P_{it} = 683.5 + 0.70\, P_{i,t-1} + 0.47\, Z_t - 164.1\, \text{May} - 83\, \text{Jun} + u_t$	0.95
19. Heifers	$P_{it} = 0.73\, P_{i,t-1} + 0.61\, Z_t - 98.2\, \text{May} + u_t$	0.97
20. Heifers	$P_{it} = 0.52\, P_{i,t-1} + 0.89\, Z_t + 0.48\, \text{MA(1)} + u_t$	0.95
21. Heifers	$P_{it} = 0.74\, P_{i,t-1} + 0.36\, Z_t - 95.6\, \text{May} + u_t$	0.93
22. Heifers	$P_{it} = 317.2 + 0.79\, P_{i,t-1} + 0.39\, Z_t - 127.7\, \text{May} - 88.7\, \text{Jun} + u_t$	0.97
23. Bulls	$P_{it} = 0.82\, P_{i,t-1} + 0.40\, Z_t - 4.98\, \text{Trend} + 0.50\, \text{AR(1)} + u_t$	0.96
24. Bulls	$P_{it} = -207 + 0.81\, P_{i,t-1} + 0.44\, Z_t - 3.26\, \text{Trend} - 39.7\, \text{Dec} + u_t$	0.98
25. Bulls	$P_{it} = -452.4 + 0.84\, P_{i,t-1} + 0.53\, Z_t - 5.52\, \text{Trend} + u_t$	0.97
26. Cows	$P_{it} = -513.7 + 0.84\, P_{i,t-1} + 0.70\, Z_t - 8.23\, \text{Trend} + u_t$	0.95
27. Cows	$P_{it} = -439.5 + 0.74\, P_{i,t-1} + 0.66\, Z_t - 7.52\, \text{Trend} + 82.9\, \text{Mar} + u_t$	0.90
28. Cows	$P_{it} = -626.5 + 0.70\, P_{i,t-1} + 0.82\, Z_t - 9.24\, \text{Trend} + 0.43\, \text{MA(1)} + u_t$	0.92

All coefficients reported on the table significantly differ from 0 at a 95 % confidence level. Non-significant estimates were omitted.